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Rheological model for tumor cell progression and metastasis

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Abstract: Tumor cell progression and metastasis are complex phenomena, which involve ongoing molecular and cellular changes. Despite the considerable progress that has been made in the fundamental understanding of the biological and genetic events governing both phenomena, there is still much to be elucidated with regard to the impact of the tumor microenvironment on tumor initiation and progression and the response to treatment. As such, the development of a theory correlating tumor cell progression and metastasis with biomechanical abnormalities in tumors and their microenvironment due to the continuous buildup of mechanical stresses may be viewed as a timely – and indeed urgent – need.

We present ongoing development of the rheological model capable to simulate for tumor cell progression and metastasis by focusing on epithelial to mesenchymal transition (EMT) in carcinomas. The model treats the carcinoma as visco-elastic fluid and aims to be able: (i) to account for the mechanical properties and the structural alterations caused by the EMT, (ii) to model the motility of both individual cells and cell colonies, and (iii) to take into account realistic variations in the sizes and shapes of cells in different regions of
the cell colony.

The digital images of carcinomas obtained by employing of the developed model have been extensively validated by comparison with the data available in the literature in terms of the conservation of area after cell division, the cell area doubling time, the duration of the cytokinesis process, and the temporal evolution of the proliferation and the tumor area. Additionally, it was verified that the morphology of the digitally generated carcinoma satisfies the local minimum of the total mechanical energy.

Keywords: rheological model; cell proliferation ; epithelial to mesenchymal transition (EMT)

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