soon, and in the meantime we must settle for smaller victories. But such changes may be hastened by the contributions of more statesmen like Frank Rhodes, who can remind us of the better angels of our natures.

BOOKS: STATISTICS

Casting Light on the Shadow of Doubt

Jane Hawkins

All animals that compete for their food are capable of some form of taking risks. Humans are distinct among creatures by their tireless quest for certainty and truth in an unpredictable world. One of the earliest records of written thought is an Egyptian document from 2200 B.C. that discusses a conflict between evidence and witnesses in the case of a contested will. Games of chance are also ancient; an Egyptian tomb painting from 3500 B.C. shows a nobleman in an afterlife game of chance. He plays a board game where pieces are moved around according to a throw of a symmetric animal bone.

Today, as evidence is gathered in 60 countries on the attacks on the World Trade Center and the Pentagon, only a few facts can be established with mathematical certainty. The perpetrators did not survive the crime, and the hijacked eyewitnesses perished as well. Therefore the search is for co-conspirators, and the conclusions about their involvement in the attacks will involve conjecture.

As James Franklin discusses in *The Science of Conjecture: Evidence and Probability before Pascal*, from the time of ancient Greece to the present, scholars have written copiously and rationally about proof, uncertainty, and risk. In 1654, the subject of chance was formalized by Pascal and Fermat with their establishment of the branch of mathematics called probability theory. Since then, probability has fanned out into many sophisticated areas of mathematics, science, and engineering through attempts to predict uncertain outcomes and to prove reliability; chaos theory is one of the popular great grandchildren of Pascal's original theory of dice. The author, a mathematician and philosopher at the University of New South Wales in Australia, claims that theory of evidence, originally intertwined with and indistinguishable from probability theory, developed more or less independently after Pascal. He argues convincingly that evaluation of certainty involves moral and philosophical issues not relevant in math, and likewise mathematical certainty is not required in law or religion.

The Science of Conjecture
Evidence and Probability before Pascal
by James Franklin
Johns Hopkins University Press, Baltimore, 2001. 511 pp. $55, £36.95. ISBN 0-8018-6569-7.

Mathematical certainty of Osama bin Laden's involvement in the recent attacks may never materialize. More than two weeks after 11 September, the *New York Times* asserted that not a single living person could be directly connected to the crime through "hard evidence." Recognizing that much evidence will be kept secret during the investigation, we are still left with the issue of what constitutes acceptable proof. The book offers a compendium of premodern alternatives to certainty.

The first three chapters of *The Science of Conjecture* deal with the development of the law of evidence from ancient times to the mid 1600s. Franklin highlights a "consistent tradition of dealing explicitly with evidence that falls short of certainty." He presents a comprehensive treatment of the history of the relations between probability and methods of evidence. In the course of demonstrating that in many matters we should look beyond mathematical proof and quantitative analysis to consider evidence, Franklin provides an extensive sample of quotations and sources spanning several millennia.

Even though probability was not developed as a formal mathematical subject until Fermat and Pascal laid out the groundwork, the topic was discussed both qualitatively and quantitatively for many centuries before that. Franklin leads us through these discussions, demonstrating that rational evaluations of risks and games of chance, as well as an appropriate vocabulary, were in place long before the math. Furthermore, the legal, moral, philosophical, and business domains influenced the gradual development of the mathematical subject of probability, with the result that language frequently describes the certainty of evidence better than numbers can. In other words, "proof beyond a reasonable doubt" should never be assigned a number.

Franklin writes, "One of the pleasures of studying the ancient world is that a large proportion of what one has to read is of good quality, since the better works have enjoyed a higher survival rate...." Casting the widest possible net over risk, evidence, and probability of the past, he treats us to scholars' and religious leaders' views on gambling, insurance contracts, trial evidence, scientific theories, and proof of the existence of God. His helpful commentary is sprinkled with dry wit along the way.

Eventually, the data collection surrounding the events of 11 September will end and experts will announce the most likely scenario of the crimes and publish the "final" list of victims. Then we, as individuals, will have to decide how to find moral certainty in the unknowable. (Moral certainty, as Franklin discusses, was introduced in the 1400s to denote an acceptable level of uncertainty. It has since evolved into proof beyond a reasonable doubt.) *The Science of Conjecture* opens an old chest of human attempts to draw order from havoc and wipes clean the rust from some cast-off classical tools. These can now be reused to help build a framework for the unpredictable future.

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BROWSINGS

The Rainbow Bridge. Rainbows in Art, Myth, and Science. *Raymond L. Lee Jr., and Alistair B. Fraser.* Pennsylvania State University Press, University Park, PA, and SPIE Press, Bellingham, WA, 2001. 407 pp. $65. ISBN 0-271-01977-8.

Rockwell Kent's *Entrance of the Gods into Valhalla* (1927) (left) depicts Bifrost, the bridge between Earth and the home of the Norse gods. The colorful arc of the rainbow has also been seen as a sign of good fortune, a symbol of God's covenant in Judeo-Christian culture, and the bearer of the gods' messages of war and retribution to the ancient Greeks. It assumes countless, often unnatural, forms in art and advertising (where it has been used to sell items ranging from cars and motel rooms to chocolate chip cookies and detergents). And it has inspired research in optics, meteorology, and color theory. Lee and Fraser combine informative text, images, and diagrams in this eclectic survey of cultural and scientific perspectives on the interaction between sunlight and raindrops.