Publicizing Mathematics

Mathematics Today. Twelve Informal Essays. LYNN ARTHUR STEEN, Ed. Springer-Verlag, New York, 1978. viii, 368 pp., illus. $12.

Mathematics has the worst public relations of any of the sciences. Usually remote, it seldom offers the journalist a handle for a story. Worse yet, its most effective publicists, elementary school teachers, frequently dislike science in general and mathematics in particular. In the last few years the leaders of the mathematical community, alarmed by cuts in support for basic research, a decline in the numbers of undergraduate and graduate math majors, and a shortfall in academic slots for new Ph.D.'s (a fate previously reserved for doctorates in the humanities), have tried to compensate for the lack of favorable publicity.

Mathematics Today, a collection of essays by well-known mathematicians, is an effort in this direction. As set out in the preface, the object of the book is "to convey to the intelligent nonmathematician something of the nature, development, and use of mathematical concepts, particularly those that have found application in current scientific research." Now the phrase "intelligent nonmathematician" is ambiguous; I am sure that each essayist held in his mind a different image of that beast. Thus, while any high school student could grasp the two opening essays, "Mathematics today" and "Mathematics—our invisible culture," and the concluding one, "The relevance of mathematics," the audience for others is, to varying degrees, less broad.

The more motley the group of readers, the more effort the authors must put into their exposition. As they compose each sentence they must think not only of its substance but of the persons who will read it. It is hard to maintain such a schizophrenic vigilance. But Ronald Graham, in his contribution to this volume, "Combinatorial scheduling theory," has not let his eye stray far from a plausible image of an "intelligent nonmathematician." Any reader of the *New York Times* could follow most of his essay, and anyone with four years of high school math could master every step.

Graham's choice offers a paradigm of good public relations. It opens with a practical problem (how to schedule the ten tasks of assembling a bicycle), quickly encounters counter-intuitive paradoxes, includes an (optional) mathematical proof, generalizes the problem, illustrates the mutual dependence of pure and applied mathematics, reports on the latest research, and presents unanswered questions. In parting it offers an astonishing morsel that even a child could relish: It is possible to place far more than 100,000 times 100,000 nonoverlapping 1-inch squares in a square of side 100,000.1 inches. Moreover, Graham chose a topic that invites the reader's participation.

In "What is a computation?" Martin Davis matches Graham's triumph. Not only does he describe the most general computer and computation, he spends time with a particular example, showing how to program an archetypal computer to double the number of 1's on a tape of 1's and blanks. He then goes to theoretical questions, discussing the unsolvability of the halting problem, an unsolvable word problem, and undecidable statements. While an "intelligent nonmathematician" could follow the gist throughout, it would take some sophistication to follow a few of the head-breaking steps. An undergraduate who knew a little abstract algebra or set theory could understand the whole essay.

A subject like statistics, which ordinary mortals breathe daily, is easier to expose to a heterogeneous audience. David S. Moore, in "Statistical design of experimental data," also has managed, by judicious choice of topic and example, to show that fascinating mathematical questions lie strewn about us—if we only would look.

Other essays are devoted to number theory, algebra, geometry of the universe, meteorology, the four-color problem, economics, and population biology. While each is of merit, they are not as successful as the three mentioned.

Any scientist, engineer, or mathematician could read the whole collection with profit, but I suggest that the "intelligent nonmathematician" begin with the essays by Graham, Moore, and Davis in that order, then browse as fancy dictates.

The authors have evidently been persuaded to descend at least partway toward that nebulous reader. I suggest, however, that, in case of a sequel, each essay, when still in manuscript, be judged by a jury of its author's nonpeers. Such a jury might consist of three bright high school students, three lay readers of the *Times*, three junior math majors, and three scientists who apply mathematics. Simply impaneling this jury would define the phrase "intelligent nonmathematician" precisely. Moreover, such a jury would have the clout to compel each author to go all the way, not just partway, toward the reader. In short, I am urging the use of a little of the market research techniques usually squandered on less noble goals, such as the development of sugared breakfast cereals.

