violating decays of mesons and the Z boson are discussed. Camilleri, Lisi and Wilkerson take up neutrino masses and mixing. Some of the excitement generated by the recent progress in this area is conveyed by the authors through a synthesis of the different strands of development. The basics are reviewed first, covering oscillations between massive neutrinos both *in vacuo* and in matter. Atmospheric as well as accelerator-generated neutrinos are covered in one section and solar plus reactor neutrinos in another. The absolute mass probe in tritium beta decay and the Majorana mass probe in neutrinoless nuclear double beta decay are also discussed. The authors then project prospects for long baseline experiments and provide an overview of neutrino masses. Efforts at detecting ultra high energy astrophysical neutrinos in giant terrestrial detectors are briefly mentioned. Missing is any discussion of current theoretical ideas, such as the three types of the proposed seesaw mechanism and their linkage with leptogenesis.

In summary, this is not a book for beginners. Rather, it provides a perspective to researchers involved in high energy physics and allied areas. Despite a few omissions here and there, this will be a valuable and useful review-cum-reference volume to them. Every library with a high energy physics section needs to acquire it.

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**Annual Review of Biomedical Engineering, 2008.** Martin L. Yarmush, James S. Duncan and Martha L. Gray (eds). Annual Reviews, 4139 El Camino Way, P.O. Box 10139, Palo Alto, CA 94303-0139, USA. Vol. 10. 427 pp. Price not mentioned.

Biomedical engineering is an established area of research that encompasses many disciplines. It is often difficult to define its scope in terms of the fundamental subjects of engineering or science. When one probes deeply into a specific biomedical engineering topic, it becomes biology, chemistry, medicine or physics, or a combination thereof. If the investigation is focused on an application, it is not different from an engineering study – chemical, electrical or mechanical, albeit applied to a biomedical problem. Putting together an *Annual Review* on this topic too is equally difficult: the topics of current research in this area are too varied and too many to capture in a single book of 15 chapters. Fifteen reviews presented in this edited volume can be divided into six categories: biomechanics, biosensors, devices, drug-delivery systems, electronics and circuits, and imaging. Thus, it is only a sampler of ongoing work in this interdisciplinary field. Nevertheless, the authors of individual chapters have made a commendable effort in making each chapter self-contained to provide a bird's-eye view of the topic with a good dose of references.

Biomechanics, an important component of biomedical engineering for a long time, deservedly occupies one-fifth of the book. Biomechanics of today is not just focused on bones and muscles; its focus is more on the smaller scales than it was before. The changes in the mechanical behaviour of cells and tissues are correlated to their state of health or disease. A mechanical property such as stiffness can well be a new biomarker. There are a number of studies in this direction, but this topic has not been considered in the present volume. The chapter on modelling catch bonds – the adhesive bonds that become stronger and longer-lived in the presence of a force that tends to break them – comes closest to this aspect. This type of modelling requires a delicate balance of classical mechanics and statistical mechanics, so that the molecular behaviour and microscopic cellular behaviour are correlated well. Experimental measurements can be made at both the levels today, although with debatable accuracy. Therefore, modelling effort should manage with the uncertainties in the measured data and lack of complete physical understanding of the underlying mechanisms. Many simplifying assumptions are made only to relax and refine them later. Most studies on cellular mechanics give an impression that the field is still in its inception. A better developed area in biomechanics is the modelling of blood flow (haemodynamics) and the complex mechanical behaviour of tissues. Thus, one can see in the chapter on simulating the fluid–solid growth behaviour of aneurisms in intracranial and abdominal arteries. Here, the modelling is much more advanced, wherein continuum mechanics of solids and fluids is brought to bear properly. The latest advances in imaging can be combined with these sophisticated modelling techniques so that patient-specific assessment can be made for personalized diagnosis and therapy. The third chapter on biomechanics addresses an entirely different topic in a completely different way. It describes techniques that are useful in scientifically assessing mechanical trauma and abuse in young children due to vigorous shaking, falls and hitting. It uses computer models of humans to estimate the extent of abuse and trauma. The biomechanics modelling tends to be empirical and software-oriented because of the nature of understanding required here.

Investigations on biosensors form a significant part of biomedical engineering research today. It requires a close collaboration among biologists, chemists, bioengineers, and the modern-day manufacturers – the micro- and nano-fabrication researchers. It is an exciting field that poses many intellectual challenges in making the sensors selective and accurate, small and portable, fast, and finally affordable to people around the world. The chapter on point-of-care diagnostics addresses this important need and provides a good overview of different settings ranging from a modern-day, fully equipped hospital laboratory in a developed country to a hospital in an underdeveloped country, where basic facilities and trained personnel are lacking. The authors correctly note that critical need for diagnosis of infectious diseases is more in the latter setting than the former. A number of research issues related to this global healthcare are discussed in this chapter. It makes a good reading to understand the societal needs as well as basic scientific and technical challenges involved in it.

