Torque, speed and assembly of the E. coli flagella motor

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The bacterial flagellar motor (BFM) rotates at hundreds of Hz to propel swimming bacteria, driven by an electrochemical ion gradient across the cytoplasmic membrane. The motor consists of a rotor ~50 nm in diameter surrounded by up to ~11 ion-conducting stator units which exchange between motors and a membrane-bound pool. Measurements of the torque-speed relationship guide the development of models of the motor mechanism. Previous reports that speed near zero-torque in H^+-driven motors is independent of the number of units implied that units worked independently with high duty ratio. However, recent observations that the number of stator units in a motor depends upon external load reopen this question. Here, we show multiple speeds near zero-load in both Na^+ and H^+-driven motors. Additionally, we measure the torque-speed relationship of one and two H^+ units, up to and beyond their zero-torque speed, by selecting for the number of H^+ units and controlling the number of Na^+ units to vary motor speed, in hybrid motors. These experiments confirm that speed near zero torque in H^+-driven motors, like Na^+ motors, increases with the number of stator units. Our data constitute 75 torque-speed curves for the chimeric motor at various values of electrical and chemical potential and stator number, plus two for the wild-type motor. Simple re-scaling of torque and speed collapses all 77 curves onto a single universal curve. We discuss the implication of these findings with respect to the torque generating mechanism of the BFM and specifically the duty ratio of the stator units.

In addition, we will describe briefly attempts to template the assembly of rings of FliG with DNA scaffolds.