Galvanotactic Segregation of Healthy and Cancerous Breast Cells

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In the United States alone, 1.6 million new cases of cancer were reported in 2012. On average, 12% of women will develop breast cancer at some point in their lives. Yet even with modern medical procedures and extensive research in the field, cancer treatment is largely variable. For instance, the success rate of chemotherapy varies from as low as 24% to 81% for various classifications of leukemia. A contributing factor to the evasiveness of cancer to many treatments is the process of metastasis, wherein cancerous cells migrate from a primary tumor to establish secondary tumors throughout the body. In fact, the five-year survival rate for women with breast cancer drops from 99% for local tumor growth down to 23% for the metastatic variant. Therefore, understanding the mode of transport of cancerous cells and their response to external stimuli is of critical importance to segregating cancer cells from healthy tissue in a directed fashion to increase the success of treatment methods.

It is well known that different cells respond to external electric fields. The presence of an endogenous electric field provides a cue for natural wound healing in epithelial cell sheets, directing cell sheet migration towards the cathode. In contrast, previous research has shown that metastatic breast cancer cells display a robust response to an applied electric field and migrate anodically. Therefore, a difference in the response to an electric field should be present between healthy breast epithelium and metastatic breast cancer cells. The aim of this work is to quantify the differences in cellular response to an electric field and selectively segregate cancer cells while preserving healthy tissue.

Bulk separation processes have been utilized for healthy and cancerous breast cells before, but these processes require suspension of cells into solution. Dielectrophoresis, for instance, can be used to separate healthy (MCF-10A) cells from metastatic (MDA-MB-231) cells in a microfluidic flow device. Understandably, it is not possible to reintroduce the healthy cells collected from this unit operation into the tissue it was removed from. In order to produce a device which can be used *in situ* in the body of a patient, it is crucial to perform the separation in such a way that allows healthy cells to remain adherent to an extracellular matrix, preserving their form and function.

The proposed research will focus on elucidating the transient period of cellular response to an electric field in both the MCF-10A and MDA-MB-231 cell lines. The motile response of cells to an electric field is time dependent, and this time dependency should vary between cell lines. It is expected that the time delay of the motile response of cancer cells will be less than the time delay of healthy cells due to the aggressive nature of metastatic cells. Utilizing differences in time response to the electric field, rather than the steady state motion of cells within the field, it should be possible to segregate cancerous cells from their healthy counterparts without disrupting the behavior of the healthy tissue. For this reason, prototype devices utilizing cell specific electrical signals may be utilized to localize the position of cancer cells and improve conventional treatment methods such as chemotherapy and radiation therapy.