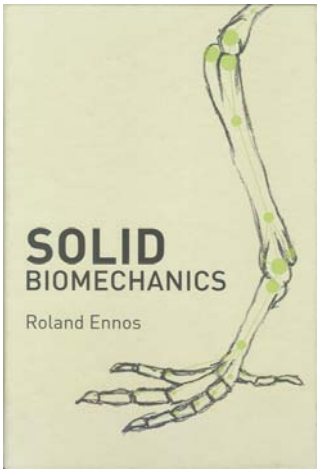


Solid Biomechanics. Roland Ennos. Princeton University Press, 41, William Street, Princeton, New Jersey 08540, USA. 2012. xiv + 250 pp. Price: US$ 65.00/ £44.95.

The formulation of classical mechanics during the Renaissance era spun off a rich tapestry of scientific ideas that sought to understand if animal and plant design also conformed to the principles of mechanics. Among the great natural philosophers of the time who articulated these questions was Leonardo da Vinci (1452–1519) who studied human anatomy and bird wing design to develop ways by which humans could fly, and Galileo Galilei (1564–1642) who investigated the trade-offs between strength and weight of columns using bones as examples of hollow columns. During the same era, William Harvey (1578–1657) demonstrated that the human heart was a mechanical pump with passive valves that permit blood flow in one direction. Other prominent thinkers like Rene Descrates (1596–1650) speculated about whether animals were essentially machines that can be described using the same mechanical laws and Giovanni Borelli (1608–1679) who demonstrated the role of muscles in generating mechanical forces. Over the next two centuries however, the nascent field of biomechanics made little progress as classical mechanics became the purview of physicists whereas organismal biology became the territory of biologists. Early in the last century, D'Arcy Thompson's influential book *On Growth and Form* revived the interest in using physical forces and mathematical descriptions to explain biological patterns[1]. There was a major surge of interest in the study of biomechanics in the 1950s and 1960s which led several biology departments across universities in US and Europe to focus on the role of mechanics in physiology. These efforts developed a new kind of biologist/engineer who tried to understand how the principles of materials and mechanics guide the design of biological entities at all scales from cells to whole organisms. Many influential texts in biomechanics emerged from such efforts primarily by biologists, such as Vogel's *Life in Living Fluids*[2], Wainwright's *Mechanical Design in Organisms*[3], but also by engineers such as Gordon's *The New Science of Strong Materials*[4] and Fung's three comprehensive books on *Biomechanics*[5–7]. This vast and growing body of literature now gives us fascinating insights into diverse natural phenomena from the architecture of sea shells, to the mechanics of bones and tendons and blood vasculature, to flight of insects and birds. More recently, such efforts have also led to reverse engineering and several modern inventions including aeroplanes or Velcro that owe their inspiration to biology spawning a new field of biomimetics.

It is in this broad landscape that Roland Ennos firmly places his book on *Solid Biomechanics*. His book has evolved from an upper undergraduate/ graduate level class on biological materials and structures in the University of Manchester and treats the subject from a relatively intuitive viewpoint that makes the book easy to read. Relying on his own wide research experience, he uses diverse examples from biology to highlight how various materials in nature meet the challenges that animals face for survival. He uses biological materials as examples to demonstrate the use of pliant and rigid structural materials. The book is organized into four major (and one minor) sections that cover basic concepts of the theory of elasticity (Section 1), the diverse types of biological materials that make up the world at various scales of organization (Section 2), the nature of biological structures and tissues formed from such materials (Section 3) and the mechanical interactions between biological entities and their environment (Section 4). Ennos mainly uses a linear elasticity framework to describe mechanical properties such as Young's modulus, Poisson's ratio, etc. and only goes as far as one can go with a highly simplified approach. Nevertheless, he is able to cover a vast number of biological examples at diverse scales of organization.

The book is less sure about dealing with important solid mechanics concepts such as fracture and fatigue, and advanced topics such as nonlinear elasticity to describe the large deformations displayed by most biological tissues. These are also very important from the biological perspective because they often prescribe the limits of performance of a biological material. One might have expected a whole chapter, rather than a few sections, devoted to the topics of fracture and fatigue. Another area that is clearly lacking is a section on materials selection based on specific design criteria, commonly called the Ashby charts[8], that prove very useful in our understanding of materials in nature and in the industry. In handling of the material within this book, Ennos constantly articulates experimental techniques and challenges involved in the characterization of complex and heterogeneous materials of difficult shapes which underscore the importance of empiricism in the field of biomechanics. A broad section on plant related materials based on the author's own work is emphasized that will doubtless inspire many students to explore the area of plant biomechanics.

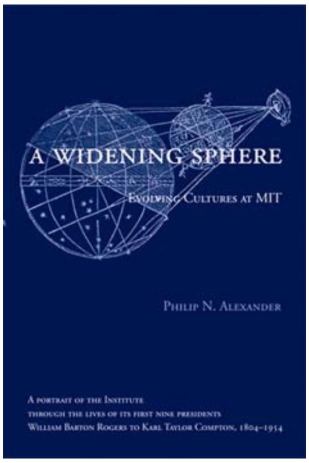
The style is easy to read and the book is primarily aimed not only at a biologist who wishes to understand the physical underpinnings that drive the lives of plants and animals, but also at an engineer who seeks interesting biological phenomena to model from the mechanical perspective. Another stand out feature of the book is the clarity of the illustrations which are uncluttered, yet adequate. Hardened solid mechanists who find themselves complaining about the lack of mathematical depth or rigor in the treatment of the material, or biologists who wish for more detailed examples should both bear in mind that the book is meant to serve as a primer for undergraduates in *both* fields. There is no dearth of specialized material in these areas – however a book like this at early stages is critical to inspire biologists to apply engineering principles in their research, and for engineers to identify the broad areas where the knowledge of materials and mechanics can be used to tackle exciting questions in addition to generating a new formalism to tackle the complex heterogeneous, nonlinear and viscoelastic properties displayed by most biomaterials.

