Electrostatics-Driven Assembly of Tightly Packaged DNA

Fascination with nucleic acids has transcended their role as the carrier of genetic information. Our research is inspired by the prevalence of compact DNA/RNA assemblies in biology, medicine, and engineering. Observing DNA as one of the most highly charged biomolecules, we aimed to elucidate the role of ubiquitous cations in the self-assembly of tightly packaged DNA. We have combined small angle x-ray scattering methods and physical theories to quantify how the interaction between DNA helices is modulated by cations of various valences. Surprisingly, the electrostatic repulsion between DNA is reversed into attraction by tri- and tetra-valent cations, and the attraction takes on the form of water-mediated hydration force. Our recent work probes the liquid crystalline DNA inside bacteriophage lambda, and provided the missing experimental quantification of the rather large DNA pressure (~50 atmospheres) inside the phage. Our future research will extend into the study of the viral and cellular mechanism of DNA assembly and disassembly and its relation to gene regulation, and expand into the study of biomolecular conformational changes including RNA folding and biomineralization.