All things considered, however, I feel that this attempt has been surprisingly successful. The first printing is already sold out (permitting the swift correction of several errata). Perhaps some publisher may venture to produce the next volume in what should be an endless series.

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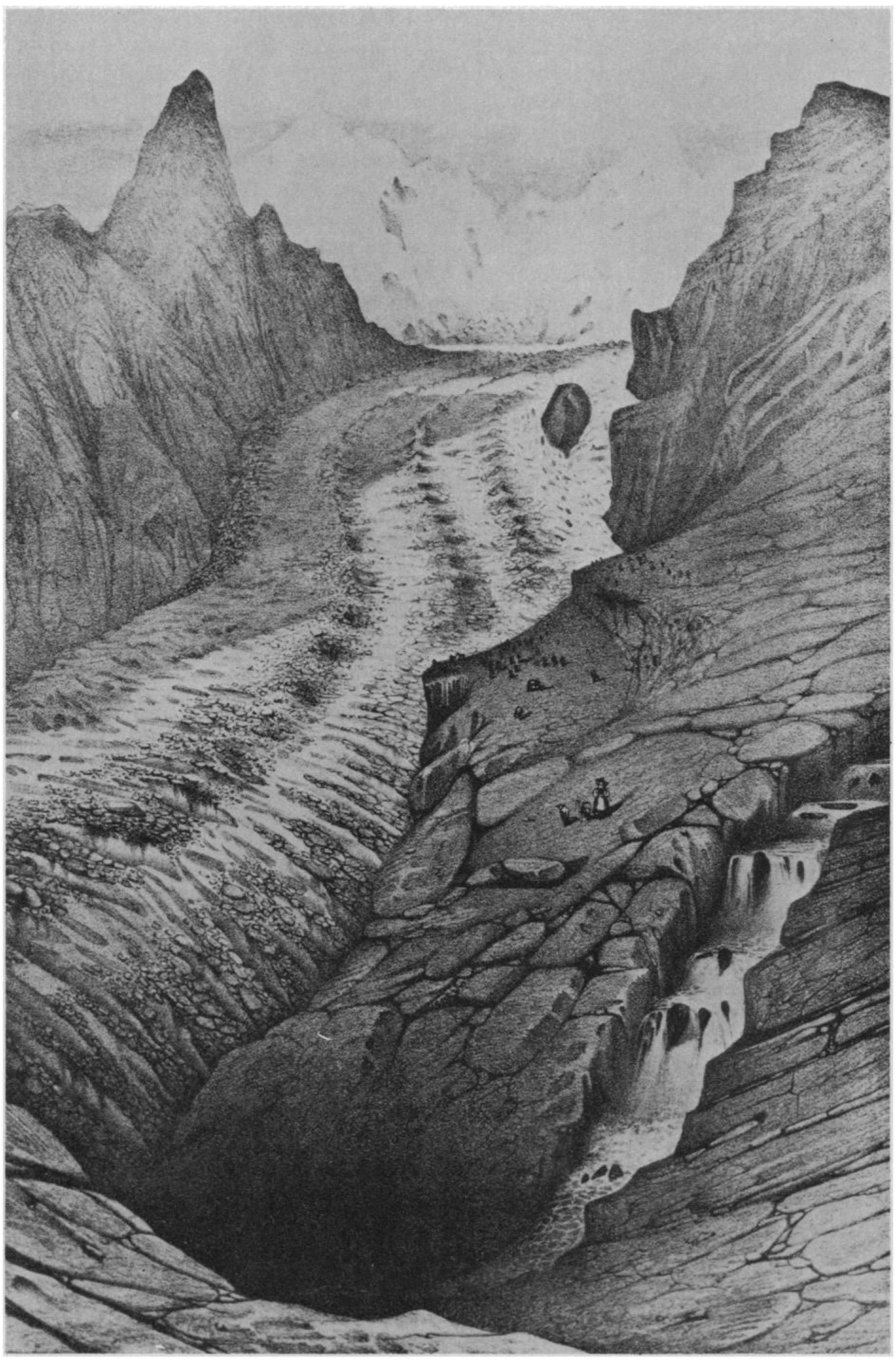
A Geologic Puzzle

Ice Ages. Solving the Mystery. JOHN IMBRIE and KATHERINE PALMER IMBRIE. Enslow, Short Hills, N.J., 1979. 224 pp., illus. $12.95.

