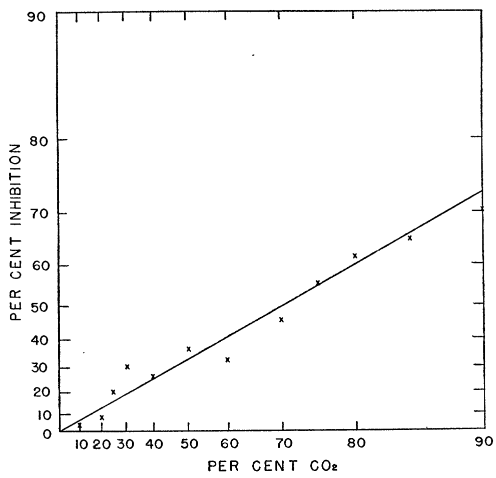

Fig. 2. Inhibition of growth at various levels of CO_2 for *E. coli.*

percentage inhibition of growth at that concentration. The slope of the CO_2-response curve depends on the temperature and the organism's response to CO_2. As the temperature departs from the optimum for growth, the response slope becomes steeper as a result of increased growth inhibition at lower temperatures for any given CO_2 level (*2, 4*). The effect of temperatures higher than the optimum has not been studied.

Experimental studies were carried out at 25°C to determine the amount of growth of *Escherichia coli* under different CO_2 concentrations. Test tubes containing equal amounts of bacteria in nutrient broth were placed in sealed 1-lit flasks containing the desired atmospheric mixture and placed on a shake machine for 24 hr. The oxygen concentration was maintained at 20 percent, except at the 85- and 90-percent CO_2 levels, where the oxygen concentration was 15 and 10 percent, respectively. Growth was expressed as a function of the amount of turbidity produced in the test tubes. The results plotted on a log-log scale are presented in Fig. 2.

The fit of the data, both experimental and from the literature, would seem to justify the validity of this method. The use of this type of representation has several advantages: (i) it makes possible direct comparisons between organisms; (ii) errors in collected data become immediately apparent; (iii) a large number of data may be presented graphically without confusion; and (iv) it makes possible the experimental determination of only a few growth points, with the others derived from the graphic representation. An inherent drawback, however, is that data derived from two organisms grown at the same temperature may not be strictly comparable if the optimum growth temperatures lie far apart.

It can be seen from Fig. 1 that the curves of organisms (*D, E,* and *F*) that are capable of growth in the lower soil depths are more gently sloping than surface or aerial types (*A, B,* and *C*). This means that at any particular CO_2 concentration, their growth is inhibited less than the growth of organisms that are usually confined to upper soil leaves or aerial environments. This tolerance to CO_2 probably plays an important part in their occurrence in a subterranean environment where concentrations of CO_2 normally range from 3 to 10 percent. Their ability to grow at lower soil levels allows them to escape competition with the many microorganisms that exist at or near the soil surface.

References

1. G. P. Gladstone, P. F. Fildes, G. M. Richardson, *Brit. J. Exptl. Pathol.* **16**, 335 (1935); J. W. Hes, *Nature* **141**. 647 (1938); A. Rippel and F. Heilmann, *Arch. Mikrobiol.* **1**, 119 (1930); G. E. Rockwell and J. H. Highberger, *J. Infectious Diseases* **40**, 438 (1927).
2. W. Brown, *Ann. Botany (London)* **36**, 257 (1922).
3. A. Burges and E. Fenton, *Trans. Brit. Mycol. Soc.* **36**, 104 (1953); H. Fellows, *J. Agr. Research* **37**, 349 (1928); N. S. Golding, *J. Dairy Sci.* **23**, 891 (1940); J. P. Hollis, *Phytopathology* **38**, 761 (1948); D. C. Neal and R. E. Wester, *ibid.* **22**, 917 (1932).
4. R. G. Tomkins, *J. Soc. Chem. Ind. (London)* **51**, 261 (1932).
5. J. W. Foster and J. B. Davis, *Arch. Biochem.* **21**, 135 (1949).
6. E. Bateman, *U.S.D.A. Tech. Bull. 346* (1933).

31 January 1955.

Communications

Carbon-14 Dates from Ellsworth Falls, Maine

Through the kindness of H. R. Crane and the Radiocarbon Laboratory, Michigan Memorial-Phoenix Project, the ages of two samples submitted by us have been obtained. These samples were taken from the Smith Farm, Ellsworth Falls, Maine, during a program of excavation covering the summers of 1947–50, inclusive, under the auspices of the Robert Abbe Museum of Bar Harbor, Maine, and the Robert S. Peabody Foundation for Archaeology. They yielded the first radiocarbon dates for the archaic in eastern New England.

