to say that a perfect vacuum has never been obtained. In any radiation-shielded experiment at very low temperatures, say 0·1°K or less, the vapour pressure even of helium is so low that there will be as many as one free molecule of gas in the cooled volume less than once a century.

The logarithmic notation, as in the case of pH, or of the decibel used by the electrical engineer, is valuable where very long ranges are habitually used, with only moderate accuracy required. For limited ranges and high accuracies it is not advantageous.

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[1] McCormick, N. G., *Nature*, **208**, 334 (1965).

PROF. FREMLIN'S criticism is based primarily on the inability of the equation, $Y = \exp(-kt^{-c})$, to describe adequately natural processes that do not have apparent sigmoidal time-course curves. Of the three hypothetical situations presented, I agree that the first would describe a typical sigmoid curve which can be generated by the basic equation. The time-course of the type of process outlined in the second case would resemble a frequency distribution function, a curve which is generated by the first derivative of the equation[1]. My colleagues and I have suggested that the equation may represent a new type of distribution function[2]. The similarities between the parameters of the equation and those of the Weibull distribution function[3] have been noted[4].

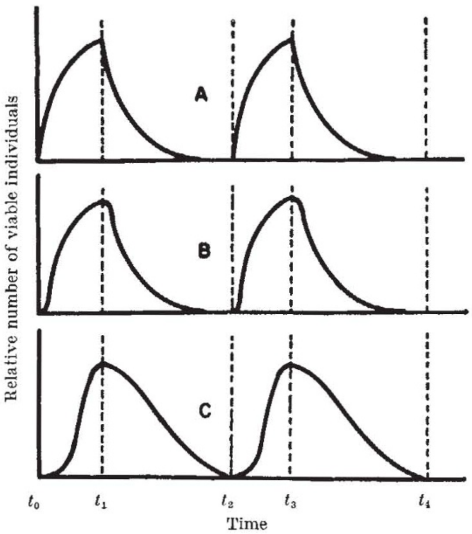

Fig. 1.

Fremlin states that the third hypothetical case gives rise to a curve resembling that known as a "relaxation oscillation", in which instance the resulting curve could not be generated by the equation. He refers to a stable periodic variation which implies to me that each cycle of growth must achieve the same maximum density before it declines into the death phase. If the curve describes a relaxation oscillation it must increase in some exponential manner to a maximum, then decrease in an exponential manner, as in Fig. 1A. Any process of growth as it occurs in nature will possess an induction period and the sharpness of the peak will be rounded off as in Fig. 1B. In this case the "relaxation oscillation" might be represented by the following series of sigmoidal growth curves and sigmoidal decay curves:

$$\int_{t_0}^{t_1} Y'_a \,\mathrm{d}t - \int_{t_1}^{t_2} Y'_b \,\mathrm{d}t + \int_{t_2}^{t_3} Y'_c \,\mathrm{d}t - \int_{t_3}^{t_4} Y'_d \,\mathrm{d}t \ldots \qquad (1)$$

where Y'_a and Y'_c are the rates of increase for the phases of growth and Y'_b and Y'_d are the rates of decline for the death phases. As an alternative, the experimental curve might better resemble a series of distribution functions as in Fig. 1C. This curve might be represented by the series

$$\int_{t_0}^{t_2} Y''_a \,\mathrm{d}t + \int_{t_2}^{t_4} Y''_b \,\mathrm{d}t \ldots \qquad (2)$$

Depending on the values of k and c for each function, either equation can generate a relaxation oscillation in which each successive wave is diminished in amplitude. By proper selection of the limits of integration the duration of each succeeding cycle can be made to increase. These properties are more likely to be found in nature than an oscillation with periods of constant amplitude and equal duration. It may be of some interest that higher order derivatives of the equation generate damped oscillation curves with cycles of decreasing amplitude and increasing duration.

A discussion of the aforementioned points is relevant to the acceptance or rejection of the proposal of exponential time scales[5]. A polemic over the issue of logarithmic scales of temperature of pressure can, however, serve no useful purpose at this time. Fremlin states in several instances that inconvenience is a major reason for not considering these scales. It is my contention that the inconveniences are not insurmountable and are far overshadowed by the possibilities of a better understanding of nature. The main point I am trying to make is the proposal that all processes in nature conform to exponential functions of time, and that the time-scale of each process is exponentially related to the time-scale of every other process. I am proposing a different kind of clock than the one our senses dictate, an inconvenient clock, perhaps, but a clock that affords a different perspective into nature's time-scale.

I would like to point out that the equation applies ideally to a process in a closed system where the time-course of the process is determined by the initial conditions. So long as no outside influence is exerted on the system after time zero (t_0), the process (Process I) flows smoothly and continuously. The instant any condition changes, Process I is terminated and a new process (Process II) comes into existence, with new initial conditions and a new time zero (τ_0). All preceding events experienced by the constituents of Process II are of no consequence because they are all incorporated into the new initial conditions. Thus Process II cannot continue to be timed in reference to the former t_0, but only with reference to the new τ_0 involving its own initial conditions.

My reply to the criticism of the statement concerning a perfect vacuum is that so long as the data must be expressed as the probability of finding a molecule within a specified volume of space at a specified time, I can agree only that the probability approaches zero as the temperature approaches absolute zero and, accordingly, the vacuum approaches a perfect vacuum.

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