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Multivalent counterions inhibit DNA ejection from viral capsid
TOAN NGUYEN — Viral DNA packaged inside a bacteriophage is tighly bent. This stored bending energy of DNA is believed to be the main driving force to eject viral DNA into host cell upon capsid binding. One can control the amount of ejected DNA by subjecting the virus to a solution of PEG8000 molecules. The molecules cannot penetrate the viral capsid, therefore, they exert an osmotic pressure on the virus preventing DNA ejection. Experiments showed that for a given osmotic pressure, the degree of ejection also depends on the concentration of small ions in solution. Interestingly, for multivalent ions (such as Mg2+, Spd3+ or HexCo3+), this dependence is non-monotonic. We propose a simple electrostatic theory to explain this non-monotonic behavior. This is based on the fact that DNA molecules can invert its net charge at high enough multivalent counterion concentration. In other words, as multivalent counterion concentration is increased from zero, charge of DNA molecules change from negative to positive. At the concentration where DNA net charge is zero, the DNA molecules experience an attraction between different segments and DNA ejected amount is reduced. At low or high counterion concentration, DNA segments are charged (negatively or positively), repel each other and DNA ejected amount is increased. Fitting the result of the theory to experimental data, we obtain a numerical value for Mg2+ mediated DNA - DNA attraction energy to be -0.008kT per base.

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