However, while the preface and foreword emphasize that the term 'cold atoms' refers to neutral atoms as well as ions, there is no article that deals with laser-cooled ions, a field that also has witnessed rapid progress during the recent past. Two other areas, in my opinion, have not received due attention in this book. They are trapping of single atoms, and individual site addressing in optical lattices, both of which have great potential for application, especially in quantum information and quantum computing. Nevertheless, the compilation provides an excellent overview, and amply shows how rich the field of cold atom physics is and how these sub-microscopic, sluggish particles have been able to shed light on unexpected areas in physics. The authors have written the various chapters in a manner that the subject may be understood by a physicist from any field. In fact, most chapters will be easily understood by a person who has completed his Master's in physics. The editors have done a good job of ensuring uniformity in level throughout. Clear figures and explanations enable one to get the gist of the work. Adequate referencing enables interested readers to pursue the field further. The authors have explained the subject matter well, without oversimplification that could lead to dilution of content. I recommend the book to every researcher in this field, as it provides a good compilation of the latest developments in the field. I recommend this book to every student aspiring to make a career in cold atom physics, as it gives a clear overview. I would also recommend this book to every physicist, as it shows how far-reaching the impact of this field has been. I look forward to the next book in this series.

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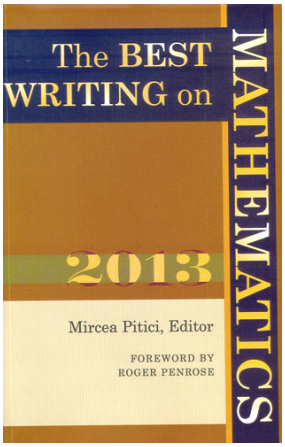
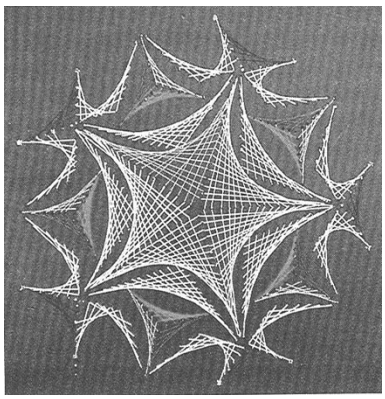


The Best Writing on Mathematics – 2013. Mircea Pitici (ed.). Princeton University Press, 41 William Street, Princeton, New Jersey 08540-5237, USA. 272 pp. Price: US$ 21.95/£14.95.

The book under review attempts to bridge the peculiar disconnect that exists between being actively engaged in doing mathematics and feeling the need (if at all) in communicating the basic ideas and results to the general public. It succeeds in doing so, in no small measure, by presenting a wide variety of eminently readable essays on various ideas in mathematics, both old and new, and the myriad and unexpected ways in which some have touched our lives.

To provide only a glimpse of its contents, there are fascinating accounts on the development of mathematical instruments, thoughts on the relevance of mathematics in society and education, and probes into whether the subject ought to be taught in a fundamentally different manner in contemporary times. The reader will also find several illuminating articles on the synergy between geometry, art, architecture, music and fashion apparel. There are essays dealing with the subjects of randomness, probability and large complex systems – systems that seem to be governed by universal laws independent of those that are more dominant on much smaller scales.



A pattern made from strings.

I agree with the author when he writes in the Introduction that the chasm between doing and communicating mathematics to a non-specialist is inevitable up to a point because of the very nature of the subject. However, emphasizing the importance of effective communication, he adds that 'writing about mathematics offers freedoms of explanation that complement the dense texture of meaning captured by mathematical symbols' – I could not agree more.

This book is the fourth in a series of such compendia, each consisting of scholarly articles most of which were published in 2012. The author deserves to be congratulated for his painstaking efforts in compiling these selections year after year.

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The Believing Brain. Michael Shermer. Constable and Robinson Limited, London, 2011. 464 pp. Price: £9.99.

