Unsimple Truths: Science, Complexity, and Policy.

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the classroom will recognize many of the elements of good teaching in the ways we are encouraged to approach outreach.

What if media mavens and policymakers do not come calling? Where can you meet journalists? How do you pitch your story? What makes a successful op-ed piece? Baron has some answers. She shares her knowledge about how to get media traction for scientific discoveries and, for that matter, how to judge for yourself whether those discoveries are strong candidates for media attention. Baron drills down to the details: Are you ready with compelling photographs? Can you write a press release? She dissects and presents "Anatomy of an Outreach Effort" (box 12.3). Finally, she guides us through the foreign terrain surrounding political outreach. From dress codes to one-pagers, she covers the admittedly nerve-racking process of congressional testimony. (Scale it down, and you are ready for your county commissioners!)

Outreach is not cheap and is not without some surprises. In the final section, Baron devotes a chapter to dealing with backlash, be it from special interest groups, peers, or the media. In a summary chapter, she offers comments on what she sees as "Ten Steps to Success." This chapter is perhaps most notable for its (and the book's) final sentence. Baron shares a question from the poet Mary Oliver: "Tell me, what is it you plan to do with your one wild and precious life?"

To my knowledge, no other book attempts to assist scientists in doing the critical task of outreach to media, politicians, and the wider community. Because Baron understands scientists, journalists, and policymakers—and because she cares passionately about how science is translated into care for our planet—she can write an accessible book that nonetheless delivers the detail and hands-on instruction scientists need for success.

Escape from the Ivory Tower is well organized with short, to-the-point chapters that are punctuated by examples, interviews, and gentle humor. In the world of science we sometimes forget that a book can be an easy, pleasant read and still teach us quite a bit. Nancy Baron knows that, and she has delivered that book. The result is unlike anything you've read before—and it is something you need to begin reading now. This is not a book for your bookshelf. It is a book for your backpack, your briefcase, your graduate students, and the trunk of your car, in case you need a refresher on the message box or simple inspiration before a chat with a newsperson or a visit to your elected officials. This is a book to be read, enjoyed, and dog-eared—assuming, of course, you want your science to matter.

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SMALL, WARM, AND FUZZY

Unsimple Truths: Science, Complexity, and Policy. Sandra D. Mitchell. University of Chicago Press, 2009. 160 pp., illus. $27.50 (ISBN 9780226532622 cloth).

In *Unsimple Truths: Science, Complexity, and Policy*, Sandra D. Mitchell accomplishes an enormous amount in very short compass. Starting from the actual practice of (mainly) biological and (some) social sciences, she presents a workable and effective philosophy of science focused particularly on sciences dealing with complex subject matters. Drawing on nicely handled examples from psychiatry (e.g., major depressive disorder), biology (e.g., recent genetics and genomics, drug discovery, the study of insect societies), and the policy world (e.g., climate change and economic problems), Mitchell develops and illustrates a philosophy of science suited to the complexities scientists face. The result is a compact and elegant presentation of a philosophy she calls "integrative pluralism," challenging many orthodox positions in the philosophy of science. While keeping her examples in the foreground, Mitchell provides a philosophical basis for rethinking the methods for analyzing complex systems in situations involving considerable uncertainty. She also demonstrates by example the value and reach of her philosophical approach in contrast with more conventional philosophies of science, from Popperian falsification and standard forms of inductive reasoning to sophisticated forms of theory and model testing.

Mitchell argues that many traditional philosophies of science handle Newton's laws or those of electrodynamics, for example, by using the concept of supposedly exceptionless, necessary scientific laws pertaining to all physical systems. These philosophies, she maintains, do not provide appropriate guidance for biologists and other scientists dealing with complex situations and systems. Although her philosophy is built to provide ways of coping with considerable uncertainty about the underlying laws, the causal structure of the systems under investigation, the outcomes of particular situations, and the consequences of particular interventions, her aim is not just epistemological. Rather, she builds on the very character of complex systems and the issues addressed in dealing with them. Mitchell argues, in effect, that law-likeness and the extent to which laws determine outcomes are matters of degree.

