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Non-planar flagellar beating enables helical navigation by chiral microswimmers[1] DARIO CORTESE, University of Exeter, KIRSTY Y. WAN, Living Systems Institute, University of Exeter — Helical alignment towards gradients in space and time is a ubiquitous mechanism by which ciliated and flagellated organisms achieve deterministic reorientation in space. Here, we consider the biflagellate green alga Chlamydomonas reinhardtii which rotates steadily at 1-2Hz in the absence of stimuli while swimming on helical trajectories. To date, the mechanism underlying this behaviour has not been confirmed. We prove for the first time that rolling motion derives from a consistent, non-planar beat pattern. We demonstrate beat non-planarity by high-speed imaging and micromanipulation of live cells. To relate the observed flagellar beat patterns directly to the free-swimming dynamics, we construct a fully 3D theoretical model of Chlamydomonas. Incorporating geometrical parameters from the experimental data, we reproduce the sense and magnitude of the axial rotation observed in real cells. In particular, we deduce that helical swimming arises from an asymmetric flagellar driving. Cells are able to reorient towards or away from directional stimuli by actively modulating this bilateral asymmetry. We conjecture that molecular and physiological differences between cis and trans flagella underlie intracellular control over biflagellar dominance, which is critical for steering or taxis.

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