Extract from:

ESSAY

The Microbial Olympics

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100 μm freestyle swimming

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The 100 μm freestyle final takes place in the Oxford microscopic pool and should be an exciting race. Microorganisms range from less than 1 μm to more than 100 μm in length, so a sporting contest is ensured by limiting contestants to micrometre-sized bacteria that swim by rotating helical flagella. Pre-competition favourite, the tiny but speedy *Bdellovibrio bacteriovorus*, was disqualified in the heats for eating another competitor. Fans of *Salmonella enterica* and *Helicobacter pylori* were left disappointed after they failed their random pathogenicity tests.

Bacteria swim to optimize their environment or to escape predators. They are typically too small to notice any variations across their length, so instead change swimming direction randomly, but do this less often when thing are getting better (for recent reviews of bacterial motors and chemotaxis, see REFS 15,16). This is a handicap for a straight sprint, so half of the finalists are genetically modified to lack sensory responses. The singly flagellated contestants, *Rhodobacter sphaeroides*, *P. aeruginosa* (competing in its second event of the games) and *Vibrio alginolyticus*, start well (see Supplementary information S1 (movie)). The multiply flagellated, sodium-driven chimeric *E. coli* matches their pace, but its proton-driven relative falls behind. Ten micrometres in, the puller *V. alginolyticus* is attracted to the pool surface and swims in circles, failing to complete the race. In what turns out to be a photo finish (FIG. 1), *R. sphaeroides* wins by a body length, in 2.02 seconds, taking gold after surviving a post-race challenge for seemingly crossing its lane line. The chimeric *E. coli* survives a late slowdown to finish in 2.08 seconds, taking silver from *P. aeruginosa* at 2.12 seconds. The pusher *V. alginolyticus* comes in a close fourth, and 1 second later proton-driven *E. coli* edges out *Yersinia enterocolitica* for fifth place. *Rhodospirillum rubrum* was never in the contest, taking more than 15 seconds to finish.

As in the early human Olympic Games, contestants for the Microbial Olympics swimming were chosen on the basis of their ability to travel to the event; they were in Oxford freezers and easy to culture. With widening access and more rigorous selection, we expect a steady improvement in performance. *B. bacteriovorus* could break the 2 second barrier, and a large marine sulphur bacterium such as *Thiovulum majus* could swim the race within 0.2 seconds, if only it could be easily cultured in the lab and would fit into the lane. Given the vast range of uncharacterized species in the oceans and the promise of synthetic biology, who knows what the 2016 games will bring? In 2012, however, we salute the gold medallist, *R. sphaeroides*!

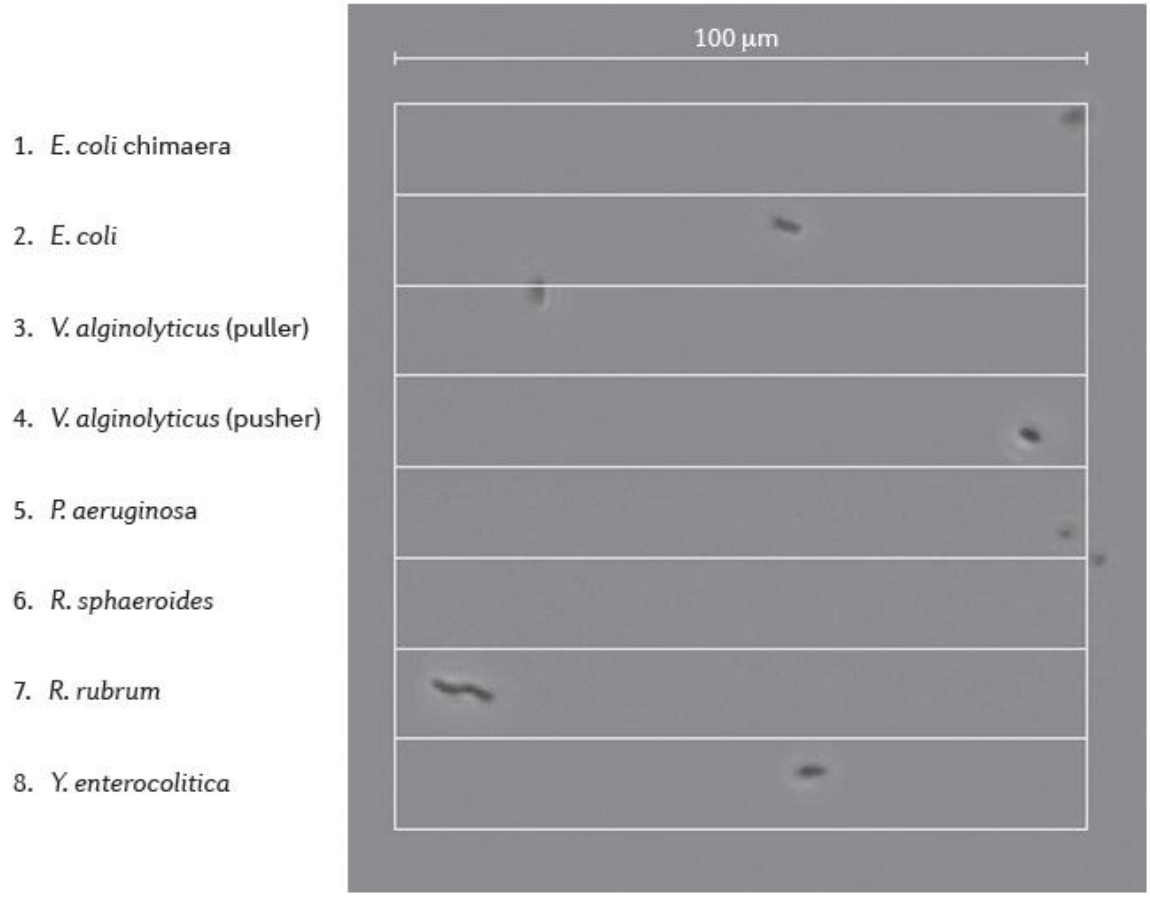

Figure 1 | **The 100 µm freestyle swimming.** Contestants (and country of origin) by lane: (1) sodium-driven chimeric *Escherichia coli*, with multiple flagella (Japan); (2) proton-driven *E. coli*, with multiple flagella (USA); (3) sodium-driven *Vibrio alginolyticus*, with a single polar, clockwise locked 'puller' flagellum (that is, the flagellum pulls the cell body along behind it; Japan); (4) sodium-driven *V. alginolyticus* with a single polar, anticlockwise locked 'pusher' flagellum (that is, the flagellum pushes the cell body along in front of it; Japan); (5) proton-driven *Pseudomonas aeruginosa*, with a single polar flagellum (Australia); (6) proton-driven *Rhodobacter sphaeroides*, with a single subpolar flagellum (USA); (7) proton-driven *Rhodospirillum rubrum*, a spiral-shaped bacterium with multiple flagella at each pole to both push and pull (USA); and (8) proton-driven *Yersinia enterocolitica*, with multiple flagella (Belgium). See Supplementary information S1 (movie) for a video of the race.