Galileo points the way

Scientists should think big, but pay attention to the details.

Galileo's Finger
by Peter Atkins
Oxford University Press: 2003. 380 pp. £20. The US edition will be published in June (420 pp., $30).

Frank Wilczek

D. ORTI/THE ART ARCHIVE/NATIONAL PALACE MEXICO CITY

Reaching for the stars: Galileo explains his vision in this painting by Felix Farra from 1873.

In *Galileo's Finger*, Peter Atkins, a distinguished chemist and skilled writer, plays a game that I suspect all reflective scientists have indulged in: identifying the Ten Great Ideas. On the whole, he plays it very well. This is a charming and ambitious book that I would not hesitate to recommend as a gift for a young person on the threshold of a scientific career, or as the basis for a course or discussion group on general science. Of its kind, it is the best I have encountered. The specific criticisms that follow should be taken within that context.

The book has three underlying themes: exposition of science, promotion of scientific theses, and discussion of the scientific method. The bulk of the book falls under the first aspect, exposition. Atkins' 'ten best' list comprises biological evolution, DNA as the basis of heredity, atomism, conservation of energy, entropy, quantum theory, symmetry, Big Bang cosmology, relativity, and logic as the foundation of mathematics, leading on to universal machines and undecidability. Each of these topics gets a richly textured chapter of roughly 40 pages, touching on the history of the idea, its intellectual relatives and recent developments.

For example, the chapter on atoms begins with a discussion of pre-Socratic speculations on a universal substance and Aristotle's misconceptions, and the prescient formulations of Lucretius. There is then a nice account of the emergence of scientific chemistry with Antoine-Laurent Lavoisier, John Dalton's predictive atomism, and Stanislao Cannizzaro's convincing, accurate formulation. Next comes the theory of atomic structure based on quantum mechanics and wave functions, and the foundation it provides for the periodic table of elements. It includes a striking modern image of silicon atoms, made using a scanning tunnelling microscope, and well-thought-out illustrations of intricate atomic wave functions, as predicted using Erwin Schrödinger's equation. The discussion is self-contained and elementary, but honest and never patronizing. Justice is done to subtleties such as electron spin and the Pauli exclusion principle.

The final chapter, entitled "Arithmetic", touches on foundational issues and is rather different to the others. Its relationship to established natural science is much less clear. Rather, in this chapter Atkins seems to be building towards some intriguing but wild speculations (clearly labelled as such) that appear in the last few pages, around the theme: "There is therefore an intrinsic logical structure to the universe, which has the same structure as arithmetic… Our brains, and their product mathematics have exactly the same logical structure as the physical universe itself."

Well, maybe. But I'd have liked to see some acknowledgment of the obvious objection that the mathematical formalisms that have been most fruitful in science, involving real numbers, limits and locality much more than discrete arithmetic, seem on the face of it to be contrived and indirect from the point of view of abstract logic.

The wonderful image of Galileo's finger — specifically, the middle finger of his right hand, which is preserved in the Museo di Storia della Scienza in Florence, Italy — leads off the whole book, and introduces its methodological undercurrent. The vessel that contains the finger bears a remarkable inscription: "Do not look down upon the relic of a finger… By preparing a small piece of fragile glass it first dared a feat which long ago was beyond the powers of young Titans, who piled mountains high in a vain attempt to ascend to lofty citadels." This is the essence of Galileo's scientific method and, I trust, ours: fearless in conceptual daring, but humble in its respect for observation and facts.

Unfortunately, Atkins' own discussion of scientific method is marred by a weird blunder, which appears in various forms at different places in the book. The most egregious example occurs prominently in his concluding epilogue, in the book's penultimate paragraph: "Suppose that a future version of M-theory settles down into a form that predicts all known masses of the fundamental particles, all the values of the fundamental constants, and the structure of spacetime, but suggests absolutely no other experiment. It would not be falsifiable."

But of course such a theory would be falsifiable. All you'd need to do is measure the masses and fundamental constants more accurately than before, and check whether the more accurate determinations agree with theoretical predictions. (And by the way, M-theory in its present form is nowhere near predicting all these things; actually, it predicts none of them.)

Earlier, Atkins makes related, although more measured, comments about quarks: "I warned that I was preparing your mind for the possibility that science will have to modify its criteria of acceptability. That was in connection with quarks: quarks have not been seen, and perhaps cannot be seen, yet we are increasingly confident of their existence as so much that can be verified flows from it. That is verification by implication, rather than verification by experimentation: verification by hearsay,

rather than verification by direct experience."

But quarks have been observed, using appropriate special-purpose microscopes, within protons (Jerome Friedman, Henry Kendall and Richard Taylor received the Nobel Prize in Physics for this work in 1990), and have even been visualized directly through the jets that they produce following high-energy collisions. They have been studied in great detail, and their behaviour is in harmony with a uniquely predictive and beautiful theory. True, quarks cannot be isolated and studied at leisure, but neither can, say, living dinosaurs, nor any number of other scientific constructs (including, until fairly recently, electrons). There is nothing in the study of quarks and gluons that requires any compromise of scientific method. Indeed, perhaps nowhere else in contemporary science is that method applied with such quantitative rigour.

In general, Atkins' discussion of recondite frontiers of fundamental physics is somewhat shaky on the distinction between what is known and what is speculated. He short-changes the former and revels in the latter. This would be only a minor annoyance, except that some of his major rhetorical points and conclusions, hinting that a revision of scientific method is or ought to be under way, hinge on this very discussion. ■

Frank Wilczek is at the Center for Theoretical Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139-4307, USA.

