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Mechanics of Adenovirus: role of core proteins in viral mechanics and stability

Human adenovirus contains a double-stranded DNA genome packed with the positively charged viral proteins V, VII and X and the terminal protein. Protein V is believed to connect the inner capsid surface to the outer layer of the nucleoprotein core. Here we explored the mechanical properties and in vitro disassembly of particles lacking protein V (Ad5-ΔV). The Ad5-ΔV particles were softer and less brittle than the wild type ones (Ad5-wt), but they were more prone to release pentons upon mechanical fatigue at low forces. After mechanical disruption of the capsid, core components did not readily diffuse out of Ad5-ΔV particles, unlike Ad5-wt, and the core lacking protein V was more condensed than the spread-out core of Ad5-wt. These observations suggest that protein V is not involved in condensing the genome, but instead antagonizes the condensing action of the other core proteins and facilitates genome release from partially disrupted capsids. In summary, we suggest that protein V (1) provides mechanical reinforcement, stiffens the capsid and stabilizes pentons, and (2) helps to release the viral genome from the capsid by keeping it attached to capsid fragments that are released during virion disruption. This scenario is in line with the location of protein V and its role in virus cell entry, and provides evidence for a bridging function of V between the capsid and the core.
In the same way we study the morphology and mechanics of adenovirus particles with (Ad5-wt) and without (Ad5-VII-) protein VII. Ad5-VII- particles are stiffer than Ad5-wt, but DNA-counterions revert this difference, indicating that VII screens repulsive DNA-DNA interactions. Consequently, its absence results in increased internal pressure. The core is slightly more ordered in the absence of VII and diffuses faster out of Ad5-VII–than Ad5-wt fractured particles. In Ad5-wt unpacked cores, dsDNA associates in bundles interspersed with VII-DNA clusters. These results indicate that protein VII condenses the adenovirus genome by combining direct clustering and promotion of bridging by other core proteins. This condensation modulates the virion internal pressure and DNA release from disrupted particles, which could be crucial to keep the genome protected inside the semi-disrupted capsid while traveling to the nuclear pore.

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