as a link between Maxwell and Einstein, connecting the physics of two centuries.

In the end, however, something remains beyond reach, even for Cercignani. "We can conjecture, but we cannot present conjectures as proved circumstances. Thus, we must leave a veil of mystery over the final act of the life of Ludwig Boltzmann." □

G. F. Bignami is at the Italian Space Agency and University of Pavia, Via E. Bassini 15, 20133 Milan, Italy.

Aiming for that goal of zero emission

Green Chemistry: Theory and Practice
by P. T. Anastas and J. C. Warner
Oxford University Press: 1998. 134 pp. £45, $85

Green Chemistry: Frontiers in Benign Chemical Synthesis and Processes
edited by P. T. Anastas and T. C. Williamson
Oxford University Press: 1998. 364 pp. £65, $115

Roger Sheldon

In 1856, W. H. Perkin, who was 18 years old at the time, attempted to synthesize quinine by dichromate oxidation of a raw material obtained from distilled coal tar. This resulted in the serendipitous discovery of the first synthetic dye, aniline purple. Within a few years a commercial plant was in operation, and this is generally recognized as the first industrial organic synthesis. The organic chemical industry was born, and the next 100 years witnessed the remarkable contributions of synthetic organic chemistry in increasing life expectancy, providing food, clothing and shelter and improving the quality of life in general.

The turning point in this remarkable success story came in the early 1960s, with the realization that a price was being paid for these achievements. The publication of Rachel Carson's *Silent Spring* in 1962 alerted the public to the negative effects of the accumulation of synthetic chemicals, such as DDT, in the environment. The environmental movement was born, and for the next three decades much effort was devoted to studying the effects of various synthetic chemicals on the environment, a recent example being the role of chlorofluorocarbons in the depletion of atmospheric ozone. The emphasis was clearly on the products rather than on the processes by which they were being produced.

In the 1990s, we are now focusing on the processes used in synthesizing organic chemicals. And the conclusion is clear: many of these processes generate enormous waste, for example as inorganic salts in aqueous effluents and volatile organic molecules in air emissions. The cause is also clear: many industrial organic syntheses use antiquated technologies involving stoichiometric inorganic reagents such as the dichromate oxidation used by Perkin almost a century and a half ago. Historically, as Paul Anastas and John Warner point out in *Green Chemistry: Theory and Practice*, synthetic chemists have not been particularly environmentally conscious, since their involvement was at the beginning of the chemical synthetic chain whereas problems were mostly encountered at its end.

The solution is the replacement of these technologies with cleaner catalytic alternatives. The emphasis is on eliminating waste at source — primary pollution prevention — rather than finding incremental end-of-pipe solutions. This has now become known as green chemistry, and is defined by Anastas and Warner as: "The utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products". The tools of green chemistry are alternative feedstocks, solvents and reagents, and catalytic versus stoichiometric processes. And the book introduces and explains the concept of atom efficiency in organic synthesis — fundamental to pollution prevention. (However, I found the treatment rather superficial, and was surprised to read that light is considered a feedstock.)

Hence, the concept of green chemistry encompasses both alternative products and alternative processes. It is a useful working definition, but concentrates too much, for my taste, on hazardous substances rather than the goal of reducing all waste (zero-emission plants).

The book defines the 12 principles of green chemistry — described as the Hippocratic oath for chemists. The first principle is that it is better to prevent waste than to treat or clean up waste after it is formed; the other 11 can be roughly paraphrased as: processes should be atom- and energy-efficient, use renewable rather than depleting raw materials and avoid using toxic and/or hazardous reagents and solvents, and products should be designed for non-persistence in the environment. The concept of green chemistry is closely related to, or perhaps even synonymous with, that of sustainability (defined as the ability to maintain the development of the quality of life while not compromising the ability of our progeny to do the same).

The examples of green chemistry used are predominantly taken from the Green Chemistry Challenge Awards, which are sponsored by the US Environmental Protection Agency and, consequently, are heavily biased towards the United States. And some are rather contrived — a broad scope is implied for a photochemical alternative to Friedel Crafts acylation, but it is actually very limited.

