man, they usually imply the additional assumption that optimum growth leads also to long duration of life, commonly termed longevity. There is no doubt that the nutrition of animals that are to be slaughtered for meat shortly after they mature should be considered from the point of view of rapid growth, since that implies efficient feed conversion. On the other hand at the present time it is the general practise of those who are concerned with child nutrition to attempt to attain the maximum growth of the child without regard to the possible interrelationship between such growth and a short life span. The same philosophy dominates the practises of rearing dairy calves and horses to maturity as rapidly as possible although it is desirable that they have a long productive life span.

In 1912 Slonaker[1] reared three male rats upon an omnivorous diet. Their mean length of life was 1,222 days, but it required 391 days for these rats to attain their maximum weight. A study of Slonaker's growth data indicates that these rats really grew very slowly to maturity and that they did not grow rapidly and then merely fatten to a maximum weight as middle age approached. I have disregarded Slonaker's data upon exercised rats, because there is nothing in the literature for comparison. I have not cited his data upon the vegetarian groups because they died relatively young and need not be considered in a discussion of longevity.

In a report concerning the rat diet that has proved satisfactory as far as reproduction and growth in our colony is concerned, Maynard[2] showed most of the growth of the male rat takes place before the sixteenth week with a gradual weight increase until the twenty-eighth week. During the past four years we fed a group of seventy-five male rats upon this diet until they died. Their mean age at death was 503 ± 12 days. Only 1 of these rats lived for more than 900 days.

Although Slonaker's data are very limited they indicate that our rats upon the stock diet are dying in middle age. Our rats matured rapidly, those of Slonaker slowly.

In our studies upon brook trout we have reported experiments twice in which trout that failed to grow lived much longer than those that grew upon similar diets.[3, 4] This first called our attention to the possible relationship between the rate of growth and the span of life within a given species. A relationship between rate of attaining maturity and life span between various species is frequently mentioned by early biologists, however Zabinski[5] from his studies with insects has noted the possibility of prolonging life by retarding the growth rate. Osborne and Mendel[6] suggested the same possibility from their studies with rats.

Miss Campbell[7] found she could extend the mean length of life as well as the growth of rats slightly by increasing the milk in the diet. In the light of Slonaker's data, these findings have only negative bearing upon the problem of longevity because even her group that lived the longer died in approximately middle life at a mean age of 664 days. All her many hundreds of rats died without any attaining the mean age of Slonaker's three males and her value for mean age disregards early deaths. Therefore her data indicate nothing concerning the interrelationship of growth and longevity. Her findings also confirm those of others that the female rat grows more slowly and outlives the male.

We may then have diets that are entirely satisfactory for growth and reproduction and these same diets may be unsatisfactory for longevity. It is known from many experiments that we may have a slow growth rate and a short life span upon a deficient diet. No one has ever found it possible, however, to have both rapid growth with early attainment of maturity, and longevity. It is possible that longevity and rapid growth are incompatible and that the best chance for an abnormally long life span belongs to the animal that has grown slowly and attained a late maturity.

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3 J. W. Titcomb, *et al.*, *Trans. Am. Fish. Soc.*, 58: 205. 1928.

4 C. M. McCay, *et al.*, *Trans. Am. Fish. Soc.*, 61: 58. 1931.

5 J. Zabinski, *Jour. Exp. Biol.*, vi: 360. 1929.

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7 H. Louise Campbell, Thesis, Columbia Univ. (1928).

SOLUBLE SESQUIOXIDES AND ORGANIC MATTER FROM ALKALI TREATMENTS ON SOILS

ALKALI treatments, equivalent to one ton per acre, on Appalachian upland podzol soils of Quebec have been studied in percolators in an attempt to break down the relatively large amount of organic matter and to decrease the acidity (pH about 5.0, "lime requirement" 3 tons CaO per acre). The results found differ from those reported by Meyer[1] based on the effects of calcium carbonate applied to Caddo silt loam of pH 4.8. Liming podzol soils has not produced the large increases in soluble iron and organic matter found in the case of the acid Louisiana soils. On the other hand, equivalent treatments with sodium hydroxide and sodium carbonate on these podzol soils give marked increase of soluble organic matter in

1 A. H. Meyer, "Iron Toxicity from Liming," SCIENCE, 76: 56. 1932.

colloidal suspension in the soil solution. In addition, iron and aluminum are found adsorbed by this organic material to the extent of about 40 p.p.m. and 20 p.p.m. of the soil, respectively. These soils and soil solutions with this treatment remain acid between values of pH 6.1 and 6.7.