The book ends on a rather tantalizing note regarding cell mechanics which is surely the next frontier of modern biomechanics. Coming from an established researcher in the area, this book will inspire uninitiated readers and students to invest a career in this area of work much as Steven Vogel's *Life in Moving Fluids* inspired a generation of biological fluid mechanists.

1. Thompson, D., *On Growth and Form*, Cambridge University Press, Cambridge, 1917.
2. Vogel, S., *Life in Moving Fluids*, Princeton University Press, Princeton, New Jersey, 1996.
3. Wainwright, S. A., Biggs, W. D., Currey, J. D. and Gosline, J. M., *Mechanical Design in Organisms*, Princeton University Press, Princeton, New Jersey, 1982.
4. Gordon, J. E., *The New Science of Strong Materials or Why you Dont Fall through the Floor*, Penguin Books, New York, 1976.
5. Fung, Y. C., *Biomechanics: Mechanical Properties of Living Tissues*, Springer-Verlag, New York, 1981.
6. Fung, Y. C., *Biodynamics: Circulation*, Springer-Verlag, New York, 1984.
7. Fung, Y. C., *Biomechanics: Motion, Flow, Stress, and Growth*, Springer-Verlag, New York, 1990.
8. Ashby, M., *Materials Selection in Mechanical Design*, Butterworth-Heinemann, Burlington, Massachusetts, 1999.

NAMRATA GUNDIAH[1,*]
SANJAY P. SANE[2]

[1]*Mechanical Engineering Department, Indian Institute of Science, Bangalore 560 012, India*
[2]*National Center for Biological Sciences, Tata Institute of Fundamental Research, GKVK Campus, Bangalore 560 092, India*
**e-mail: namrata@mecheng.iisc.ernet.in*



A Widening Sphere: Evolving Cultures at MIT. Philip N. Alexander. The MIT Press, 55 Hayward Street, Cambridge, MA 02142. 2011. xi + 508 pp. Price: US$ 29.95 (cloth).

In 1991, having just completed a book about the history of the California Institute of Technology (Caltech), I asked the school's four living presidents if they would write something from their perspective about how a modest Pasadena school, which in 1891 was devoted mainly to manual training, transformed itself into one of the world's great scientific centres. They had no trouble pinpointing the philosophy and the causes behind the school's success.

Lee DuBridge, the physicist who had the longest tenure of any Caltech president (1946–1969), took it as axiomatic that a small number of great scientists had made it possible for the school to grow and prosper. An institution is often said to be the shadow of a man, DuBridge added, pointing to Robert A. Millikan, the school's first chief administrative officer. In his opinion, Millikan, who refused the title of president while serving in that role from 1921 to 1945, had done more than any other single person to forge Caltech's character and secure its future.

Presidents Harold Brown (1969–1977) and Marvin Goldberger (1978–1987) emphasized the value of selecting the best people, concentrating on carefully selected fields of activity and knowing when to move into new areas of teaching and research. Thomas Everhart, who became Caltech's fifth president in 1987, added an additional ingredient: the ability to adapt to changing times in ways that do not compromise the mission or integrity of the institution.

Despite these lucid and well-informed prescriptions, my own research left me with the sense that a great mystery surrounds institutions of higher learning: Why do some schools succeed and flower whereas others go nowhere, stagnate and even wither away? Caltech originated as the brainchild of MIT graduate and astronomer George Ellery Hale, who had come to Caltech's home city of Pasadena as Director of the Solar Observatory on nearby Mount Wilson. Hale, who joined the board of Caltech's then-struggling forerunner, Throop University, believed that southern California needed a technical institution comparable to MIT. In pursuit of this vision he managed to lure both Arthur Amos Noyes, MIT's former president and the nation's leading physical chemist and Millikan, America's premier physicist and a Nobel laureate at the University of Chicago, to Pasadena, where they joined Hale in constituting Caltech's founding troika. Their singular abilities and synergy were certainly crucial to Caltech's success. But they do not tell the whole story either.

Now Philip N. Alexander, research associate in the program in writing and humanistic studies at MIT and longtime member of the MIT community, has taken up this question as it applies to what Caltech likes to call 'That Other Institute of Technology'. His new book, *A Widening Sphere: Evolving Cultures at MIT*, traces the university's history from its founding as a small technical institute in Boston's Back Bay in 1861 – and greatly overshadowed at the time by its venerable neighbor across the Charles River, Harvard University – to 1954. Like a number of other writers who have addressed the evolution of technical schools in recent books – notably Robert Seidel and Charles Vest – Alexander takes a historical approach to his subject, offering a detailed portrait of MIT through the lives of its first nine presidents, from William Barton Rogers, born in 1804, to Karl Taylor Compton, who died in 1954, six years after turning over the reins to James Killian.

Alexander casts a wide net, drawing on a host of source materials in MIT's Institute Archives, Special Collections and elsewhere, as well as on numerous oral histories and monographs. His portraits of MIT's presidents and their times are deft and illuminating. He recounts the political and entrepreneurial skills of MIT's first president, William Rogers,