8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

CONTINUUM MODELING AND FINITE ELEMENT SIMULATION OF CELL MOTILITY

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Key Words: *Continuum Modeling, Cell Motility, Growth, Finite Elements.*

ABSTRACT

Cell motility, and in particular crawling, is a complex process, with many as yet unknown details. However, various models of the motion of cells are already emerging. These models concentrate on different aspects of cellular behavior, from the motion of a single cell itself, to -taxis behaviors, to population models. Models of single cells seem to vary significantly in their intended scope and the level of detail included.

Most single cells are far too large and complex to be globally amenable to fine-scale modeling. At the same time, cells are subject to external and internal influences that are connected to their fine-scale structure. The authors of this work contend that the cell's motion can be modeled at the continuum scale, but with consideration made for the appropriate fine-scale dependencies.

This presentation addresses several modeling aspects. At the continuum level, the relationships between force and displacement in the bulk of the cell are modeled using the balance laws developed in continuum mechanics. Allowances are made for the treatment of and interaction between multiple protein species, as well as for the addition of various terms into the balance laws (e.g., active stresses) [1,2]. Various assumptions regarding the nature of cell crawling itself and its modeling are discussed. For instance, the extension of the lamellipod/detachment of the cell is viewed as a growth/resorption process [3]. The model is derived without reference to dimensionality.

The second component of the presentation concerns the numerical implementation of the cell motility model. This is accomplished using finite elements, with special features (i.e., ALE) being used to handle certain stages of the motility. In particular, the growth assumption used to model the crawling motion is represented using ALE. Results from representative finite element simulations are shown to illustrate the modeling capabilities.

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