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A Mathematical Description of a Growing Cell Colony Based on the Mechanical Bidomain Model

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Abstract : The mechanical bidomain model is used to describe a colony of cells growing on a substrate. Analytical expressions are derived for the intracellular and extracellular displacements. Mechanotransduction events are driven by the difference between the displacements in the two spaces, corresponding to the force acting on integrins. The equation for the displacement consists of two terms: one proportional to the radius that is the same in the intracellular and extracellular spaces (the monodomain term) and one that is proportional to a modified Bessel function that is responsible for mechanotransduction (the bidomain term). The model predicts that mechanotransduction occurs within a few length constants of the colony's edge, and an expression for the length constant contains the intracellular and extracellular shear moduli and the spring constant of the integrins coupling the two spaces. The model predictions are qualitatively consistent with experiments on human embryonic stem cell colonies, in which differentiation is localized near the edge.

Keywords : cell colony, integrin, mechanical bidomain model, stem cell, stress-strain, traction force
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