Issue 66

Exponential Growth

Exponential growth is deceptive because nothing seems to happen for a long time and then the situation explodes dramatically. Here are two examples.

The Sunday newspaper is 2.5 centimeters (1 inch) thick. Fold it in half, and it's 5 centimeters thick. Imagine you could go on folding it indefinitely. How many times would you have to fold it to make it become 1,500,000,000 *kilometers* (93,000,000 miles) thick, the distance to the sun? Answer: Just 43 times. The last fold would add half the total distance. By contrast, 43 steps of *linear* growth would make the paper only 112 *centimeters* (44 inches) thick.

Again, would you rather be paid a million dollars a day for a month or receive 1 penny the first day, 2 the second, 4 the third, 8 the fourth day, and so on, doubling each day—an exponential rate of increase? If you choose exponential growth, you receive only $5.12 on the tenth day, but on the twenty-eighth day you outstrip your million-dollar-a-day colleague. If you went on to day 44, you would receive all the money in stock in the entire U.S., and by day 50 you would own the entire wealth of the world.

In real life, population growth is exponential in many countries. The doubling time for a population growing at the rate of 2 percent a year is 70/2 = 35 years. In general, for any quantity growing exponentially, the doubling time in years = 70/percent growth per year. Thus, if electric power use is growing at 5 percent per year, a seemingly harmless rate of increase, it will have doubled in 70/5 = 14 years. This formula also applies to your money earning 5 percent in a bank savings account.

World population is growing at the rate of 2 percent per year. This means we must double world food production in 70/2 = 35 years simply to hold constant the fraction of the world's population that is starving.

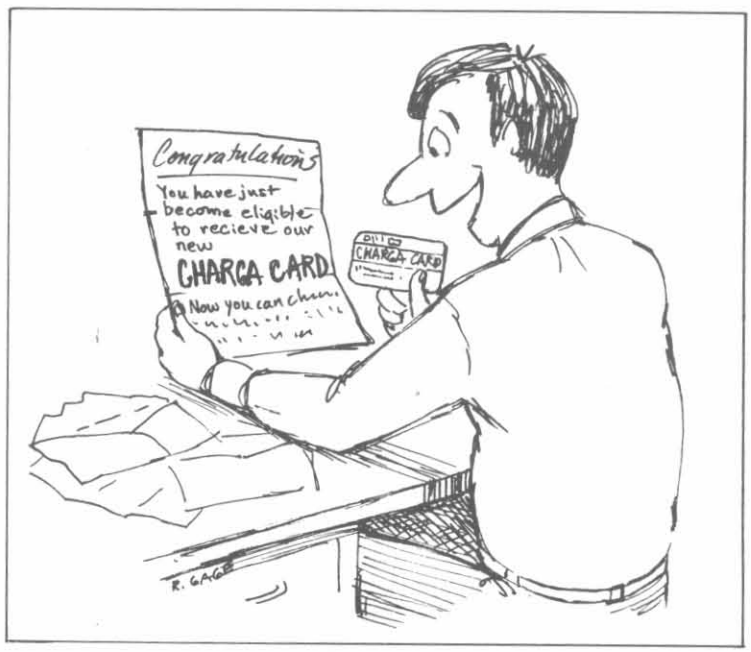
Modern agriculture is based on petroleum-derived fertilizers and petroleum-powered farm machinery. (In the U.S. 750 liters [200 gallons] of gasoline or its equivalent are used to raise 1 hectare [2½ acres] of corn.) But

world reserves of petroleum are being depleted exponentially. As exponentially exploding populations press against exponentially declining and irreplaceable natural resources, the world is steadily losing its capacity to feed itself.

How much longer may our petroleum, coal, and iron resources last? How much longer may a community's underground water supply (yours?) keep up with an exponential growth of population? How much longer may commercial whaling continue? Whatever the answer, one thing is certain if the use of the resource is growing exponentially: whatever the limit, half of the entire resource is used up in just *one* doubling time—the last one. This mathematical certainty means that the depletion of a fixed natural resource will lead to a sudden crisis unless foresight and long-range planning are supported by political and economic action long before that painful last doubling.

Can you find examples of such foresight? Or examples of foresight that have led to effective planning?

(See "Petroleum Depletion," p. 65 and "Tragedy of the Commons," p. 110.)



Resources about to be exponentially depleted.