Exploring the Nano-Mechanical Structure of Viral Capsids Using Force Spectroscopy

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Protective shells of viruses are regular, self-assembled, nanometer-sized containers which are minimalistic in design, but combine passive and active functions. Bacteriophage capsids are capable of carrying a highly compacted genome under considerable pressure. We used Atomic Force Microscopy (AFM) to image and probe the mechanical properties of various capsids. We found that bacteriophage capsids are tough like hard plastic, while displaying surprising elasticity. In contrast the capsid of the plant virus CCMV is very soft. Interestingly this capsid doesn't store its genome under pressure. We also observe that the elastic response to local indentation is linear over a large force range. This response, however, varies across the surface and is correlated to the shell protein organization. As a result we can resolve the hexameric and pentameric protein organisation on the shell surface. Repeated pushing on viral shells cracks this structure, weakening, but not necessarily changing its elastic response. Characterization of the breakage lines gives information about the arrangement and the local interactions of the protein subunits in the shell.