SCIENCE

http://www.aaas.org

Publisher: Richard S. Nicholson
Editor-in-Chief: Floyd E. Bloom
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, Pamela J. Hines, Barbara Jasny, Katrina L. Kelner, Paula A. Kiberstis, Linda J. Miller, L. Bryan Ray, Phillip D. Szuromi, David F. Voss
Associate Editors: Gilbert J. Chin, Suki Parks, Linda R. Rowan
Letters: Christine Gilbert, *Editor;* Steven S. Lapham, *Assistant Letters Editor;* Charlene King, *Assistant*
Book Reviews: Katherine Livingston, *Editor;* Jeffrey Hearn, *Editorial Assistant*
Editing: Valerie Jablow, *Supervisor;* Cara Tate, *Senior Copy Editor;* Jeffrey E. Cook, Harry Jach, Erik G. Morris, Christine M. Pearce
Copy Desk: Ellen E. Murphy, *Supervisor;* Sherri Byrand, Joi S. Granger, Daniel T. Helgerman, Beverly Shields, Kameaka Williams, *Assistant*
Editorial Support: Carolyn Kyle, *Editorial Assistant;* Michele Listisard, Diane Long, Patricia M. Moore, Ted Smith, *Manuscript Assistants*
Administrative Support: Sylvia Kihara, Brent Gendleman
Computer Specialist: Roman Frillarte
Telephone: 202-326-6501; **FAX:** 202-289-7562; **TDD:** 202-408-7770

News Staff

News Editor: Colin Norman
Features Editor: Tim Appenzeller
Deputy News Editors: Joshua Fischman, Jean Marx, Jeffrey Mervis
News & Comment/Research News Writers: Linda B. Felaco (copy), Constance Holden, Jocelyn Kaiser, Richard A. Kerr, Andrew Lawler, Eliot Marshall, Elizabeth Pennisi, Kimberly Peterson (intern), Robert F. Service
Bureaus: Marcia Barinaga (Berkeley), Jon Cohen (San Diego), James Glanz (Chicago), Dennis Normile (Tokyo), Wade Roush (Boston)
Contributing Correspondents: Barry A. Cipra, Elizabeth Culotta, Ann Gibbons, Charles C. Mann, Anne Simon Moffat, Virginia Morell, Gary Taubes
Administrative Support: Scherraine Mack, Fannie Groom
Telephone: 202-326-6500; **FAX:** 202-371-9227;
Internet Address: science_news@aaas.org

Art & Production Staff

Production: James Landry, *Director;* Wendy K. Shank, *Manager;* Lizabeth A. Harman, *Assistant Manager;* Laura A. Creveling, Cynthia M. Penny, *Associates;* Leslie Blizard, *Assistant*
Art: Amy Decker Henry, *Director;* C. Faber Smith, *Associate Director;* Katharine Sutliff, *Scientific Illustrator;* Holly Bishop, Elizabeth Carroll, *Graphics Associates;* Preston Morrighan, Patricia M. Riehn, *Graphics Assistants*
Technology Manager: Christopher J. Feldmeier

***Science* International: Europe Office**

Editorial: Richard B. Gallagher, *Office Head and Senior Editor;* Stella M. Hurtley, Julia Uppenbrink, *Associate Editors;* Belinda Holden, *Editorial Associate*
News: Daniel Clery, *Editor;* Nigel Williams, *Correspondent;* Michael Balter *(Paris),* Patricia Kahn *(Heidelberg),* Richard Stone *(Russia), Contributing Correspondents*
Administrative Support: Janet Mumford; Anna Sewell
Address: 14 George IV Street, Cambridge, UK CB2 1HH
Telephone: (44) 1223-302067; **FAX:** (44) 1223-302068
Internet address: science@science-int.co.uk

EDITORIAL

The Metaphor of Distributed Intelligence

Not too long ago, the metaphors of science migrated easily to the realm of political and economic affairs. But today we either avoid scientific metaphors altogether or we lean on a crutch of Industrial Revolution metaphors that are splintering with age. In particular, we continue to rely on the metaphor of the factory—of mechanized mass production—well after it has exhausted much of its supportive force.

Let me propose an updated metaphor that is more appropriate to the times and more muscular in its power to explain: the metaphor of distributed intelligence. In the beginning of the mainframe computer era, computers relied almost totally on huge central processing units surrounded by large fields of memory. The design was much like that of a mass-production factory. Then along came a new architecture called massive parallelism. This broke up the processing power into lots of tiny processors that were distributed throughout the field of memory. When a problem was presented, all of the processors would begin working simultaneously, each performing its small part of the task and sending its portion of the answer to be collated with the rest of the work that was going on. It turns out that this "distributed intelligence" approach is more effective for solving most problems.

But somehow this idea, revolutionary as it was in the computer world, never traveled to other regions of our lives and didn't come anywhere near politics. And that's a shame. Because in the realm of politics or economics or public policy, the metaphor of distributed intelligence has enormous explanatory power. It offers insight into why democracy has triumphed over governments that depended exclusively on a central authority, and it helps explain why private-sector organizations are shedding their middle layers and transferring power, information, and influence to front-line workers. It also helps tell us why scientific concepts sometimes elude the vast majority of our elected officials. Individuals' lack of scientific understanding undercuts support for the pursuit of further understanding, which fosters deeper ignorance, which further erodes support for battling that ignorance. It's a vicious circle.

At the very moment when a new age demands continued investments in science and technology, there are some in Congress who are threatening to turn the clock backward with the largest cuts in 15 years. Their science policy is straight out of science fiction. A few may talk like Johnny Mnemonic, but most support policies designed for Fred Flintstone. They promise to boldly go where no Congress has gone before, but their flight plan will take us into the ground.

If the guiding metaphor is the factory, such proposals don't seem outlandish. After all, the goal of the factory is to crank out more and more of the same thing at a lower and lower cost. Shaving a little here and a little there is smart business. But if the guiding metaphor is distributed intelligence, such proposals are terribly misguided because the circle of riches and research that distributed intelligence can produce is needed now more than ever and has already made a difference in this country. If we abandon our commitment to science and fail to understand the power of distributed intelligence, we risk losing the chaotic and unpredictable breakthroughs that basic science produces.

Here at the edge of a new century, we have a choice of two paths. One path retreats from understanding, flinches in the face of challenges, and disdains learning. It leads to a know-nothing society in which the storehouses of knowledge dwindle, the spigots of discovery are turned off, and missions of exploration are stalled on the ground. This society bases regulations on suspicion instead of science, says that DDT isn't harmful, and claims that global warming is the empirical equivalent of the Easter Bunny. But there's another path—infinitely brighter and considerably more American. It leads to a learning society whose government continues to fund basic science and applied technology and in which the virtuous circle of progress and prosperity is alive and functioning. And it's a trail that's within our power to blaze.

We have in our hands and minds and souls the power to create this learning society, which harnesses the power of distributed intelligence and uses it to improve our lives. As the very embodiment of that ideal, you have an obligation to help make it happen.

Vice President Al Gore

This editorial is adapted from a speech given on 12 February 1996 at the AAAS annual meeting in Baltimore, MD.