cepts of similar intellectual power for the science of self-organization. He has identified several candidates—the edge of chaos, the complexity catastrophe, the topology of combinatorial spaces, and self-maintaining organizations in random grammars. If his project is to be successful this is the way to go. But suggestive as many of his proposals are, it is not clear whether they are just facets of a deeper principle yet to be discovered or what their actual range of legitimate applications and their explanatory potential are. For instance, the dynamical properties of systems at the edge of chaos, as expounded by Christopher Langton, are an important discovery, but how can we ensure that this concept does not degenerate to an empty metaphor for everything that exists somewhere between two extremes? It is not that Kauffman does not see the difference between an empty metaphor and a scientifically valid concept. The question is rather how to recognize it in practice. I hope that Kauffman's book will be a strong stimulus for many scientists to search actively for the principles that govern the organization of living states of matter.

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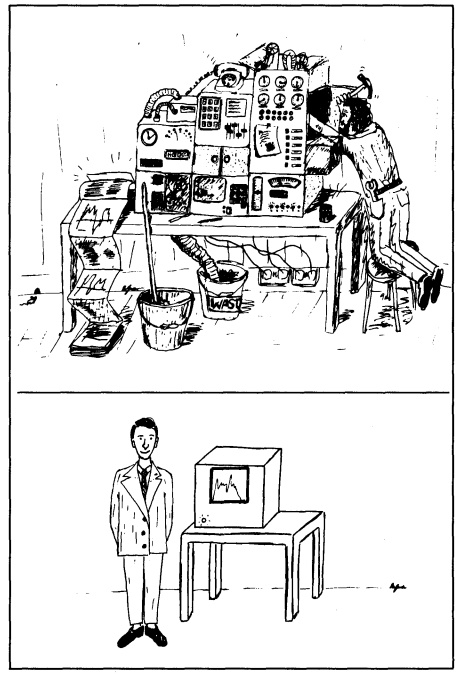
## Cell Measurement

**Flow Cytometry.** First Principles. ALICE LONGOBARDI GIVAN. Wiley-Liss, New York, 1992. xiv, 202 pp., illus. Paper, $34.95.

A flow cytometer measures physical and chemical characteristics of single cells or organelles passing through the apparatus in a fluid stream. On the basis of measurements of light scattering and of the fluorescence of labeled antibodies and other dyes, subpopulations of cells in mixed populations can be identified, counted, subjected to quantitative analysis, and physically separated (sorted) for further study.

Flow cytometers perform the T lymphocyte counts used to monitor the course and treatment of HIV infection and have also been used to isolate human chromosomes for the construction of genetic libraries, to separate X- and Y-chromosome–bearing sperm, to identify the elusive hematopoietic stem cell, to count single virions and large molecules, and to reveal at least one widely distributed but previously unknown genus of marine microorganisms.

The first commercial flow cytometer capable of fluorescence measurements appeared in 1970. The first book on flow



"Two opposing fantasies of what flow cytometry is all about." [From *Flow Cytometry*, drawings by Ben Givan]

cytometry appeared in 1980; a thousand copies were sold. There are now approximately 7000 instruments worldwide, and they help generate seven of every thousand new biomedical publications. The instruments themselves have evolved from temperamental behemoths, now, like the dinosaurs, on view at the Smithsonian, to user-friendly benchtop systems employing personal computers for data acquisition and analysis. The user-friendly instruments, however, demand an increasingly sophisticated diet of cell samples stained with three or four different fluorescent reagents, and their associated computer monitors yield multicolored displays resembling five-dimensional Rorschach tests and only slightly more susceptible to intuitive objective interpretation.

Although there are now a dozen or so books on various aspects of flow cytometry, Alice Givan's is the only one written for the beginner; Givan leads the novice into a field in which "computer buffs, electronics experts, mathematicians, laser technologists, and organic chemists rub shoulders with biologists, physicians, and surgeons around the bench." In a chatty, matter-of-fact style, the author introduces the instruments and their history, the physical and chemical principles involved in the optical measurements made in flow cytometers, and the methods of data analysis used in the most common applications—characterization of mixed cell populations using fluorescently labeled monoclonal antibodies and analysis of the cell cycle based on measurements of DNA content. She then takes up the uses of flow cytometry in clinical hematology, immunology, and oncology and discusses chromosome sorting and other applications to molecular biology. The last two chapters treat newer areas of interest, including flow-cytometric methods for kinetic measurement of physiologic characteristics such as cytoplasmic calcium ion concentration and for characterization of bacteria and phytoplankton. Many well-chosen illustrations, most of which are taken from the current literature, supplement the text. The book concludes with a brief list of general references and a longer, thoughtfully written glossary.

No book on a field in flux can provide more than a snapshot; *Flow Cytometry: First Principles* does as good a job as any book could in portraying the sense and the direction of motion of the discipline. In the preface Givan states: "I have tried to describe the theory of flow cytometry in a way that also provides a firm (and accurate) foundation for those few who will want to study the technique in greater depth." Writing clearly, and with obvious wit and enthusiasm, she has succeeded.

