BOOK REVIEWS

Problems Beyond Pesticides

Our Stolen Future. Are We Threatening Our Fertility, Intelligence, and Survival? A Scientific Detective Story. THEO COLBORN, DIANNE DUMANOSKI, and JOHN PETERSON MYERS. Dutton, New York, 1996. xii, 307 pp. $24.95.

From the first sentence it is clear that this book was not written for scientists. Rather, it seeks to engage a large, general audience in an issue that has already sparked considerable interest among researchers and government regulatory agencies—environmental threats posed by hormone-disrupting chemicals. The tactics used to attract this general audience are likely to turn many scientists away. The breathless, often clumsy, literary style is reminiscent of a grade B novel: "McLachlan, a fifty-year-old man with a head of curly gray locks and merry dark eyes that gleam like onyx . . . " (p. 70). This tone is irritating and distracting.

Even more likely to raise scientific ire is the authors' lack of discrimination between anecdotal reports and meticulous scientific studies. One paragraph describes a carefully crafted study; the next indulges in wild speculation. Conjecture that the recent drop in Scholastic Aptitude Test scores may be due to exposure to pesticides is juxtaposed with discussion of the careful, well-controlled studies of Fred vom Saal concerning the effects of intrauterine position in rodents on adult behavior. This lack of selectivity diminishes the impact of the book because it raises questions about the scientific judgment of the authors.

If these—assuredly serious—flaws turn scientists away from the message of *Our Stolen Future*, it will be unfortunate. The book raises frightening questions about the impact of man-made chemicals on our planet. It details the mass of accumulating evidence that toxicants in our environment may be disrupting developmental processes by interfering with the actions of endogenous hormones, and it describes the ubiquity of such toxicants in the biosphere. Herring gulls forming same-sex pairs and abandoning their eggs, eagles failing to show nesting behavior and neglecting their young, wild otter populations in severe decline, alligators with undersized penises, feminized roosters, high mortality among mink pups, still-born lambs, decline in great-white-bear populations—the list goes on and on. Many of the studies are less than perfect, but their commonality is striking, and when seen as a whole they have great weight. We agree with the authors that "the pieces of this scientific patchwork quilt have, despite admitted gaps, a cumulative power that is compelling and urgent" (p. 170).

Perhaps the most important reason for scientists to read this book is that it explicitly challenges us to reevaluate our role with respect to the making of public policy. Environmental and occupational regulations are based on evidence gathered by researchers in laboratory and field. However, the process by which the regulations are established can be unsettling to those who have provided the evidence. As students, we were taught to withhold final judgment until incontrovertible proof was established. Yet governmental standards and regulations must often be established in the absence of sufficient proof. They are often based on flawed or preliminary scientific studies.

Should the same rules by which scientific studies are evaluated apply to deciding whether to license a new chemical? Colborn and her colleagues say no: "Those who demand such definitive 'proof' before reaching a judgment are certain to be waiting an eternity . . . it is important to recognize at the outset that those responsible for safeguarding human health will have to act on information that is less than perfect" (pp. 196–197). They argue that the threat of endocrine disrupters is so great that if we fail to act immediately we jeopardize the future of humanity and of countless other species.

The urgency of the present authors' message is strongly reminiscent of that of Rachel Carson in *Silent Spring*, a comparison the authors encourage. The critical response to *Our Stolen Future* is also strongly reminiscent of the response to Carson's book. In both cases, some segments of the scientific community have come out swinging. For instance, in 1962, a review of *Silent Spring* in *Chemical and Engineering News* (**40**, 60) stated, "In view of the mature, responsible attention which this whole subject receives from able, qualified scientific groups . . . (whom Miss Carson chooses to ignore); in view of her scientific qualifications in contrast to those of our distinguished scientific leaders and statesmen, this book should be ignored." In 1996, a discussion of *Our Stolen Future* in the *Washington Post* (31 March, p. C3) quoted John Giesy, past president of the Society of Environmental Toxicology and Chemistry as saying, "Frankly, Colburn doesn't know very much. She reads the entire literature and picks and chooses things that support her preconceived views." It also quotes Larry Lipshultz, professor of urology at Baylor College of Medicine: "Something is missing in *Our Stolen Future* and that's called science."

Perhaps the critical reaction to *Silent Spring* has lessons for our own times. As its reviewer in the *New York Times* stated, "despite the drawbacks of 'Silent Spring'—and to some extent because of them—it is an important book. 'Uncle Tom's Cabin' would never have stirred a nation had it been measured and 'fair' " (Books of the Times, 27 Sept. 1962, p. 35). The *Christian Science Monitor* noted, "Miss Carson has undeniably sketched a one-sided picture. But her distortion is akin to that of the painter who exaggerates to focus attention on essentials. It is not the half-truth of the propagandist" (27 Sept. 1962, p. 11). Even after Carson "stirred a nation," the regulatory community took 10 years to respond to a growing threat. From a distance of more than 30 years we know that Carson's anxiety about DDT and chlordane was not misplaced. Do we have the luxury of waiting another 30 years to determine if Colborn and her colleagues are overstating their case against PCBs and other so-called endocrine disrupters?

Silent Spring caused a momentous shift in our perception of our relation to the environment. The authors of *Our Stolen Future* urge us to make another shift: "If this book contains a single prescriptive message, it is this: we must move beyond the cancer paradigm. . . . This is not simply an argument for broadening our horizons to recognize additional risks. We need to bring new concepts to our consideration of toxic chemicals. . . . Hormone-disrupting chemicals are not classical poisons or typical carcinogens. They play by different rules." The authors urge that "if we are to come to grips with this threat, we must also shift to a different way of making judgments about environmental contaminants. . . . This real-world environmental detective work comes to judgment based on 'the weight of the evidence' rather than on scientific ideals of proof that are more appropriate to controlled laboratory experiments and the practice of science than to problem-solving and protecting public health in the real world. As some have noted, it is akin to the

decision-making process a physician uses to diagnose a case of appendicitis—where failing to act has grave consequences" (p. 203).

