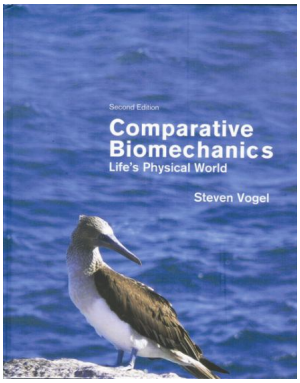

Comparative Biomechanics: Life's Physical World (Second Edition). Steven Vogel. Princeton University Press, 41, William Street, Princeton, New Jersey 08540, USA. 2013. x + 628 pp. Price: US$99.50/£69.95.

Nature provides countless examples of organisms that use mechanical solutions to overcome their natural challenges. Such phenomena are ubiquitous and surround us: spider webs can withstand the impact of flying prey, human blood vessels can tolerate thousands to millions of cycles of stress–relaxation without fatigue, trees grow reaction wood to offset the stress under windy conditions, butterflies use capillarity of their proboscis to sip nectar, etc. However, to study these in any detail, it is as important to investigate the underlying mechanics as it is to explore the biological context in which these phenomena occur. Because similar physical challenges (e.g. swimming) must often be tackled by animals of vastly different sizes (e.g. minnows versus whales, or larval versus adult fish), the biomechanical strategies may also vary from animal to animal. Thus, the role of mechanics (or biomechanics) is integral to any study in animal physiology and evolution. In biology, the term 'comparative' refers to the study of specific questions in different, well-chosen systems or animals. Comparative biologists may choose to study this diversity for a variety of reasons, but the grand unifying theme of such researches is usually to understand how past evolutionary forces shaped (or 'engineered') the present diversity of form and function in molecules, cells, tissues and organisms. Comparative biomechanics also tackles questions from an evolutionary viewpoint, but here the term 'comparative' also helps distinguish it from human biomechanics and its more applications-oriented focus.

This field is at least as old as Aristotle, but it has flourished only in the recent years as a formal discipline when mechanical and materials engineering and physics began to merge with biology. Over the years, Steven Vogel has been among the most prominent communicators of this exciting topic. He has authored several popular science books including the classic *Life in Moving Fluids* and *Cats' Paws and Catapults* over past 2–3 decades. These books have inspired generations of fresh graduates from biology, physics and engineering to take up careers in comparative biomechanics; their influence on the field has been truly transformational. As these students matured to become educators and undertook to teach courses in comparative biomechanics, there was a clamor for a proper textbook on the topic. This book by Vogel aims to fill that gap while not compromising his basic focus on communicating the importance of mechanics to biologists. It is an elegant and lucid *albeit* informal exposition on this topic replete with numerous fascinating examples and, as is the author's wont, many (dreadful!) puns that help keep the tone of the book light and readable.

Vogel's book is addressed primarily to the neophyte biologist. It assumes and provides no more than a high-school level familiarity of the key physical concepts. The book makes the important point that even an elementary application of these concepts equips us to understand a wide range of biological phenomena that surround us. As is often the case, pitching these concepts at a layman readership means that each concept cannot be treated with its full mathematical rigour. This is not the book that will provide detailed derivations of the physical formulae. It states the required formulae and tries to provide a good intuitive feel for what they mean and where they can be applied. However, in the sheer variety of natural examples ranging from unicellular organisms to marine invertebrates, to aquatic and terrestrial vertebrates as well as trees and plants, the scope of the book is simply staggering. When focusing on a physical concept, Vogel flits back and forth between xylem vessels and arteries and pneumatic rubber tyres and worm burrows, emphasizing the underlying physical similarity in these examples.

The book is organized into four main sections, beginning with an insightful section on the field of comparative biomechanics and its basic tools and terminology. Of particular importance here is the discussion centred on the issues of design and adaptation in biomechanics. The early practitioners of comparative biomechanics adopted a terminology that was distinctly engineering (or design) centric and at odds with modern evolutionary thinking. Vogel recognizes this fact, but does not eschew such terminology. For instance, he recognizes that terms such as 'safety factor' or 'tolerance' are borrowed from engineering literature and inherently teleological, and uses them wherever required with the appropriate cautionary remarks. These remarks provide the topic with a philosophical depth that has been lacking in previous treatments. He recognizes organisms as imperfect products of evolution rather than as perfect optimized machines that engineers often imagine them to be. Another critical section relates to the importance of dimensionless numbers. Because dealing with biological diversity in a scale-independent manner is central to many generalizations, dimensionless numbers are often invoked in comparative biomechanics. Vogel illustrates their importance using numerous examples from fluid and solid mechanics, and sets the tone early that the applicability and caveats of such numbers need to be intuitively understood. Because these preludes relate the physics to biology, they are essential reading even for people who may otherwise be comfortable in their knowledge of mechanics.

