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Nature's Compass: The Mystery of Animal Navigation

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that is, many will use it as a reference work. But doing so will shortchange both the reader and those who clearly worked hard to create a volume of this caliber. To conduct a review of the book, I had to read all of it—not a trivial task—but I profited from the experience. To state what has long been known: Working across disciplines can be painfully difficult, but sustainability science and its applications in society demand the effort. Nowhere else is the idea that the whole is greater than the sum of its parts more relevant.

Despite its breadth, *Biodiversity in Agriculture* leaves one wanting in some obvious areas, particularly those in which the science has societal implications. Although there are lively discussions about the risks of genetic erosion by domestication and about the mitigation of genetic pollution by using sterile stocks in aquaculture, little is provided on the implications of genetic modification to biodiversity or sustainability in agriculture. Transgenics is a pivot point in agriculture's development and certainly a hot-button issue, in both the public and commercial sectors, but academics may be repelled from confronting it by perceived consequences to funding and career advancement.

Similarly, discussions on the sustainability of the modern industrial model of agriculture and its potential impacts on biodiversity (among other things) are limited. Perhaps this subject is not consistent with the context or spirit of the symposium, although Jack Harlan's independence and dedication to academic freedom are legendary. For example, Juan F. Medrano (chapter 27) discusses the extent to which inbreeding is currently incorporated into California's massive dairy industry. The suggestion that such a system could become sustainable, even with the use of genomic tools for genetic selection, places a heavy burden of proof on the industry. Modern alternative agricultural models (particularly those based on direct marketing) and small-scale, local, and organic techniques are also not addressed in any meaningful way. Although they represent a miniscule portion of today's market share, these traditional-agriculture-based approaches are emergent. They have enormous implications for biodiversity and for the future (i.e., the sustainability) of agriculture, particularly in developed countries.

These shortcomings, although they are not insignificant, can be forgiven when considering the sheer breadth and quality of the work and the possibility that the topics missed in Harlan II may form a portion of a third Harlan symposium. On balance, Jack Harlan would probably be pleased with *Biodiversity in Agriculture*.

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BEING HUMBLED BY ANIMAL NAVIGATION

Nature's Compass: The Mystery of Animal Navigation. James L. Gould and Carol Grant Gould. Princeton University Press, 2012. 320 pp., illus. $29.95 (ISBN 9780691140452 cloth).

As one of nature's most awe-inspiring and fascinating phenomena, the innate ability of animals to navigate accurately during their daily routines or during long-distance migrations across the globe engages us deeply on both intellectual and emotional levels. *Nature's Compass: The Mystery of Animal Navigation* provides the first serious treatment for the nonspecialist in 20 years of the myriad problems faced by animals that must navigate and the various solutions that have evolved to achieve this goal. Animal navigation is complex, and this book tackles the disparate topics of the geometry and physics of navigation, as well as the aspects of animal behavior, physiology, cognition, and evolution involved in the tapestry of techniques that allow animals to navigate successfully.

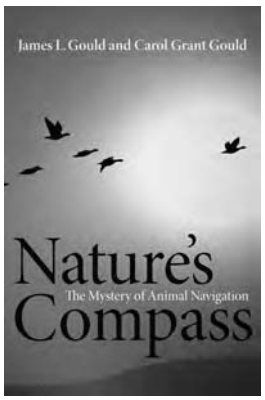
The book's scope is vast and ranges from local movements (e.g., ants returning to their hole in the sand, honeybees returning to their hive) to the immense cross-hemispheric movements of migratory birds and marine mammals. *Nature's Compass* also provides a detailed history of how researchers, using a host of cues and strategies, have overcome many of the immense challenges of deciphering the mechanisms that animals use to navigate. Yet, significant puzzles and unanswered questions remain, as the book also reveals. This is a reader-friendly and engaging contribution to the literature of navigation at a time when the field has shifted into a highly technical arena that would otherwise be inaccessible to all but the specialist.

Coauthor James L. Gould is a professor of ecology and evolutionary biology at Princeton University who has conducted seminal research on animal navigation primarily—but not exclusively—using honeybees and homing pigeons as model systems. Carol Grant Gould is a widely published popular science writer. Prior to *Nature's Compass*, the Goulds had already written an impressive collection of nine books. That writing experience shows here, and the combination of scientist and science writer successfully produces entirely accessible prose despite the book's complexity. Each chapter is a narrative that blends rigorous scientific principles and research designs with anecdotes of the people involved and the natural history of the organism in question.

