MODEL ORGANISMS

Rachel A Ankeny and Sabina Leonelli

Reviewed by Jessica Bolker

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Model organisms dwell at the interface of philosophy and biology, a location that raises many interesting epistemological issues. Philosophers have generally been quicker than biologists to recognize this, and in this volume Ankeny and Leonelli explain why: a species only becomes a model after a scientific community decides that it is a reliable tool for specific research purposes, effectively taking its epistemic status for granted. Thus, the designation of a species or strain as a 'model organism' is based on a prior epistemic commitment that underlies both the power and the limitations of model-based research in biology. Ankeny and Leonelli examine the source of that commitment and some of its consequences, and ask 'how [...] the epistemic structures and shared scientific practices within the community of scientists focused on these organisms influence the ways in which research is conducted and how these organisms are understood'. The schema they present is philosophically coherent and interesting, though largely decoupled from the concerns of practicing scientists.

Ankeny and Leonelli set the stage by noting that 'Much biological research aims at extrapolating knowledge beyond the organisms that are actually being studied' (p. 2)—and this is especially true when the organisms being studied play the role of 'models'. The authors offer a detailed description of that role, and articulate a set of philosophical commitments and (to a lesser extent) scientific assumptions that it entails. In their view, organisms qualify as models based on 'the representational power attributed to them' (p. 9). A model organism is taken to represent a specific range of other organisms (its scope) and be useful for studying certain types of phenomena (its targets). These qualifications are framed largely in sociocultural terms: the criteria for a species to count as a 'model' are based on the reputation of that species in a particular scientific community, rather than the biological characteristics of the species. As a biologist I find this a bit odd, but biologists are clearly not the intended audience of this volume. For an audience of philosophers, the book presents a framework for thinking about models that emphasizes their role in scientific practice and highlights key 'representational commitments' this role entails.

Those commitments centre on 'the specific modes of intervention and standardization used to establish and develop' a model. Foremost among these are 'abstraction' and a carefully constructed form of 'placelessness'. Abstraction involves 'the selection of traits on which researchers wish to focus (and thus to stabilize and control)', with that control extending beyond the organism to simplified and standardized environments that help ensure the 'replicability of specimens with particular traits, as well as the stability of their features regardless of the time and location of their use' (p. 21). Because carefully stabilized 'families of specimens' are isolated from the complex relationships that enmesh organisms in natural contexts or ecosystems, they can serve as platforms on which diverse kinds of experiments and knowledge can be integrated. This 'placelessness' with respect to biological ecosystems in turn enables model organisms to 'anchor […] a broad and ever-evolving *modelling* ecosystem' (p. 24; emphasis added). The practical and epistemological advantages of such abstraction are clearly articulated here, and certainly borne out by the power and success of model-based research in many areas of biology.

But accepting the underlying assumptions (for example, the environment is not critical to the aspects of biology that models are used to study, and standardization of all but a handful of predetermined traits is desirable) takes models further and further away from the real biological world. The authors acknowledge the artificiality of strictly delimited and standardized models ('Model organisms are the right tools for a very specific type of scientific job, that of investigating and manipulating organisms that are kept in isolation from their natural environment' (p. 17); 'Organisms are reproduced and modified under such controlled and purpose-oriented conditions that they may end up bearing relatively little resemblance to their relatives in the wild' (p. 20)). However, they remain silent on how this artificiality affects the ability of models to shed light on biology in the real world. If representational scope is limited to other organisms with little variation, and the target phenomena for which models are useful exclude those with significant environmental inputs, this dramatically constrains the utility of model organisms. In particular, it severely undermines their value for biomedical research intended to translate to humans (who are notoriously variable and influenced by their environment).

A central concern for scientists working with model organisms is what criteria to apply when choosing and evaluating them. What makes a good model for a particular research programme? Ankeny and Leonelli base their criteria on 'plausibility': in their framing, the 'goodness' and epistemic power of a model arise from scientists' beliefs about its efficacy, and its concomitant endorsement and use by a scientific community. In contrast, scientists themselves are often concerned with a model's perceived validity—which receives scant attention here. (The decision to eschew any consideration of mechanisms would in any case pose a serious obstacle to such a discussion.) Because the authors' central concern is not models themselves, but rather how scientists conceptualize them, they de-emphasize organisms' natural or intrinsic attributes in favour of traits that are historical and/or human-imposed, such as standardization. While the latter sorts of traits are central to community acceptance of a model, they are not necessarily linked to the model's ability to yield knowledge that will translate to other systems or species. The translatability or (to use Cartwright's term; Cartwright and Hardie [2012]) 'exportability' of knowledge from a model system to other species, or a model's ability to support generalizations, ultimately depends on how well its biological characteristics match those of other species: the extent to which the model actually represents their biology, not just how well researchers believe it does so.

