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Cell adhesion and dynamic fibre redistribution within two-scale moving boundary cancer invasion

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Cancer cell invasion, recognised as one of the hallmarks of cancer, is a complex process involving the secretion of matrix-degrading enzymes that have the ability to degrade the surrounding extracellular matrix (ECM). Combined with cell proliferation, migration, and changes in cell-cell and cell-matrix adhesion, a tumour is able to spread into the surrounding tissue. We highlight the multiscale character of this process through a double feedback link between the cell-scale molecular processes and those occurring at the tissue level. In order to gain a deeper understanding of the mechanics of cancer cell invasion, we look to further investigate the surrounding microenvironment of a tumour.

The ECM is a key biological structure that not only provides structure and support to surrounding cells, but also acts as a platform on which the cells can communicate and exercise spatial movement. There are several other vital structures within the ECM, however we are going to focus primarily on fibrous proteins, such as fibronectin. These fibres are key players in the function of healthy cells, contributing to many essential processes such as cell migration, differentiation, migration and proliferation. They also play a crucial role in tumour progression with the ability to anchor cells to other components of the ECM.

In this work we consider the two-scale dynamic cross-talk between cancer cells and a two component ECM (consisting of both a fibrous and a non-fibrous phase). To that end, we incorporate the dynamics interlinked macro-micro cells-ECM interactions within inside the tumour support that contributes simultaneously both to cell-adhesion and to the dynamic re-arrangement and restructuring of the ECM fibres. Furthermore, this is embedded within a multiscale moving boundary approach for the cancer cell population in the presence of cell-adhesion at the tissue scale and matrix degrading enzyme molecular processes and fibre redistribution considered at cell-scale. Computational simulations will accompany the presentation of the overall modelling framework to examine the impact of different levels of adhesion between cells in conjunction with the continuous ECM fibres restructuring on cancer invasion patterns.

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