Living at Micro Scale: The Unexpected Physics of Being Small.

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diverse lineages. Similarly, analyses of multiple genes and now whole genomes have engendered several hypotheses in which eukaryotes arose through some kind of fusion or symbiotic event between an archaeon and bacterium, contradicting Woese's view that the three domains descended independently from a common ancestral "progenote." It remains to be seen what impacts these data will have on future depictions of the tree of life.

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THE MECHANICAL WORLD OF MICROORGANISMS

Living at Micro Scale: The Unexpected Physics of Being Small. David B. Dusenbery. Harvard University Press, 2009. 448 pp., illus. $51.50 (ISBN 9780674031166 cloth).

Our everyday experiences help us develop intuition for basic physical and dynamical processes. For example, when swimming, we take it for granted that we can glide significant distances after pushing off from the pool wall. However, when we then try to apply our intuition to the world of motile microorganisms we run into surprises. If microorganisms attempted to glide through water, they would come to rest after moving only about an Angstrom; they would never get anywhere! The book *Living at Micro Scale: The Unexpected Physics of Being Small* summarizes the basic mechanical features of life at the scale of microorganisms and includes a broad range of fascinating topics that are discussed qualitatively and quantitatively. The world of motion is dominated by the viscous (or frictional) features of any flow—which engineers, mathematicians, and physicists refer to as "low Reynolds number flows"—and encompasses the dynamics of bacteria, phytoplankton, algae, and many other kinds of single cells or cell clusters.

Living at Micro Scale covers many topics, and is written in a well-organized and refreshing style, so there will be new ideas for physical, mathematical, and biological scientists to explore. A distinguishing feature of the book is the author's continual attempt to provide quantitative guidelines to basic aspects of size, shape, type of locomotion, and chemical uptake rates. Author David B. Dusenbery has written broadly on quantitative features of the dynamics of microorganisms over many years. In this book he synthesizes his work and that of many other scientists who have been captivated by the physical world of living microorganisms. I believe that some aspects of the book will be of interest to almost any reader, though some comfort with quantitative discussions is required.

The book is structured into four main parts: physical ideas for thinking about mechanics of size and shape at low Reynolds numbers, physical ideas that affect various modes of locomotion through fluids, orientation to different gradients of stimulants, and finally, the various modes of interactions between microorganisms. The writing is clear and the book is logically organized. Occasional historical remarks serve to remind the reader of important landmarks in our understanding and discovery of the world around us. One of the book's strengths is that Dusenbery makes continual use of quantitative, mostly algebraic relationships, giving the book a distinct place in the literature. Even nonquantitative readers are likely to appreciate conclusions extracted from Dusenbery's arguments, but I did wonder whether some other format of presenting the main results would have been useful for readers less comfortable with the physical and mathematical principles.

In such a wide-ranging discussion, incorporating a large set of topics from classical physics, it is inevitable that a specialist reader would find some of the quantitative arguments in this book misleading. I found myself making a number of remarks of that type when reading about fluid mechanics in the text, and I imagine the knowledgeable microbiologist might feel similarly about some features of the biological discussion. However, the main message in every section is generally clear; Dusenbery has a gentle style for presenting an argument aimed at establishing quantitative trends and relationships as well as for identifying questions involving "optimization." As such, the book will provide a wide and rich set of examples for most any type of biomechanics course. It has much the spirit of the biomechanics books wonderfully written by Steven Vogel, though Dusenbery goes further in bringing in quantitative arguments.

As I read *Living at Micro Scale,* I recognized that in some sense, there are two distinct audiences for this book: (1) physical scientists interested in quantitative aspects of biofluid dynamics in general and swimming microorganisms in particular, and (2) biological scientists comfortable with algebraic arguments who seek a mechanistic understanding of the microbiological world at the scale of individual cells. It is precisely a result of these two distinct audiences that I think many of the quantitative arguments would have benefited from figures and pictures and a more transparent definition of variables; nonquantitative readers may find the lack of diagrams a significant hurdle to understanding the text.

A second, small point of confusion results from several instances in the book where Dusenbery uses the term "relative velocity" or "relative speed" (together with the symbol *U,* commonly used for velocities) to refer to a speed per unit length, which a physical scientist would refer to as a (shear) rate. Additionally, one major shortcoming of the book is the lack of high-quality (color) images of

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actual microorganisms. Surely, many readers would find the diversity of microbial life, including various sizes, shapes, and appendages, to be captivating and motivating. Moreover, such images would nicely emphasize important themes raised in the book, such as convergent evolution.

