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The Viral DNA Packaging Motor of Bacteriophage Lambda[1]

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Terminase enzymes are common to both eukaryotic and prokaryotic double-stranded DNA viruses. These enzymes, which serve as molecular motors that selectively "package" viral DNA into a pre-formed procapsid structure, are among the most powerful biological motors characterized to date. Bacteriophage lambda terminase is a heteroligomer composed of gpA and gpNu1 subunits. The smaller gpNu1 subunit is required for specific recognition of viral DNA, a process that is modulated by ATP. The gpA subunit possesses site-specific nuclease and helicase activities that "mature" the viral genome prior to packaging. The subunit further possesses a DNA translocase activity that is central to the packaging motor complex. Discrete ATPase sites in gpA modulate the DNA maturation reactions and fuel the DNA packaging reaction. Kinetic characterization of lambda terminase indicates significant interaction between the multiple catalytic sites of the enzyme and has led to a minimal kinetic model describing the assembly of a catalytically-competent packaging motor complex. Biophysical studies demonstrate that purified lambda terminase forms a homogenous, heterotrimeric structure consisting of one gpA subunit in association with two gpNu1 proteins. Four heterotrimers further assemble into a ring-like structure of sufficient size to encircle duplex DNA. The ensemble of data suggests that the ring tetramer represents the biologically relevant, catalytically-competent motor complex responsible for genome processing and packaging reactions. We present a model for the functional DNA packaging motor complex that finds general utility in our global understanding of the enzymology of virus assembly.

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