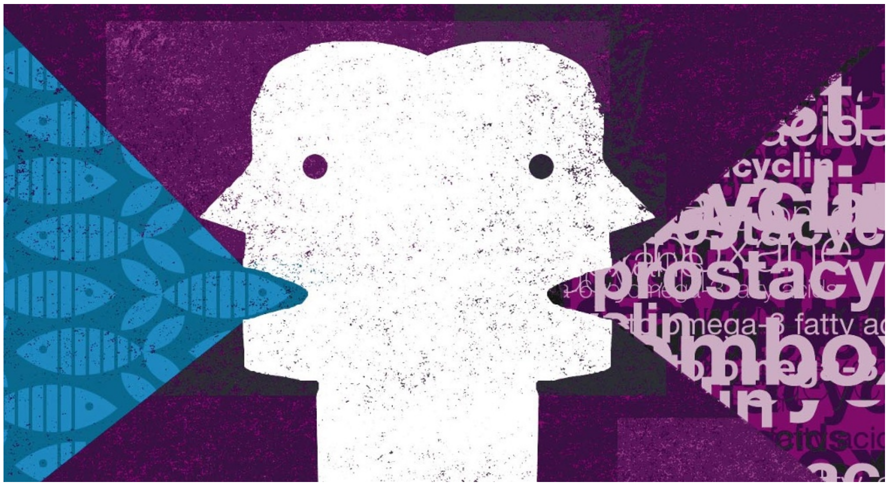
following year on a short expedition to observe whether riboflavin deficiency was related to snow blindness among the Canadian Inuit. It is reported that he failed to keep any written record in his diaries but embellished the tale in later life to suggest that he had joined the expedition because he was interested in the fact that the Inuit diet was high in fat, rich in essential fatty acids, and yet the Inuit were free from heart disease. During this period of his life, Sinclair's work was concerned with thiamine and diseases of the nervous system, and there was no evidence of his having any interest in cardiovascular disease and dietary fat. His epic letter to the *Lancet* in 1956, in which he suggested that cardiovascular disease was caused by a deficiency of essential fatty acids, was an important stimulus to future research.

But Sinclair was blinkered by the deficiency paradigm. And the book perpetuates the myth that he was responsible for drawing attention to the cardioprotective properties of omega-3 fatty acids. What he failed to note was that the balance of omega-6 to omega-3 fatty acids was important to health. Indeed, for many years he promoted the consumption of a diet high in omega-6 fatty acids. The major impetus for cardiovascular research on the omega-3 fatty acids arose from the work of Salvador Moncada and John Vane on prostacyclin, and Philip Needleman on thromboxane, published in 1976, three years before Sinclair embarked on his Eskimo diet to demonstrate the effects of omega-3 fatty acids from fish oils on haemostasis.

Sinclair's life-long ambition was to establish a department of nutrition at Oxford. He was appointed reader in human nutrition there in 1951. There is little doubt that he was an able scholar, but his ability as a research scientist is questionable because of his lack of attention to detail and failure to publish his results in peer-reviewed journals. He was a prolific letter-writer and collector of manuscripts (including a collection of erotica) and, following his death, these sold for more than £85,000 (US$124,000).

Like a few other famous nutritionists, such as Boyd Orr and Robert McCarrison, Sinclair liked to dabble in the politics of food and influence national policy. But his outpourings tended to be based on belief and theory rather than evidence and he was openly contemptuous of the work of his contemporaries, such as John Yudkin and Elsie Widdowson. But to his credit, Sinclair truly understood the complexity of the relationship between diet and health and recognized the need for a multidisciplinary approach.

As a scientist, he came to be regarded as a dilettante; his research lacked focus and was unsystematic. This, coupled with his failure to complete projects and produce peer-reviewed publications, and his sniping at influential contemporaries, eventually resulted in his ejection from Oxford's Department of Biochemistry in 1956 by Sir Hans Krebs, and his



readership was not renewed in 1958. For the rest of his working life, Sinclair remained in the wilderness of his self-styled National Institute of Nutrition, which was situated in the grounds of his home at Lady Place in Sutton Courtenay. On his death, he bequeathed his estate to establish a chair in nutrition at Oxford which the university declined. The offer was eventually taken up by the University of Reading, where the Hugh Sinclair Nutrition Unit thrives under Christine Williams.

