How Not to be Eaten: The Insects Fight Back

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differences, Sansom demonstrates that natural selection can operate more efficiently to increase overall network fitness. After examining several other assumptions of Kauffman's model, Sansom concludes that it is simply too unrealistic to be useful as a general framework for understanding how natural selection operates on gene regulatory networks. He finds Kauffman's model particularly far removed from the processes that take place during embryonic development, which have been a focus of systems biologists and which involve some of the most thoroughly investigated gene networks.

In the second half of his book, Sansom develops an alternative model that he calls *connectionist networks*. He bases this model on concepts that were originally developed in the field of artificial intelligence, where they are known as *parallel distributed processors* or *neural networks*. A key feature of connectionist networks for Sansom is accuracy, which in this context, means that a gene's expression responds in appropriate and useful ways to changes in its microenvironment (in the broad sense, including, e.g., not just the physical environment, but hormones, disease, the developmental stage). This contrasts with Kauffman's view that gene expression occurs in fixed cycles and is largely independent of what is going on outside the cell.

The central thesis of *Ingenious Genes* is that connectionist networks provide a more biologically realistic model of gene network function than Kauffman's model does and that this model explains why gene networks can be highly adaptable. Perhaps not surprisingly for a philosopher of science, Sansom argues these points primarily from first principles rather than from a body of experimental evidence. (This is not a book for those brushing up on the latest empirical research in systems biology.) However, he does outline some general empirical predictions that can be tested. Many of these predictions are based on what happens to the expression of a gene when its regulators are expressed in different combinations and at different levels (e.g., Do multiple regulatory inputs act in a Boolean, additive, or nonlinear manner to influence the target gene? Do regulators consistently act as either activators or repressors?).

Interestingly, systems biology has barely begun to explore these questions of regulatory logic. *Ingenious Genes* provides a compelling reason to begin a serious empirical investigation of the logic of gene regulation, with a particular view to understanding how this logic evolves. Models serve a variety of functions in biological research. Precisely how well connectionist network models conform to real biological networks is, to my mind, less important than the fact that they provide an excellent framework for future research. By identifying an important, unresolved problem and laying out a clear proposed solution, *Ingenious Genes* makes a thought-provoking contribution to both systems biology and evolutionary biology.

Reference cited

Kauffman SA. 1985. Self-organization, selective adaptation and its limits: A new pattern of inference in evolution and development. Pages 169–207 in Depew DJ, Weber BH, eds. Evolution at a Crossroads: The New Biology and the New Philosophy of Science. MIT Press.

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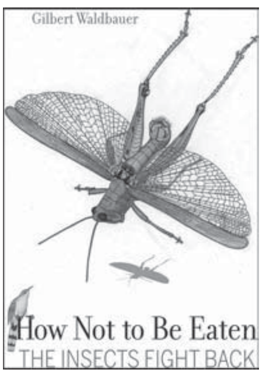
DISSECTING THE INSECT SURVIVAL GUIDE

How Not To Be Eaten: The Insects Fight Back. Gilbert Waldbauer. University of California Press, 2012. 240 pp., illus. $27.95 (ISBN 9780520269125 cloth).

Metaphorical evolutionary arms races, such as those between prey and their predators, are well-studied and important examples of coevolution (see, e.g., Geerat J. Vermeij's book *Evolution and Escalation: An Ecological History of Life*). The participants in these races must compensate for newly evolved defenses and counterdefenses by evolving new capabilities. Critical examples often come from studies of insects, in part because the multitude of possibilities is extensive as befits such a diverse group. The natural history of insects always tantalizes, offering us unexpected glimpses into a world seldom recognized except by keen observers. Vintage writing about insect natural history—seen in *Life on a Little Known Planet* by Howard E. Evans, Niko Tinbergen's *Curious Naturalists*, and May R. Berenbaum's monthly columns in *The American Entomologist* (collected in her book *Buzzwords*)—represents some of the best examples of the genre. In *How Not To Be Eaten: The Insects Fight Back*, author Gilbert Waldbauer successfully frames the natural history of insect predator–prey interactions against the understanding that predation has an inordinate influence on insect adaptation. This is important, given that insects play significant and central roles in natural food webs and ecosystem function.

