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Modeling in biology and economics

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Much of biological and economic theorizing takes place by modeling, the indirect study of real-world phenomena by the construction and examination of models. Books and articles about biological and economic theory are often books and articles about models, many of which are highly idealized and chosen for their explanatory power and analytical convenience rather than for their fit with known data sets. Philosophers of science have recognized these facts and have developed literatures about the nature of models, modeling, idealization, as well as testing of models and explanation by models, for both biology and economics. The impetus for this special issue came from our recognition that there is remarkably little overlap between the "modeling in biology" and "modeling in economics" literatures, despite many of the same themes appearing in these literatures.

The papers in this issue cluster around two central themes: tensions at the intersection of biology and economics, and methodological issues arising in these disciplines. Robert Fumagalli considers the prospects for incorporating neurological data into economic models. After reviewing and reconstructing economists' typical lines of argument against such a merger, which he finds wanting, Fumagalli argues for a pluralistic position and a limited role for neuroscience in economics. In a similar vein, Till Grüne-Yanoff's contribution considers the history and conceptual difficulties of evolutionary game theory applied to the social sciences. He argues

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that economists have typically taken an uncritical attitude towards the importation of biological concepts such as replication and selection into their models. Nevertheless, he argues that there may be avenues for a more reasonable interpretation of these models that show how their mechanisms could be instantiated in social situations.

A general theme of many of the contributions to this issue is what happens when ideas embodied in one discipline's models are imported into another. Colin Rice and Joshua Smart consider this against the background of using biological concepts in economics models. Their paper considers the development of the subfield in economics called "evolutionary economics." Although much of their paper is aimed at clarifying the philosophical issues at stake in this field, they begin to draw more general lessons about borrowing models across disciplines by identifying and analyzing specific strategies including the incorporation of assumptions from another domain, analogical uses of components of models from another domain, and directly applying another domain's theories. Similar issues are addressed by Jonathan Grose's paper about costly signaling theory, which was developed independently in biology (under the label 'the handicap principle') and in economics. Grose compares the role of modeling to that of empirical data collection in contributing to the widespread acceptance of this theory.

Johannes Martens' paper looks at the flow of the ideas from economics to biology, focusing on the tendency among some biologists, particularly in behavioral ecology, to treat organisms as if they were rational agents attempting to maximize a utility function. Is this harmless heuristic reasoning, or is it a misleading way of thinking about adaptation? Elliott Sober has previously argued that it can be misleading; by contrast, Martens argues that when used carefully, the heuristic is legitimate because it helps to make good predictions in contexts where cooperation can evolve.

The second set of papers in this issue concern the more general methodological issues of scientific explanation and robustness. Robert Sugden's contribution challenges a simple picture about modeling, which says that models are always constructed to explain specific targets. Instead, he argues, modeling can involve developing a "credible world" in which some mechanism explains some regularity. The modeler then argues that there may be a part of the real world in which a similar regularity occurs. If this is the case, then the model would give some support to the hypothesis that a mechanism similar to that of the model is at work. Sugden's analysis is illustrated using Schelling's model of segregation, Maynard Smith and Parker's model of asymmetric animal contests, and several others. He refers to this use of models as "explanations in search of observations," putative explanations of yet unobserved regularities. In their contribution, John Matthewson and Brett Calcott go further in separating models from their targets. They suggest that models can be mechanical without their targets being mechanical or without the mechanisms of the model and those of the target being similar. Yet even in such situations, they argue that mechanical models can explain the behavior of their targets. This, allows for explaining population-level phenomena *as though* they were governed by particular kinds of mechanism without claiming that they are so governed.

Papers by Odenbaugh and Alexandrova, as well as Knuuttila and Loettgers, concern the methodology surrounding robustness analysis, an idea introduced to philosophers of science by Richard Levins and William Wimsatt in relation to biological models. Knuuttila and Loettgers propose to enrich the discussion of robustness analysis by distinguishing between causal isolation and independent determination, two types of robustness analysis. They argue that causal isolation has an especially important role to play in theoretical results because it allows for the construction of new, synthetic models drawing on isolated factors derived both from modeling and experiment. Odenbaugh and Alexandrova's paper councils caution. Robustness analysis, they argue, cannot be used in a confirmation-theoretic manner. Rather, its best use is as a method for model-based discovery of novel phenomena.

Taken together, these articles show some of the most exciting work being done at the interface of philosophy of biology and philosophy of economics. We hope that this body of work will stimulate further investigation of the commonalities and differences between these two sciences.