Mechanical properties of cancer cells, related to metastatic potential

Master student project assignment

Introduction

Mechanics plays a bigger role in biology than most people might think, particularly in health and disease. From a mechanical engineering point of view, biological cells are composed of proteins that are connected to form a network called the cytoskeleton. This structure determines the cell’s mechanical properties such as stiffness and viscoelasticity. Different cell types have different structures, and also diseases like cancer can modify the structure, resulting in a change of mechanical properties.

Particularly, in the process of cancer metastasis (spreading of cancer), mechanics most probably also plays a role. In the whole metastatic cascade, cancer cells need to move through tissues, and pass barriers such as blood vessel walls during which they need to deform. We expect that the mechanical stiffness of cells may well play a determining role in these processes.

Project

By carrying out migration experiments in microfluidic chips, we have recently found that different breast cancer cell subtypes show different migration behavior, with different migration speeds when migrating through a dense fibrous network that represents the tissue surrounding breast tumors (Fig. 1). We want to know whether these effects can be associated with mechanical stiffness differences between the cells.

We have developed a method to quantitatively measure the elastic properties of cells: Capillary Micromechanics (Fig. 2), which we have already applied to white blood cells (Fig. 3).

In this project, we will use Capillary Micromechanics to measure the mechanical properties of different breast cancer cell subtypes, and correlate the results with the observed migratory behavior. To this end, the Capillary Micromechanics setup must be redesigned to make it robust for cell characterization, the setup must be realized, experiments must be performed using various breast cancer cells, and the results must be analyzed in the context of metastasis.

Fig. 1: Some breast cancer cells move faster though dense tissue than others, which is relevant for cancer metastasis [1]. Do the mechanical stiffness of the cells play a role?

Fig. 2: Capillary Micromechanics method to measure elastic properties of cells [2].

Fig. 3: The elastic modulus of white blood cells, measured with Capillary Micromechanics, showing the effect of treatment of the cells with certain chemicals that change cell structure [3].

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