"primarily a scientific biography" of Nernst, and it is just that: a long, carefully constructed trek through his published papers and associated studies from his contemporaries, as they apply to the scientific problems he investigated. Electrochemistry, thermodynamics, high- and low-temperature studies of the properties of materials, even his invention of an electrolytic lamp, are admirably woven together as the logical outcome of his own background and the scientific problems facing physical chemistry at the turn of the century. This was an exciting period in physical sciences, when atomism finally won the day against positivist diehards like Wilhelm Ostwald, and when radical theoretical changes appeared on the scene with Planck's quantum theory and Einstein's "*annus mirabilis*".

All of the heroes and villains of our textbooks appear here, but, of course, they are not judged as such by the author. Ludwig Boltzmann, Nernst's early mentor who sowed the seeds of atomism in his students; Svante Arrhenius, who first proposed the theory of electrolyte dissociation; Planck's early sorties into the field of thermochemistry; Kamerlingh Onnes, discoverer of superconductivity (a phenomenon partially anticipated by Nernst during the period of his low-temperature studies); Fritz Haber, of the ammonia synthesis process, who, together with Nernst, participated in the German poison gas project during the First World War.

There are some shortcomings to the book, understandably so in such an ambitious undertaking. It is questionable whether Nernst was "a key figure in the transition to a modern, quantum theoretical physical science", as the author claims. And with reference to thermodynamics, Nernst's heat theorem is indeed often called "the third law of thermodynamics" in treatises on the subject, but just as often it is not given that distinction, because it isn't logically comparable to the all-encompassing first and second laws. Barkan uses Helmholtz free energy to illustrate thermodynamicists' need for a means to predict the conditions under which reactions occur spontaneously, but she never mentions the Gibbs free energy or the Gibbs chemical potential, which are more commonly used today, more useful and which had already been published by the period covered in the text.

Some of the key scientific figures, whose work is described in such meticulous detail, emerge as rather nebulous figures. The conflict between Planck and Nernst, for example, over the latter's thermodynamic treatment of electromotive force is given an entire chapter, but not much emerges that gives insight into the characters involved. Only in the description of the 16-year battle by Arrhenius to prevent the Nobel Committee from awarding Nernst the coveted prize do we get a glimpse of men rather than scientists. And here, when the last word has been read, one is moved to wonder if Nernst may have been more sinned against than sinner.

The final paragraph of Barkan's book, summarizing the conclusions based on her research, states "The post-1895 revolution in the physical sciences happened individually, collectively, and in a variety of locales. It did not occur only because industry, the state, and the rising middle classes impinged and led to this transformation; or because science and scientists contributed to these social, political changes. Rather, it happened because particular experimental, theoretical, technological agendas were developed by specific people, research groups, countries, in unique ways because of distinctive, special circumstances."

But although the prose is somewhat ponderous, could this possibly be an admission that individual scientists actually lead the way in scientific progress? And that individual scientists are prompted in what they aspire to by other individual scientists who preceded them?

In the final analysis, Barkan's book provides an exceptionally convincing account of an era that is probably of greatest interest to physical chemists. Perhaps the narrow focus of the subject matter on a single person — one, moreover, whose place in the gallery of the greats is a matter for argument — throws a more concentrated light on the subject than would an historical tome of the period as a whole. We recommend this book, but, because it includes much that is controversial, we suggest that it be read in parallel with other recent books about the history of physical chemistry, for example Keith Laidler's *The World of Physical Chemistry* (Oxford University Press), or John Servos's *Physical Chemistry from Ostwald to Pauling: The Making of a Science in America* (Princeton University Press), which have a different perspective, but cover much the same ground in scientific content. □

Charles Tanford and Jacqueline Reynolds are at Tarlswood, Back Lane, Easingwold, York YO61 3BG, UK.

Quantum behaviour

Introduction to Quantum Computation and Information
edited by Hoi-Kwong Lo, Sandu Popescu and Tim Spiller
World Scientific: 1998. 348 pp. $52, £35

David P. DiVincenzo

Pure information, increasingly divorced from the physical products of farm and factory, is the lifeblood of modern civilization. Or so we are told. In our networked world, the digitized, packetized, encrypted creations appearing on our screens seem to have less and less to do with the ink and paper of which they used to be made. But the scientists who deliver these ethereal forms to us are increasingly concerned with how the processing and delivery of information is affected by its physical embodiment.

As the miniaturization of information progresses to its inevitable endpoint of one bit per atom, the unintuitive and paradoxical physics of the quantum will apparently increase our capacity to process and deliver information even further. The watershed theoretical developments of the past few years have shown that computations that are intractable on computers based on the laws of classical physics, such as the prime factorization of an integer, may become feasible if we use the quantum nature of the matter making up the computing device. Further-

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more, we can communicate more securely and efficiently if we pass quanta rather than bits over our networks.

These developments are admirably reviewed by the contributing authors to *Introduction to Quantum Computation and Information*. The book fills a gap between the turgid prose of the burgeoning research literature and the superficial accounts in the popular press.