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## Chemistry of the Cosmos

**Elements and the Cosmos.** MIKE G. EDMUNDS and ROBERTO TERLEVICH, Eds. Cambridge University Press, New York, 1992. xiv, 332 pp., illus. $59.95. From a conference, Cambridge, U.K., July 1990.

Bernard Pagel, the honoree of these proceedings of the 31st Herstmonceux Conference, is an irrefutable argument against general policies of compulsory retirement. After reaching the statutory maximum age for a British civil servant at Royal Greenwich Observatory, where he was a recognized expert on the abundances of the elements in different kinds of stars, he became professor of astrophysics at the Nordic Institute for Theoretical Physics in Copenhagen and is now considered the foremost authority on the amount of helium left from the Big Bang. Somewhere, a farsighted institution undoubtedly awaits the Danish witching hour and further developments in Pagel's interests.

The subject of the book, nucleosynthesis and galactic chemical evolution, is a many-faceted one, requiring an understanding of nearly all of astronomy and significant chunks of chemistry and physics as well. The goal is to

measure the chemical composition of the full range of cosmic objects—stars, galaxies, quasars, and all the rest—and then to figure out how they got that way. En route, we need (i) laboratory data on atomic transition probabilities and other properties, (ii) spectroscopic data on strengths of emission and absorption lines, (iii) enough understanding of radiative transfer to turn those data into relative abundances of all the elements present, (iv) laboratory data and calculations for nuclear reaction rates and products under conditions expected in the early universe and in stars, (v) models of the structure and evolution of stars to tell us which reactions will occur and how long they will take as a function of stellar mass and composition, (vi) an assumption about conditions in the universe 10 to 20 billion years ago (generally the standard hot Big Bang), (vii) plausible scenarios describing the rate of transformation of gas into stars and the mix of stellar masses formed at each stage, and (viii) an intuitive grasp of which comparisons of observation and theory will best test whether we are approaching the right answers.

*Elements and the Cosmos* addresses many aspects of these necessary steps to understanding nucleosynthesis and chemical evolution. Some contributions are very sharply focused on C IV absorption lines in quasars, the gas in a particular spiral galaxy, or the neutron-capture cross section of krypton and zirconium. Others paint with broader brushes. Some of the latter (especially Gustafsson on stellar abundances and Reeves on cosmological nucleosynthesis) are a good starting place for a graduate student or postdoc approaching the topic, and will remain so for some time.

Conference proceedings are an easy target. Besides the unevenness of the contributions, this one has about as many typefaces as it has papers and some ugly pages, but also a useful, comprehensive index. On the positive side, ten such volumes, representing the state of the art in the subfields that most interest you, take up no more shelf space than three months' worth of an archival journal and are much more likely to contain the numbers and references that you need. If the origin and abundances of the elements is one of these subfields for you, this volume will serve the purpose very nicely until the next conference comes along. Moreover, when you reach the age at which you're asked to give historical review talks and after-dinner speeches, the old conference volumes on the bottom shelf will provide illuminating snapshots of "what we knew when."

Pagel began the last session of the conference by saying that "the best thing about a conference is not so much what you learn as what you unlearn." The subject of nucleosynthesis and chemical evolution is not now changing so fast that much unlearning was needed at this gathering. Chances are, then, that the book will remain current long enough for you to order, receive, and read it. Meanwhile, I am very happy to have the review copy among my ten recent proceedings volumes.

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**Astrophysical Disks**. S. F. Dermott, J. H. Hunter, Jr., and R. E. Wilson, Eds. New York Academy of Sciences, New York, 1992. viii, 341 pp., illus. Paper, $85. Annals of the New York Academy of Sciences, vol. 675. From a workshop, Gainesville, FL, Sept. 1991.

**Beginning Again**. People and Nature in the New Millennium. David Ehrenfeld. Oxford University Press, New York, 1993. xiv, 216 pp. $22.

**Beyond Southern Skies**. Radio Astronomy and the Parkes Telescope. Peter Robertson. Cambridge University Press, New York, 1992. xii, 357 pp., illus. $75.

**Comprehensive Dictionary of Physical Chemistry**. L. Ulický and T. J. Kemp, Eds. Alfa, Bratislava, Czecho-Slovakia and Horwood (Prentice Hall), Englewood Cliffs, NJ, 1992. 472 pp., illus. $45. Ellis Horwood PTR Prentice Hall Physical Chemistry Series. Translated from the Slovak.

**Comprehensive Handbook of Psychopathology**. Patricia B. Sutker and Henry E. Adams, Eds. 2nd ed. Plenum, New York, 1993. xiv, 864 pp., illus. $95.

**Concepts of Symbiogenesis**. A Historical and Critical Study of the Research of Russian Botanists. Liya Nikolaevna Khakhina. Lynn Margulis and Mark McMenamin, Eds. Yale University Press, New Haven, CT, 1992. xxxii, 177 pp., illus. $35. Bio-Origins Series. Translated from the Russian edition (Leningrad, 1979) by Stephanie Merkel and Robert Coalson.

