draw meaning from the data that are available. A nationwide data set of losses from 1975 to 1998 was compiled to assess the trends. Temporal patterns of deaths and injuries, monetary damages, and—in some cases—the number of events are systematically examined by year in chapter 5, and the authors undertake a systematic spatial assessment of the statewide totals in chapter 6. Explanations for some of the patterns are offered, particularly for the most significant disasters and for the states with most events or the greatest losses. Further refinement and evaluation of patterns of economic losses and death are undertaken by normalizing losses by population, land area, and gross domestic product (GDP). The authors advance the discussion from simple descriptions of loss patterns to explanations of the patterns of disaster-loss burden, and some surprises emerge from the arithmetic. For instance, North Dakota, Iowa, and Mississippi not only suffered the greatest monetary losses per capita during the period, but also suffered the greatest losses of property and crops compared to their state GDP! For a final analysis, the authors created an overall hazard score (averaged proportion of the states' contributions to the national totals of events, deaths, and damages) and used it to rank the states. Using this ranking, states were assigned to categories of "proneness," from highest (Florida, Texas, and California) to lowest (Rhode Island, Delaware, Alaska and other small or lightly populated states). The conclusion we are to draw is that the amount of loss a state has experienced indicates its disaster proneness.

Finally, "Charting a Course for the Next Two Decades" by Cutter describes what is needed to produce the models and data appropriate for mitigation and planning assessments. In order for an effective assessment of events and losses to occur, progress is required in several areas: development of vulnerability science, the creation of a national hazard events and losses database, and the establishment of a national loss inventory and events clearinghouse. To do so, Cutter argues, we need to rethink the way we monitor, assess, and manage our vulnerabilities. She briefly describes the shifts needed in data gathering and provision, sustainability and distributive justice, strategic planning, research funding, and societal awareness of issues that influence the prospects for disaster.

While *American Hazardscapes* is intended to provide a broad understanding of the geography of loss due to hazards in the United States, it suffers from its openly acknowledged limitations. Though criticizing the quality of currently available data, the authors use those data to indicate the prospects for future disasters. The elimination of extreme events is no longer believed to be the key loss reduction. Instead, we must identify and avoid places too dynamic for permanent occupation and adjust to the inevitable events in ways that limit prospects for loss. Mitigation must address the vulnerabilities that cause greater exposure and profound upset of our social systems and create more complex catastrophes.

The data employed in this assessment describe (however imperfectly) the losses suffered over two and a half decades. The largest disasters overwhelm the patterns of loss in their analysis. The authors imply, based on proneness rankings, that those who lost the most are the most prone to loss. But in reality, losses are byproducts of the interplay of two dynamic geographies: the pattern of extreme events and the pattern of human use of the landscape. The former is often poorly understood, may not behave consistently, and may operate on greater than twenty-five-year cycles. The latter may change so rapidly that it surpasses our capacity to measure it and map it, and postdisaster land use and human perception may be radically changed. These geographies were outside the scope of this book, however, and given new homeland security efforts and reorganization of the Federal Emergency Management Agency, the past is an even poorer indicator of the future. Key Words: *disaster proneness*, *hazards assessment*, *spatial patterns*, *United States.*

A New Kind of Science. Stephen Wolfram. Champaign, IL: Wolfram Media, 2002. xiv and 1,196 pp., notes, and index. $44.00 cloth (ISBN 1-579-008-8).

Reviewed by Lee De Cola, U.S. Geological Survey, Reston, VA.

Over 350 years ago, Galileo published "Discourses on Two New Sciences," laying the foundations for the science of mechanics. Now Stephen Wolfram has published a similarly titled book in his own bid to foster a new field of inquiry. Only time will judge his success, but given the author's stature, genius, and consummate marketing skill, it is important that geographers be familiar with this work. Although few of us will (or should) read each of the book's 1,200 pages, we can profit from at least some familiarity with its arguments—and for all its bulk, the book is not very expensive. Moreover, it is densely illustrated with many delightful examples of Tufte's (1983) "small multiples." It is written in lecture style, yet some will find it digressive and overly conversational (the author himself attempts to excuse this, but apologies did not diminish my frequent annoyance).

