Multiscale Methods to Model Complex Multicellular Systems

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This Lecture is devoted to the development of mathematical tools for the modeling, qualitative analysis, and simulations of complex systems in life and human sciences. Namely of systems of many living individuals interacting in a non-linear manner. As known, it is very difficult to understand and model these systems based on the sole description of the dynamics and interactions of a few individual entities localized in space and time. Moreover, interactions are not additive and their modeling should take into account the ability of the interacting entities to develop specific strategies based on the states and localization of all interacting entities.

Focussing on living systems, definitely the most sophisticated class of complex systems, two main questions can be naturally posed:

Do complex living systems exhibit common features?

Are the analytic and computational tools offered by mathematics able to capture, in the modeling approach, the above mentioned common features?

The presentation is focused on multicellular systems and genetic diseases and is divided in three parts. The first one reports about recent developments of system biology related to the, so called, kinetic theory of active particles [1],[2], which provides some answers to the above questions. The second part presents an application to model cell degeneration due to mutations focusing on keloid formation triggered by a virus [3] and degeneration into cancer phenomena [4]. The third part deals with the derivation of macroscopic biological tissue models from the underlying description delivered at the cellular scale. The derivation leads to classical and modified Keller and Segel type models [5],[6].

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