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Beyond Wormlike Chain: An effective theory of mesoscale DNA mechanics PHILIP NELSON, University of Pennsylvania, PAUL WIGGINS, ROB PHILLIPS, Caltech — The wormlike chain model has come to dominate physical discussions of DNA conformation, due in part to its spectacular success in modeling the force-extension of single molecules. This model rests upon an assumption of linear bending elasticity in a rod-like polymer chain. But we show that force-extension relations are actually rather insensitive to the details of the stress-strain relation, and in particular do not test the linear-elasticity hypothesis. A renormalization-group flow toward the linear-elastic model hides deviations from linear elasticity on length scales larger than a few helical turns. Our results can be seen as validating the wormlike chain model for the long-scale (small curvature) regime of DNA mechanics, but many important biological processes such as DNA looping operate on shorter scales. We will show how recent experiments on DNA cyclization, and DNA contour analysis by scanning force microscopy, imply a stress-strain relation on intermediate length scales that is quite different from the simple linear form [cond-mat/0409003, Phys Rev E in press]. This revision of DNA mechanics has implications for the structure and dynamics of DNA loops essential in gene regulation.

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