Manner of expressing Rate of Ribonucleic Acid Biosynthesis

ENRICHMENT of a medium supporting slow, balanced growth of bacteria (*Aerobacter aerogenes*¹ or *Salmonella typhimurium*²) is followed by a period of accelerating growth during which the ribonucleic acid (RNA) : protein ratio of the bacterial protoplasm increases considerably. It has recently been stated in papers from this laboratory¹ and elsewhere² that the rate of RNA synthesis during this adjustment period is even higher than it will be later when the new, high growth-rate is established. (The phrase, 'rate of RNA synthesis', refers to the rate of accumulation of total RNA, of which approximately 80 per cent is ribosomal. In the conditions of growth employed in the experiments being discussed, measurements of total accumulation are essentially measurements of ribosome synthesis, since turnover is slight.) This assertion is based on the fact that when the logarithm of RNA per ml. of culture is plotted against time, the slope immediately after enrichment of the culture is usually greater than that which will be maintained afterwards.

We wish to point out that the value obtained from such a slope represents the amount of RNA made per hr. per unit of RNA ($dR/dt \times R^{-1}$) and is not necessarily a meaningful expression of the rate of the biosynthetic process. In fact, unless the synthesis of RNA is truly an autocatalytic process, this manner of expressing its rate can be quite misleading. If alternatively, for example, one expresses the rate of RNA formation as the amount made per hr. per unit of protein ($dR/dt \times P^{-1}$), the data cited above (as

well as new experiments to be reported³) give no indication of an overshoot in the rate of RNA synthesis by a culture in accelerating growth. Rather, the rate of RNA synthesis (expressed in this manner) simply increases, upon enrichment of the medium, to the value characteristic of the new growth-rate.

To illustrate our point we have drawn an idealized curve which describes the accumulation of RNA and protein in such an experiment (Fig. 1). The rate of RNA synthesis, calculated per unit of RNA and per unit of protein, is given for three points: (A) balanced growth before enrichment; (B) unbalanced growth immediately after enrichment; (C) balanced growth after adjustment of the culture to the new medium. For purposes of comparison, each expression has been multiplied by a constant (c_1 or c_2) chosen so as to yield values at point A of 1. It is evident that the two ways of expressing the rate of RNA synthesis give qualitatively different impressions of what happens to this process following enrichment of the medium. Expressed per unit of protein, the rate of RNA synthesis quickly increases to the new higher value, while expressed per unit of RNA it overshoots (in this example by 100 per cent). The magnitude of the overshoot depends on the absolute increase in the growth-rate (over the range where RNA content of the bacteria is a function of the growth-rate) and on the rapidity with which the rate of RNA synthesis expressed per unit of protein reaches its new value.

Whether or not one concludes that RNA synthesis is faster during accelerating growth depends on how the kinetic data are expressed, and a choice between methods of expression must await elucidation of how RNA is made.

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¹ Neidhardt, F. C., and Magasanik, B., *Biochim. Biophys. Acta*, **42**, 99 (1960).

² Kjeldgaard, N. O., Maaløe, O., and Schaechter, M., *J. Gen. Microbiol.*, **19**, 607 (1958).

³ Fraenkel, D. G., and Neidhardt, F. C., *Biochim. Biophys. Acta* (in the press).

Fig. 1. Increase in ribonucleic acid (RNA) and protein (PROT) per ml. of culture before and after enrichment

The figure is idealized from data in the papers cited, and fulfills the following specifications: (1) The growth-rate finally reached after enrichment is exactly double that before. (2) The RNA : protein ratio at the higher growth-rate is double that at the lower. (3) The rate of RNA synthesis, expressed as the amount of RNA made per hr. per unit protein, increases instantly to the value characteristic of the higher growth-rate. Actually, such a curve may be determined simply by the third of these specifications, together with the assumption that the rate of protein synthesis (dP/dt) is proportional to the RNA content of the culture.

	$c_1 \cdot \frac{dR}{dt} \cdot \frac{1}{R}$	$c_2 \cdot \frac{dR}{dt} \cdot \frac{1}{P}$
A	1	1
B	2	2
C	4	4

Effect of Temperature and Potassium Gibberellate on Phases of Growth of Algerian Ivy

THE application of gibberellic acid to mature, fruiting shoots of *Hedera* was found^{a,b} to cause a reversion from the shrubby fruiting form to the juvenile vining type of growth. Our experiments have confirmed this response but indicate that it depends on the maintenance of a sufficiently high temperature following treatment.

Plants of *Hedera canariensis* were treated in mid-summer in a 60° F. minimum glasshouse with potassium gibberellate in concentrations of 0.0, 0.18, 0.91 and 1.8 mgm. a plant, applied in capillary melting point tubes inserted in decapitated stems, using ten plants per treatment. In 120 days, all the treated plants were juvenile, but only 30 per cent of the controls exhibited any juvenile characteristics. Identical treatments were applied in a lath-house outdoors in January in uncontrolled temperatures in which the minima ranged from 38° to 55° F. for most of the experiment. Although the plants grew