developed for the analysis of lengthy temperature records, and has since been applied to electroradiograms, ballistocardiograms, electrophoresis patterns, tonograms, and a variety of data recorded at timed intervals. One of the chief advantages of this method is that mean values can be obtained directly on the original graph, without transcribing the numerical values or performing any arithmetical calculations.

Method. As an example, let us take eight values recorded on ordinary rectangular graph paper at points $A, B, C \ldots H$ (Fig. 1). The technique will be seen to be the same no matter how small or how large the number of points. It is assumed that the horizontal spacing or "timing" between the points is uniform.

Place a ruler so that it passes through points A and B. Start with the pencil at A and draw Ab, stopping on the vertical line midway between A and B. Next, with the pencil held at b, turn the ruler so that it passes through b and C. Draw bc along bC, stopping on the vertical line through B. Next, with the pencil held at c, turn the ruler so that it joins c and D, and draw cd as shown. Continue in this manner, each time directing the straightedge toward the next in the series of points and advancing the pencil to the right by half the space between the vertical lines through the original points, until arriving at the final point h. The height of h above the horizontal axis, measured according to the vertical scale used for the graph, provides the desired mean value.

Although the simplicity of this method renders it relatively free from error, a brief check is readily available and should be performed. Start at H, and along HG draw Hg' (Fig. 1), then $g'f'$, and so on until a' is reached. The point a' will coincide with h if no errors have been made.

Proof. By employing a few properties of centroids (centers of gravity), a nonalgebraic proof can be provided. Assume that a mass of 1 unit is placed at each of the points $A, B, C \ldots H$. Then the centroid of all of these points will have a height above the horizontal axis equal to the arithmetic mean value of the height of the individual points. In arriving at the centroid

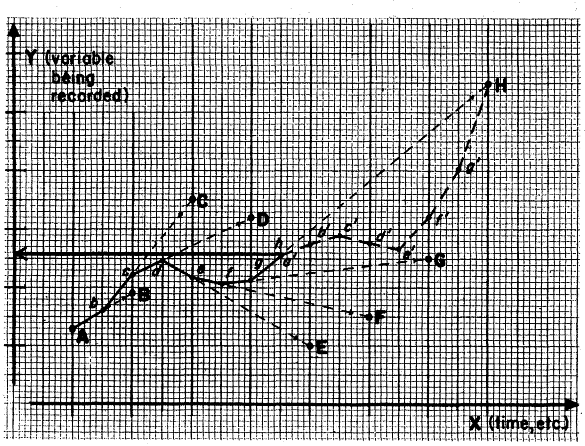

Fig. 1. Graphical determination of mean values.

geometrically, points A and B with mass 1 unit each may be replaced by a mass of 2 units placed at b. This may be represented by the symbol b_2. The centroid of b_2 and C_1 is situated at c, along the segment bC, dividing the length bC in proportion to the masses, and nearer to the "heavier" point. Similarly c_3 and D_1 may be replaced by d_4, and so on until h_8 represents the combined mass at the centroid.

Comments. The procedure described may be applied to a record consisting of any number of discrete points. In the case of a continuous graph, it is necessary to mark off, along the graph, points equally spaced horizontally, and to apply the method to these selected points. The accuracy of the final result will in general increase as the subdivisions are made finer.

In order to estimate areas under curved graphs (that is, the area between a portion of the curve, two vertical lines and the corresponding portion of the horizontal axis), it is necessary merely to multiply mean value, as derived above, by the length of the horizontal extent.

A review of the relevant literature on graphical methods revealed only a single reference (*2*) to a method at all comparable. However, the present method proved to be considerably easier and more rapid to apply.

References and Notes

1. From the Ophthalmology Research Laboratory (I. H. Leopold, director), Albert Einstein Medical Center, Northern Division. This work was made possible by a grant from the Weinstock Fund.
2. J. Lipka, *Graphical and Mathematical Computation,* Pt. II. Experimental Data (Wiley, New York, 1921), pp. 237–242.

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Inhibition of Root Growth by Azaserine

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The tumor-inhibitory substance, azaserine, produced by an unidentified *Streptomyces,* has been shown to possess antibiotic activity on a wide range of organisms (*1*). This substance, identified as *O*-diazoacetyl-L-serine (*2*), completely inhibited a wide range of organisms at concentrations of 25 to >100 μg/ml. Some organisms are more sensitive; 50-percent inhibition of several bacilli was obtained at 2 to 4 μg/ml; *Escherichia coli* was inhibited 50 percent by 9.3 μg/ml; two clostridia, *Cl. feseri* and *Cl. hemolyticum* were completely inhibited at 0.5 μg/ml, and *Cl. perfringens* and *Cl. septicum* at 2.5 μg/ml (*3*).