I should also note that there are a number of appendixes. Perhaps a couple of them will be useful to a reader, though I fail to see how a two-page description of calculus (without a figure illustrating the derivative as the rate of change) is useful to anyone, or how a reader could benefit from a three-page description of the Navier-Stokes equation, which applies to any Reynolds number (and not simply to "high" Reynolds numbers, as the title of the appendix implies). It did not help that in the latter appendix, the only two numbered equations (A.11.1 and A.11.2) both had misprints.

A number of topics involving the mechanical world of microorganisms are not mentioned at any length in the book—biofilm formation; adhesion of bacteria to surfaces; "gyrotaxis," which refers to the swimming of bottom-heavy algae that are able to orient in a flow; and the movements of multicellular Volvox—though Dusenbery does discuss simple orientations by distributed mass density. Nevertheless, the range of coverage and topics that are included is very large, and the author provides plenty of material for a curious reader or a university course. I am confident that readers interested in biomechanical themes will enjoy *Living at Micro Scale* because of the elegance with which Dusenbery weaves the concepts of classical physics into a quantitative characterization of the world of microorganisms.

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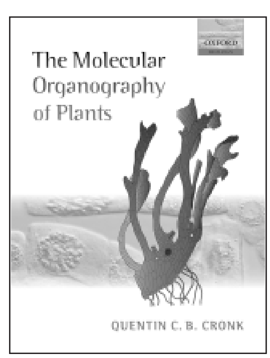
FITTING PLANT GENES TO SHAPES

The Molecular Organography of Plants. Quentin C. B. Cronk. Oxford University Press, 2009. 288 pp., illus. $70.00 (ISBN 9780199550364 paper).

The Molecular Organography of Plants seeks to integrate the genetic findings of the last 20 years with morphological and evolutionary botany of the previous 100 years. Its author, Quentin C. B. Cronk, of the University of British Columbia, is a classically trained botanist and evolutionary biologist who has more recently worked in the integrative field of plant developmental evolution, making him well suited to write this text. The book's primary emphasis is morphological diversity and evolution, using the relevant developmental genetic work to highlight particular points or themes. In this way, it serves as a bridge between purely morphological works, such as Adrian Bell's invaluable *Plant Form*, and model system–centric developmental genetic texts, such as Leyser and Day's *Mechanisms in Plant Development*.

Cronk's approach is fundamentally morphological, and tracks the major



organ systems: stems, roots, leaves, sporangia, and sporophylls. First, however, he gives a very useful overview of plant evolution and general evolutionary concepts (e.g., homology, heterochrony). This chapter lays a foundation for the rest of the book by covering the positions of major fossil taxa in the context of current phylogenetic hypotheses, and how they influence ancestral character state reconstruction. In addition, it establishes the historical perspective that is a consistent thread throughout. I particularly enjoyed the discussion of the different approaches to the problem of seed plant relationships taken by E. J. H. Corner and K. R. Sporne, and of what the first angiosperm may have looked like (issues that remain with us to this day). Cronk displays a sense of history and humor that is both entertaining and refreshing.

Each successive chapter follows a similar path, considering the possible origins of fundamental structures, their evolution in land plants, their various diversifications, and a relatively brief overview of their genetic underpinnings, often with useful findings or speculations on how these genes may have contributed to the evolution of the structure. I found the figures to be excellent overall, including the line drawings and color plates. Cronk goes to considerable lengths to introduce a wide variety of terminology, both developmental and anatomical. I might quibble with some of the uses—can we really say that mosses have protosteles? I've always considered the use of stele to be restricted to taxa with true vasculature, but that is part of the charm of botany—there is always room for variation in usage and interpretation. A more unfortunate mix-up occurs in the second chapter, where the words anticlinal and periclinal are reversed; I'm sure that the typo will be corrected in future editions, and as the terms are used properly elsewhere in the book, I imagine most students will properly reorient themselves.

Although "molecular" is in the title, this work is not a comprehensive developmental genetic text. I don't believe it was intended as such, but sometimes I did wish that extra space were committed to a more detailed explanation of the relevant genetic pathways or hypotheses. This was especially true for me in the section titled "Molecular theories for the origin for the flower," in which a

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