process could, and should, be carried out by one unaided human brain."

But mathematicians, Stewart says, are "much more interested in solving problems than in philosophizing about their methods." There is no reason to think they can't accommodate computer proofs. Even without electronic help, proofs often get incomprehensible, so mathematicians frequently reduce them to essentials. Stewart compares the process to giving driving directions from point A to point B. We leave out details such as "Exit your house, go down the walkway, open your car door, get in." In the same way, mathematical proofs often begin by jumping ahead to a "signpost" spot.

Mathematical proofs are really narratives, Stewart says. "Poetic" proofs—short, snappy, and sometimes elegant—are the discipline's delicacies. The mathematician Paul Erdös once speculated that such proofs reside in a book owned by God, who occasionally offers mere mortals a glimpse. More common are the "novel-like" proofs, such as the one occupying several hundred pages in Bertrand Russell and Alfred North Whitehead's *Principia Mathematica* (1910–13) showing that 2+2=4. (Russell is said to have come close to a nervous breakdown verifying it.) Today's computer proofs are more like a "telephone directory." Yet even they can contain bits of poetry. At the bottom of Thomas Hales's massive proof of Kepler's idea is a "poetic" insight that reduces the proof to "a very large list of routine computations."

At worst, Stewart concludes, computer-driven proofs are "acceptable." At best, they "open up new realms of discovery, relieving the human brain of routine tasks, leaving it free to concentrate on the big picture."

SCIENCE & TECHNOLOGY

How Many Dead?

THE SOURCE: "The Number" by Dale Keiger, in ***Johns Hopkins Magazine***, Feb. 2007.

WERE NEARLY 700,000 CIVILIANS killed in the first three years of the Iraq war? When epidemiologists Gilbert H. Burnham and Leslie F. Roberts of Johns Hopkins University's Bloomberg School of Public Health published that estimate in the British medical journal *The Lancet* a few weeks before the 2006 U.S. congressional election, it made headlines around the world, reports Dale Keiger, a senior writer for *Johns Hopkins Magazine.* British prime minister Tony Blair and President George W. Bush both rejected it. "I don't consider it a credible report," Bush said.

Around the time the study appeared, the U.S. and Iraqi governments were citing 30,000 Iraqi deaths, while other sources put the death toll up to several times greater.

Official estimates are based only on reports from hospitals and morgues, and it's generally believed that they understate the total. Burnham and Roberts used the "cluster survey" technique epidemiologists employ to track the spread of disease to arrive at their estimate. Eight Iraqi surveyors interviewed people from nearly 2,000 households in 47 selected areas in Baghdad and elsewhere in Iraq to determine how many deaths had occurred in their families. Then Burnham and Roberts calculated a mortality rate for the entire country. Their conclusion: Iraqis had died at the rate of 1,000 per day during the previous year.

The new study's methodology was quickly questioned. Lurking in the background was a political question: Was it just a coincidence that an earlier controversial Burnham-Roberts estimate had appeared just before the 2004 U.S. election? An article in *Science* (Oct. 20, 2006) highlighted objections by British researchers Neil Johnson, Sean Gourley, and Michael Spagat. "When a survey suggests so much higher numbers than all other sources of information, the purveyors of this outlier must make a good-faith effort to explain why all the other information is so badly wrong," Spagat said. That was missing. The three argued that the Johns Hopkins researchers had introduced bias by focusing their Baghdad interviews in areas near main-street intersections, where violence is centered. Another British researcher questioned how so large a survey could have been done so quickly.

Burnham and Roberts counter that their researchers *did* sample away from main streets, but say that the records were destroyed to protect the identity of respondents. Since that eliminated the possibility of reproducing or checking the results, it made Spagat, Gourley, and Johnson more suspicious. Spagat, an economist at the University of London, has called for an investigation.

A colleague of Burnham and Roberts, Scott Zeger, believes that the two researchers did "the best science that could be done under the circumstances." Iraq, after all, is a war zone, not a laboratory. Says Zeger: "Noisy data is better than no data."