Anastas and Warner's prediction of future trends is a mixed bag of well-defined goals, for example new catalytic oxidation technologies with O_2 or H_2O_2, and rather nebulous and/or contrived concepts such as "biomimetic multifunctional reagents" and "combinatorial green chemistry" (whatever that may be).

Green Chemistry: Frontiers in Benign Synthesis and Processes, edited by Anastas and Tracey Williamson, his colleague at the Environmental Protection Agency, contains more chemistry for chemists to get their teeth into. It is a useful collection of articles devoted to different aspects of green chemistry and is complementary to the Anastas/Warner book. One chapter (and the foreword) is written by Barry Trost, the champion of atom efficiency in organic synthesis.

Again, however, the contributions are overwhelmingly biased towards US academia and, as a result, the examples tend to be rather dry and concentrate on the authors' own work, thereby failing to provide either an overview or industrial relevance for the topics. It is also a pity that there are not more contributions from industrial groups — Monsanto, Mitsubishi, Rhône-Poulenc and Lonza come readily to mind. □

Roger Sheldon is in the Department of Organic Chemistry and Catalysis, Delft University of Technology, Julianalaan 136, 2628 BL Delft, The Netherlands.

Information, information

The Touchstone of Life
by Werner R. Loewenstein
Oxford University Press: 1999. 366 pp. $30

Nancy Lane

Information — biomolecular information — is this book's central character, and the story tells how living systems have evolved. According to Werner Loewenstein, evolution is guided by "the principle of information economy in self-developing systems, by an accretion of information circles in a process of least information cost". To grasp this argument, one must read on, crossing a terrain of historical detail and complex metaphor.

Starting with the Big Bang and the origin of the Universe, Loewenstein sets up a battle between two information systems, with information-conserving connections (information loops and self-catalysing systems) winning the day. The text, peppered with intriguing facts and often speculative figures, then proceeds to the complexities of modern cellular biology. A major theme is cell communication. The specificity of biological control and its strict information economy are also stressed throughout. Possible mechanisms for the cellular basis of cancer, theories of neuronal communication and, especially, the thorny issue of the basis of human consciousness are all dealt with in some detail, albeit, unsurprisingly, inconclusively.

Alas, the story's complicated grandeur will probably be incomprehensible to anyone not familiar with biophysics and molecular biology, while those who are will already know it well. For whom, then, is the tale told? This book is not for lay-readers, so perhaps it is for those with a background in the biomolecular sciences who want to be brought up to date, or those who want to brood on our origins.

Loewenstein's extensive musings and explanations are generally far from tedious. Indeed, he has clearly thought long and hard about how to present complex concepts and what metaphors will be effective. Concepts of "the circus", "loops within loops", "multiplex" forms of apparatus and driver "demons" enliven the arguments. He weaves his story in an engrossing theatrical context, centring on the conservative forces of "Lady Evolution" that led to the cellular subunits comprising today's organisms, and beyond to cell subordination and differentiation.

There seems little doubt that Loewenstein sees this book as an opportunity to broadcast his contribution to the field of cell-to-cell communication and the control of cell growth. Channels — his consuming passion — are paid particular attention. His bias towards the importance of his own laboratory's work, and his tendency to ignore that of other, particularly non-American, labs is striking. The blurb even claims that Loewenstein is the "man who ... opened the field of cell–cell communication".

Loewenstein plumbs the known depths of cellular and molecular biology with verve, always attempting to set the facts in the context of how the processes might have evolved and why they need to be so sophisticated and complex. In all this he succeeds in gripping fashion, yet the demands he makes of his readers may well deter all but the highly knowledgeable or utterly determined. □

Nancy Lane is in the Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK.

Science in culture

Babes in bottles

The anatomical art of Frederik Ruysch

Martin Kemp

The sight of pickled babies and their severed parts, floating in jars of balsamic liquor, adorned with lace cuffs, elaborate hats and festoons of beads, is bound to make the modern spectator feel uneasy. Yet seventeenth-century visitors to the "cabinet" of Frederik Ruysch in Amsterdam appear to have expressed no disgust. The science and aesthetics of anatomical preparations were clearly very different from those in a modern anatomical museum.