Adriano Barenco lays out the basics of the factoring and searching quantum algorithms that captured the attention of much of the quantum-physics community. The first few chapters develop the basic language of quantum communication, and the unique features of the quantum state of separated quanta that we refer to as 'entanglement'. Michael Berry gives one of the most concise and correct definitions of quantum teleportation seen anywhere: "the dissolution of an object in one place in a way that enables it to be perfectly reconstituted elsewhere."

The theory of quantum cryptography and the extensive experiments and efforts at deployment in the field are also well surveyed. Other chapters deal with experimental efforts to implement quantum information processing in ion traps and in nuclear magnetic resonance spectroscopy.

Although the book's theoretical chapters will be useful for a long time, the experimental discussions may soon become obsolete in the face of entirely new approaches to quantum information processing, such as those provided by solid-state physics.

A striking feature of quantum information theory is that error correction is possible in quantum information processing. It was a great surprise that quantum error correction could be done even in principle, since the quantum phase is among the most fleeting, delicate and easily destroyed quantities in physics. The protocols that Andrew Steane and John Preskill helped to develop are not particularly simple or easy to understand, but their chapters are carefully constructed and very informative.

Preskill offers some of the most intriguing ideas in the book. There is a longstanding question of how the irreversible physics of black holes permits the quantum behaviour of our world to be apparently reversible to high precision. Preskill suggests that the true theory of gravity incorporates quantum error correction mechanisms that hide the irreversibility of gravity from our observations. If these ideas prove to be true, that most unphysical of quantities, pure information, may after all be capable of informing our understanding of the physical world in a most profound way. □

David P. DiVincenzo is at the IBM T. J. Watson Research Center, PO Box 218, Yorktown Heights, New York 10598, USA.

Science in culture

HULTON GETTY

The Café Scientifique

www.aesops.force9.co.uk/cs/index.htm
Duncan Dallas

Science discovers café society, once the domain of poets and writers.

The Café Scientifique started last May in Leeds. I happened to read the obituary of Marc Sautet, the founder of the French '*Cafés Philosophiques*', where people meet to discuss philosophy in cafés on Sunday mornings. It occurred to me that the British would never take this up, as they don't take philosophy seriously enough, but they might be prepared to discuss science — a subject they respect.

So in a local wine bar, I advertised an evening "where, for the price of a cup of coffee or a glass of wine, anyone can come to discuss the scientific ideas and developments which are changing our lives". On the first evening, with a speaker on Darwinism, I had no idea whether the audience might consist only of myself and a few friends.

In the event, between 40 and 50 people turned up, virtually the capacity of the café, and this has been the average size of the audience since then. There are a few regulars, but many new faces appear each week. We meet fortnightly, and invite a speaker to talk for about half an hour. Then there is a break to replenish our glasses, followed by questions and answers for an hour. Interest has been such that another Café Scientifique has been set up in Nottingham, with a further one planned for Newcastle.

Nowadays it appears necessary to fund university chairs to study how to make the public understand science. So why has this format worked so well?

There is no agenda, hidden or overt, to defend or sell science. If people don't like what they hear, they object forcefully. The subjects, or speakers, are picked because they are what people want to hear and they are often controversial. The audience sets the agenda, not the scientists. Not surprisingly, the biosciences feature heavily, but the café has also tackled chemistry, physics, maths and IT. The venue, a café-bar, is where the audience feel comfortable. The atmosphere is friendly and convivial, rather than academic and competitive. This is not a 'self-improving' audience, in the way that Victorian scientific societies arose. People don't just want to listen. They want to participate and be heard on equal terms with the scientists.

It is also, as it turns out, an income-generating idea for the wine bar, so there are no start-up or organizational costs. Indeed, we pay the speakers' expenses by passing a hat, '*le chapeau scientifique*', round the audience. Since the Café Scientifique works in a suburb of Leeds (not even the university suburb), it could work anywhere.

Although I didn't know it, at around the same time in France, other Cafés Scientifiques were appearing, no doubt also inspired by the *Cafés Philosophiques*, so it looks as though it is an idea of its time, possibly even a movement.

There may well be something of interest happening here, something of real importance to science, and I use an analogy from medicine. In the late 1970s, medicine was a successful, authoritarian profession, rather like much science today. By and large, patients gratefully accepted any treatment from doctors. During the 1980s all of this changed —the fitness movement started, alternative medicine became established, funding crises proliferated, AIDS became a problem, self-help groups and ethics committees grew up, anxiolytic drugs were found to be addictive, and so on. Today, medicine is a battleground of politics, economics and philosophy. This has not stopped the progress of orthodox medicine, but doctors now work in a very different environment, subject to different constraints and conditions.

Since the end of the Cold War, science has come to the centre of the agenda in environmental politics (global warming), economics (BSE), consumer choice (GMOs) and medicine (genetics).

Under these circumstances science can no longer be taken on its own terms. Many new ways of addressing science will be invented, not all of them rational or favourable. The Café Scientifique is just a harmless straw in what might become a cold wind. What is critical is that scientists don't repeat the early mistakes made by doctors, who often buried their heads in the sand and hoped the new attitudes would go away. Scientists can no longer define the terms of the debates about science. □

Duncan Dallas is at XYTV, The Old Stables, 7 Regent Street, Leeds LS7 4PE, UK.