The book may be divided into four major parts. The first six chapters are an exhaustive review of cellular systems: structures composed of a large number of units that simultaneously communicate with just a few of their neighbors according to fixed rules. Although cellular automata (regular arrangements of integer-state units, each with the same neighborhood) are the commonest and simplest examples, Wolfram extends his survey into a wide range of related models, including computational "machines," fractal generators, graphs, and networks, the last probably the most fruitful area of research and the one he develops in greatest detail, for reasons that are made clear below. The argument of this section is that simple systems often generate completely unexpected degrees of complexity. The author stresses his observation about this phenomenon, known in the complexity literature as "emergence," rather too many times for my taste, but it is the foundation for the rest of the discussion.

The second part (chapters 7–10) is a long and often wordy survey of illustrations and applications of cellular systems to such scientific disciplines as physics (the author's home field), chemistry, and biology, as well as their associated subfields. Although a reader wishing to follow the main argument could skip this second part, there is something here for everyone, and the thrust of the discussion is the underlying unity of many scientific models, from mathematics through the physical and natural sciences. Yet, as a geographer with strong interests in the currently hot field of biology, I was somewhat disappointed: in particular, I would have thought such topics as molecular biology, neuroscience, and social insect communication would be obvious application areas. In fact, it may be possible that biological models (with their notions of complexity versus complicatedness and ecology, for example) will shed more light on the problems of "hard" science than we have suspected.

The book's concluding chapters, 11 and 12, constitute its third part, which presents Wolfram's two core arguments. The first point is that, although there are many types of computational systems—hardware, circuitry, and languages from low to high—almost all are members of a broad class of universal machines that can be programmed to do the same basic calculations. Because these operations themselves may, often recursively, be strung together to generate the same kinds of patterns (of which Wolfram shows many examples), all computers are essentially identical. This argument seems quite reasonable (and no doubt explains why many programmers still do everything they need with FORTRAN!), although perhaps parochially grounded in current, limited notions of what constitutes a computer. The final chapter generalizes this argument by introducing the concept of computational equivalence: *any* complexity-generating system—whether on paper, in silicon, or in nature itself—may be regarded as a computer; "almost all processes that are not obviously simple can be viewed as computations of equivalent sophistication" (p. 716). Moreover, if we regard matter, space, and time as aspects of a holistic information system, the universe itself can consequently be regarded as a computer and therefore understood in terms of how it processes states from one instant to the next.

The fourth part of the book—probably more than half of the text—consists of a "notes" section, including detailed expansions of arguments, Mathematica code, and yet more, often-rambling scientific history and speculation. I read or skimmed each of the notes sections along with the corresponding sections of the text. A very fruitful graduate seminar could be built around this material, especially if the class implemented the computer code available on Wolfram's Web site. Although the complete Mathematica software itself is expensive, a cheaper, limited-function subset is available for the examples in the book itself.

The book is important to geographers in three respects. First, it presents a comprehensive review of cellular automata and related models and could be read as a textbook on the subject, although there are more concise treatments. Wolfram develops such models from the point of view of geometry, states, rules, and resultant patterns in a very detailed dialectic that resonates with geography's own preoccupation with process and pattern. However, I was disappointed in the treatments of pattern. Wolfram pays little attention to spatial scale; he ignores spatial statistics and autocorrelation; and the definitions of simple/random/complex/complicated are confused. But any well-informed scientist must understand the fundamentals of cellular systems, which have been relatively untapped as explanatory models (although there are exceptions; see, for example, Couclelis 1992; Clarke and Gaydos 1998).

Second, sections of the book dealing with applications touch on many topics of interest to us, particularly: such fractal/scaling phenomena as streams, fractures, and topography; the partitioning of space; and image processing, including a fascinating multiscale treatment of perception. Geographers themselves have long been intrigued by these topics. Nevertheless, it would be a mistake to wade through these arguments without having thoroughly digested Mandelbrot's (1983) earlier and far more geographically literate book on the geometry of nature.

Third, from a more fundamental geographic perspective, the most fascinating discussions in the book relate to notions of space. I would distill the argument as follows. Western science is built upon models that distinguish among space, time, and matter as separable aspects of a universe that is itself obviously holistic and inseparable. Wolfram calls for a reintegration of these aspects. If the universe (perhaps at a very small scale) is indeed composed of discrete units interacting only with their immediate neighbors, then "at the lowest level space is in effect a giant network of nodes" (p. 475) and time simply the unfolding of evolving patterns. Although this is a crude paraphrasing of an extremely intricate argument, Wolfram's integration obviously goes far beyond geography's modest attempts to reassert the importance of space (!), and since reading the book I have found myself speculating on what it might mean for our own science if indeed "space becomes the only thing in the universe" (p. 474).

