Daniel R. Brooks, Eric P. Hoberg, Walter A. Boeger, *The Stockholm Paradigm: Climate Change and Emerging Disease*. Chicago/London: The University of Chicago Press, 2019, 400 pp., \$40.00 (paper)/\$120.00 (cloth)/\$10.00–\$40.00 (e-book)

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Accepted: 7 March 2021 / Published online: 17 March 2021
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Half of the earth's organisms are estimated to be parasites and pathogens. Only around 10% of them are formally known to science. And a great number of them would readily take up residence in our bodies or those of the plants and animals we depend on, should the opportunity arise. But how do these opportunities come about? How is all this connected to climate change? And can we do anything about it?

In answering these questions, *The Stockholm Paradigm*—authored by three renowned experts in parasitology and evolutionary biology—is perhaps one of the most important works of current science literature. Not quite a popular science book in the traditional sense, it seeks to reach the interested public as well as researchers and policymakers with its timely message. Its contents revolve around breaking down two major misconceptions that have pervaded the realms of human and veterinary medicine, parasitology, and evolutionary biology for centuries. Firstly, that shifts in host–pathogen associations happen rarely and only through mutation events. Secondly, that such changes are impossible to anticipate and thus can only be reacted to once a crisis is already underway.

By taking us on a whirlwind tour through the history of such diverse topics as evolutionary biology, the history of vaccines, past pandemics, and climate change, Brooks, Hoberg, and Boeger dismantle our preconceived notions about host–pathogen co-evolution, they explain how we got into the current mess, as they aptly call it, and propose a possible way to get out of it before it is too late.

The book is structured into 10 chapters dense with scientific detail, each with a pithy summary, illustrated with numerous explanatory figures, and supplemented by a vast array of notes and references. For the reader less acquainted with evolutionary

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theory or computer modelling, some sections and figures may be somewhat technical or difficult to grasp at first, but the witty writing style, the persistent repetition of the most crucial concepts, and the adorable cartoonish animals featured in many illustrations entirely make up for some of the more challenging parts.

At the core of the book's explanations is the concept of 'sloppy' fitness space, wherein a constant oscillation between exploitation and exploration allows pathogens to occupy new host species with startling ease. These models clash with our intuitions about supposedly perfectly co-evolved host-parasite pairs that would require just the right mutation at the right time to permit any expansion or change of the host range. This untangling of the 'parasite paradox'—i.e., how highly specialized pathogens are ever able to acquire new hosts—is only one half of the puzzle presented within the book. We also learn how pathogens thrive on opportunity, on chance encounters with suitable new hosts facilitated by ecological perturbations, and how the current climate crisis combined with the hyperconnected world of technological humanity offers more of these opportunities than we are comfortable imagining. Numerous mathematical models and real-world examples throughout the earth's history and involving a diverse set of host–pathogen associations serve to illustrate the book's main messages: our reliance on globalization, the proliferation of urban environments, the exploitation of the biosphere, and man-made climate change have put our crops, our livestock, and our own species at risk of devastating consequences brought about by emerging infectious diseases (EIDs). Only a year ago, this message would have been brushed off as interesting but overly apocalyptic by most readers—now we know better.

Admittedly, reading this book in the midst of the ongoing COVID-19 crisis is a challenging task. Learning about the diversification of tapeworms and the intricacies of the Milanković cycles, just as the second wave of the pandemic is sweeping across the globe, feels a bit like studying the history of the firehose while your house is burning down. Mentions of SARS-like viruses in wild reservoir hosts that should be closely monitored are chilling to read, as are the grim pictures painted by a hypothetical flu pandemic in 2030, with devastating socio-economic consequences. Unsurprisingly, in predicting what nobody wanted to hear, the authors themselves feel they are part of the so-called Cassandra Collective, but they have been astonishingly correct so far.

Some readers may thus grow impatient with the rich background information and seek more concrete advice for the crisis at hand. Those may be tempted to leave the—albeit truly fascinating—historical and theoretical chapters for better times and start at the end of chapter 7 ('An Integrated Research Program', p. 191), where the most important evolutionary processes are once more summarized, or with chapter 9 ('Evolutionary Triage', p. 225) where the DAMA Protocol is finally introduced. The name of this novel action plan is an acronym for the steps it consists of: Document, Assess, Monitor, Act. It calls for taxonomists, medical professionals, computer experts, evolutionary biologists, policy makers, citizen scientists, and many others to do their part in getting ahead of the EID crisis by identifying and surveying potentially dangerous pathogens before the situation becomes critical. If implemented globally, it would enable us to move from the previous reactive response to EIDs towards an entirely proactive way of "finding them before they find us" (p.

227). Indeed, to anticipate outbreaks and even over-prepare for these coming scenarios would be sure to save time, money, and lives. Because if the authors are correct in their predictions—and all signs currently point in that direction—the COVID-19 pandemic is but the tip of the EID iceberg.

This is primarily a book about evolution. As such, concrete medical action plans or a critical evaluation of our capitalist systems are only marginally touched upon. But, according to the authors, understanding pathogen history and evolution holds the key to saving technological humanity from the onslaught of those many EIDs that have yet to explore the immense opportunity space that climate change and human civilization have provided them with. Like the pathogens themselves, this evolution is neither heroic nor evil. It cannot be stopped to preserve supposedly pristine ecosystems or made to do our bidding with technological tricks. It is, however, the biosphere's tried and true method of recovery through change—and now “the biosphere is beginning to cope with climate change without asking our permission and without waiting to see whether we will participate” (p. 252).

As the proposed DAMA Protocol illustrates, understanding how pathogens may shift to new hosts is crucial, but it is only the first step. If we are to tackle the EID crisis, individual responsibility and collaborative action will be essential. Our lifestyles based on ever-increasing exploitation of the biosphere's resources will have to undergo drastic changes. Furthermore, connecting medicine, governments, scientists and the public to the necessary funds and infrastructure as well as to each other seems ambitious but feasible on paper. Ironically, despite pointing out the traditional shortcomings in establishing channels between these realms, the authors may have been overly optimistic here, judging by the lack of global communication and cooperation, and by the rampant science denial that is currently observable in the wake of the ongoing pandemic.

Some may fear the insights provided by *The Stockholm Paradigm* have come too late. The EID crisis has already started, and—to put it mildly—it has caught us somewhat insufficiently prepared. But if we aim to respond to the book's final message, if we manage to transform our fear into hope and learn from our past mistakes, all is not lost. If we are to get through this alive, this book certainly offers countless valuable lessons to take with us into an uncertain future: “The danger is great, time is short, and we are unprepared. *But we are not dead yet*” (p. 224).

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