

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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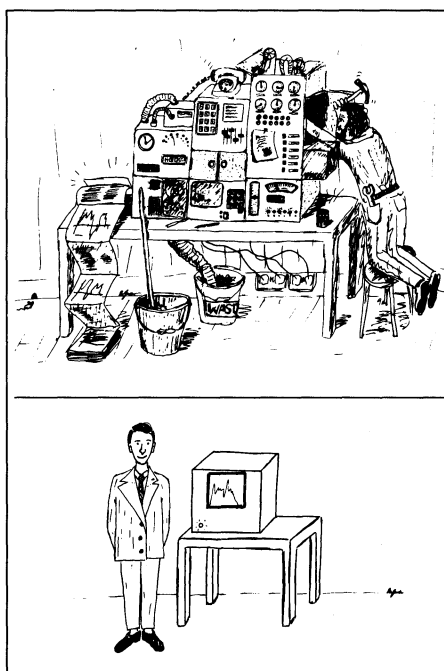
## Cell Measurement

**Flow Cytometry. First Principles.** ALICE LON-  
GOBARDI 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 measure-

ments 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