

The Bioengineer's Bookshelf

Mechanics and Thermodynamics of Biomembranes, by E. A. EVANS and R. SKALAK, 254 pp, \$34.95, CRC Press, Boca Raton, Fla., 1980. Available as one bound volume, or as *CRC Critical Reviews in Bioengineering*, Vol. 3, issues 3 and 4, 1979.

One of the most exciting and rapidly growing areas of research in cell biology today is the structure and function (mechanical and chemical) of cell membranes. Numerous review articles and texts have appeared in the past ten years on the ultrastructure and transport function of biomembranes, but there has been no unifying text outlining the new developments in the continuum mechanics of biomembranes in this same period. This book by Drs. Evans and Skalak is a very welcome and much needed addition to the field. It provides at the same time an excellent tutorial introduction for engineering and physical scientists interested in a continuum mechanical and thermodynamic description of biomembrane systems and a valuable reference text for advanced researchers in the field. Two particular strengths of the presentation are that it ties together the mechanical concepts of deformation, rate of deformation and force resultants with thermodynamic concepts that provide constitutive relations for the material properties of membranes and then relates this theoretical framework to an impressive array of biological membrane experiments that are described in some detail in the last third of the book.

The first three introductory sections assume no specialized knowledge of membrane mechanics on the part of the reader. These sections systematically develop the governing relations for the deformation and rate of deformation of a thin surface material with averaged properties in the thickness dimension and examines the conditions of mechanical equilibrium on a surface element. The theoretical development assumes that mechanical properties in the thickness direction change discontinuously on a molecular scale whereas properties in the plane of the membrane can be treated as an isotropic continuum. This is a reasonable hypothesis for the red cell membrane and many simple lipid-protein bilayers.

Section IV first presents the mathematical theory of reversible and irreversible membrane work and then relates this thermodynamic description to elastic and viscous membrane processes. Multilayered systems are then treated and the concept of membrane bending stress introduced by allowing chemical forces to produce different interfacial energies in the coupling between the layers. The theoretical formulations for viscoelastic, thermoelastic, creep and viscoplastic behavior are then presented.

One of the outstanding parts of the book is section V, where a host of biological membrane experiments are described to illustrate the application of the theoretical models. These experiments include: membrane area dilation under tension, elastic deformation under fluid shearing stress, membrane bending stress due to osmotic swelling, temperature effects on membrane elastic, viscous and compressibility properties, time dependent recovery and viscoelastic response of red cells to extensional deformation and permanent plastic extension of red cell membranes once the yield stress is exceeded.

Both of the authors have devoted most of their research to the study of red cell membranes where the assumption of isotropy in the plane of the membrane is reasonable. The exclusion of other biomembranes, except for simple amphiphilic bilayers, is the most important shortcoming of the present book. Ultrastructural studies have shown that most cells with nuclei have specialized internal structures of in-

tramembranous particles in the plane of the membrane which are of particular importance in endocytosis, exocytosis, vesicular transport or in the interaction between cells in the formation of various cell junctions. One would like to see these more difficult problems discussed in a general introduction and some thought given in the conclusion as to how the present planar isotropic theory might have to be modified to take account of either the spatial inhomogeneity in the plane of the membrane or of the molecular force fields that arise in the interaction between cell surfaces. One must stand before you can walk, and walk before you can run. Similarly, this book is an exceptionally good beginning, with much to be mastered before we can tackle the difficult and exciting problems that lie ahead.

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The Fluid Mechanics of Large Blood Vessels, by T. J. PEDLEY, 446 pp., \$48.50, Cambridge University Press, Cambridge, New York, Melbourne, 1980.

I first saw a prepublication copy of this book on March 27, 1980 when Dr. Tim Pedley and I both attended the Conference on Fluid Mechanics in Aachen, Germany to celebrate the inauguration of the reconstructed building of the famous Aerodynamisches Institute. I was at once impressed by the book's richness of material and depth of treatment. I was allowed to keep it overnight, but I was not able to read it extensively because I had to prepare my lecture to be presented the following day. Hence, I was delighted when my copy finally arrived. Reading it at leisure, I find it meets all my expectations.

This book is concerned with large blood vessels (the heart, arteries, and veins). The chapter headings are:

- 1 Physiological Introduction
 - 2 Propagation of the Pressure Pulse
 - 3 Flow Patterns and Wall Shear Stress in Arteries
 1. Straight Tubes
 - 4 II. Curved Tubes
 - 5 III. Branches Tubes and Flow Instability
 - 6 Flow in Collapsible Tubes
- Appendix: Analysis of a Hot-Film Anemometer

The major historical outline of the subject is given in the Preface. The history of this book is mentioned there too. For example, it is stated that the first draft of this monograph was completed in December 1976, and, together with the review article "Pulmonary Fluid Dynamics" (*Annual Review of Fluid Mechanics*, Vol. 9, 1977, pp. 229-274), was awarded the Adam Prize of the University of Cambridge for for 1975-76. The author did not say when the last draft was delivered to the printer, but the references list contains some entries of 1979 papers.

Chapter 1 gives a brief account of the anatomy and physiology of large blood vessels, with clear explanations of the experimental methods and of the need for mathematical analysis. The active contraction of muscle is considered briefly, the literature is reviewed, but neither the heartbeat, nor the action of the vascular smooth muscle is analyzed. The entire book is focused on the passive aspects of the circulation. The large blood vessel is treated as an elastic (sometimes viscoelastic) body. The left heart is regarded only as a source of blood flow, providing a certain flow rate into the aorta, and a pressure at its entrance; and the right heart is just a sink for the vena cava. But there is a nice discussion of the action of heart valves and the left ventricular ejection.