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Turning by buckling: a cheap evolutionary strategy for turning among marine bacteria KWANGMIN SON, JEFFREY GUASTO, ROMAN STOCKER, MIT — Marine bacteria have long been known to swim forward and backward ('run and reverse') by controlling the rotational direction of a 20 nm helical flagellum. Recent detailed observations have shown that these bacteria can also make sharp, $\sim 90^\circ$ turns, an astounding feature for a micron-scale organism with just one degree of freedom under its control. We demonstrate that a buckling instability originating from the flexible linkage ('hook') between the body and the flagellum is responsible for the reorientation. Using high-magnification (40$\sim$100X) observations based on high-speed video microscopy (420$\sim$1000 fps), we captured the extreme deformation of the flagellum and the hook involved in this process. The mechanical properties of the hook are finely tuned to the hydrodynamic loads experienced by the cell: the hook becomes unstable only when the compressive load during the onset of forward swimming exceeds the threshold for Euler buckling. Combining the data with a model of buckling of thin structures, we show that bacteria take advantage of the flexibility of the flagellum and the hook to generate a turn, which may represent the evolutionarily cheapest bacterial strategy to actively change direction.

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