This little book is an absorbing account of one of the great quests of geologic science—the quest for the cause of climatic change during the ice age. The book starts with the story behind the struggle of Louis Agassiz to demonstrate that continental glaciers once covered much of Europe and North America. It then considers the theories that have been proposed to explain the ice age. After dismissing all other theories as implausible or untestable, the book focuses on the astronomic theory of the Serbian mathematician Milutin Milankovitch, which is based on the geometric perturbations of the earth in relation to the sun—the eccentricity of the orbit, the inclination of the axis, and the precession of the equinoxes. The book comes to a climax with an account of the ocean-core studies that support the Milankovitch chronology of climatic change.

The pace quickens as the account approaches the present, for here John Imbrie himself is one of the central figures, and the account is augmented by anecdotes about conversations in Parisian cafes, professional rivalries among the main actors, and the hunches and hopes of the many scientists trying to find explainable patterns in the geologic record of climatic change. The oceanographic orientation of the authors is clear. For example, in a chapter describing early opposition to the Milankovitch chronology, they point out that the glacial record in the American Midwest calls for a major interstadial interval (the Farmdalian) 25,000 years ago, the very time at which Milankovitch calls for a radiation minimum and thus a glacial interval. Although the oceanographers have appealed to a lag of 7000 years between the climatic impetus 25,000 years ago and the ocean response 18,000 years ago, such a lag is less easily defended when a vegetational response is involved. This terrestrial contradiction to the Milankovitch chronology, so fully posed in the book before the oceanographic revelations are laid out, is not fully resolved in the climactic chapter, where it is stated that John Imbrie's filter analysis of the paleoclimatic curve for two Indian Ocean cores shows that "the 41,000-year climatic cycle did lag behind variations in axial tilt by about 8000 years. And . . . the 23,000-year climatic cycle lagged systematically behind variations in precession." One can believe that it takes 8000 years to form an ice sheet, but it is not so apparent why ocean temperatures so far from the ice sheets should have such a lag, or why the well-dated Farmdalian interstadial interval (recorded by soils or pollen sequences in central and southeastern North America) was a secondary response to delayed ice-sheet retreat rather than a contemporary response to climatic change. The ocean record has great strength in its length and in the replication of so many paleoclimatic cycles, which match in such a convincing way the major fluctuations in the Milankovitch curve. But for the last 40,000 years—where radiocarbon dating provides the kind of chronologic detail not possible for earlier time, and where the terrestrial record is strong and varied—the Milankovitch curve is not yet a fully satisfactory explanation for the paleoclimatic events.



Zermatt glacier in the Swiss Alps as depicted in Louis Agassiz's *Etudes sur les Glaciers*, 1840. [Reproduced in *Ice Ages* with permission of A. V. Carozzi and the University of Neuchâtel]

Some other references in the book to terrestrial affairs are also weak. For example, the tundra bordering the ice sheet in Europe was not marked by heather on boggy soils, as the book reports. Such a landscape comes instead near the end of an interglacial cycle, and the grasslands assigned to the end of an interglacial cycle come during the time of ice retreat. Past interglacial cycles lasted for 15,000 to 30,000 years, according to the record provided by annually laminated lake sediments, rather than the 10,000 years indicated by the radiation maxima. The postglacial climatic optimum in Europe was probably drier than today, not wetter, and oak trees were not more extensive at that time in Scandinavia (hazel was). Straight correlation of European and North African Holocene dry phases is not justified—in fact the two may be out of phase.

One of the distinctive attractions of the Milankovitch hypothesis is that it not only is testable by paleoclimatic field evidence but makes predictions for the future. Thus the authors close with the statement that the present interglacial epoch will end in 2000 years, after numerous minor climatic changes such as those of the last few decades and the last few centuries—assuming that climatic modification through carbon dioxide pollution does not intercede.