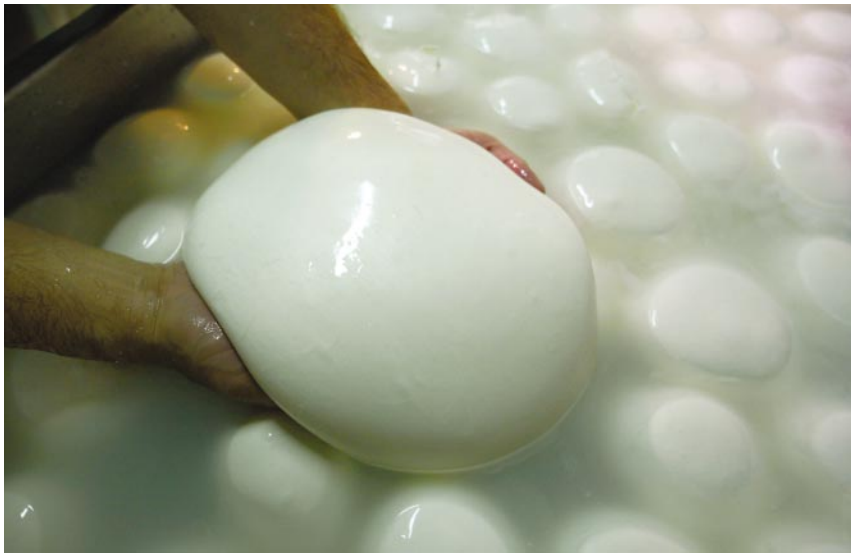
The fat of the land

The Hungry Gene: The Science of Fat and the Future of Thin
by Ellen Ruppel Shell
Atlantic Monthly Press/Atlantic Books: 2002/2003. 294 pp. $25/£17.99

Peter Kopelman

> *"Nay sir, whatever maybe the quantity that a man eats, it is plain that if he is too fat, he has eaten more than he should."*
> **Dr Samuel Johnson**

"Obesity is the trillion-dollar disease," according to the chief business officer of one of the world's fastest-growing biotechnology companies. He confesses to Ellen Ruppel Shell, the author of *The Hungry Gene*, that if it were his choice, he would focus his company's activities on obesity. Presumably Shell's incentive to follow this lead combined scientific intrigue and a potentially huge readership; she admits that "like most Americans of a certain age and sensibility, I am painfully conscious of my body weight". What follows is a 'tabloid' (as opposed to 'broadsheet') analysis of the causes and consequences of increasing body weight and obesity on global society.



G. SPOSITO/REUTERS

Full fat: mozzarella is the cheese used on pizzas, but the buffalo-milk version has a variety of uses.

The book begins as a detective story with the 'victim' — a patient with morbid obesity — undergoing gastric bypass surgery. The clues are explored through a historical perspective of corpulence across the centuries, which confirms that extreme obesity and medical concerns are dominant factors of the twentieth and twenty-first centuries. To tell the tale, Shell, a correspondent on *The Atlantic Monthly* and an associate professor and co-director of the Program in Science Journalism at Boston University in Massachusetts, cleverly interweaves science and historical fact.

She leads the reader to rodent models of obesity and the classical parabiosis experiments in which the circulations of lean and obese mice were linked; these suggested the existence of a circulating satiety factor that curbs eating. Jeffrey Friedman is introduced as a larger-than-life scientist (with "a tall man's gently sloping shoulders, he has a tangle of dark hair, a moustache, and hands big enough to palm a basketball") whose laboratory identified the satiety factor that is released from adipose tissue and named it leptin.

Here the reader is initiated into scientific research conflict: according to Shell, colleagues were used for their advice and favour and then dropped when the final discovery was made, patented and sold to the highest bidder. Many scientists who spent much time with the author may rightly blush at her assertions — it is an unusual experience to read so openly about esteemed and active scientists.

The author follows the thesis that leptin deficiency underlies human obesity by describing the findings from Stephen O'Rahilly's group at Cambridge University. They identified a pair of young cousins with leptin deficiency, the elder of whom lost significant amounts of weight following treatment with leptin injections. The book begins to lose pace after this chapter with the realization that the cloning of a 'hungry gene' is not proving to be the salvation of mankind from extreme corpulence.

What follows is a predictable onslaught on industry: the pharmaceutical industry for corrupting physicians and scientists who are involved in obesity research, and naturally the food industry. Nevertheless, it is to Shell's credit that she realizes that drugs are not the solution to obesity: "Weight loss drugs are an iffy proposition for everyone. Unlike leptin, which resolves a rare genetic defect, obesity drugs are not meant to treat a specific pathology. Rather they are designed to interfere with what is essentially a healthy, smoothly running system." True to this, she describes the horrific consequences of the "rapid westernisation of unassuming cultures in the Pacific islands". In Kosrae, it seems, most middle-aged adults are now condemned to develop type 2 diabetes, coronary heart disease and hypertension, and die young, all because the worst of the Western diet has displaced traditional eating.

In contrast, Shell describes David Barker's belief that much of the current problem results from intra-uterine nutrient deprivation. Barker builds a theory of increased prevalence of obesity, hypertension and diabetes in later life on studies of babies conceived during the Dutch famine in 1944–45. This hypothesis is supported by Barker's work on a British cohort born in Hertfordshire when food was more plentiful. Barker's theory remains plausibly compelling, but Shell addresses counter-arguments only in the bibliography. Intra-uterine nutrition undoubtedly represents just one facet of a series of complex issues that underlie today's pandemic of obesity.

The author concludes her pursuit of the cause of obesity with an onslaught on the