lisher, explains the *logic* of infinity and related concepts in a non-technical fashion and is therefore of value to the non-specialist in mathematics who is interested in its logical basis without bothering about the technicalities. More such books are appearing in the market, covering very similar themes[2]. The 'pioneer' in this regard was perhaps George Gamow's entertainer of half a century earlier[3], which provides the 'appetizer' for them. The present book[1] however also deals with some technical aspects like the formal proofs of the Goedel Theorems and a fuller exposition of the 'transfinite cardinals' of Cantor theory, topics which are not easily found in most textbooks, and should thus be useful to the more serious student of mathematics, who is further helped to develop his logical thinking capacity without external aid, through a collection of puzzles/paradoxes whose answers are given at the end of the book. Another item of delight is the story of Rucker's personal encounters with the 'Mathematical Genius' (who very rarely granted interviews). The serious student of mathematics may profitably combine books of this kind with more 'substantial' classics like Courant's 'What is Mathematics?'[4] to grasp the abstract ideas and methods of mathematics in a more palatable and wholesome fashion.

To summarize, the book whose style will please both the uninitiated and the more serious thinker in mathematics, ventures to convey to both the abstract concept of *infinity* in all its forms, both 'potential' and 'actual', spatial and temporal, large and small. The main lesson seems to be that even mathematics as an 'exact science' has its limitations (thanks to the Goedel Theorems and the like) which have led to at least *two schools* of thought: Platonistic versus Formalistic, and encouraged the (more holistic) intuitionists to lean towards Mysticism[1], a subject which is beyond the scope of this review.

1. Rucker, R., *Infinity and the Mind*, Birkhauser, Boston, 1982.
2. Barrow, J. D., *Pi in the Sky*, Little-Brown, Boston, 1993.
3. Gamow, G., *One, Two, Three, Infinity*, 1950.
4. Courant, R. and Robbins, H., *What is Mathematics*, Oxford Univ. Press, NY, 1978.

A. N. MITRA

244 Tagore Park,
Delhi 110 009, India

Conversations on Mind, Matter and Mathematics, by Jean–Pierre Changeux and Alain Connes, edited and translated by M. B. DeBevoise. Princeton University Press, 41, William Street, Princeton, New Jersey, USA. 1995. Price: $24.95; £19.95. 260 pp.

Many thinkers over millennia have pondered over the problem of the relationship between mind and matter. In the secular part of the Western tradition, avoiding reference to individual development and destiny, the origins of such enquiry, as in so much else, go back to the Greeks. Here one encounters the contrasting views of Plato on the one hand, and of Democritus, Epicurus and Lucretius on the other. For Plato, all objects and experiences in the world were shadows or pale imitations of a fixed sphere of ideas, beyond space, time and sensation, where alone perfection and the highest truths were attained. Democritus and his followers adopted in contrast a more pragmatic materialist point of view, giving primacy to experience and knowledge of the world directly accessible to us. Passing over many centuries, we come to Descartes and his 'cut': a sharp distinction between mind and matter, a dualism, with the former not reducible to the latter. In our own times, with stupendous advances in both the physical and the life sciences, gifted scientists have devoted themselves to these questions. Thus one recalls Schrödinger's *Mind and Matter*, subtly influenced both by his wave mechanics and his leanings towards Vedanta; and more recently Max Delbruck's *Mind from Matter? An Essay on Evolutionary Epistemology*, where a deep understanding of Darwinian evolution and Lorenz's ideas on phylogenetic and ontogenetic 'learning' were brought to bear on the problem.

Questions in this realm are easily posed; not so easy however to find convincing answers, or even agreement on the characteristics of an acceptable answer. Some perennial problems that suggest themselves: is the statue already present in the uncut marble before the sculptor goes to work, and does she merely uncover what was pre-existing? Is a new mathematical concept an invention or a discovery, an exploration of a fixed continent of mathematical truths?

Conversations on Mind, Matter and Mathematics is an exhilarating dialogue between a biologist and a mathematician, faithfully recorded and beautifully translated, on these and related problems, with special reference to mathematics. Changeux is an outstanding neurobiologist, from the Lwoff-Monod-Jacob school; while Connes is an equally gifted mathematician with a deep feel for theoretical physics. Much of their conversation is an argument that is never resolved: through his experience in mathematics Connes firmly believes that mathematics exists 'out there' as a territory independent of us, available for exploration. He feels so because of the frequent occurrence of different individuals finding the same answer to a given problem; by the power of axioms to hold within them many consequences which with effort we unravel; and by the apparent independence of many mathematical creations from sensory experience. Equally passionately Changeux—surely influenced by neurobiology— insists on the constructivist viewpoint: mathematics is a product of the human brain, taking inputs from the physical world; all mathematical steps and arguments are specific achievements within the brain, using its material basis and organization, its evolved capacity for logical reasoning. The relative complexity of certain parts of mathematics is no proof of its independent existence or reality. Mathematics as a language to describe nature, so spectacular in physics, is not independent of the brain; even those results which today appear as finished products evolved in societies and cultures, and once did not exist. To Connes' challenge: 'Will we ever "see" a brain conceiving a mathematical idea, a concept, a step or an argument?', Changeux answers confidently—'Yes, one day we will!'.

