in some way be cut off by biology. It was a broad intellectual thrust throughout the English-speaking world, affecting psychiatry, psychology and education as much as anthropology. Writings by John Dewey, John Watson, B. F. Skinner, Talcott Parsons, Bronislaw Malinowski, Boas (pre-Mead) and M. F. Ashley Montagu were far more influential than Mead's youthful book.

Freeman sees the controversy over that book as overridingly important, saying that "Mead's demonstrably erroneous conclusions about Samoa were seriously questioned for the first time early in 1983. Indeed, before the year was out, the scientific standing of Margaret Mead's Samoan research had become the ruling *cause célèbre* of twentieth-century anthropology." Of course, this exaggerated claim gives Freeman's own 1983 book a crucial role in the modern history of the discipline.

Let me suggest some more plausible candidates for the ruling *cause célèbre* of twentieth-century anthropology: fighting racist theories, demonstrating the flexibility of sex roles, promoting respect for exotic traditions, challenging the ethnocentrism of psychologists, sociologists and historians, fighting colonialism, questioning research methods that 'objectify' non-Western people, preserving disappearing cultures and resisting the generalizations of sociobiology. To every one of these genuine *causes célèbres*, Mead made a significant contribution.

In the interests of full disclosure, I should say that Freeman takes me to task for calling Mead "one of the greatest of all social scientists" and suggesting that she might have deserved the Nobel Prize. I attributed these comments to youthful enthusiasm (they occur in a 1982 book of my own) until I checked the context. I described then-current knowledge of biological bases of human behaviour, and, in the forthcoming second edition, as in the first, my overall viewpoint on this is closer to Freeman's than to Mead's.

Yet I stand by my strong statements about her. As the context makes clear, I was moved to such praise by re-reading Mead's 1948 book *Male and Female*, which includes material not just on Samoa but on seven different traditional cultures she had studied directly. She used ethnographic data from these and other cultures to launch a frontal assault on the then-prevailing Western idea that every major aspect of gender-assigned roles stemmed from biological determinants, and was therefore inevitable and unchangeable.

Today, everyone who is not a religious fundamentalist or an unlettered boob of the male sex agrees that Mead was right and the prevailing idea was wrong. Mead's book, which preceded Simone de Beauvoir's *The Second Sex*, Betty Friedan's *The Feminine Mystique* and all the feminist sociology that followed, sowed the seeds of freedom and equal opportunity now enjoyed by millions of women in the West and, increasingly, by scores of millions throughout the world.

Still, as my use of her work showed, she also provided the facts needed to show some of the *limits* of sex-role variability, especially in physical aggression. This does not change her fundamental conclusions, nor, certainly, the policy implications, but it modifies Mead's view to some extent. What greater tribute could an anthropologist have than to have provided ethnographic data on disappearing cultures that a later author could use to qualify her conclusion? As anthropologist Melvin Ember has said, Mead was a natural historian of human societies. A Nobel Prize went to Niko Tinbergen, Konrad Lorenz and Karl von Frisch in 1973 for work on the natural history of animal behaviour. A Nobel Prize might well have acknowledged Mead's work, which had much further-reaching consequences.

Mead published more than 30 books, of which *Coming of Age in Samoa* was the first and one of the shortest. It was very popular and it made her name, but it does not have the importance Freeman accords it in the history of American anthropology, nor even in Mead's reputation. Through her other books, hundreds of articles, museum exhibits and countless interviews and speeches, she helped make it necessary to consider the habits and practices of non-Western cultures before making generalizations and certainly before making policy.

She promoted breast-feeding when American paediatricians sought to abolish it, and opened the minds of obstetricians about natural childbirth in an era when millions of babies were born heavily sedated. She helped change thinking about child-rearing, education, sex, menopause, ageing and race, based on her own and others' fieldwork in cultures once considered too exotic to be relevant. Mead trained dozens of anthropologists and inspired hundreds of others, many of whom went on to criticize her work and challenge her views. She was opinionated, outspoken and easy to disagree with. Provoking disagreement was part of her personal style.

She got some things wrong? Mendel recorded data too good to be true, Darwin was a Lamarckian, Freud belittled the importance of child abuse, Einstein rejected quantum theory, Heisenberg opposed "Jewish" physics and Lorenz published a scholarly article claiming that racial mixture was dangerous. Few are willing to dismiss these thinkers or diminish their contributions because of such intellectual, or even moral, lapses. No doubt it is worthwhile to point out the lapses, and it is at least of historical interest to understand how they developed. In this spirit, Freeman has made a worthwhile contribution to the history of anthropology. But Mead's reputation endures. □

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The shape of infinity

An illustration by Robert McCall of the docking module from the Apollo–Soyuz project, taken from *NASA & The Exploration of Space (With Works From the NASA Art Collection)* by Roger D. Launius and Bertram Lurch (Stewart, Tabori & Chang, $60).

Unstable door to the future of computing

The Feynman Processor: Quantum Entanglement and the Computing Revolution
by Gerard J. Milburn
Perseus: 1998. 194 pp. $23, £15.95

John Preskill

During the second half of this century we have witnessed staggering progress in the development of information technology. At present, the pace of progress shows no sign of slowing. But in the early twenty-first century, conventional integrated-circuit technology will approach the fundamental limitations imposed by the atomic size scale. At that stage, continued improvement in computing performance, and the continued expansion of the world economy, may hinge on the development of radically new methods for processing information.

The inescapable principles of quantum mechanics dictate that information encoded at the atomic scale ('quantum information') must differ substantially from 'classical information', such as that encoded in the characters printed on this page. In some ways, quantum effects pose serious challenges for the reliable storage and processing of information. Due to the uncertainty principle, quantum information cannot be read without being disturbed; correspondingly, it is highly unstable and cannot be copied accurately.