Sample M-89 was taken from a pit that appears to equate with middle levels of the deposit including archaic remains of Red Paint character. Above it was a deposit comprising floors in which sherds of Vinette I pottery and later Point Peninsula pottery types were found. Although two pits containing Vinette I sherds were at comparable levels, they could be traced upward to these floors and are not connected in any way with sample M-89. Two runs of this sample produced the following: first run, 4150 ± 450 yr; second run, 3800 ± 400 yr. The average age is therefore 3959 ± 310 yr, or 2005 B.C.

Sample M-90 was taken from a pit that appears to equate with the latest expressions of archaic Red Paint. It assayed at 3350 ± 400 yr, or 1400 B.C.

A more complete description of conditions and associated artifacts will appear in the January 1956, issue of *American Antiquity.*

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15 February 1955.

To Users of the Hunter Color and Color Difference Meter

Since there has been a considerable amount of interest in our paper "New method of presentation of food samples to the Hunter color and color difference meter" [*Science* **120**, 666 (22 Oct. 1954)], we have prepared detailed blueprints of the spinning attachment described in the article. Those who wish to build the instrument for use in their own laboratories may obtain copies of these drawings from the Department of Food Technology, Oregon State College.

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21 March 1955.

On Hazards of Nuclear Power Plants

Weil's article, [*Science* **121**, 315 (1955)] was very interesting, although some details of the case of the Chalk River misfortune would have brought the discussion more into the realm of the here-and-now than the apparently purely theoretical.

I would like to suggest a type of design for power reactors that would confine disaster by-products to the premises and, perhaps, save the major portion of the plant from contamination.

If a reactor were built of massive construction as to tensile strength and mass of the walls and top, if the floor of the containing building were of similar construction, and if the whole were hermetically sealed, with the floor of the reactor relatively weak, blow-out and gravity would express the contents downward. Underneath, a large water trap would receive the debris and gas, the walls of the building extending well down into the reservoir, with a moat of sufficient dimensions around the building to accommodate the water displaced from the reservoir. A sufficient air-filled space above the water in the reservoir would act as a pneumatic cushion during the initial surge in order to permit the water mass to be displaced without undue shock.

Dimensions should be such that all gases would be confined to the inner chamber; excess volume and pressure would only reduce the reservoir chamber level to the point where it would pass under the intervening wall and up through the deep water in the moat. Condensation by cooling and by going into solution under the conditions of turbulence and pressure would greatly eliminate the initial volume of gas produced.

Confining the radioactive materials to the underground chamber, with only flat surfaces to be decontaminated, would greatly facilitate reconditioning; and the floor and tunnel across the moat of heavy construction would insure maximum protection to personnel and would permit early reactivation.

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11 March 1955.

Graphic Determination of Averages

In describing the graphic procedure for determining a simple arithmetic average, S. I. Askovitz [*Science* **121**, 212 (1955)] reports his inability to discover an applicable precedent in the relevant literature. This deficiency probably results from greater interest in graphic moving averages, which statisticians occasionally employ. To my knowledge, McChesney (*1*) has been the only investigator to deal with the subject formally. A brief elaboration should in no way detract from Askovitz' sound logic.

Suppose the points at the coordinates (x_1,y_1), (x_2,y_2), (x_3,y_3), and (x_4,y_4) are *A, B, C,* and *D,* respectively. Let *b* be the point at one-half the distance from *A* to *B*; and, similarly, let *c* be the point at one-half the distance from *B* to *C*. Connect *b* and *C* with a ruler, and at $x=2$ designate m_1 (*2*). Next connect *c* and *D,* and at $x=3$ designate m_2. The readings for m_1 and m_2 express the two three-point moving-average values for the four *y*'s. This technique can be adapted to other types of moving averages, including those reiterated.

After plotting a series of (equally weighted) observations on a scatter diagram, an analyst usually wants prompt answers to two questions before proceeding to more detailed objective treatment: (i) Are the data normally distributed? (ii) What would a smoothing disclose concerning the trend, or curve, of mean relationship? The analyst would answer the first question by passing perpendiculars through the two medians and seeing how the observations are arranged. In the absence of any compulsion to start over again with the *y*-values, *x*-values, or both transformed into more tractable form, an appropriate moving average may afford the basis for drawing a freehand curve, or provide a clue to the function that will best depict the central tendency.

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References and Notes

1. R. McChesney, *J. Am. Stat. Assoc.* **23**, 164 (1928).
2. I located m_1 in the process of arriving at a simple average.

24 February 1955.