All substantive laws (unlike laws of logic) are context limited—even the constants pertinent to quantum mechanics depend on the quantity of mass-energy in the universe at the time of the Big Bang. The laws of chemistry depend on those of physics, but they apply only after the universe had cooled sufficiently to allow the formation of atoms and molecules. Some of them depend on relative availabilities of various compounds or even of various isotopes and relevant

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environmental stabilities. Many biochemical laws, for example, depend on the availability of enzymes that are not generally available except as products of the evolution of chemical processing systems within organisms. Biological laws concerning numerous systems are limited in their scope and in the character of the exceptions they allow and the character of the circumstances that yield those exceptions. Indeed, without the catalytic action of appropriate enzymes, the chemical reactions required for life would take impossibly long. Thus, the regularities of the genetic code are not intrinsic to the structure of the genetic material as such, but depend systematically on the availability of the appropriate enzymes and on various material structures within living systems that are required for the processing of genetic information. Exceptions to the standard code depend on the local context that determines which transfer RNAs are available. I draw from this the general moral that coevolutionary processes have produced the regimes in which the regularities of genetics are feasible, and therefore within which life as we know it arose.

Mendel's laws are weaker; they pertain only to cells or organisms that have chromosomes with a certain amount of cohesion, on which genes are linearly arrayed and subject to various regularities of gene expression. Because those laws result both from the regularities of gene expression and from chromosomal mechanics, the perturbations that cause exceptions to Mendel's laws can be recognized and classified. The phenomena of crossing over and of meiotic drive and posttranscriptional blocking of gene expression yield exceptions to Mendel's laws. Yet Mendel's laws, though not free of exceptions, do govern significant phenomena within a domain that can be fairly clearly demarcated in familiar ways. Mitchell continues the chain of examples into developmental biology, ecology, and evolution, but always with an eye to a general account of the kinds of complexity involved and the various methods scientists have developed to handle them.

Standard philosophies of science treat scientific laws on the model of logically necessary truths: A general claim is either (physically) necessary or it is contingent (only "accidentally true"). Mitchell argues that any such sharp dichotomy is insufficiently rich to handle complex multilevel causation. Her point is not that reductionist analysis is unimportant (e.g., favoring the "genuine" laws of physics as opposed to the "accidental" generalizations of biology); rather, she seeks to honor the strengths of reductionism and to recognize its limits. She argues that whether reductionist analysis is appropriate depends both on what is to be explained and on the character and complexity of the relevant causal situation, system(s), or interactions. The sciences that deal with complexity build on and use all the resources of the powerful theories and tools developed to handle cases treatable by reductionist analyses. Otherwise, they could not get off the ground. But there is now ample evidence that, for example, the etiology of various cancers or of major depressive disorders is not simple. Both examples involve open hierarchical systems in which molecular and environmental factors, but also cellular and organismal histories, affect the predispositions of the individual and can act as triggers of varying strength depending on the way in which the relevant system is poised at different stages of its history. Very often, multiple causes of quite different sorts are involved, with complex feedback loops that alter the impact of particular factors in ways that depend on very different sorts of contingencies.

Major depressive disorder illustrates the point clearly: Genetic factors (e.g., the *5-HTT* gene), developmental history (e.g., childhood abuse, which can affect serotonin uptake and alter responses mediated by the amygdala), and various stressful life events all play partial causal roles in leading to major depressive disorder, but none of these partial causes is necessary or sufficient for the occurrence of the disorder, and the sequence in which various causes occur is a significant factor in the impact of the other causes. Mitchell devotes considerable attention to such points and discusses many of them in detail, developing strategies that one might adopt in investigating such complexities or in attempting to reduce the impact of unfavorable events or circumstances. (Parallel points apply, of course, for seeking to achieve a desired effect.)

Mitchell's philosophy is pluralist because, as she argues, there is no clean way to draw system boundaries or to isolate uniquely the relevant causal factors in cases of the character on which she focuses. Thus, there is no uniquely correct description (say, at the molecular level) of the causes of depressive disorders, for these also depend on the historical sequence of environmental causes that indirectly alter the neural system and, even more indirectly, the biochemical sensitivities of the affected individual. The philosophy is integrative in that it not only encourages but also requires salient work based on the disparate and sometimes conflicting theories at different levels of analysis to be taken into account and integrated into scenarios that examine how complex systems evolve and interact in ways too rich to describe here. Remarkably, Mitchell is able to condense her account of numerous examples into a coherent, helpful, and persuasive philosophical approach to the study of such complex matters as these. *Unsimple Truths* is, of course, only a foray into the direction that Mitchell is pointing, but I strongly recommend it as a significant improvement over much recent philosophy of science, of particular value to biologists and other scientists dealing with complex phenomena.

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