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Quantifying Chromatin Stability Through Variations in Mg2+ And Nucleosome Spacing

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Chromatin structure influences DNA accessibility and thereby a wide range of DNA-mediated processes. Linker DNA, which spaces neighboring nucleosomes, and Mg2+ ions are known to influence chromatin structure, but a thorough quantification of their combined effects on the level of individual chromatin fibers is currently lacking. Using single-molecule force spectroscopy, we determined how Mg2+ affects the stability of reconstituted chromatin fibers by assessing two force regimes representing distinct phases of force-induced nucleosomal unwrapping. We found that the force required for unwrapping the nucleosome inner turn is decreased in the presence of Mg2+. In contrast, Mg2+ stabilizes the outer turn for fibers with long linkers. Comparing the force response of chromatin fibers with a short and long linker length allowed us to distinguish the effect of nucleosome stacking from outer turn unwrapping. Intriguingly, we found that the work required to stretch fibers with different linker lengths in the low force regime was similar, implying that nucleosome stacking does not significantly increase chromatin fiber stability. Instead, quantitative shape analysis indicates that linker length affects chromatin structure. Taken together, these results suggest that partial unwrapping of the nucleosome is required to relieve strain in the linker DNA to accommodate nucleosome stacking.