This is no detective story: there are no elegantly designed experiments or startling discoveries. It is a salutary warning to nutritionists that scientific progress is made by good experimental design and meticulous attention to detail and not by travelling the world on lecture tours. ■

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In for the count

Mathematical Mountaintops: The Five Most Famous Problems of All Time
by John Casti
Oxford University Press: 2001. 288 pp. £19.95, $25

Simon Singh

The recent boom in mathematics bestsellers has contributed a great deal towards raising the public profile of the subject. But such books ignore a significant section of potential readers, namely those who have more of a mathematical background than the general reader but who are not professional mathematicians. Such mathematical enthusiasts have no doubt enjoyed some of the popular books, but would really prefer a more technical treatment. This is exactly what John Casti provides in *Mathematical Mountaintops*. It is neither a textbook nor a pop maths book, rather it is a serious in-depth look at the great problems of mathematics.

Casti has picked "the five most famous problems of all time", and spends 30 to 40 pages describing each one. The problems are Hilbert's tenth problem, the four-colour problem, the continuum hypothesis, the Kepler conjecture and Fermat's last theorem. Each of these has now been solved, so, in addition to outlining the problem, the author is able to explain the solution and recount the story behind it. Four of the problems have been written about extensively elsewhere, but perhaps not with Casti's balance of technical explanation and background narrative.

Casti's remaining problem, the Kepler conjecture, has (to my knowledge) not been written about since the recent announcement that it has been proved, and provides perhaps the most interesting chapter. The problem dates back to 1606, when Johannes Kepler posed a question in a paper for his patron Johann Matthäus Wacker of Wackenfels, Knight Bachelor. Kepler asked, what is the most efficient way to stack spheres so as to minimize the spaces between them? Alternatively, what is the best way to pack oranges in an infinite box? Kepler proposed that the best arrangement was the face-centred cubic lattice, in which every sphere in the first layer is surrounded by six others, and each subsequent layer is built by putting spheres in the dimples of the layer below. This arrangement has a packing efficiency of 74.048%. Grocers, who traditionally stack oranges in this way, suspected that Kepler was right, but it took mathematicians almost four centuries to prove it.

There were some notable milestones along the way. In 1694, Isaac Newton and the Scottish astronomer James Gregory argued about the sphere-kissing problem: what is the maximum number of spheres you can place simultaneously in contact with a central sphere? Newton said that the answer was twelve, which is easily achievable, but Gregory was convinced that it was possible to squeeze in a thirteenth sphere. Newton turned out to be right, but this took 180 years to prove.

The Kepler conjecture was eventually proved in 1998 by Thomas Hales of the

University of Michigan, following an approach developed in the 1950s by the Hungarian mathematician Lázlo Fejes Tóth. Hales showed that it was possible to determine the maximum packing efficiency by analysing a cluster of just 50 spheres. Each sphere has a position in three-dimensional space, so the packing efficiency depends on an equation containing 150 variables. Maximize the equation and you have the maximum packing efficiency, although this is not a trivial problem.

Hales and his graduate student Samuel Ferguson maximized the equation, thanks to some clever mathematical short-cuts and a tremendous computing effort which used a program that relied on three gigabytes of storage. The fact that Hales's proof relies so much on a computer gives rise to one of the most interesting aspects of Casti's book, namely the validity of computer proof.

In fact, although each chapter is about a particular problem, these problems are used to convey broader ideas about the nature of mathematics in general, its motivation and objectives, its culture and rules. Over the past 25 years, the use of computers has changed the nature of mathematics, solving some previously intractable problems, but sowing discord within the mathematical community.

For example, Casti writes about the four-colour problem, which was also solved with the aid of a computer. After Kenneth Appel and Wolfgang Haken proved it in 1976, their lectures were sometimes met with hostility from their colleagues and some professors barred their graduate students from talking to the notorious duo because this was a computer proof, not a traditional proof. A rumour began to spread that there was a bug in the program, but no bug was ever found. In fact, it was the hand-generated part of the proof that contained errors, none of which turned out to be serious.

