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Editorial

Theoretical frameworks and models for biological systems

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Abstract: This editorial deals with the topic of the special issue devoted to the modeling of complex biological systems. The development of theoretical frameworks and specific models for complex biological systems has recently gained much attention and an interplay among different scholars has emerged thus allowing the possibility to develop a multidisciplinary and a multiscale approach.

Preface

The present special issue refers to the modeling of the emerging phenomena arising in complex biological systems and more specifically to the recent different approaches that have been proposed and developed in the applied sciences in order to better understand their evolution. The reader interested in a more deeper understanding of the properties of a complex system is referred to the recent paper [1] and to the books [2,3,4].

The analysis of biological systems, especially of the complex fashion, requires a detailed knowledge of the elements composing the systems and of the relationship/interactions among the different elements. The complex mechanisms which allow the evolution of a complex biological system are not completely understood and the development of theoretical frameworks and specific models is thus required. The interest in the modelling approach is a prominent research field that has allowed on one hand to give an explanation to some of the complex emerging behaviours and on the other hand the origin of interdisciplinary fields. Indeed the interplay among different scholars coming from different research fields (biology, mathematics, physics, information sciences) has been increased in the last and this new century. Different definitions and approaches have been proposed and employed in an attempt to construct an interdisciplinary general theory. However biology, differently from physics, deals with living matter composed by elements, which are usually cells, that are able to express a function, to take a decision, to interaction with immediate or far neighbors.

The term model has a different meaning in the different applied sciences. In the theoretical sciences (e.g. mathematics, physics) usually the term model denotes a system of differential or algebraic equations whose solution is an ensemble of functions describing the time evolution of a variable of the system which can depend also on the space and the velocity variables. Generalized kinetic theory approaches and in general nonequilibrium mechanics statistical approaches have been also proposed.

A theoretical model, frequently and more properly called framework, is based on the definition of some parameters/functions which have a specific biological meaning (proliferation rates, mutation rates, interaction rates); in mathematics and physics, when the magnitude of the parameters is assigned the term model is employed and the predictive capability of the model is tested with respect to real or empirical data.

In biology and in the medical sciences the term model is employed to denote the ensemble of procedure in which all scholars are trained. The medical model embodies the history, the diagnosis, the treatment. The term also refers to the framework of assumptions underpinning the relationship between doctor and patient.

Theoretical frameworks have been developed at different levels (nano, micro, meso, macro) and the emerging phenomena resulting as the interactions between the elements at the different scales have been the interest of many researchers (multi-scale modeling). As already mentioned, mathematical models are based on differential or algebraic equations, physical models are based on physical principles and theories; beside the mathematical and physical models, the computational approach has recently gained much attention. In a computational framework, also called multiagent-based framework, the particles, called agents, evolve according to some rules which take into account metrical or plus in general topological properties [5]. The tools employed for the analysis and simulations of mathematical and computational models comes from the dynamical system theory, including the stability theory, the chaos theory, and the inverse problems theory.

The papers published is the present special issue are devoted to new theoretical frameworks proposed in biosciences, further developments of existing frameworks, and with the related specific models and experiments.

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