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DBIO Best Thesis Award: Mechanics, Dynamics, and Organization of the Bacterial Cytoskeleton and Cell Wall

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Bacteria come in a variety of shapes. While the peptidoglycan (PG) cell wall serves as an exoskeleton that defines the static cell shape, the internal bacterial cytoskeleton mediates cell shape by recruiting PG synthesis machinery and thus defining the pattern of cell-wall synthesis. While much is known about the chemistry and biology of the cytoskeleton and cell wall, much of their biophysics, including essential aspects of the functionality, dynamics, and organization, remain unknown. This dissertation aims to elucidate the detailed biophysical mechanisms of cytoskeleton guided wall synthesis. First, I find that the bacterial cytoskeleton MreB contributes nearly as much to the rigidity of an *Escherichia coli* cell as the cell wall. This conclusion implies that the cytoskeletal polymer MreB applies meaningful force to the cell wall, an idea favored by theoretical modeling of wall growth, and suggests an evolutionary origin of cytoskeleton-governed cell rigidity. Second, I observe that MreB rotates around the long axis of *E. coli*, and the motion depends on wall synthesis. This is the first discovery of a cell-wall assembly driven molecular motor in bacteria. Third, I prove that both cell-wall synthesis and the PG network have chiral ordering, which is established by the spatial pattern of MreB. This work links the molecular structure of the cytoskeleton and of the cell wall with organismal-scale behavior. Finally, I develop a mathematical model of cytoskeleton-cell membrane interactions, which explains the preferential orientation of different cytoskeleton components in bacteria.