Counterion-mediated DNA-DNA interactions

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The physical properties of DNA are strongly effected by small mobile counterions present in solution. In the most dramatic example, multivalent counterions (charge greater than +2) can precipitate DNA from dispersed solution to form a condensed phase. Microscopically, this indicates a shift from counterion-screened repulsive forces between DNA to counterion-induced attractions between DNA. These attractions appear to be outside the scope of traditional electrolyte theories and attempts to describe them go back over 30 years.

Using magnetic tweezers, we measured the strength of DNA-DNA interactions over a wide range of counterion conditions. We find that changes with counterion concentration can be explained using traditional electrolyte theories, provided that Bjerrum pairing at high concentration is accounted for. This explains the peculiar DNA condensation phase diagram, including the resolubilization seen at high counterion concentrations. Left unclear, however, is the physical mechanism for counterion-mediated attractions. By a combination of osmotic stress and magnetic tweezers measurements, we derive experimental constraints on the forces and discuss possible mechanisms for counterion-mediated attractions.