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Physics of adhesion and elasticity of biological cells[1]

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Forces exerted by adherent cells are important for many physiological processes such as wound healing and tissue formation. By pulling on their environment, cells sense rigidity gradients, boundaries and strains induced by the presence of other cells. Many cell types respond to these signals by actively adjusting the magnitude and direction of the adhesions that connect cells to surfaces or to each other. These adhesions are formed from membrane-bound integrin proteins and other cytoplasmic proteins that form condensed domains that grow in the direction of externally applied or internal, cytoskeletal forces. We present a model for the adsorption of adhesion proteins from the cell interior to the adhesion site and the resulting, force-sensitive anisotropic growth. The theory couples the mechanical forces to the non- linear adsorption dynamics and predicts the growth velocities of the back and front of the adhesion in qualitative agreement with experiment. The adhesion forces generated by a collection of cells in a tissue significantly alter the overall elastic response of the system. We model an ensemble of cells by an extension of the treatment of dielectric response of polar molecules to elastic interactions. By introducing the elastic analogy of the dielectric constant of the medium, we are able to predict the average cell polarization, their orientational order, and the effective material constants.

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