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Seasons of Life: The Biological Rhythms That Enable Living Things to Thrive and Survive

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Mitchell recounts the tics and foibles of her scientist sources, often world-class researchers in their fields. She may be a bit starstruck at times—too many sources are labeled "brilliant." Far more important: She makes it obvious early on that she is struggling to keep her emotional balance under successive waves of terrifying—her word—research about the nearing fate of the world's oceans.

It becomes clear that this is not self-involved melodrama but an indispensable context for the research, and several of the scientists whom she accompanies show the same anxiety. The conservation agenda has moved with breathtaking speed, after all, from individual species, to ecosystems, to biomes, to global climate and the oceans. Depression has become for some scientists an occupational hazard as the subject matter of their research—coral, for example—is extinguished. An empath, Mitchell is able to draw out her sources' reactions to their own findings, and their implications for the future, in terms that engage the reader below the neck.

A sample: "Once they figured out how low the carbonate ion concentration would fall if carbon dioxide concentrations in the atmosphere kept rising, they realized they were looking at a marine Armageddon," Mitchell recounts.

One researcher, Joan Kleypas, "ran into the bathroom outside the committee room and threw up."

On global overfishing: "We don't realize how absolutely exceptional this time is.... We are at the stage of losing the ability of things to come back on their own," Dalhousie University biostatistician Boris Worm tells Mitchell. "I'm absolutely hopeful," he adds. "I would be suicidal if I weren't hopeful."

Michael Kendall, of the Plymouth Marine Laboratory in England, trying to crack the bemused, detached ineffectuality at a marine management conference, tells his audience: "All these changes have happened before, but never, ever as rapidly. These are the fastest broad-scale changes the marine system has ever experienced." He is almost pleading with them at the end: "We can't just sit on our hands and wait."

Mitchell also pursues the sources of hope, the researchers' "coping strategies" in the face of the accumulations of unnerving data. It is well for shell-shocked scientists to defend their optimism; hopeless is useless. "The ocean contains the switch of life," as Mitchell concludes, "and that the human hand is on that switch, is a concept on the frontier of scientific thought."

Along with keeping her own hopes together, Mitchell has reportorial challenges that face all environmental journalists—how to recount credibility-enhancing but granular details of research without the narrative trailing off into the weeds; how to explore an issue by focusing on just a few researchers while doing justice to dissenting interpretations or contradictory research findings, and keeping them all in proportion.

These are handled adroitly. Though her conclusions are necessarily subjective at times, they're also frank in their indeterminacy—"We don't know what's going to happen" is a frequent refrain. The story's power, and urgency, are hyper-audible.

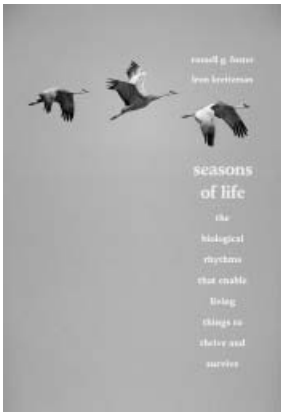
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SEASONAL TIMING OF LIFE AND DEATH

Seasons of Life: The Biological Rhythms That Enable Living Things to Thrive and Survive. Russell G. Foster and Leon Kreitzman. Yale University Press, 2009. 320 pp., illus. $28.00 (ISBN 9780300115567 cloth).

This book, *Seasons of Life: The Biological Rhythms that Enable Living Things to Thrive and Survive*, is Russel G. Foster and Leon Kreitzman's second on the subject of biological rhythms. The first, *Rhythms of Life* (2004), dealt with the role of circadian (daily) rhythms in programming life-cycle and physiological events; the current volume extends this discussion to seasonal cycles, in particular circannual, or yearly, rhythms. Foster is a professor of circadian neuroscience at Oxford University, specializing in the molecular and neurobiology of



biological timing, and Kreitzman is a science writer and broadcaster. The book is appropriately dedicated to the late Eberhard Gwinner, who discovered circannual rhythms in birds and elucidated their role in the seasonal cycles of breeding and migration. This is not an advanced biological treatise, but rather an up-to-date summary aimed at readers with some biological background.