Ever since the discovery of 'neurons', the brain – be it that of mouse or man – has been one of the most exciting frontiers of scientific research. Books reporting on such research therefore are welcome and more so when they deal with important 'cultural' issues concerning science. This book is by Michael Shermer, a psychologist, historian of science, founder of the *Skeptic* magazine and a columnist for *Scientific American*. In this interesting book, the author cuts an interpretative swathe through modern brain research and tries to link brain-specific facts concerning the biology of belief to larger questions of cultural evolution and the scientific method.

The central claim in the book is the assertion that beliefs come first and are then followed up by rationalizations of that belief. He links this up with the notions of patternicity and agenticity – our

predisposition for searching for patterns and endowing them with meaning through appropriate agency (chapters 4 and 5). In turn, this predisposition is viewed as arising in human behaviour through selection by evolutionary processes, because of its survival value. That provides the biological basis for the title of the book. The brain is a product of evolution and thus trained to detect patterns. In the process, it makes errors. We believe that a ghost haunts the abandoned house next door, when it maybe our neurons buzzing us about the neighbourhood cats and dogs that are prowling around in the middle of the night. Shermer believes that these errors can be rectified by science or to be more precise, an application of the scientific method.

The centre piece of rational discourse and the scientific method is of course the brain. Shermer links consciousness with the brain or rather with appropriate regions of the brain (chapter 6). But from the errors in the brain or made by the brain, to its rectification by the scientific method is quite a distance – one that needs to be taken step by rational step if the thesis of the book is not to be undone by a leap of faith in the last instance. Or does the belief in the scientific method require a leap of faith – a belief first, followed by rationalizations? This would be consistent with the thesis proposed by Shermer that beliefs come first and thus to resolve this dilemma, it is necessary to take a closer look at his main proposal.

We may be wired so that beliefs come first before a reasoned argument for the same, but why this priority of belief over reasoned arguments? Perhaps it is obvious – Shermer is a psychologist – that this has to do with the nature of individual identity within a broader social grouping to which we all belong and that this identity based on loyalty to social groups, has for long been considered primordial, outside the framework of rational discourse. Solving a puzzle posed by a pattern maybe fun as long as it does not threaten your identity. How can puzzle-solving threaten your identity? Here it is agenticity or the attribution of cause to patterns that can threaten social stability and hence can reflect back – as negative feedback – on the person making the attribution. Hence, prioritizing beliefs over reasoned arguments may have to do with whether such beliefs conflict with social identity. Whether such an argument actually translates into a corresponding fact about the way the brain functions, is of course a different question.

While we believe that Shermer is right in proposing the scientific method as a tool to correct the errors made by the brain, the weakness of the book lies in not providing an explanation for science as a 'social method' that arose as a result of cultural evolution in exactly the same process that gave rise to religion? Thus in the book the scientific method is a given, comprising the sum of all scientific theories – the correct ones – and which is able to rectify the 'cognitive biases' that arise at the individual level (p. 328). But how this came about, in spite of the belief structure of the brain suggested by the author, is an interesting question that begs an answer. The lack of conceptualization of science as a social method, as something that exists *ex nihilo*, rather than as a transformative process, reduces it to a series of individual discoveries within specific disciplinary narratives that leaves several questions concerning the link with biology and the neural basis of belief, to which the book is mainly devoted, dangling in mid air, in spite of several interesting examples from the history of science that the author provides to elucidate his theory of the scientific method.

The brain may well be prone to errors of perception, but it is also the locus of individual creativity and any explanation for the scientific method must also include the special role that the individual plays in the process of building up of scientific knowledge. Often, it is the individual that is the hero or heroine of the scientific narrative. Historically, the creation, discovery and dessimination of secular scientific knowledge was embedded in larger and often non-secular traditions in different parts of the world. One of the central concerns in any knowledge-creating process, whatever be its formal historical context, is to guard against errors in the transmission of knowledge. Modern technology in the form of printing changed the dynamics of a hitherto linear process of knowledge dessimination by bringing in multiple points of error detection, in effect, one for each individual reader of a scientific text and moreover, one who could potentially be a more objective reader than one who belongs to the school of the author of the text. From 'gentlemen' and 'amateur' scientists to notions of 'citizen scientists' and modern-day 'academics', embedded as he/she is in the more formal tradition of knowledge creation under the aegis of the modern state or in the less formal modern corporations, the role of the individual has expanded to keep pace with the increase in the dessimination and accessibility of knowledge.

