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Viral DNA Packaging at Base Pair Resolution

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Homomeric ring-ATPases of the ASCE family are responsible for a variety of important cellular functions, ranging from DNA translocation to protein degradation. The bacteriophage phi29, a model system for this family, uses such a ring-ATPase to compress its genome to near-crystalline density within a protein shell. To determine the mechanism of this packaging motor, we used a novel high-resolution optical tweezers to observe the discrete increments of DNA packaged by a single bacteriophage. Analysis of these steps reveals that each subunit waits to utilize ATP until four out of five subunits are loaded. The DNA is then packaged in not one step but in a coordinated burst of four 2.5-base-pair steps. In parallel, we determined how the motor engages the DNA by challenging the motor with a series of short regions of chemically modified DNA. Take together these studies reveal a surprising degree of inter-subunit communication, in which the identical subunits take on different properties based on their context in the ring. Because of its relationship to the ASCE family, the mechanism we determine for the packaging motor of phi29 may have implications for the general mechanism of a diverse set of cellular motors.