Seasons of Life is really two books. The first several chapters address seasonality and circannual rhythms in plants and nonhuman animals. The last several deal with human biology, from the influence of seasons on birth and lifespan to the seasonality of disease, both obvious (influenza in winter) and more subtle (breast cancer in spring). Although readers of *BioScience* probably won't find much new biology in the first part of the book, the story is well told and could serve as a

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useful resource for lecture preparation or outside reading assignments. The book contains some fascinating facts: Reindeer have blue eyes in winter and yellow eyes in summer, apparently as an adjustment to changing light conditions. The great tits of Oxford have successfully adjusted their breeding schedules to the earlier emergence of their winter moth caterpillar prey, but those in the Netherlands have not. Matters are more complicated in the elaborate food webs of Cape fur seals, and the authors suggest that the effects of climate change and decisions about hunting or culling can be nonobvious or even counterintuitive. As a zoologist, I found the description of the use of bioluminescent luciferin to study plant growth patterns in *Arabidopsis* both interesting and enlightening.

Historical background lends strength to this book's discussion of seasonal timing in animals and plants. The discovery of photoperiodism by Garner and Allard in plants and by Marcovitch in aphids in the 1920s is nicely covered. Hamner and Bonner in the United States and Bünning in Germany, whose hypotheses and experimental designs drove work on seasonal timing for at least the next 50 years, are then described. Experiments to test hypotheses about photoperiodic timing are complex, but the authors explain them clearly here, and include a useful glossary.

Discussions of molecular and physiological aspects of seasonal rhythms are better presented than those pertaining to ecological or behavioral aspects. For some areas of behavior and ecology, the authors seemed a bit out of their depth and were prone to error or misinterpretation. For example, with respect to migration, albatross foraging excursions are an example of long flights that are *not* migration, but the authors treat them as part of a broad range of migratory movements. It is misleading to say that the evolutionary origins of migration are "hotly debated," as there is consensus that migration is an ancient behavior that evolved independently many times as an extension of traits already present for other purposes. The suggestion that, of the two major species of locust, *Locusta migratoria* and *Schistocerca gregaria,* the former is irruptive whereas the latter is migratory obscures much more complex biology; these species are both irruptive *and* migratory. The authors miss an opportunity by failing to discuss *S. gregaria* especially in more detail. This species is seasonally tied to rainfall, the intertropical convergence zone, and wind directions in ways that can dramatically contradict the statement that they make movements between winter (*sic*) and summer breeding grounds. Neither locust species is limited to North Africa, as implied; both range over virtually the entire African continent with (migratory) excursions to southern Europe and western Asia. A discussion of a particularly interesting and varied aspect of seasonality, not limited to locusts, is absent.

Biologists are likely to be less familiar with the many influences seasons have on human health and demography, and should find much that is interesting food for thought. Whether humans are photoperiodic is the subject of debate, which the authors summarize nicely; however, the seasonal patterns of human births and deaths are more distinct. In the Northern Hemisphere, births peak in spring, with a secondary peak in September and a trough in November and December. In some, but not all, industrial countries, the pattern seems to be disappearing. Lifespan is longer by several hundred days on average for those born in November versus those born in March. In French-Canadian women, the month of birth predicts fitness as measured by the number of grandchildren produced. There are hints that nutritional factors may be involved, but clearly there is still much research to be done.

A consultation with my clinician daughter indicated that much of this book could provide guidelines and insights for physicians and public health professionals. Seasonal patterns take us back to basic biological and evolutionary principles that are fundamental to understanding health and disease, and can provide clues to disease risks and causes. For example, vitamin D deficiency during pregnancy appears to increase the risk of schizophrenia in offspring. Could the similar link between winter pregnancy and schizophrenia reflect lower winter availability of vitamin D? There also appears to be complex interactions among influenza, the season of pregnancy, and mental illness in offspring. Other examples of correlations between season of birth and illness include diabetes, asthma, and Hodgkin's disease. The authors argue persuasively that seasonal effects can be useful to health research and may indicate new ways of looking at interactions between genes, environments (including social environments), and patterns of illness and good health.

The book closes with some examples of how changes in seasonal life history patterns reflect human-induced climate change. Some of the changes are genetic, whereas others reflect nongenetic physiological adjustments. In any case, the evidence that climate change influences life history timing is compelling. Indeed, as the authors say, "we are all phenology freaks now," or at least we should be.

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NEW TITLES

Adventures among Ants: A Global Safari with a Cast of Trillions. Mark W. Moffett. University of California Press, 2010. 288 pp., illus. $29.95 (ISBN 9780520261990 cloth).

All about Birds: A Short Illustrated History of Ornithology. Valérie Chansigaud. Princeton University

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