Such is the heady stuff recorded in these conversations. That such a gifted pair should have come together for this exploration—though they agree to disagree—is remarkable indeed. The range is wide, the pace breathtaking. Perhaps Connes' clearest statement of his position is this: 'It's humility, finally, that forces me to admit that the mathematical world exists independently of the manner in which we apprehend it, that it isn't localized in time and space'. Yet he admits that the tools used to explore this world are products of human culture. In answer, Changeux traces the origins of speech and logic to homo erectus 400,000

years ago, and speaks of a time when our present conceptual abilities and the power of the sixth sense were not present at all. The brain is definitely a product of biological evolution, and as it has developed so have its capacities. Connes is willing to admit some differences between physics and mathematics, since for the former Nature is the final arbiter. Yet if one clings too hard to his general viewpoint, one must ask: where were Newton's and Maxwell's equations before Newton and Maxwell? Here one is reminded of Heisenberg's dictum: 'nature is prior to man, but man is prior to natural science'.

Among many other insightful accounts, the description of Hadamard's analysis of the process of mathematical creation is enthralling: the four stages of conscious mental preparation, unconscious incubation, sudden illumination, and then the verification and polished presentation of results. To go through such experiences is truly moving. And there is a very real role here for emotion and fear too. Changeux describes the results of neurobiological research on the structure, organization and complexity of the brain, and successes in relating 'mental experiences' to localizable activity in the brain. He even suggests that Darwinian selection may operate in the realm of mathematical argument and debate. On the way the duo educate one another—and enchant the reader—on the latest lessons of neuroscience and the structures of mathematics and physical theories.

The book concludes with an essay by Changeux on the need for a new rational understanding of ethics, free from dogma and mythology. He pleads for an approach based on experience, both of the species and of the individual, leaving room for growth. His quoting Darwin to the effect that man is 'a moral being', and remarks on the predisposition towards sympathy and cooperation among individuals, are encouraging—almost too good to be true. Would that such a universe of informed debate, reaching beyond grasp of technical details of science to broader and general perspectives, could one day be created in our own midst!

N. MUKUNDA

Centre for Theoretical Studies and
Department of Physics,
Indian Institute of Science,
Bangalore 560 012, India

Annual Review of Physiology 1995. Hoffman, J. F. and Weer, P. D. (eds). Annual Review Inc., 4139, El Camino Way, P.O. Box 10139, Palo Alto, California 94303-0139, USA. Volume 57. 905 pp. Price: USA $49, elsewhere $54.

The *Annual Review of Physiology* has a long sustained tradition of publishing good articles on selected topics and/or areas relating to different fields of physiology, thereby highlighting the important developments in a particular field. I was particularly delighted to accept the offer to review the 1995 volume, for the reason that it has review articles on membrane ionic channels and cellular and neurophysiology which are closer to my research interests.

The Review begins with an autobiographical sketch by Hans J. Schatzmann, where he has attempted to convey the excitement of his many years of research on the ion pump mechanisms in biological membranes.

The comparative physiology section has topics related to thermal adaptation in membranes (J. R. Hazel), temperature–protein interactions (G. N. Somero), where the recent discoveries of temperature effects on protein structure-function and gene regulation in the experimental contexts are reviewed and attempt made to relate them to concerns of comparative, evolutionary and environmental physiologists. There is additionally a review on the evolution of endothermy in mammals (J. Ruben).

Among the topics covered in the section on Respiratory Physiology, there is a review by N. J. Gross on a recently identified enzyme surfactant convertase, a serine protease which acts on lung surfactant, converting one of the subtypes, tubular myelin (TM) to the small vesicle (SV) subtype. Drazen, Gaston and Shore review three different chemical regulatory mechanisms of pulmonary tone, viz. cysteinyl leukotrienes (LTD4 being most potent), neuropeptides and nitrogen oxides, and the physiological significance of these in regulating airway tone in human asthma. While the individual effector systems are known, it is not clear how the three different effector systems function in an integrated fashion, which is where future research would be directed.

In the Endocrine Physiology section, Inagami, Naruse and Hoover review the current status of research on the thin unicellular layer, endothelium which forms a permeable and physical barrier protecting vascular smooth muscle cells, as an endocrine organ with multiple functions.

There is also a review by Woodruff and Mather on the recently discovered modulators of follicle stimulating hormone release, viz. inhibin, activin and follistatin. There are recent references on relationship between aberrant production of inhibin and cancer.

The section on Renal and Electrolyte Physiology has articles dealing with the role of reactive oxygen metabolites (S. V. Shah), transforming growth factor-beta and Angiotensin II (Ketteler, Noble and Border), and platelet growth factor in the pathogenesis of renal disease (H. A. Aboud).

The Cell Physiology section has an interesting and up-to-date review on mechanosensitive or stretch-activated channels by Henry Sackin. A hypothetical scheme with different pathways for how stretch-activated cation channels and stretch-activated K channels might be involved in volume regulation of the cell and K homeostasis is presented. I found this scheme particularly interesting. The earlier debate on the mechanosensitivity being an artefact of the patch-clamp technique, has been recently put to rest by the work of Sukharev *et al.* (*Nature*, 1994, **368**, 265–268), by demonstrating that mechanosensitivity is an intrinsic property of certain channels that can be reconstituted into different lipid environments. Mechanosensitive channels are attracting a lot of current interest amongst cellular physiologists, and considering their mechano-transducer property, are found in cell systems where mechanosensation is required, viz. muscle spindles, vascular endothelium and auditory cells. They are also found in plant and fungus cells. Stretch-activated plant channels are suggested to be important in mediating the geotropic response by transducing mechanical (i.e. gravitational) signals, an interesting biological feature.

Membrane ionic channel-linked diseases are beginning to be understood, and pathological situations arising from channel dysfunction are beginning to be classified under 'channelopathies'. Like the CFTR chloride channels, abnormalities