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### Making $e$ Easy;

Science 11-20-1998

Any study of exponential growth--from bacterial populations to interest rates--depends on a fundamental constant called  $e$ . Because this number (often rounded to 2.718) can't be expressed as a fraction, scientists must estimate it with an approximate formula. Now a self-taught inventor and a meteorology professor describe in the October issue of *Mathematical Intelligencer* several new formulas for  $e$  and use them to calculate it to thousands of decimal places with a desktop computer.

For both bankers and bugs,  $e$  describes a basic limit to exponential growth. For example, if you invested \$1 at 100% interest, compounded monthly, you would have \$2.61 in a year. If the interest were compounded every 30 seconds, you would end with about a dime more. No matter how frequently you earned interest, you could never take home more than  $e$  multiplied by the number of dollars you first deposited.

Harlan Brothers and John Knox, a meteorologist at Valparaiso University in Indiana, derived their first approximation by averaging a simple textbook formula,  $(1 + 1/n)^n$ , that slightly underestimates  $e$ , with another,  $(1 - 1/n)^{-n}$ , that slightly overestimates it. This doubled the number of correct decimal places (the higher the  $n$ , the more decimal places can be achieved). With further tinkering, they were able to improve the accuracy sixfold.

The new formulas would require too much computer memory to challenge the most accurate estimate of  $e$ , which is already known to 50 million decimal places, says numerical analyst **Simon Plouffe** of Hydro-Quebec in Montreal, holder of several numerical computation records. That doesn't worry Knox, who says "What we've done is bring mathematics back to the people," by demonstrating that amateurs can find fresh ways of representing  $e$ . "I'd like college math teachers to add it to the curriculum" to show students that the textbooks don't always have the last word.

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