In contrast to science as a 'social method', it is the individual scientist that carries the torch as it were, of the evolutionary processes of 'patternicity' and 'agenticity'. The search for mathematical laws may well be the modern version of patternicity (pp. 72–73), while the search for 'cause', as in the physical sciences, that of agenticity (p. 103). The scientific method, according to Shermer, corrects the many cognitive biases that occur at the individual level due to the propensity of the brain to believe first and reason later. Then the scientific method is the error detecting mechanism par excellence. This explains well certain aspects of the scientific method with the caveat mentioned above. But it also stops short of explaining the role of individuals – and in particular the role of those extremely gifted individuals that we call 'geniuses' – in the process of discovery in science. Indeed, one could argue that this latter role, as a discoverer, is the more positive role that the individual scientist plays during his lifetime, the role that we celebrate and extol in our own versions of the scientific method. And perhaps, this goes beyond the processes of patternicity and agenticity that Shermer invokes to explain the belief mechanism of the brain.

While the process of discovery in science remains one of the most enigmatic of human activities, it has nonetheless occurred on a sufficiently large scale and with sufficient frequency over the last two or three centuries and with significant consequences for humanity at large, so as to make the question of whether there is any 'method in the madness', more than just an academic one and in particular, relevant for countries outside the advanced West, for developing an institutional framework for science. Shermer's own analysis, coming as it does from a psychologist, we believe, provides clues to the processes involved in the discovery of patterns. Making a discovery involves not just the discovery of a new pattern, but it also involves a break or discontinuity with the existing methods of analysis or of understanding

patterns. Often, the break or discontinuity is what makes the pattern interesting and at the same time, its acceptance problematic. We may call this the method of innovation. It is in direct contrast with what one may call the 'traditional method' of extending a pattern by continuity or by incrementally small steps. On the other hand, as far as individuals are concerned – and from what we may infer from published accounts, particularly so for the successful ones – the process of discovery is often, though not always, driven by a sense of the inevitability of the truth of the 'pattern' that excludes all other objective criteria that negate the pattern and focuses exclusively on the clues favouring the pattern. In short, it is a process driven by subjectivity, that in some sense negates the very founding principle of science, viz. objectivity. It must be emphasized that subjectivity involved in the process of discovery is more than mere belief. It is belief that puts the individual at risk of social rejection. The discussions on pp. 147–149 on Karry Mullis and Alfred Russel Wallace are examples – we believe, by no means unique – of the nature of subjectivity in science.

The book is divided into four parts: 'Journeys of belief', 'The biology of belief', 'Belief in things unseen', 'Belief in things seen'. Each part is divided into chapters, with a total of 14 chapters in the book. Part 1 describes the life experiences of three individuals, in matters of faith and belief and includes the author's own journey from a 'born again Christian' to a skeptic – an Indian equivalent would be a rationalist. The author refers to his own views as 'belief dependent realism', patterned on 'model dependent realism', a philosophical position taken by Stephen Hawking and Leonard Mlodinow (p. 391). Part 2 is in some sense the core of the book and puts forward Shermer's thesis on the 'neural' basis of belief. Part 3 is an explanation of supernatural ('unseen') phenomena on the basis of the model, set out in Part 2. In Part 4 the author applies his theory to 'things seen', including politics and science. While his model of politics is in some sense based on 'genetic determinism', there are choices: he views the liberal–conservative divide in politics as an outcome of a more basic choice of values (or beliefs) that we humans possess and which presumably have evolutionary significance, e.g. values like harm/care, fairness/reciprocity on the liberal side and in-group/loyalty, authority/respect, purity/sanctity on the conservative side (p. 286). Chapters 13 and 14 on geographies of belief and cosmologies of belief have interesting examples from the history of exploration and science that Shermer uses to highlight the nature of science as an 'error correcting' mechanism acting on individuals prone to various kinds of 'cognitive biases'.

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