But the implications of quantum mechanics for the future of information technology are not all disheartening — far from it. A growing community of physicists and computer scientists are recognizing that a quantum computer (a device that processes information encoded in a quantum state) could have astonishing power. The key to that power is 'quantum entanglement': the parts of a quantum system exhibit peculiar correlations that cannot be easily simulated by any classical device. Properly exploited, quantum entanglement can unleash a new type of massively parallel processing that could never be approached with conventional silicon-based technology. Indeed, a quantum computer operating on just a few hundred atoms could perform (in effect) a number of simultaneous computations far exceeding the number of atoms in the visible Universe! Thus a quantum computer, if and when constructed, will perform in the blink of an eye certain computations that would run for eons on today's supercomputers.

A reader seeking an accessible account of these exciting developments could hardly do better than to consult *The Feynman Processor* by Gerard Milburn. (The title honours the physicist Richard Feynman, who presciently recognized the potential of quantum computing in the early 1980s.) Milburn, a professor of theoretical physics at the University of Queensland, writes in a light and inviting style (some of the jokes are actually funny), but the content of the book is serious and highly ambitious. Milburn knows his subject well, and guides the reader through the intricacies of quantum randomness, quantum correlations and quantum information processing at a surprisingly sophisticated level.

Informed opinion about the prospects for quantum computing covers a wide spectrum, as enthusiasm for the potential power of quantum information processing is tempered by awareness of the immensity of the technological challenge. Milburn sides squarely with the optimists, stating: "a quantum computer is not only possible, but inevitable. It may take decades, perhaps a century, but a commercially viable quantum computer is a certainty."

That snappily optimistic tone energizes much of the book. A fine example is Milburn's attitude towards the irreducible randomness of the quantum world. The outcome of a quantum measurement cannot be predicted with certainty, even by someone with complete information about the system being measured. This cosmic dice game, so distressing to Einstein, is to Milburn only a cause for wonder and exhilaration; he exclaims that "the universe is an inexhaustible source of information, a bottomless reservoir of surprise".

Considering how hard Milburn works to keep the presentation entertaining and understandable, he packs an impressive amount of material into less than 200 pages, and the typical reader will be challenged to follow the carefully woven arguments in detail. The diligent reader will be amply rewarded with an assortment of insights into the elements of quantum algorithms, the perplexing properties of quantum information and the schemes for processing it that are now being pursued in laboratories around the world.

Naturally, so ambitious a book is not without flaws. For example, the discussion of quantum teleportation gives a misleading impression about the amount of classical communication required to perform this feat. I also feel that Milburn's discussion of the foundations of computation muddles the distinction between computability (in principle) and tractability (in practice). Even a careful reader might easily draw the incorrect conclusion that a classical computer is incapable of simulating a quantum computer. In fact, such a simulation is not impossible, only woefully inefficient.

Despite a few such quibbles, I recommend this gracefully written and informative book to non-specialists seeking an up-to-date, accurate and uplifting perspective on the profound potential of quantum information processing. □

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Tides in our time

Tides: A Scientific History
by David Edgar Cartwright
Cambridge University Press: 1999. 292 pp. £45, $69.95

Paul Melchior

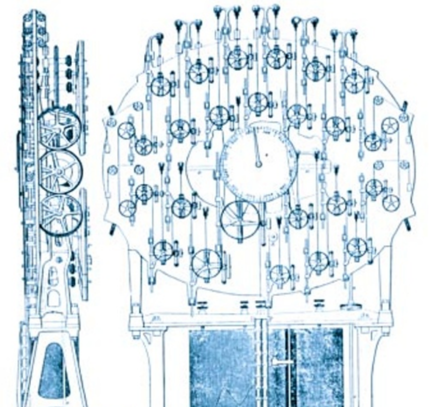
No comprehensive account of how we have come to understand the striking phenomenon of tides has been published since 1911 with the re-released edition of *The Tides and Kindred Phenomena in the Solar System* by George H. Darwin. Now comes David Cartwright's *Tides: A Scientific History*, a major contribution to the history of the astronomical and geophysical sciences, filling that serious gap in the scientific literature.

Our centuries-long struggle to identify the astronomical and geophysical causes of tides in all their diverse manifestations has not been without trials and errors. The road often led up blind alleys, but the course had become less tortuous and the path ahead clearer by the end of the seventeenth century. However, the most likely definitive solution has been found only in the past 20 years.

Cartwright reminds us that Pierre-Simon Laplace had written: "... *le problème des marées est le plus épineux de toute la mécanique céleste!*" Just as this "thorny problem" is finding a solution, it is timely that a leading specialist should write its history. The book testifies to Cartwright's great erudition and presents considerable and often original work. His description of the observations and mathematical advances that make up the history of the science of tides is clear, rigorous and enjoyable. Over the 300 pages, none of which is superfluous, Cartwright's sequence of chapters takes on the rhythm of the history.

The author comes up with some surprises; he points out, for example, that the term 'Coriolis acceleration', which is frequently used by scientists, was introduced by Laplace before Coriolis was even born. Or, the fruit of his own research, he tells us that the first person to observe the semi-diurnal oscillation in surface barometric pressure in the tropics was Robert de Paul, chevalier de Lamanon, during the journey of the explorer J.-F. Galaup de La Pérouse in 1785.

Cartwright describes the apparently contradictory facts available in the 1800s that the Moon's motion seemed to be increasing, that the distance between the Earth and the Moon seemed to be increasing by around 3.6 centimetres every year, and



A mechanical tide predictor built in 1877–79 and designed by Edward Roberts.