I found reading the book an exciting journey, occasionally skipping those parts that were not relevant to the argument, repeated an earlier development, or seemed to have little relevance to my own broad interests. I hope this review will inspire a few readers to examine the book. But the decision to read it from cover to cover rests largely upon the answer to the question: in what sense is this a new science? Because it is so dense, so methodically argued, and so well illustrated, the book might appear to introduce an entirely new model of reality. Yet, given that the specification and behavior of cellular automata are well known, Wolfram has not introduced a new field. Nor is this a new way of doing science, in that during the past half-century, the computer has become firmly established as an analytical partner, an experimental tool, an environment for limitless simulation, and even (à la Newton's clockwork) an increasingly sophisticated paradigm for natural processes. And the argument that a particular entity (forms, atoms, information) is really the fundamental—even the only—thing that exists is an ancient form of ontological speculation. One need only ponder the last paragraph of *The Origin of Species* to appreciate how long we have been in awe of nature's skill at producing complexity from simplicity.[1]

So is the universe really (just) a computer—perhaps a four-dimensional discrete-state icosahedral cellular automaton running on one of $2^{2^{13}}$ possible rules? We shall probably never know, and although Wolfram's book feels a bit like a very old kind of science, it is certainly a beautiful new way of doing metaphysics.

Key Words: *cellular automata*, *computers*, *history of science*, *mathematics*.

Note

[1] "It is interesting to contemplate an entangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us. . . . There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this

planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved."

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A River Running West: The Life of John Wesley Powell. Donald Worster. New York: Oxford University Press, 2001. xii and 673 pp., maps, photos., illus., notes, biblio., and index. $35.00 cloth (ISBN 0-19-5099991-5)

Reviewed by Bryon Middlekauff, Department of Geography, Plymouth State College, Plymouth, NH.

Published nearly a century after John Wesley Powell's death, Donald Worster's *A River Running West* is a fitting tribute to the man. A leading figure in the field of environmental history, the author is the Joyce and Elizabeth Hall Professor of American History at the University of Kansas. Previous biographies have focused on Powell's explorations of the Colorado River, his work as an ethnographer among native Americans, and his life story, but *A River Running West* is the most recent and most thorough. Previous important biographies include Stegner's *Beyond the Hundredth Meridian* ([1954] 1992) and Darrah's *Powell of the Colorado* (1951).

Worster subdivides his biography of Powell into three parts and thirteen chapters. The three chapters in part 1 detail Powell's early family history. This part covers several regions of Great Britain and follows the family emigration to New York City in 1830, its settlement in Palmyra, New York, and later migrations to and within the Midwest. Worster devotes considerable attention to Powell's development of an interest in natural history as a youth, his rather irregular education, and his sacrifice in the Civil War.

The author firmly establishes the tone for this first section by documenting in great detail the family's frequent relocations and the elder Powell's devotion to Methodism and evangelism. "Wes" 's parents were as "unsettled in the New World as they had been in the Old" and continued to follow the calling "come west and help us." As a small child, Wes accompanied a self-taught naturalist searching out Native American burial mounds, fossils, plants, and animals. It was here that his interest in natural history first found nurture, but its development would have to wait. As the family relocated several times within Ohio and to south central Wisconsin and Illinois, circuit preaching held much more interest for the elder Powell than farming and tailoring; thus, many of the farm duties were left to Wes and his brothers. Wes also had no love for working the land and decided to seek out formal schooling. One season of education prepared him for a teaching position in a rural school district. There he remained until declaring himself a naturalist and deciding that he needed additional formal education. Powell dropped out occasionally to earn sufficient funds for tuition or because he was dissatisfied with the curriculum, choosing to be distracted several times by trips in small wooden boats floating down the Mississippi River.

Powell's loss of an arm at the battle of Shiloh is familiar to most physical geographers, but Worster's attention to the details surrounding it—just as he covered Powell's early family background, early life, and education—is extraordinary. The final chapter in part 1 documents Powell's enlistment, within one week of the declaration of war, in the Union Army. It continues through his assignments during the Civil War period, including duty at Vicksburg and the battle at Shiloh. Though much of his duty was routine, he did become involved in developing fortifications for the city of Vicksburg. At Shiloh, a Confederate minie ball struck his right wrist as he raised an arm to caution his men about the recoil from a cannon. As a result, surgeons amputated his arm about two inches