

**Fracture: A Topical Encyclopaedia of Current Knowledge.** Genady Cherepanov (ed.). Krieger Publishing Company, 1998. Price: \$ 179.50 (cloth) 892 pp.

Fracture is a natural reaction of solids to relieve stress and *shed* excess energy. Fragility of solids is a constant threat to our survival as we drive over a bridge; go through a tunnel; or, live inside a building. Our bones and teeth are just as fragile as the glass and china we use. Trees bow in the wind before they break; and, a blast of gunpowder breaks a mountain into a million fragments. Earthquakes shake and break the thin crustal shell on which we live. We accept fracture as a part of life and admire solids for what they provide. Fragility is *not* always perceived as a baneful threat because if all solids were unbreakable, we would not be able to break things when we *want* to. Just imagine an unbreakable eggshell that cannot be hatched; or, a hard grain of wheat that cannot be ground. Whether it is cracking bottles, breaking wood, or chipping rock for making sculptures, controlling fracture holds the key. Thus, in a way, fracture, like fire and wind, is both a foe and a friend of mankind – friend if controlled foe otherwise. *Prediction, prevention, control and treatment* of fractures represent a big bulk of engineering and medical practice today. Fracture has brought together a diverse group of professionals ranging from orthopaedics and dentists to crash helmet designers and earthquake experts. This coming together of engineers and doctors has led to major breakthroughs in fracture treatment and control. A spectacular array of products including injectable glues, metallic implants and reinforcing devices is now available for fixing fractured bones, teeth and cartilage<sup>1</sup>. Fracture phenomena in general are about just as wild and unpredictable as fire, wind, rain and thunder. Taming these elements of nature to protect life and property is the principal theme of control. Today, we have buildings that are fire-proof, rain-proof and even earthquake-proof (designed to rock but not break in case of an earthquake).

All these engineering and medical marvels notwithstanding, strategies for prediction and prevention of fracture are largely unclear. Though a *post mortem* can tell us *how* a thing broke, it is hard to

tell *when, where* and *why* fractures strike solids. Fractures unleash even more extraordinary issues as in the emission of electrons and photons from fracturing rocks and ceramics<sup>2</sup>. Another issue of great concern is bone fracture. Natural healing is so good that it is hard to tell where it broke in younger people<sup>3</sup>. However, in older adults, particularly women and some rare neonatal cases (*Fragilitas ossium*<sup>4</sup>), healing becomes difficult. Current science of fracture is in vigorous pursuit of answers to these questions.

This rather long and rambling prelude serves us to highlight the vast appeal of the subject in anticipation of a sprawling coverage of topics expected of an encyclopaedia. The book under review does *not* meet the expectations of general readers and new scientists exploring interdisciplinary ideas of great current interest. Nor does this volume address computer models and *molecular* simulations, currently a rage in solid state science. Instead, the encyclopaedist Cherepanov weaves a dramatic tale of fracture *mechanics* narrated through articles and commentaries interspersed with some interesting historical, biographical and anecdotal information on people and events. When compared to the monumental compilations by Liebowitz<sup>5</sup> and Sih<sup>6</sup>, each running over 4000 pages in seven volumes, Cherepanov's single volume 870-page encyclopaedia is like a bird's-eye view of the vast landscape of fracture mechanics. This encyclopaedia emanates a fresh and rich mathematical flavour of Soviet contributions to the subject making up nearly 40% of the pages. This is indeed a commendable effort to make their work accessible to English readers. These contributions also serve to highlight some original work in fracture mechanics of interest to bibliographers.

Presented in 41 chapters by over 50 international experts, the book opens with two republished articles of the two grandmasters: Griffith (ch. 1) and Irwin (ch. 2). Four more republished articles of Cherepanov (ch. 3), Knott (ch. 13), Leonov and Panasyuk (ch. 19) and Eshelby (ch. 23) along with four commentaries by Bui (ch. 6), Dugdale (ch. 9), Cottrell (ch. 18) and Yokobori (ch. 34) recreate the early excitement in the development of fracture concepts, experiments and applications.

The remaining chapters describe the seventies developments which brought

together mechanical, civil, aerospace, marine, chemical and metallurgical engineers to address fracture problems using the Griffith–Irwin concepts. This promoted the establishment of standard testing and design procedures to help avert catastrophic brittle failure in service. These chapters are contributed by senior workers in the field like Erdogan (ch. 5), Folias (ch. 12), Salganik (ch. 16) Liebowitz (chs 26, 27) and Nishioka (ch. 30).

Theocaris (ch. 10), Karihaloo (ch. 21), Evans *et al.* (ch. 39) and McCartney (ch. 41) address fracture problems in composites, a major research pursuit over the last 20 years. This is also the case for dynamic fracture mechanics, which has evolved rapidly following the widespread use of computer techniques.

This new encyclopaedia does not provide much material on experimental development which also perhaps reflects the declining emphasis on experiments in current science and engineering education. Unfortunately, theoretical and numerical methods are still not powerful enough to address all the complexities attending fracture phenomena. Particularly dynamic problems are highly sensitive to the material, problem geometry and the loading parameters. There are times when theoretical and numerical predictions become rather embarrassingly absurd. This is the reason why automotive, aerospace, nuclear and chemical industries rely more on field inputs and customer feedback; and, theoretical and numerical models serve only as guides. Dynamic fracture phenomena are still far too complex to expect computer simulations to mimic reality for a long time to come.