Dr Ruysch was Praelector Chirugiae et Anatomiae for the City of Amsterdam over a remarkable span of time, from 1667 until his death in 1731, as well as serving as the supervisor of its botanical garden. He was the subject in 1670 and 1683 of two paintings in the famous series of Dutch "anatomy lessons", of which Rembrandt's recently restored "Anatomy of Dr. Nicolaes Tulp" is the most celebrated. An acclaimed teacher and popular public dissector, Ruysch gained international fame for anatomical preparations made by his secret techniques of injection, in the form of isolated systems such as blood vessels and of whole corpses prior to dissection.

One witness to Ruysch's collection delighted in "groves of plants and designs of shell-work with skeletons, and dismember'd limbs ... with apposite inscriptions from the Latin poets". His grand house in Amsterdam became a tourist attraction, visited by "generals of armies, ambassadors, electors, and even princes and kings". One such monarch, Tsar Peter the Great of Russia, was so impressed that he purchased the whole ensemble in 1717 for the princely sum of 30,000 guilders and installed it in his new city of St Petersburg, where many specimens still survive in the Kunstkammer of the National Academy of Sciences.

One lost exhibit, illustrated in a folding plate in Ruysch's *Thesaurus Anatomicus* of 1717, took the form of a small mountain scattered with gall, kidney and bladder stones on which flourishes a forest of injected vessels. The elaborate tableau is completed with three grieving infants' skeletons, creating a miniature 'theatre' on the theme of the transience of life. The "trees" of vessels and bodily rocks stress the microcosmic conception of the human body as a "lesser world".

Many of the preparations displayed the whole or parts of babies, whose small corpses were available to him through his obstetric activities and were readily susceptible to injection. Ruysch did not concentrate on the kind of monstrous deformities that attracted popular curiosity, but focused instead on preparations that aspired to evoke the beauty of "innocents", dead before their time. In the Kunstkammer, we see amputated limbs emerging from lace cuffs, tenderly supporting a dissected heart, an intact placenta. An eye dangles from tiny fingers on a fine thread in an example remaining in Leiden. In the above example from St Petersburg, now housed and bottled far more plainly than in its original context, an infant's head, horizontally sectioned to reveal the open cranium, conceals its severed neck behind a fine scarf of lace, while its glass eyes regard the enquiring viewer with an eerie similitude of consciousness.

M. KEMP

Ruysch's "Head of Infant with Dissected Cranium and Glass Eyes", from the Kunstkammer of Peter the Great in the Museum of Anthropology and Ethnography in St Petersburg.

Having experienced fleeting lives, at best, Ruysch's infant subjects have been accorded a kind of immortality, cheating rigor mortis and even long-term decomposition. At least, this is how they were seen at the time. As a poem printed in Ruysch's *Thesaurus* said, "Through thy art, O Ruysch, a dead infant lives and teaches and, though speechless, still speaks. Even death itself is afraid." □

Martin Kemp is in the Department of the History of Art, University of Oxford, 35 Beaumont Street, Oxford OX1 2PG, UK.

New Journals

This year, *Nature*'s annual new journals review supplement will appear in the issue of 2 September. Publishers and learned societies are invited to submit journals for review, as well as details of any eligible electronic journals, taking note of the following criteria:

- Journals must have first appeared during or after June 1997 and issued at least four separate numbers by the end of May 1999.
- Journals covering any aspect of science are eligible, although those dealing with clinical medicine and pure mathematics are excluded, as are newsletters and publications of abstracts.
- Frequency of publication must be at least three times a year.
- The main language is English.
- Deadline for submission is 5 June.

Please send at least four different issues (the first, the most recent and any two others) of each eligible title, together with full details of subscription rates, to: Isobel Flanagan, *Nature*, Porters South, Crinan Street, London N1 9XW, UK. Tel: +44 (0)171 843 4542. e-mail: i.flanagan@nature.com