The book emphasizes the incredible diversity of solutions that insects have displayed through evolution to ward off the continual challenges that face them. To illustrate such a diverse array of predator–prey interactions, Waldbauer organizes his book according to the many ways that prey can thwart detection or reduce predators' capture efficiency—fleeing and hiding, mimicking or appearing to be something not considered edible, inducing startle responses, reducing risk through safety in numbers, maneuvering with defensive tactics, and warning predators by using chemical defense signals. To complete the continuously evolving cycle, Waldbauer also describes predator countermeasures that arise to combat these prey defenses.

How Not To Be Eaten is engaging in its descriptive and wide-ranging examples. Waldbauer's writing highlights an understanding of the detailed natural history of each species, and it also focuses on the multiple kinds of approaches taken by investigators to devise and test hypotheses of how insect prey reduce their predation risk. Each chapter provides appropriate and interesting case studies to illustrate its main points, and the author's chosen examples are a blend of contemporary studies mixed with important classics. Both the scientific audience and those who simply appreciate organismal diversity and who are keenly interested in the natural world will enjoy this book.



Each chapter section describes how a specific adaptation might work in certain instances. In each of these cases, the author surveys previous studies to inform the reader about the general scope of evidence documenting how the mechanism in question serves to limit predation risk. Few examples are presented that refute specific hypotheses, but some are acknowledged. One example surprised me: Despite widespread acceptance of its efficacy, there is no evidence offered for or against the adaptation of disruptive coloration to reduce predation risk as a successful tactic in natural systems. In most cases, however, affirmative studies dominate the text in order to make the point that successful adaptations by insects are manifested in the many types of their effective defenses.

Despite the range of fascinating examples described in the book, I was somewhat disappointed in one aspect: The book does not offer a developed presentation of the underlying evolutionary dynamics associated with these complex relationships. After all, most traits are the result of integrated morphological and behavioral features that match fairly closely in a finely tuned adaptation. Although Waldbauer presents some evidence that even rudimentary change in antipredator traits confers fitness benefits that lead to the evolution of more complex combinations, such discussions are dispersed casually throughout the book, thus diluting a critical message.

What is missing, for the most part, are theoretical contexts and hypotheses of the more complex ecological and evolutionary dynamics that are critical for understanding the evolution of predator–prey adaptations and their ecological consequences. For example, the relative roles of density- and frequency-dependent selection and their significance to the evolution of mimicry systems are not explained directly. Recent studies on sensory bias, which have been focused on constraints on predators' perceptual capabilities (e.g., sensitivities to different wavelengths of light), and the resulting evolution of antipredator traits are also not included. Lip service is given to the role of natural selection in the evolution of many interesting interactions, but the details about how natural selection acts in specific cases are not well developed overall.

Although evolutionary dynamics are critical to fully understanding the adaptations included in the book, these concerns are fortunately not a major distraction, because the examples are so interesting. Besides, this was not a major goal of the author, and my desire for more detail attests to the interest generated throughout by his examples.

With case studies that combine natural history, observation, and some manipulation to illustrate the diverse approaches used by insect prey to reduce predation risk, Waldbauer succeeds in highlighting the intense and captivating evolutionary arms race taking place among insects. Some examples described in this book are already part of the public consciousness, and other, lesser-known examples are now presented for all to appreciate. In *How Not To Be Eaten*, Waldbauer provides not only a life history but a roadmap for developing new fascinating studies of interactions between insect prey and their predators. Moreover, the book gives us motivation to spend a little more time wandering out into the world and taking a closer look at insects as they fight back in an intense, ongoing battle.

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DEFENSE SYSTEMS IN EVOLUTION

Evolution in a Toxic World: How Life Responds to Chemical Threats. Emily Monosson. Island Press, 2012. 232 pp., illus. $35.00 (ISBN 9781597269766 cloth).

It is the general impression in environmental toxicology that life has had to cope with toxic stresses only since the industrial era, an awareness that was stimulated by Rachel Carson's publication of *Silent Spring* 50 years ago. As Emily Monosson demonstrates in *Evolution in a Toxic World: How Life Responds to Chemical Threats*, however, living things have been dealing with chemical and physical threats for millennia and have developed defenses against these threats. Many of these defenses are highly conserved—DNA repair, for example, and antioxidants. Yet, toxicologists seldom consider evolution when they plan their studies and should integrate such awareness in order to have better understanding of their findings and to develop more interesting hypotheses to test. Moreover, only a tiny fraction of chemicals in use have ever been tested for toxicity, but improvements in analytical chemistry allow us to detect ever-smaller