The impact of biomedical engineering on healthcare needs of the society comes to the surface in two other aspects covered in this book. These pertain to the prosthetic devices and drug-delivery systems. Prosthetic devices of today are not limited to artificial limbs and hearing aids; they are available for internal organs. Two chapters in this book deal with mechanical circulatory support devices for treating heart failure and devices for prosthetic vision. Both these chapters

take a realistic view in presenting the material so as not to promise the moon, but uncover the intricacies involved. The two organs that we take for granted when they work are incredibly complex when a biomedical engineer tries to make substitutes for them. Mechanical circulatory systems, as discussed in a chapter of this book, present the advances in design, prototyping and clinical trials that combine the knowledge base of sophisticated pump technology, advanced manufacturing, epidemiology and physiology. The chapter notes that these devices are now available for advanced stages of heart failure, but efforts are underway to make them available for patients who have the disease in the initial stages. Prosthetic vision is a much a more complex problem, as can be understood from the chapter that deals with it. The authors make justifiable comparisons to cochlear implants to show that this problem is a few orders of magnitude more complex. A simple argument is to compare the number of hair cells in the cochlea and acoustic nerve fibres (both about 15,000) with the number of photoreceptors (120 million) and optical nerve fibres (about 1.2 million) in the human eye. So, while a cochlear implant is fine with about 20 electrodes, a retinal prosthesis would require 1000 such electrodes. The best retinal prosthesis in the market today has about 60 electrodes. The chapter proceeds to explain the issues involved by first presenting the types of visual disabilities and then discussing how electrode-based visual-assist devices can enable partial perception of vision. Of necessity, this line of work needs an understanding of optics, physiology and psychophysics. The complexities notwithstanding, the authors of both chapters end on an optimistic note that better things are possible and are on the way.

Drug delivery is a fast-growing branch of biomedical engineering. Like the other aspects, this too has microscopic as well as molecular approaches. Two chapters individually address each of them. Aerosol-based drug delivery for treating lung diseases shows the interplay between physiology, fluid mechanics and particle transport. Viral gene delivery vehicles, as described in an informative chapter, show that molecular engineering has promise to exploit nature's well-evolved 'courier' molecules – the viruses – to deliver specific genetic payloads to particular cells.

Communication and processing of information is integral to living things and hence it is equally important for engineered biomedical devices and systems. Three chapters of the book are devoted to highlight this aspect. The chapters are well sampled: one deals with the cell-to-cell communication and quorum sensing in bacteria to understand the mechanisms of film formation and spreading of an infection; the other deals with the technology of microelectrodes used for stimulation and recording of signals for hearing, vision and motor abilities, and the third deals with ways to keep the power consumption low in processing electronics in biomedical devices because the battery is often the bottleneck in determining the life of a device.

The sixth aspect highlighted in this book is imaging. Biology research thrives using a microscope. This continues today in the biomedical engineering field as newer and more sophisticated imaging techniques are being developed and used. Four chapters present these advances and cover fluorescence and magnetic resonance imaging technique in depth, and show how fast 3D imaging is being developed and used. Image processing, an equally important and sophisticated research topic, is also discussed to highlight the importance of the interpretation of a captured image.

In summary, this book succeeds in capturing the pulse of current biomedical engineering in its 15 chapters. There are of course many more topics not covered here. This is only the tenth volume of the *Annual Review Biomedical Engineering*. A glance at the cumulative index of all the ten volumes at the end of this book shows that covering the breadth and depth of the field is a continuing process. The extensive bibliography given in each chapter is a treasure for those aspiring to work in those areas even in today's knowledge-at-the-finger-tips era, because we save time as someone has already done the hard work of collecting and collating the references for ready use. The formatting of this book also needs a special mention. The book is a visual treat: a software professional sitting next to this reviewer during a train ride commented that she would want to read this book just because 'it looks beautiful'. Crisp fonts, pleasant colours, cleanly annotated figures, well-organized tables, a reference list with authors' comments on selected papers, and wide margins with text to explain the jargon of the field make this book appealing to the eye and the mind. It would have been nice if all the authors had used the last two formatting features to help the reader a little more.

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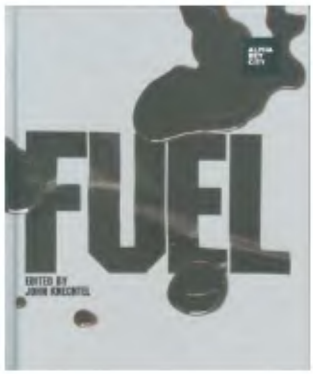


**Fuel.** John Knechtel (ed.). Massachusetts Institute of Technology and Alphabet City Media, Inc., The MIT Press, 55 Hayward Street, Cambridge, MA 02142, USA. 2009. 351 pp. Price: US$ 15.95.

This book is essentially a collection of articles and theme-based photo-features by writers and artists, which conveys perspectives on the impending fuel and energy crisis, some alternatives for the post-carbon world, and the ecological impact caused by dependence on a single energy source for over a century. It is neither a technical publication on the topic of fuel, nor a book wholly devoted to scientific policy on fuel and energy. Rather, the objective of the book in the words of the publisher is to challenge the reader to rethink conventional ideas and offer fresh perspectives from artists, designers and writers on the central theme of fuel. This book does achieve the said objective to a great extent. There are a few articles that stand out more than others, such as the one by Imre Szeman which presents a critique of the current responses to tackle the fuel and energy crisis. He classifies them into three main types which he calls 'Strategic Realism',