Several experiments have been carried out with azaserine (*4*) on plant systems. They demonstrate the high potency of this substance in inhibiting root growth (*5*). One criterion was the effect on the elongation of the primary roots of germinating cucumber seed, var. Early Fortune, at 25°C for 96 hr (*6*). At $2\times10^{-4}M$ and $5\times10^{-4}M$ root development was completely suppressed. These seeds, if thoroughly washed with water and transferred to distilled water for an additional 4 days, failed to develop roots. At lower concentrations partial inhibition of root elongation occurred (Table 1). It was established from this and another experiment that $1.5 \times 10^{-5} M$ (2.6 μg/ml) would result in 50-percent inhibition of elongation In similar but less extensive experiments with barley and flax, elongation of the roots of the former was 50 percent inhibited by approximately $2.5 \times 10^{-5} M$ azaserine, and of the latter at the low concentration of approximately $4 \times 10^{-6} M$ (0.7 μg/ml).

In aerated water culture the growth of barley roots, var. Moore, was repressed by comparable concentrations of azaserine. The criterion in such tests is the dry weight of roots produced in 5 days at 25°C (Table 2). In this system the concentration producing 50-percent inhibition would be $1.3 \times 10^{-5} M$ (2.25 μg/ml).

Shoot growth is not affected at levels causing substantial repression of root development. Azaserine has been applied in the following ways to 8-day bean seedlings grown in vermiculite: (i) 50 μg in 0.02 ml 50-percent ethanol to the base of the unifoliate leaf;

Table 1. Azaserine repression of root elongation of germinating cucumber seed (96 hr at 25°C).

Concentration (μM)	Inhibition in root length (%)
200	100
100	84.1
40	69.4
10	38.7
3.3	14.2

Table 2. Azaserine repression of root growth of barley seedlings (5 days at 25°C in the dark).

Concentration (μM)	Reduction in root dry weight (%)
30	73.2
10	43.0
3	15.4

(ii) 100 μg in water, similarly; (iii) unifoliate leaf dipped in $1 \times 10^{-5} M$ solution for 48 hr; (iv) same as (iii) using $1 \times 10^{-4} M$; (v) 25 ml $1 \times 10^{-4} M$ solution applied to the surface of the root medium. None of these treatments produced any apparent inhibition or stimulation of growth of the shoot or of any part thereof, nor were there morphologic changes or telemorphic responses as occur with growth regulators.

These studies indicate that root growth of cucumber, barley, and flax seedlings is repressed at azaserine concentrations substantially lower than those which cause inhibition of many microorganisms, and of the same order as those reported to be inhibitory to the most sensitive microorganisms. The possibility of employing a plant system for azaserine assay is suggested.

References and Notes

1. J. Ehrlich *et al.*, *Nature* **173**, 72 (1954).
2. Q. R. Bartz *et al.*, *Nature* **173**, 72 (1954).
3. G. L. Coffey *et al.*, *Antibiotics & Chemotherapy* **4**, 775 (1954).
4. Available through the courtesy of George Rieveschl, Parke, Davis and Co., Detroit, Mich.
5. Paper No. 2 from the Plant Nutrition Laboratory, Michigan Memorial Phoenix project No. 32, of the University of Michigan.
6. D. Ready and V. O. Grant, *Botan. Gaz.* **109**, 39 (1947).

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Communications

Wastes and Nutrients

In a recent article by Paul B. Sears [*Science* **120**, 959 (1954)] appears the remarkable statement on page 960, line 7, "Nature long ago discarded the nonsense of carrying poisonous wastes and nutrients in the same vessels." To paraphrase Herbert Dingle's recent delightful article [*Science* **120**, 513 (1954)] "This statement sounds like nonsense, because it is nonsense."

The blood supply must not only convey materials destined for the retail consumers but also remove their garbage, for, apart from incidental losses occasioned by the operation of externally secreting glands, there are no other means available. Even the idea that arterial blood is a supply system, and venous blood a garbage-removal system, is entirely incorrect, both factually and philosophically. The urgent necessity of keeping the individual consumer, or tissue cell, in a reasonably ordered and stable environment—the well-known homeostasis of Cannon—is such that sudden and marked changes of all kinds are undesirable. (This matter might in itself appear to warrant serious ecological investigation.) In reality it is found that the system of supply, as well as the system of garbage removal, work on percentage rather than on absolute changes, and in this way the shocks of both deliveries and pick-ups are minimized. In this matter, the presence of garbage, especially some kinds like urea, plays a very useful role indeed, and we are in consequence led to a second criticism that the common and thoughtless use of such phrases as "poisonous wastes" on occasion may also equally become "nonsense."

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