SCIENCE

Publisher: Richard S. Nicholson
Editor-in-Chief: Daniel E. Koshland, Jr.
Editor: Ellis Rubinstein
Managing Editor: Monica M. Bradford
Deputy Editors: Philip H. Abelson *(Engineering and Applied Sciences);* John I. Brauman *(Physical Sciences);* Thomas R. Cech *(Biological Sciences)*

Editorial Staff
Assistant Managing Editor: Dawn Bennett
Senior Editors: Eleanore Butz, R. Brooks Hanson, Barbara Jasny, Katrina L. Kelner, David Lindley, Linda J. Miller, Phillip D. Szuromi, David F. Voss
Associate Editors: Gilbert J. Chin, Pamela J. Hines, Paula A. Kiberstis, Suki Parks, L. Bryan Ray
Letters: Christine Gilbert, *Editor;* Steven S. Lapham
Book Reviews: Katherine Livingston, *Editor;* Annette Theuring, *Assistant Editor;* Susan Randolph, *Editorial Assistant*
Contributing Editor: Lawrence I. Grossman
Editing: Lois Schmitt (training), Valerie Jablow, *Senior Copy Editor;* Douglas B. Casey, Harry Jach, Erik G. Morris, Christine M. Pearce
Copy Desk: Ellen E. Murphy, *Supervisor;* Joi S. Granger, Beverly Shields, Melissa M. Quackenbos, Kirsten L. Wall; Kameaka Williams, *Assistant*
Editorial Support: Sherryf Farmer, *Supervisor;* Linda Dienavs, Carolyn Kyle, Michele Listisard, Diane Long, Jennifer Mattson, Patricia M. Moore
Administrative Support: Leslie Blizard, Sylvia Kihara, Jeanette Prastein
Telephone: 202-326-6501; **FAX:** 202-289-7562; **TDD:** 202-408-7770

News Staff
News Editor: Colin Norman
Features Editor: John M. Benditt
Deputy News Editors: Tim Appenzeller, Joshua Fischman, Jean Marx, Jeffrey Mervis
News & Comment/Research News Writers: Ivan Amato, Christopher Anderson, Jon Cohen, Faye Flam, Troy Gately, *copy,* Constance Holden, Richard A. Kerr, Eliot Marshall, Richard Stone, Karen Fox, *Intern*
U.S. Bureaus: Marcia Barinaga (Berkeley), Elizabeth Culotta (Durham, NC), Anne Simon Moffat (Chicago), John Travis (Boston)
Contributing Correspondents: Joseph Alper, Barry A. Cipra, Robert Crease, Ann Gibbons, Virginia Morell, Robert Pool, Leslie Roberts, Gary Taubes, M. Mitchell Waldrop
Administrative Support: Fannie Groom, Jennifer Hodgin
Telephone: 202-326-6500; **FAX:** 202-371-9227

Art & Production Staff
Production: James Landry, *Director;* Wendy K. Shank, *Manager;* Laura A. Creveling, Scherraine B. Mack, Linda C. Owens, *Associates*
Art: Amy Decker Henry, *Director;* C. Faber Smith, *Associate Director;* Diana DeFrancesco, *Technical Illustrator;* Holly Bishop, *Graphics Associate;* Elizabeth Carroll, *Graphics Assistant*

Europe Office
Senior Editor: Richard B. Gallagher
Associate Editor: Jeffrey Williams
News Editor: Daniel Clery
Correspondent: Peter Aldhous
Editorial Associate: Catherine S. Siskos
Business Manager: Julie Eastland
Address: Thomas House, George IV Street, Cambridge, UK CB2 1HH
Telephone: (44) 0223 302067; **FAX:** (44) 0223 302068

EDITORIAL

Computing in Science

Computers have changed our lives; their effect on science has been profound. They enable us to analyze and solve problems too complex to be treated analytically; they allow us to examine and process huge amounts of data; they make it possible to control complicated instruments; they facilitate communication. In this issue of *Science* we explore some of the continuing excitement and developments in computers and computing. We present four news articles, three perspectives, and three general articles. Because the field has so much depth and changes so fast, we can only taste a little, but we have tried to choose some aspects of the field that will have a rapid impact on the practice of science and will affect many of us. Computers and computing represent a wonderful integration of fundamental science and technology with almost instantaneous application to important problems in the real world. While this is not a good model for all of scientific activity, it certainly is impressive, to say nothing of being fun to watch.

Baskett and Hennessy analyze microprocessor technology and its impact on computing. They point out three major challenges in creation of high-performance, cost-effective computers: microprocessor performance, parallel computer architecture, and software that can take advantage of these advances. They discuss the first two of these areas. Their analysis also addresses economic issues of microprocessor-based computing and the economic impact of rapid technology improvement.

Hillis and Boghosian discuss an issue which for many of us appeared to be a major problem—programming parallel computers for scientific computation. Their analysis shows that many problems lend themselves naturally to parallel computing and that ultra-specialized algorithms and software are not required. For example, many scientific problems are naturally parallel by virtue of the physical laws that govern them. Interestingly, apparently sequential problems can be made parallel by use of a different algorithm. Thus, taking advantage of improvements in hardware and architecture will be easier than expected.

Forrest discusses genetic algorithms—computer programs that evolve solutions through natural selection. That is, they are modified by some random process (equivalent to mutation or crossover), and then those programs that are most fit are selected or reproduced whereas the least fit ones are discarded. Intriguing intellectually and potentially powerful computationally, this approach is clearly well adapted to take advantage of new technology and seems likely to have a significant impact on the solutions to a variety of important problems.

Our three perspectives address some of these same issues of performance, architecture, and software. Thorndyke and Riganati discuss packaging and integration in massively parallel systems. Buzbee discusses workstation clusters and their use in scientific computing. Wulf deals with networking and our ability to take advantage of advances in computation and communication between scientists in different locations so we can benefit from collaborations.

The news articles address important applications of computing in the scientific arena. One of the major intellectual changes in science has been the ability to accumulate, access, and utilize large databases. This challenge has changed to a substantial extent the kinds of problems that we can solve and the ways we have of thinking about them. Pool, Freedman, Marshall, and Clery all address various aspects of these critical problems from electronic databases, to analysis of the database, to dealing with overloads of information. As computing becomes faster and more powerful, the complexity of problems we can solve increases. Object-oriented programming is revolutionizing the way computer codes are written; Waldrop tells us about the area, what is new, and what some of the future is likely to bring.

As much of science grows and matures, it becomes progressively arcane and daunting, both financially and intellectually to its practitioners. Computing, interestingly enough, continues to become less expensive and more user friendly. It is hard to imagine where science would be without computers. It may be even harder to imagine where it's going to be in the future.

John I. Brauman