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Book Reviews

Newton to Aristotle, Towards a Theory of Models For Living Systems

Edited by John Casti and Anders Karlqvist
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This book explores the need to incorporate the notion of final causation as an underlying paradigm for any theory of models for living systems. An important motivation of the book is to shed some light on the issue of extending the Newtonian paradigm to include the Aristotelian category of final causation. The survey is broad, including discussions at a general, epistemological level, as well as others that illustrate modelling approaches from the standpoint of specific disciplines, including physics, theoretical biology, economics and linguistics. The contributors explore the need for incorporating aspects of final causation within a framework of modelling for living systems, illustrate aspects of living systems that could not be modelled without some reference to final causes, and present specific approaches to modelling essential aspects of living systems.

The first four chapters are devoted primarily to matters of philosophy and modelling theory. In Chapter 1, Robert Rosen concludes that the fabrication of organisms is not simply the inverse of a reductionistic or syntactic analysis. He further asserts that metabolism-repair (M,R) systems capture some "irreducible organizational feature of biological cells." In the following canter, René Thom argues that some virtuality is necessary in science and identifies this claim with the Aristotelian distinction between potentiality and actuality. According to this, the aim of theoretical biology is not one of prediction, but rather "the definition of new domains of virtual processes with the aim of elucidating the way 'real' processes propagate among virtual ones." John Casti's chapter refers to the Newtonian models of systems as "metabolism only" models. An important claim is that in order to account for the fundamental properties of living systems the Newtonian framework has to be extended to include the fundamental capabilities of self-repair and replication. Casti shows a way in which the Newtonian framework could be "naturally" extended to include these fundamental features using mathematical systems theory. Casti further argues for the "(M,R)-prescription" as a natural theoretical basis for the study of adaptive and evolutionary processes. In the fourth chapter, Jan Willems addresses basic questions concerning mathematical models. He views the problem of constructing a model from data as a tradeoff between the complexity of the model, the misfit that is accepted between data available from observations and the model's predictions, and the latency found in the model. He concludes that for linear, invariant, complete systems, a model that maximizes all three aspects of this tradeoff always exists.

Beginning with the fifth chapter, the emphasis shifts to physics, economics and linguistics. In Chapter 5, Michael Conrad considers a vacuum particle model in order to study the possibility of accommodating both the conventional forces and the process of measurement. An important idea is that when the vacuum structure is altered, an underlying irreversibility is revealed. The vacuum particle model presents an evolving relationship between the structure of the "vacuum sea" and the visible distribution of mass and charge. The situation is similar to that of an evolutionary ecosystem. It also fits the hypothesis that biological evolution recruits unpicturable microphysical processes within cells for the integrated behavior of organisms and for cognition and intelligence in the context of the macrophysical architecture of the brain. The recursive interaction between the vacuum structure and the distribution of positive energy particles unmasks the irreversibility in the special cases of biological

evolution and measurement. Final cause does not enter, except in relation to the type of cyclic interactions characteristic of evolutionary systems: but Conrad does observe that fundamental irreversibility was also a feature of Aristotle's physics.

Gerald Silverberg, in his chapter, identifies the Aristotelian categories of formal and final cause with the use of rationality in economics. He also considers an evolutionary approach which he identifies with material and efficient causality. He leaves as an open question whether the direction of change and the structure of interactions as explained causally in terms of material and efficient categories converge to a "finalist" view of an economy. According to Silverberg, the notion of evolutionary disequilibrium can be taken as the driving force in processes of development and exploration. The suggestion is that the specific patterns associated with economic evolution are not matters of self-consistency, rationality, and equilibrium, but rather steady-state distributions emerging from the "nonstationary motions" of individuals. András Brody presents a model in which three basic, seemingly antagonistic views concerning the behavior of economic systems are reconciled. One is Adam Smith's idea that the market moves to equilibrium; the second, which he attributes to Marx and later to Kalecki and Goodwin, is that the movement of the market is cyclic with clearly observed periodicities; the third is the view of economic systems as showing erratic, chaotic behavior. The reconciliation of these views implies, according to the author, that a model capable of fulfilling descriptive, predictive, normative and explanatory roles must include the four Aristotelian principles of causation.

In the final chapter, David Lightfoot presents a model of the development of linguistic capacity. The idea is that the process of acquiring natural language is facilitated by information which is provided genetically. This information consists of principles and parameters which are set when the individual is exposed to some linguistic environment. The mature linguistic capacity is a result of this information. The author shows that specific ideas about the types of genetically prescribed parameters make it possible to understand how languages tend to evolve over historical time. The main observation is that, along with gradual piecemeal type of change, languages may at some point also undergo a radical shift.

The book thus covers several aspects of modelling, both at the foundational and the applied levels. Several themes recur throughout the various presentations. These themes are complementary, each touching some essential ingredient or living systems and their models. The idea of final causation, formally stated in the form of metabolism-repair systems clearly runs through a number or the papers. The idea of irreversibility is explored at the microscopic level as a basis for providing a direction to the time dimension in the physical world. The idea of evolutionary change is related to the idea of dynamic change in the context of economic systems. There is also room for the explanation of drastic changes in economics and linguistics. It is apparent from this rich, varied and enlightening discussion, that the four causal categories of Aristotle provide a broader framework than Newtonian type models, and that this can contribute significantly to identifying essential ingredients that should somehow be incorporated in models of living systems.

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