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Matrix rigidity optimizes the polarization of stem cells ASSAF ZEMEL, Institute of Dental Sciences, the Hebrew University-Hadassah Medical Center, Jerusalem, 91120, Israel, FLORIAN REHFELDT, Georg-August University, III. Physics Institute, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany, ANDRE BROWN, DENNIS DISCHER, Department of Physics and Astronomy, University of Pennsylvania, Philadelphia, PA 19104, USA, SAMUEL SAFRAN, Department of Materials and Interfaces,Weizmann Institute of Science, Rehovot 76100, Israel
— We present a theoretical model and experiments to explain the non-monotonic dependence of stress-fiber polarization in stem cells on matrix rigidity. The theory generalizes the treatment of elastic inclusions to "living" inclusions (cells) whose active polarizability, unlike non-living matter, depends on the feedback of cellular forces that develop in response to matrix stresses. We demonstrate experimentally that the stress fibers in adult mesenchymal stem cells, generally orient parallel to the long axis of the cells, with an anisotropy that depends non-monotonically on substrate stiffness. Consistent with these experiments, our theory predicts that the magnitude of the cellular force increases monotonically with the matrix rigidity while the polarization anisotropy shows a maximum that depends on the cell shape and the elastic modulus of the medium. These findings offer a mechanical correlate for the observation that stem cell differentiation optimizes in a range of matrix rigidities that depends on the tissue type.

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