Given the authors' focus on the sociocultural context within which models are used ('the epistemic structures and shared scientific practices within the community of scientists'), I was surprised by some omissions. For example, the history or origin of models, which has deeply influenced current uses, is barely addressed; that history is beautifully documented elsewhere, but only a few sources are cited.[1] The lack of historical context complicates the accounting of 'characteristics contributing to the establishment of a model organism' offered in Table 1. 'Ease of storage' and 'physical accessibility of features of interest' are classified as 'natural or intrinsic' traits. But these traits are not inherent in a species' biology; rather, they depend on available technology and infrastructure. Species that serve as models at a marine laboratory (because they are easy to collect locally and maintain in a facility with flowing seawater) may be much harder to work with elsewhere.[2] Conversely, the familiarity, tractability, and economic importance of domesticated species has promoted their popularity as models.

The 'physical accessibility of features of interest' also depends heavily on technology. While Krogh's ([1929]) use of tortoises for experiments on respiratory physiology is the classic instance of a species '"created" expressly for special [research] purposes', and accessible morphology is certainly an intrinsic feature, what else is accessible often depends on prior investments. One example is the availability of genomic data: some lineages have inherently more accessible (smaller, less duplicative) genomes than others (*Rana* versus *Xenopus*), but technological advances now provide access even in groups with inconveniently large genomes (*Ambystoma*). Other 'characteristics contributing to the establishment of a model organism' also flow from the human context—especially the existence of a sufficiently large, cooperative, and powerful scientific community to support species-specific infrastructure, from databases to stock centres (as Ankeny and Leonelli have described for several key models in their previous work).

The schema presented in this book summarizes the authors' analysis of how scientists conceptualize models, and how that shapes research. This analysis offers interesting insights into what scientists do and the epistemological roots of their practices—for instance, the recognition that a model's status and utility is defined by its acceptance within a research community as an appropriate tool for pursuing specific research goals. But I wish they had gone beyond describing current practices to more clearly articulate the epistemic challenges those practices entail, and to highlight implicit assumptions and other epistemological issues that merit scientists' attention.

The stated intent of the Elements series is to provide 'concise and structured introductions to [...] topics in the philosophy of biology'; authors are asked to 'offer balanced, comprehensive coverage of multiple perspectives, while also developing new ideas and arguments from a unique viewpoint'. With respect to the first goal, this volume is disappointing. While a handful of other scholars' views on model organisms are critiqued in detail, core issues related to mechanism, representation, and validity are elided, and the substantial body of work on the historical development of models is mentioned only in passing (the omission of Logan's work is especially surprising given the centrality of standardization to the authors' schema; see Logan [2002]). While there is clearly not room in a short volume for extensive literature reviews, readers seeking an introductory-level overview of philosophical work related to model organisms will miss out on some essential topics. In particular, scientists will find little connection to current discussions of validity (the focus of most epistemological concern in translational research), or guidance on how philosophy might contribute to the development of scientific—rather than sociocultural—criteria for identifying 'good' models.

The book is much more successful with respect to the second goal: the authors' viewpoint provides for a detailed examination of the social construction of model organisms—especially epistemic commitments that are clear to philosophers but may be invisible to scientists. Ultimately, this is a book about scientific practice, rather than about model organisms themselves or even the philosophical issues most directly relevant to their use. That is entirely appropriate for an audience of philosophers or sociologists who study scientific communities. However, scientists seeking a philosophical overview that will help them articulate and begin answering their own epistemological questions about models will need to look elsewhere (for example, Striedter [2022]).

Ankeny and Leonelli are well known for their close attention to what biologists do, how they think about what they are doing, and the epistemological dimensions of model-based research practices. This volume offers an accessible introduction to that realm of philosophy, in which researchers are the object of study. The next step is to address scientists as subjects with their own philosophical interests, by articulating the interplay of research activities and conceptual commitments in ways that can help inform and guide scientific practice.

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Notes

[1] Perhaps this reflects a length constraint imposed by the Elements series; if so, limited space would have been better used to expand on the essential history of models, rather than to speculate about their possible future 'legacy'.

[2] In fact, one element of the historical importance of marine laboratories has been their role in establishing model-centred research communities; see (Maienschein [1988]).

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