I particularly enjoyed the way the book starts with accounts of the historical saga of human celestial navigation across the oceans during the seventeenth century and the challenges that we humans have faced in at-sea navigation. These early pages set up a theme about our assumption that other animals also use various

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orientation strategies, such as maintaining constant bearings relative to a cue, vector navigating, piloting, and inertial navigation—all of which require some sort of precise timing ability—in order to migrate. The remaining chapters then reveal how animals employ similar but often very different means from humans' nautical approach to establishing their positions and discuss the wide range of available backup strategies, should any cue fail.



Appropriately, much attention is given to how honeybees and homing pigeons have solved navigation problems in different ways. Although the two species are the familiar "lab rats" of navigation research, I found the book's material to be fresh, up to date, and more interesting than previous popular treatments. In *Nature's Compass*, we go well beyond the "waggle dance" and discover how bees must keep track of and compensate for crosswinds and a moving sun and how pigeons possess the equivalent of an internal global positioning system. Examples from a large array of taxa are used to introduce key concepts, including how magnetic maps, polarized light, and even olfactory cues facilitate navigation. The book is well illustrated with numerous figures and diagrams that are essential to understanding the often-complex material.

Interestingly, the book concludes with a discussion of how stressors, such as global climate change and anthropogenic habitat loss and deterioration, can influence migratory species and ultimately disrupt their movements. Migratory species have evolved to be less phenotypically specialized than residents, and there is evidence for greater adaptation to changing climates by migrants through changes in migratory and breeding phenology. The Goulds argue that a more serious threat to migratory species is the loss of habitat they are experiencing throughout their annual cycles. Because of this, a species that may enjoy a protected breeding habitat may be nonetheless threatened by the destruction of its wintering or stopover habitat. Although the link between habitat loss and the general topic of animal navigation may seem tenuous, this last chapter nicely bridges the concepts of the speed of evolution of new migratory behaviors and the adaptation (or lack thereof) to new cues. Understanding how animals migrate may also help our efforts to conserve them.

I found few faults with *Nature's Compass* but would have preferred direct citations or footnotes within each chapter to reference key points. Instead, the authors opted for a general bibliography, by chapter, at the end of the book. This undoubtedly makes for a smoother presentation but may irritate the more serious student. I also found it curious that the authors mostly limited their book to imperial units of measure, with just an occasional smattering of metric. Adherence to metric units would have been more internationally and scientifically appealing. However, these are minor quibbles and do not detract from the Goulds' impressive encapsulation of the many facets of animal navigation.

I anticipate that this book will become an essential part of the collection of anyone seriously interested in animal navigation, and I imagine that it could readily serve as an important supplementary text in an undergraduate-level course on the topic. The reader will be left humbled by the complex and sophisticated ways in which other animals establish their location in relation to their destination—a stark contrast to our own poor innate abilities.

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AN INTERDISCIPLINARY APPROACH TO UNDERSTANDING MARKET-DRIVEN SCIENCE

Lively Capital: Biotechnologies, Ethics, and Governance in Global Markets. Kaushik Sunder Rajan, ed. Duke University Press, 2012. 528 pp., illus. $29.95 (ISBN 9780822348313 paper).

The edited volume *Lively Capital: Biotechnologies, Ethics, and Governance in Global Markets* is the primary output of a process that began in 2004 with a workshop of the same name, held at the University of California, Irvine. Amassing an interdisciplinary group of scholars (i.e., African studies, anthropology, comparative literature, history of consciousness, public policy, rhetoric, science and technology studies, and sociology), the workshop examined how new legal, social, cultural, and institutional mechanisms were emerging to regulate nascent biotechnologies. It is these broad areas of inquiry that constitute the relationship between conceptions of biotechnology and the market, and it is this relationship that is the focus of the book.

Lively Capital begins with a brief summary of the historical and sociological processes by which the life sciences—and biotechnology, in particular—have become increasingly commercialized, most notably in university settings. Universities in the United States have set a historic precedent for commercializing the process of biotechnology

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