Iron toxicity, due to increase in soluble iron after liming, has been claimed for the Louisiana soils, but the evidence that we possess indicates that the presence of the soluble sesquioxides in small amounts after sodium alkali treatment does not inhibit production from these Quebec soils but permits positive increases.

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THE ATTRACTION OF SPHERES

IT is appropriate that some warning should be given the inexperienced reader of Mr. Thaddeus Merriman's article in SCIENCE for April 14 (p. 371). His method of calculating the attraction of a homogeneous sphere upon a neighboring body involves assumptions inconsistent with the generally accepted methods of the integral calculus, as well as with the Newtonian law of gravitation. Newton's beautiful geometrical proof that the net attraction of such a sphere is exactly the same as if all the mass was concentrated at its center is, of course, fully confirmed by the rigorous analytical discussion which may be found in any standard treatise on mechanics, and so need not be reproduced here.

Mr. Merriman's proposed substitute law is inconsistent not only with theory but with the fact. For a small sphere near the earth's surface, it reduces to $F = G\frac{M, \cos\alpha}{d^2}$, when M is the earth's mass, d its radius, and α the angle between a line drawn to the earth's center and one tangent to a circle of radius 0.424 times the earth's. The factor $\cos\alpha$, which is omitted in Newton's equation, has the value 0.911 for a point on the earth's surface. Without it the attraction at the surface is known to be in complete agreement with that inferred from the orbital motion of the moon. To introduce it destroys the agreement, which provided Newton with the first conclusive test of his theory.

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APRIL 21, 1933

SCIENTIFIC APPARATUS AND LABORATORY METHODS

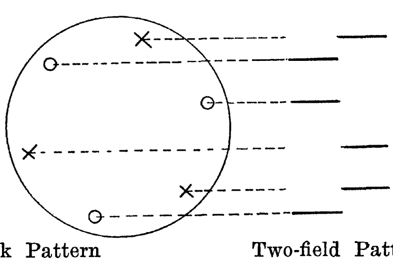
A TWO-FIELD STROBOSCOPE

IN stroboscopic observation of vibrating strings for measurement of frequency, no use seems to have been made of a two-field illumination. The two fields are contiguous and are alternately illuminated. The two-field method removes some ambiguities of the one-field method. But more important is the fact that a feeble resonance of the string to a tuning-fork or other source is more easily detected.

For the laboratory, the simplest device is the type of Neon bulb built for a. c. lighting circuits and having semi-cylindrical electrodes. Such a bulb can be held behind a string in such a manner that half of each electrode is visible. The two electrodes light up in alternation, the flash frequency of either side being equal to the frequency of the current.

For lecture demonstration, one can take a siren disk with an even number of holes. Alternate holes are half covered on the half nearest the center of the disk; the remaining holes are half covered on the side next the edge of the disk. The disk is set as closely as possible to the string, with the center of the disk level with the string. When a hole is level with the string, a strong beam of light is made convergent by means of a condenser, and is arranged to just cover either type of hole. On the other side, an objective focusses the string on a screen. When the disk is rotated and the string made to vibrate, a two-field stroboscopic view of the string is obtained. (Many other methods may be used.)

To understand the patterns seen, the procedure is to construct in advance the patterns to be expected. To do this, imagine a stroboscope disk with a single spot; rotate this at S revolutions per second, S being the string frequency; and illuminate the disk by F flashes per second. When the pattern has been worked out, project the spots of the pattern on a vertical line in the plane of the disk. Then repeat the process for a series of flashes beginning one half flash-period later. The projections of this second pattern gives the string pattern in the other field. The figure herewith illustrates the case when the flash frequency is 3/5 of the string frequency. Small circles give the first disk pattern, and crosses give the second.



Disk Pattern Two-field Pattern

Figure illustrating the construction of the two-field pattern for $F = S.3/5$.