The second and third sections deal with fluid and solid mechanics respectively, and are more straightforward. In each section, the initial chapters describe the basic physical concepts with illustrative biological examples never more than a page away. The physical concepts are treated at the level of a high-school physics textbook, avoiding more detailed mathematical treatments or derivations, but providing the appropriate formulas where required. This allows Vogel to maintain the informal tone of the text, which helps communicate these topics better. Another crucial aspect of these sections is their focus on experimental methodology. The fluid mechanics section familiarizes the reader with almost all major topics such as diffusion, convection, viscous flow, boundary layers, vorticity, laminar to turbulent transitions, flow through pipes, various dimension-

less numbers such as Reynolds or Peclet number, etc. In parallel, Vogel also covers swimming and flying in all sorts of aquatic and terrestrial animals, filter feeding, jet-propulsion, seed dispersion, water transport in plants, etc. A similar tone is maintained in the chapters on solid mechanics which deal with linear and nonlinear structural properties of composite tissues, fibre-reinforced materials, fracture mechanics, resilience, tensegrity, etc. Along the way, the readers will learn about blood vessels, sponge spicules, sea anemone body walls, bones and mollusk shells, reaction wood in trees, etc. He also discusses simple machines such as struts and levers, motors, brakes, four-bar linkages, etc. and again discusses their role in biomechanics of locomotion of animals. For good measure, Vogel also provides many thought-provoking questions at the end of each chapter as exercises.

All this makes for a heady and enjoyable mix and the book is as entertaining as it is educational. However, at almost 600 pages, it is also a formidable read in large part because its narrative style and lack of mathematical treatment does not permit any brevity at all. Despite this length, the following topics may be worth including in future editions. First, the biomechanics of life in non-continuum (granular) media such as sand or gravel is conspicuously absent. For example, lizards or insects burrowing through sand or sand-like media find no mention in the book at all. Second, whereas the book introduces physical concepts at an elementary level, it is necessary to acknowledge (perhaps as footnotes) that many of these concepts are more complex than the book may lead you to believe. The book does not mention, for example, that the bulk properties of matter are tensorial in nature. Third, more material on experimental methodology may be added in the book. In addition to the descriptions of classic physiology tools such as Scholander bomb or pitot tubes, brief descriptions of the more modern biomechanical techniques such as digital particle image velocimetry, sonomicrometry, nanoindentation, atomic force microscopy, etc. may be included, which are common tools of the trade.

In summary, this book is recommended as a necessary component of any undergraduate or beginning graduate coursework, especially those that seek to instill a multi-disciplinary outlook in biology education. Such coursework should emphasize the cautions and caveats that Vogel has incorporated in his book, so that the philosophical message of the book is not lost. One only hopes that a more accessible paperback edition book will soon become available to suit student budgets.

SANJAY P. SANE

National Centre for Biological Sciences, Tata Institute of Fundamental Research, GKVK Campus, Bellary Road, Bangalore 560 065, India
e-mail: sane@ncbs.res.in

Annual Review of Plant Biology, 2013. Sabeeha S. Merchant, Winslow R. Briggs and Donald R. Ort (eds). Annual Reviews, 4139, El Camino Way, P.O. Box 10139, Palo Alto, California 94303-0139, USA. Vol. 64. x + 885 pp. Price: US$ 97.

It is both a pleasure and a challenge to review the *Annual Review of Plant Biology* (*ARPB*), the 64th (2013) volume of which has yet again come out with an excellent compilation of review articles covering a vast array of research topics of contemporary relevance in plant biology, contributed by leading names in the field. As always, it is an excellent starting point for young researchers and specialists alike, who seek authentic reviews of the literature combining the state-of-the-art as well as future perspectives in each of the topics covered. This volume starts with a frontpiece written by Elisabeth Gantt, whose contributions are well known in phycobilisome structure/function, photosystem II and carotenoid/isoprenoid biosynthesis using N-fixing cyanobacteria as model systems. She traces her scientific career and elaborates how the flexible and inclusive US education system has aided in her progress as a researcher and scientist. Her comments on funding for basic research, especially in plant biology, 'the war on…' as a dominant metaphor even to justify research funding, the recent 'assembly-line' model of funding large research networks rather than small laboratories, gender issues, etc. though mild and constructive, address some of the core concerns in American science. They are just as relevant for those who manage science and education in India, or perhaps any other large country. There are 32 other reviews spanning about 900 pages in this volume, which can be broadly divided into crop improvement, signalling, technical advancements, genome engineering, plant organelles and plant–microbe interactions, for the purpose of this review.

Nutrition in health and disease is often dealt with as a medical specialty, but it is interesting to see a review that explores its interface with plant biology. The article by Cathie Martin *et al*. addresses the inter-relationship between dietary habits and health/disease, plant products in the modern Western diet and the beneficial role of phytonutrients in fighting chronic diseases, and the underlying metabolic, signalling, redox, chemopreventive and other mechanisms, including the role of gut microflora and epigenetic factors. Crop improvement in terms of productivity, nutrient content and resource use efficiency is one of the solutions suggested by crop scientists worldwide. Many of the reviews in this volume deal with crop improvement. Oslen and Wendel review the genetic and genomic basis of crop plant phenotypes and the genes responsible for their evolution. They also nicely bring out the point as to how advancement of methods like QTL mapping has aided in identification of domesticated traits, the associated genes and their evolution, which can be modulated for improvement of crop plants. The reviews by Schnable and Springer, and Ouyang and Zhang dwell on the molecular mechanisms underlying heterosis and reproductive isolation for further improvements in crop plant species. The article by Fiorani and Schurr gives an overview of multidisciplinary research in plant phenotyping using non-invasive and minimal invasive methods, focusing on the traits assisting the selection of genotypes with increased resource use efficiency. This is an important area of research for India, as there is no credible ranking of the varieties of any of the major crops in terms of their use efficiencies of major resources such as nutrients, water, etc. especially combining both wild and cultivated genotypes, though interest is emerging in this direction of late. Our laboratory has been ranking some rice cultivars based on nitrogen-responsive germination rates, in the hope of developing this as a non-invasive