

## Unpredictability

**The Broken Dice and Other Mathematical Tales of Chance.** IVAR EKELAND. University of Chicago Press, Chicago, 1993. vi, 183 pp., illus. \$19.95 or £15.95. Translated from the French edition (1991) by Carol Volk.

Ivar Ekeland gained a large and enthusiastic following with *Mathematics and the Unexpected*, a brilliant and charming exposition of fundamental new discoveries in the theory of dynamical systems. *The Broken Dice* continues the same theme, and in the same elegant, seemingly effortless style, but focuses more closely on the implications of those discoveries for the rest of human culture. What are chance and probability? How has our thinking about them been changed by the discovery of chaos? What are all of these concepts good for?

According to tradition, says Ekeland, King Olaf Haraldsson of Norway played dice with the King of Gautland (Sweden) for the island of Hising. The Swedish king threw a double six and said there was no point in continuing. King Olaf pointed out that two sixes might turn up again. Then he threw the dice. One was a six; the other split in two, showing a six and a one. And so King Olaf took possession of the island. Many accuse Olaf of rigging the dice, but whatever the truth it's a wonderful story, and it makes an important point about the workings of chance: there is more than one kind of unpredictability.

So what is randomness? Paradoxically, the "random number generator" in your personal computer is nothing of the kind—it applies a perfectly deterministic rule, but an unpredictable one, unless you know the secret. If this most common source of random numbers is not random at all, is there such a thing as chance? The discussion leads to foundational problems in quantum mechanics and Einstein's espousal of "hidden variables" that determine when allegedly random events, such as the decay of a radioactive atom, will occur. In short, perhaps quantum theory has a hidden secret, just like that of the computer's random number generator. But does it? Nobody knows.

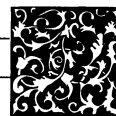
Chance leads to fate, here represented by deterministic processes in which every step is specified uniquely and precisely. And determinism leads to chaos, where again a hidden rule generates apparently random results—indeed in some cases demonstrably random results, according to any definition of randomness you care to propose. The secret this time is in the choice of initial condition, which "encodes" the desired random sequence, and of a dynamic rule

that can "decode" it, digit by digit. This is astonishingly easy to do, once you know what to look for. But it totally alters our view of what constitutes randomness.

That chaos is not truly random can be seen by considering the possibility of prediction. A truly random sequence is totally unpredictable: no amount of knowledge of the past affects the possibilities for the future. Chaos, in contrast, is predictable in the short term—an issue that is tackled in a chapter entitled "Anticipation," which begins with a legend about King Olaf's boat, *The Long Serpent*. (In a way it's a pity the book wasn't published by Viking.) What prevents lots of short-term predictions of a chaotic system from being strung together is sensitive dependence upon initial conditions—the celebrated butterfly effect—which is the subject of the next chapter of the book.

From there, the story moves toward more practical themes, risk and statistics. We find that even statisticians cannot demonstrate the occurrence of chance. They can only assume that it is present and exploit the resulting structure. As physics looks more deeply into the nature of space, time, and matter, it finds more and more that is contingent, indeterminate. But, argues Ekeland, if instead we build nature up by bringing things together, rather than dissecting them into ever tinier pieces, we find not chance but—

Ah, but, I mustn't give the game away, any more than I should if I were reviewing a detective novel. And this is just as gripping a tale. In any case, you need to read the whole story, not just the ending, be-



## Vignettes: Pictorial Trends

Some intellectuals . . . worried about the spread of illustrated books, increasingly common around the turn of the century. The ease of reproducing photographs in books meant that the author had less control; they feared that the illustrator would sway the reader more than the author, that illustrations forced people to form certain images in their mind. One letter to the editor . . . complained that illustrations . . . subverted books from an intellectual exercise into a commodity whose main purpose was to look pretty.

—Steven Lubar, in *InfoCulture: The Smithsonian Book of Information Age Inventions* (Houghton Mifflin)

At a time when the nonreading television generation is having an impact on the newspaper circulation in this country, and when, ironically, classes leading to visual skills are among the first cut by school districts feeling a financial pinch, the moment seems perfect once again for communicating knowledge with images on the hypermedia "page." Pixels are the movable type of the future.

—Barbara Maria Stafford, in *Artful Science: Enlightenment Entertainment and the Eclipse of Visual Education* (MIT Press)

cause the ending won't make sense out of context. Beg, borrow, or, preferably, buy a copy and do so. I guarantee you won't be disappointed.

Ian Stewart  
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## Reprints of Books Previously Reviewed

**Darwin.** Adrian Desmond and James Moore. Norton, New York, 1994. Paper, \$17.95. *Reviewed* 257, 419 (1992).

**Global Warming and Biological Diversity.** Robert L. Peters and Thomas E. Lovejoy, Eds. Yale University Press, New Haven, CT, 1994. Paper, \$17. *Reviewed* 258, 1505 (1992).

**The Smithsonian and the American Indian.** Making a Moral Anthropology in Victorian America. Curtis M. Hinsley. Smithsonian Institution Press, Washington, DC, 1994. Paper, \$17.95. *Augmented reprint of Savages and Scientists. Reviewed* 213, 1489 (1981).

**The Uses of Life.** A History of Biotechnology. Robert Bud. Cambridge University Press, New York, 1994. Paper, \$19.95. *Reviewed* 262, 121 (1993).

## Books Received

**AIDS, HIV and Mental Health.** Michael B. King. Cambridge University Press, New York, 1994. x, 197 pp. \$39.95; paper, \$29.95. Psychiatry and Medicine.

**Allegory Old and New.** In Literature, the Fine Arts, Music and Theater, and Its Continuity in Culture. Marlies Kronegger and Anna-Teresa Tymieniecka, Eds. Kluwer, Norwell, MA, 1994. x, 326 pp., illus. \$110 or £74.50 or Dfl. 195. *Analecta Husserliana*, vol. 42. From congresses, Cambridge, MA and Luxembourg, April 1992 and June 1992.