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Regulation of Cellular Tension in Adherent Cells

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Cells generate stress on their surrounding extracellular matrix (ECM) via myosin II motor generated forces which are transmitted through the actin cytoskeleton. The mechanisms in the cell which regulate the magnitude and spatial distribution of these stresses, however, remain unknown. Consistent with previous reports, we find that the total magnitude of traction force exerted on the ECM scales with cell size. Such scaling is observed across numerous cell types and reflects an inherent cellular tension determined by the level of myosin II activity. Surprisingly, while stiffness modulates the cellular spread area, we find this scaling relationship to be independent of ECM stiffness. To identify the biophysical mechanisms regulating the generation of tension, we utilize micro-patterning to isolate cell spread area from cell geometry and to spatially control the distribution of stress on the ECM. We find that traction stress magnitude is dependent on the local curvature of the cell. Changes in cell geometry result in a redistribution of local stresses, but little change in the total stress applied to the ECM. Finally, for a constant geometry, we find that both the total stress and the average stress exerted on the ECM increase with cell area. Together these data suggest that the cell can be modeled as a uniformly contracting mesh, where the magnitude of tension is regulated by the cell spread area, and the distribution of tension is regulated by local geometry.