idents, authors wield more influence than industrialists, travelers rate more attention than generals. In Rotter's treatment, for example, Katherine Mayo, author of the travelogue *Mother India* (1927), earns more index citations than U.S. Secretary of State John Foster Dulles.

Comrades at Odds illustrates both the virtues and the shortcomings of the new history. Rotter offers a subtle reading of heretofore-neglected source materials, and he adds to our understanding of the cultural side of this difficult relationship. But he sometimes must stretch to argue for the importance of cultural factors. One need not understand the differing roles of family in India and the United States, for instance, to fathom why conservative members of the U.S. Congress abhorred Indian socialism. *Comrades at Odds* provides valuable insights, but it will not supplant the work of more traditional scholars such as Robert McMahon, Dennis Merrill, Dennis Kux, and H. W. Brands.

—Robert M. Hathaway

Science & Technology

COSMIC EVOLUTION:
The Rise of Complexity in Nature.
By Eric Chaisson. Harvard Univ. Press. 274 pp. $27.95

If you want to patent a perpetual motion machine, be sure you have a working model. The U.S. Patent Office, flooded with doodlings by hopeful inventors, has long since decided that it won't examine claims for a *perpetuum mobile* without the article in hand.

Which, of course, rules out a patent, because a perpetual motion machine falls afoul of that ultimate trump card, the Second Law of Thermodynamics. "If your theory is found to be against the Second Law of Thermodynamics," Sir Arthur Eddington once mused, "I can give you no hope; there is nothing for it but to collapse in deepest humiliation."

Roughly speaking, the Second Law states that the disorder in the universe—its entropy—is always increasing. An ordered state, such as a box with hot air on one side and cold air on the other, will quickly deteriorate and become lukewarm throughout. But how can a universe slouching toward disorder have such orderly structures as galaxies, stars, bacteria, and people? To Harvard University astrophysicist Chaisson, this interplay between order and disorder, between energy and entropy, holds the answer to the age-old question, "What is life?"

As Chaisson describes in *Cosmic Evolution*, the Second Law has a little loophole—not really an exception, but a means for eking out an existence in a universe that's inexorably falling apart. Energy lets us make order out of disorder. An air conditioner, plugged into a wall socket, can turn a zone of lukewarm air into one with hot air on one side and cold air on the other, reversing the disorder, at least locally. Organisms do this too, taking in energy in the form of food, which keeps their bodies from literally disintegrating. So Chaisson defines life as an "open, coherent, space-time structure maintained far from thermodynamic equilibrium by a flow of energy through it." This definition covers not only bacteria and people, but stars, galaxies, and planets as well. To Chaisson, the Earth is a living object that differs only in degree from an ostrich or an aardvark.

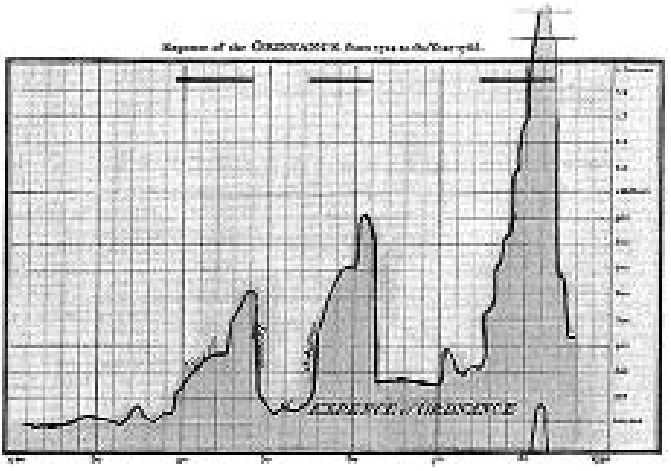
The problem with such a broad definition of life is that it becomes meaningless; cosmic evolution parallels biological evolution only in the most general sense. Still, Chaisson does give the theory some numerical muscle. He analyzes the flows of energy through various objects and shows how these flows seem to be related to the complexity of the objects. The greater the energy flow, the greater the complexity. Though following the nuances of the argument requires a basic grounding in physics, Chaisson's approach leaves one wondering, perhaps absurdly: Are hummingbirds "higher" than humans on the evolutionary ladder? Are jet engines

"alive?" In this creative, thought-provoking book, Chaisson shows how difficult even the most basic scientific questions can turn out to be.

—Charles Seife

WHEN INFORMATION CAME OF AGE: Technologies of Knowledge in the Age of Reason and Revolution, 1700–1850.
By Daniel J. Headrick. Oxford Univ. Press. 246 pp. $29.95

When I taught a course 10 years ago on the history of information, the 18th and early 19th centuries had no strong themes of their own. Before them came the ferment of the printing revolution and elite literacy; after them, the rise of mass communication, with its Faustian bargain of cheap publications on doomed acidic paper. There were, to be sure, superb studies of 18th-century book publishing, of mapmaking, of early probability theory and statistics. But these trees were far better known than the forest.



William Playfair's 1786 study of 18th-century British ordnance expenditures. The thick horizontal lines indicate periods of war.

In his previous works, Headrick, a professor of social science and history at Roosevelt University in Chicago, has chronicled technological developments in the late 19th and the 20th centuries. Historians seldom make bold claims for the period preceding their specialties, but that is what Headrick does here: he deems the years 1700–1850 a period of exceptional innovation, featuring a "cultural revolution in information systems" that prepared the way for developments ranging from the punch card to the World Wide Web.

When Information Came of Age provides a respectful overview not of hardware breakthroughs but of the conceptual leaps made by scientists, scholars, artisans, businesspeople, government officials, and publishers. It begins with monuments of system that were essential to later science—Linnaeus's binomial classification scheme, still the international standard for living matter from E. coli to Homo sapiens; Lavoisier's chemical nomenclature; and metric weights and measures. It reviews the theory and practice of quantification, the still-vibrant faith in the power of population statistics and other numbers to guide policy decisions. Headrick quotes the first director of Napoleon's statistical bureau, who acknowledged the limitations of his work: "The most exact determination of the number of vegetables that France produces will not bring forth one additional cabbage in her gardens."

The chapter on graphic representation suggests that war may be healthy for mapmaking and other arts of information display: colonial conflicts and the revolutionary era helped bring cartography to new heights. Some illustrations from the period are still reprinted in graphics texts as classics for emulation with the latest computerized methods. There was also a new wealth of textual information, led by Diderot's *Encyclopédie* and Samuel Johnson's dictionary. And the nascent U.S. Post Office and the French optical telegraph laid the foundations for today's communication networks.

As Headrick recognizes, some readers will quibble about omissions, such as the Foudrinier papermaking machine that