Casti explains that a good proof should satisfy three criteria. First, it should be convincing — in other words, mathematicians should believe it when they see it. Second, it should be formalizable, which means it can be incorporated within an established logical framework. Third, it should be surveyable, or capable of being understood, studied, communicated and verified by rational analysis. However, a computer proof fails to satisfy the third requirement, at least in any traditional sense. In the past, mathematicians could work through a proof line by line and explain it to one another. In a computer proof, the broad approach can be checked, but the detailed calculations are embedded within computer code and can be performed only by a microprocessor. The proof, to some extent, has to be taken on trust.

For readers who are particularly inspired by *Mathematical Mountaintops* and who have some spare time, Casti's final chapter briefly discusses the unsolved Clay Institute problems. Last year, the Clay Mathematics Institute held a press conference and identified seven problems that were crucial to mathematics in the new millennium. This resonates with German mathematician David Hilbert's list of outstanding problems announced in 1900. Whoever solves any of the Clay problems will win a prize of $1 million. But more importantly, they will earn a place in mathematical history and perhaps their own chapter in a subsequent edition of *Mathematical Mountaintops*. ■

Simon Singh is a science journalist and broadcaster based in London. He is author of The Code Book: The Secret History of Codes & Code-Breaking *(Fourth Estate) and* Fermat's Last Theorem: The Quest to Solve the World's Greatest Mathematical Problem *(Fourth Estate).*

Is anyone out there listening?

The World According to Pimm: A Scientist Audits the Earth
by Stuart Pimm
McGraw-Hill: 2001. 304 pp. £18.99, $24.95

Harold Mooney

Those who study global change are well versed in the sobering statistics of the enormous impact of humans on the Earth — the dramatic change in the chemistry of the atmosphere, the massive alteration of the surface of the land, the diversion and despoiling of a large fraction of the available fresh water, the depletion of ocean fisheries, the homogenization of the Earth's biota and the extirpation of large numbers of species. These scientists share a sense of frustration, however, about the fact that the general public and policy-makers are not grasping the significance of these changes nor acting to alter these trajectories for the well-being of future generations. In *The World According to Pimm*, Stuart Pimm is attempting to enlarge the army of scientists working on these issues and to engage the public in the dialogue about what is happening to the biotic resources of the Earth and how we need to change our trajectory of development in order to build a sustainable world.

To accomplish his task, Pimm has written an engaging and important book. He might well have called it "The World According to Peter, Paul and Pauly as viewed by Pimm", as the bulk of the book is devoted to an analysis of studies involving Peter Vitousek, Paul Ehrlich and Daniel Pauly. The book takes on a bold challenge — an accounting of the productive capacity of both the land and of the oceans and how humans have modified it. Pimm then documents the extent to which humans are utilizing the available fresh water and, finally, the impact of humans on the biodiversity of the Earth. He uses very simple mathematics and language to drive home the point that humans have very substantially modified the Earth's biotic resources.

The first part of the book is based on the dramatic retelling of the story first published by Vitousek and colleagues in 1986 in *BioScience*, in which they calculated that humans already use 40% of the primary productivity of the land. That is a sobering figure in view of the projections of growth of the human population during this century. There was some difficulty in getting this penetrating study published, but once it was, it was used widely. For quite a while it was impossible to go to a meeting related to the environment where the statistics of this paper were not used in the opening address. Subsequent attempts to check and recalculate the numbers, as Pimm has done, have borne out the original thesis. Pimm's recalculations are engaging; he does a very good job of making sure that the general reader can clearly understand the basis for these estimates of human use of the biosphere.

The second part of the book deals with human use of the Earth's water resources and builds on work by Ehrlich and his colleagues Sandra Postel and Gretchen Daily. They have shown that humans are using a sixth of the total estimated runoff (50% of that available), and in doing so have drastically altered the Earth's rivers — its plumbing system — especially in the Northern Hemisphere.

The work of Vitousek and colleagues inspired Pauly and a colleague to do a similar