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Elastic Deformations During Bacterial Cell Growth[1]

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The wide variety of shapes and sizes found in bacterial species is almost universally defined by the cell wall, which is a cross-linked network of the material peptidoglycan. In recent years, cell shape has been shown to play a critical role in regulating many important biological functions including attachment, dispersal, motility, polar differentiation, predation, and cellular differentiation. In previous work, we have shown that the spatial organization of the peptidoglycan network can change the mechanical equilibrium of the cell wall and result in changes in cell shape. However, experimental data on the mechanical properties of peptidoglycan is currently limited. Here, we describe a straightforward, inexpensive approach for extracting the mechanical properties of bacterial cells in gels of user-defined stiffness, using only optical microscopy to match growth kinetics to the predictions of a continuum model of cell growth. Using this simple yet general methodology, we have measured the Young's modulus for bacteria ranging across a wide variety of shapes, sizes, and cell wall thicknesses, and our method can easily be extended to other commonly studied bacteria. This method makes it possible to rapidly determine how changes in genotype and biochemistry affect the mechanical properties of the cell wall, and may be particularly relevant for studying the relationship between cell shape and structure, the genetic and molecular control of the mechanical properties of the cell wall, and the identification of antibiotics and other small molecules that affect and specifically modify the mechanical properties of the cell wall. Our work also suggests that bacteria may utilize peptidoglycan synthesis to transduce mechanosensory signals from local environment.

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