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Active mechanics and geometry of adherent cells and cell colonies

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Measurements of traction stresses exerted by adherent cells or cell colonies on elastic substrates have yielded new insight on how the mechanical and geometrical properties of the substrate regulate cellular force distribution, mechanical energy, spreading, morphology or stress ber architecture. We have developed a generic mechanical model of adherent cells as an active contractile gel mechanically coupled to an elastic substrate and to neighboring cells in a tissue. The contractile gel model accurately predicts the distribution of cellular and traction stresses as observed in single cell experiments, and captures the dependence of cell shape, traction stresses and stress ber polarization on the substrate's mechanical and geometrical properties. The model further predicts that the total strain energy of an adherent cell is solely regulated by its spread area, in agreement with recent experiments on micropatterned substrates with controlled geometry. When used to describe the behavior of colonies of adherent epithelial cells, the model demonstrates the crucial role of the mechanical cross-talk between intercellular and extracellular adhesion in regulating traction force distribution. Strong intercellular mechanical coupling organizes traction forces to the colony periphery, whereas weaker intercellular coupling leads to the build up of traction stresses at intercellular junctions. Furthermore, in agreement with experiments on large cohesive keratinocyte colonies, the model predicts a linear scaling of traction forces with the colony size. This scaling suggests the emergence of an effective surface tension as a scale-free material property of the adherent tissue, originating from actomyosin contractility.