The potential threat of endocrine disrupters is a critical issue for our time. By the manner in which we as scientists participate in the public discourse on this issue, we can help to ensure reasoned, careful deliberation of a most important question. As the authors point out, "Deciding on a wise course involves a host of considerations, and, most of all, value judgments" (p. 246). Scientists must decide whether we should contribute to the ongoing debate solely by providing data or whether we should also recognize and accept the responsibility to participate in the equally important component of policy-making that involves the rendering of value judgments. If we avoid this responsibility, then we leave it to others to decide what information is needed and how this information is to be interpreted.

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Quantum Gravitationists

The Nature of Space and Time. STEPHEN HAWKING and ROGER PENROSE. Princeton University Press, Princeton, NJ, 1996. x, 141 pp., illus. $24.95 or £16.95. Isaac Newton Institute Series of Lectures.

The theory of general relativity was formulated in a mathematically complete form 80 years ago, and the basic principles of quantum theory were laid out about 70 years ago. Nevertheless, only within the past few decades have major efforts been under way to merge these theories into a mathematically consistent and complete quantum theory of gravitation. Despite these efforts, research in quantum gravity remains highly speculative, with very few solidly established results and with wide disagreements among researchers not only about the best approach to take but even about what unresolved issues deserve the most attention.

Stephen Hawking and Roger Penrose are, without question, the leading developers of our modern view of the structure of space and time. In particular, their singularity theorems and their contributions to the theory of black holes have provided us with major new insights. Both Hawking and Penrose have given considerable thought to the relationship between quantum theory and gravitation. In view of the situation noted in the paragraph above, it is not surprising that they differ widely in their views.

"It is normally assumed that a system in a pure quantum state evolves in a unitary way through a succession of [such] states. But if there is loss of information through the appearance and disappearance of black holes, there can't be a unitary evolution. Instead, the . . . final state after the black holes have disappeared will be what is called a *mixed quantum state.* This can be regarded as an ensemble of different pure quantum states, each with its own probability. But because it is not with certainty in any one state, one cannot reduce the probability of the final state to zero by interfering with any quantum state. This means that gravity introduces a new level of unpredictability into physics. . . . It seems God still has a few tricks up his sleeve." [From chapter 3 of *The Nature of Space and Time*]

This book is based on a series of public lectures by Hawking and Penrose and is described as a debate between them. This characterization is accurate only if one understands the term "debate" in the sense used in American Presidential campaigns. Both Hawking and Penrose do an excellent job of expounding their own views and perspectives on fundamental issues related to space-time structure and quantum theory. Although they make some criticisms of each other's views as well as some criticisms of other alternative approaches (including some "one-line zingers" on string theory), most of the criticisms and responses are of a "sound bite" nature; there is relatively little direct engagement at a deep level between them in the book.

The first two chapters (one each by Hawking and Penrose) discuss some key concepts and results in modern general relativity. Almost all of these results are solidly grounded, and there is little or no disagreement between Hawking and Penrose here. Chapter 3, by Hawking, describes his work on particle creation by black holes and some related (somewhat more speculative) ideas in Euclidean quantum gravity. Chapter 4, by Penrose, primarily introduces his concerns about quantum measurement theory. Chapter 5, by Hawking, presents his (much more speculative) views on quantum cosmology, while chapter 6, by Penrose, contains a very brief discussion of twistor theory and his views on how it may be related to quantum gravity. The final chapter, entitled "debate," contains some direct engagement between Hawking and Penrose on issues such as "Schrödinger's cat," Euclidean methods in quantum gravity, and the equivalence or inequivalence of black holes and white holes. All of the main ideas in the book have appeared in previous scientific writings by the authors (and, indeed, their views do not seem to have evolved significantly in the past decade or so), but the discussion here is much more lively and informal than can be found elsewhere.

Most of the details of the arguments given in the book are far too technical for a layperson to follow—or even a physicist not specializing in general relativity or related areas. Nevertheless, even readers without much technical background should be able to enjoy the flavor of much of the discussion. This is an interesting book to read now, but it promises to become an even more interesting book for future generations of physicists, after it becomes more clear which present-day ideas lie on the path toward the development of a quantum theory of gravity.

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Books Received

Biomolecular NMR Spectroscopy. Jeremy N. S. Evans. Oxford University Press, New York, 1995. xvi, 444 pp., illus. $85; paper, $49.95.

Carbohydrate Building Blocks. Mikael Bols. Wiley, New York, 1996. x, 182 pp., illus. $39.95.

Insect Migration. Tracking Resources Through Space and Time. V. A. Drake and A. G. Gatehouse, Eds. Cambridge University Press, New York, 1995. xviii, 478 pp., illus. $74.95. Based on a symposium, Beijing, June 1992.

Modern Astronomy. J. Kovalevsky. Springer-Verlag, New York, 1995. xiv, 352 pp., illus. $64.50. Astronomy and Astrophysics Library.

Protein NMR Spectroscopy. Principles and Practice. John Cavanagh *et al.* Academic Press, San Diego, 1995. xxiv, 587 pp., illus. $59.95.

The Smithsonian. 150 Years of Adventure, Discovery, and Wonder. James Conaway. Knopf, New York, 1995. 432 pp., illus. $60.

Soils. A New Global View. T. R. Paton, G. S. Humphreys, and P. B. Mitchell. Yale University Press, New Haven, CT, 1995. x, 213 pp., illus., + plates. $40; paper, $20.