**Concise Encyclopedia of Materials Characterization**. Robert W. Cahn and Eric Lifshin, Eds. Pergamon, Tarrytown, NY, 1993. xxviii, 641 pp., illus. $300.

**Concise Encyclopedia of Software Engineering**. Derrick Morris and Boris Tamm, Eds. Pergamon, Tarrytown, NY, 1993. xiv, 400 pp., illus. $300. Advances in Systems, Control, and Information Engineering.

**Creating Artificial Life**. Self-Organization. Edward Rietman. Windcrest (TAB), Blue Ridge Summit, PA, 1993. xvi, 201 pp., illus., + diskette. Paper, $29.95.

**Cytokines of the Lung**. Jason Kelley, Ed. Dekker, New York, 1993. xviii, 640 pp., illus. $175. Lung Biology in Health and Disease, 61.

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**Encounter with Chaos**. Self-Organized Hierarchical Complexity in Semiconductor Experiments. J. Peinke *et al.* Springer-Verlag, New York, 1992. x, 289 pp., illus. $59.

**Energy Efficiency and Human Activity**. Past Trends, Future Prospects. Lee Schipper and Stephen Meyers with Richard B. Howarth and Ruth Steiner. Cambridge University Press, New York, 1992. xiv, 385 pp., illus. $49.95. Cambridge Studies in Energy and the Environment.

**Euthanasia and Other Medical Decisions Concerning the End of Life**. An Investigation Performed Upon Request of the Commission of Inquiry into the Medical Practice Concerning Euthanasia. P. J. van der Maas, J. J. M. van Delden, and L. Pijnenborg. Elsevier, New York, 1992. xviii, 262 pp., illus. $160.50. Health Policy Monographs, vol. 2. Published as *Health Policy*, vol. 22, nos. 1–2.

**Exploring Chaos**. A Guide to the New Science of Disorder. Nina Hall, Ed. Norton, New York, 1993. 224 pp., illus., + plates. Paper, $25. Reprint, 1992 ed.

**Glycoprotein Analysis in Biomedicine**. Elizabeth F. Hounsell, Ed. Humana, Totowa, NJ, 1993. xii, 306 pp., illus. Spiral bound, $49.50. Methods in Molecular Biology, 14.

**The God Particle**. If the Universe Is the Answer, What Is the Question? Leon Lederman with Dick Teresi. Houghton Mifflin, Boston, MA, 1993. xiv, 434 pp., illus. $24.95.

**Granulocyte Responses to Cytokines**. Basic and Clinical Research. Ronald G. Coffey, Ed. Dekker, New York, 1992. xviii, 721 pp., illus. $180. Immunology Series, 57.

**A Guide to NIH Grant Programs**. Samuel M. Schwartz and Mischa E. Friedman. Oxford University Press, New York, 1992. xii, 296 pp., illus. $39.95.

**Information Theory and Molecular Biology**. Hubert P. Yockey. Cambridge University Press, New York, 1992. xx, 408 pp., illus. $69.95.

**Infrared Spectra of Pesticides**. Tom Visser. Dekker, New York, 1993. xii, 425 pp., illus. $175.

**Intellect and Public Life**. Essays on the Social History of Academic Intellectuals in the United States. Thomas Bender. Johns Hopkins University Press, Baltimore, MD, 1993. xx, 179 pp. $31.95.

**Introduction to Chemical Principles**. H. Stephen Stoker. 4th ed. Macmillan, New York, 1993. Variously paged, illus. $40.50.

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**Membrane Interactions of HIV**. Implications for Pathogenesis and Therapy in AIDS. Roland C. Aloia and Cyril C. Curtain, Eds. Wiley-Liss, New York, 1992. xviii, 433 pp., illus. $140. Advances in Membrane Fluidity, vol. 6.

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**Mesoamerican Writing Systems**. Propaganda, Myth, and History in Four Ancient Civilizations. Joyce Marcus. Princeton University Press, Princeton, NJ, 1992. xxii, 495 pp., illus. $49.95.

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**Microscopic Anatomy of Invertebrates**. Vol. 7, Annelida. Frederick W. Harrison and Stephen L. Gardiner, Eds. Wiley-Liss, New York, 1992. xiv, 418 pp., illus. $185.

**Molecular Basis of Neurology**. P. Michael Conneally, Ed. Blackwell Scientific, Cambridge, MA, 1993. xxiv, 296 pp., illus. Paper, $39.95. Molecular Basis of Clinical Medicine.

**Molecular Mechanisms of Immunological Self-Recognition**. Frederick W. Alt and Henry J. Vogel, Eds. Academic Press, San Diego, CA, 1993. xiv, 259 pp., illus. $59.95.

**Probability and Random Processes**. G. R. Grimmett and D. R. Stirzaker. 2nd ed. Clarendon (Oxford University Press), New York, 1992. xii, 541 pp., illus. $80; paper, $49.95.