In summary, Cherepanov's encyclopaedia is not a feast like the treatise by Liebowitz<sup>5</sup>, but more like an appetizing salmagundi of sort. For students prepared to plough through some formidably thick and misty mathematical terrain, this book is a rare treat indeed.

1. Living glue, *New Sci.*, 3 April 1999, p. 16.
2. Enomoto, Y. and Hashimoto, H., *Nature*, 1990, 346, 641–643.
3. Andrew Weil, M. D., *Spontaneous Healing*, Little Brown and Company, London, 1995, p. 79.
4. *Chambers' Technical Dictionary, Third Edition*, 1963.
5. Liebowitz, H., *Fracture: An Advanced*

*Treatise*, (in 7 volumes) (ed.), Academic Press, New York, 1968-72.

6. Sih, G. C., *Mechanics of Fracture* (in 7 volumes) (ed.) Noordhof, The Netherlands, 1973-81.

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**Modelling in the Neurosciences: From Ionic Channels To Neural Networks.** Roman R. Poznanski (ed.). Harwood Academic Publishers, Amsteldijk 166, I Floor, 1079 LH, Amsterdam, The Netherlands. 1999. 536 pp. Price not stated.

The brain is often referred to as the most complex structure in the universe. This complexity gives rise to remarkable properties such as the mind and consciousness, as well as to a thriving philosophical debate about their nature. These questions are still out of the reach of neuronal modelling. Nevertheless, modelling has provided intriguing glimpses of how some of the properties of the brain may emerge. Abstract neural networks loosely based on biology exhibit useful (and brain-like) functions such as learning by example, robustness, and the ability to generalize. Realistic neuronal modelling, which this book examines, is beginning to provide the theoretical counterpart of experimental neuroscience, and to answer many questions about the higher functions of the brain.

Both experiments and theoretical studies have shown the need to adopt a multi-level approach to analysing brain function. Even the level of molecular and genetic events can affect the entire central nervous system, and *vice versa*. Most neuronal modelling has focused on the biophysical level: from currents passing through ion channels up to the level of large assemblies of neurons. This description encompasses many levels of neuronal function, and is the domain of this book. Biophysical models of single neurons are conceptually very simple,

and are among the most quantitatively accurate models in biology. Highly accurate models can be constructed by subdividing cells into interconnected 'compartments': small cylindrical segments of the neuron, each with its own complement of ion channels. Compartments are represented by an equivalent circuit, which takes into account membrane resistance, capacitance, and ionic conductance. Within each compartment, ion currents are typically described as variable conductances in series with the ionic reversal potential. It is the modulation of these conductances which gives each current its unique character. For example, synaptic currents are often modelled as simple 'alpha-function' responses to an action potential, whereas  $\text{Ca}^{2+}$ -dependent voltage-gated channels may require multiple state variables as well as Ca-concentration information in an extended Hodgkin-Huxley formulation. Network models can be constructed, then, by assembling several single-neuron models and interconnecting them through synaptic conductances.

Perhaps the most difficult question in such modelling is: how much biological detail is needed to make a model useful? There are many approaches, from analytical models which assume that a cell merely performs a weighted sum of inputs, to painstakingly detailed models with tens of thousands of compartments for a single neuron. It is an open question as to whether a simplified analytical description of a cell is more informative than a detailed numerical model. Most workers are happy to draw upon results across the spectrum. The introductory chapter, however, contains a somewhat surprising polemic issued from the viewpoint of one of the schools of thought in neuronal modelling, which does justice neither to the diverse viewpoints in the field nor to the otherwise excellent material in the book. The main influence of the editor's strong feelings about the 'right' approach to neuronal modelling is seen in the emphasis on analytical rather than brute-force computational approaches to characterizing different levels of neuronal function.

As the title indicates, successive chapters present models ranging from ion channels, through neuronal substructures and single neurons, to small networks and on to large network simu-

lations. Two early chapters describe statistical approaches to interpreting experimental data at the limit of resolution for ion channels and synapses respectively. Here the application of modelling is to devise descriptions of the system which can then be tested using Monte Carlo methods to find the best fit to the data.

Two particularly interesting chapters address the issue of designing morphologically realistic neurons and networks. Neuronal geometry is a crucial determinant both of electrical properties and of neuronal connectivity. Every neuronal type has certain characteristic branching patterns, which are nevertheless unique from one cell to another. How does one represent the diversity of a subclass of neurons, while retaining the distinguishing features of this subclass? A return to the biological roots provides a solution to this problem: the neurons are 'grown' according to biologically motivated rules. How does one decide on which connections to make? It is plausible to think that the spatial separation between dendrites and axons plays a role here, and methods are described to utilize this information efficiently.

Several chapters present exquisitely detailed analyses of passive cable properties of neurons. This is one section where the reader might feel that the simplifying assumptions may render the analysis less useful: few real cells have completely passive dendrites. Such analyses may be more interesting as mathematical exercises than as descriptions of real neurons. Related chapters on active properties of cells also trade calculus for computer time by using analytic expressions to approximate excitable cells, rather than conventional compartmental models. Again, one has to balance analytic convenience against biological realism when 'reducing' cell models; speed should no longer matter. A generic personal computer in 1999 is powerful enough to model a 50-compartment neuron with a full complement of Hodgkin-Huxley-type ion channels in real time, that is, the model will function at the same speed as the real cell would.

Models of specific neuronal systems are well represented in the book. These range from studies of active dendrites to retinal and associative memory networks. Each of these will be useful both as illustrations of a diverse range of model-