I know from personal experience that John Imbrie, a paleontologist from Brown University, is a master of anecdotal reporting, but the flavor and the even pace of the book may well be a tribute to Katherine Imbrie, his daughter, who is an editorial assistant at the Museum of Science in Boston. These authors have combined to weave an intricate story through a century and a half of research on two continents and in the oceans. Although the book is not *The Double Helix*, its personalized approach holds attention and makes complicated relations seem simple and important. It is excellent for those wishing to gain a historical perspective on a major line of geologic research that rivals continental drift in the perennial puzzlement it has engendered for generations of geologists.

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Oceanography Under Sail

On Almost Any Wind. The Saga of the Oceanographic Research Vessel *Atlantis*. SUSAN SCHLEE. Cornell University Press, Ithaca, N.Y., 1978. 302 pp., illus. $15.

I read *On Almost Any Wind* with mixed emotions—a sense of adventure, a sense of familiarity, a sense of loss. The saga of the R.V. *Atlantis* must touch every oceanographer, not only for her formidable scientific accomplishments, but moreover because she *sailed*—a sailing vessel is unlike any motor-driven ship, it is a creature of the sea.

This is the material of which legends are made. I entered oceanography at the very end of its sailing epoch. The R.V. *E. W. Scripps* was just retired when I entered the Scripps Institution of Oceanography in 1956; the R.V. *Vema* had just had her sailing capability removed when I saw her in New Zealand around 1961; the R.V. *Atlantis* was no longer truly operational when I came east in 1962. Susan Schlee revives that adventurous era to the delight of those of us who entered oceanography with romanticism in our hearts and curiosity in our minds.

The *Atlantis* belongs to an earlier time when questions were simpler, funds were limited, the scientific world was a small fraternity, and ships under sail were still common or a common memory. She began her career in 1931 in the midst of economic hard times as the research vessel of the newly formed Woods Hole Oceanographic Institution, funded by the Rockefeller Foundation.

The *Atlantis* was the first American ship specially designed for oceanographic research. At a length of 142 feet, she was quite large for a sailing ketch but a fine size for a research vessel. This strikes a good balance between seaworthiness, range, manning requirements, and research capability. Smaller vessels tend to be too much limited by weather and range, and significantly larger vessels are less efficient because of the limitations that exist on the number of operations that can be carried on at one time.

The *Atlantis* was a pioneering ship, and her scientific accomplishments were impressive. Fine scientists carried out their studies aboard her and became famous in the process, or laid the foundations for later fame—fame at least within the profession. A sampling of her work includes studies of the Gulf Stream and its meanders, under Columbus Iselin, the ship's first master; of the geophysical properties of the sea floor (the earlier studies often were marked more by energy expended than results obtained), under Maurice Ewing; of the ocean's sound properties, under J. Brackett Hersey; of deep midwater fauna, under Albert Parr; and of submarine canyons, under Henry Stetson.

Susan Schlee has drawn a lifelike portrait of men who sailed aboard the *Atlantis*. I have known only a few of the men personally, but the portrait is one that typifies research vessels. There is dedication and disinterest, friendliness and sharp conflict, great competence and the opposite, rigid morality and otherwise—yet overriding all is the hugeness of the sea and the smallness of the ship. The sea's beauty and lethality work on those confined aboard a ship only 150 paces long to weld them into an extended family with common goals. That "family" may not be a loving one but it is real, and each member periodically puts his life into the hands of his shipmates.

Schlee captures the ambiguous relationship between the scientific party on the one hand and the officers and crew on the other. This relationship can vary from close to sour, depending upon the personalities involved, the weather, the length of the cruise, and so on. The cook is clearly shown to be a vital element.

It is revealing to note the similarities and differences between life on the *Atlantis* and life on a motor-driven oceanographic vessel. The scientific routine is

The *Atlantis*'s trawl "comes up with its net torn off the head rope. The National Geographic Society helped sponsor several [Mid-Atlantic Ridge] cruises, and while this sponsorship produced great photographs and good science, it also yielded some flowery prose that embarrassed [Maurice] Ewing for years." [Photograph by Robert F. Sisson ©National Geographic Society; reproduced in *On Almost Any Wind*]