Dynamics of active cellular response under stress

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Forces exerted by and on adherent cells are important for many physiological processes such as wound healing and tissue formation. In addition, recent experiments have shown that stem cell differentiation is controlled, at least in part, by the elasticity of the surrounding matrix. Using a simple theoretical model that includes the forces due to both the mechanosensitive nature of cells and the elastic response of the matrix, we predict the dynamics of orientation of cells. The model predicts many features observed in measurements of cellular forces and orientation including the increase with time of the forces generated by cells in the absence of applied stress and the consequent decrease of the force in the presence of quasi-static stresses. We also explain the puzzling observation of parallel alignment of cells for static and quasi-static stresses and of nearly perpendicular alignment for dynamically varying stresses. In addition, we predict the response of the cellular orientation to a sinusoidally varying applied stress as a function of frequency. The dependence of the cell orientation angle on the Poisson ratio of the surrounding material can be used to distinguish systems in which cell activity is controlled by stress from those where cell activity is controlled by strain.

Selected publications

De, R., Zemel, A., and Safran S. A. (2007) Dynamics of cell orientation. Nature Physics, 3, 655-659. (See also, News and Views of Nature Physics, 3, 592-593.)

De, R., Zemel, A., and Safran S. A. (2008) Do cells sense stress or strain? Measurement of cellular orientation can provide a clue. Biophys J: Biophys Lett., 94, L29-L31.

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