of densities. It will be recalled that the practical separating power of a centrifuge depends not only upon the maximum magnitude of the rotational speed but upon the radius of the rotor as well. It is found desirable to make the peripheral velocity as large as possible. Fig. 4 shows an arrangement that

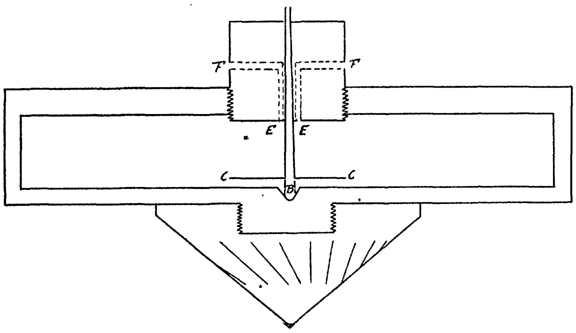

FIG. 4

has some advantage and is very stable. The size of the rotor can be varied over wide ranges. We have used them, for example, from 1 cm to 10 cm in diameter, but the size apparently is not restricted. Peripheral speeds of over 3×10^4 cm per sec. have frequently been attained. A convenient size one inch in diameter made of steel will rotate, when loaded with water, 3,500 revolutions per sec. with the compressor giving only about 1,200 cubic inches of air at a pressure of 100 lbs per square inch above one atmosphere, per minute. For this the angle of the stator $\beta = 91.5°$ and the angle of the rotor $\alpha = 103°$. The 8 holes LL′ were drilled with no. 73 drill.

By adjusting the air pressure the speed of revolution can be varied over wide ranges. The speed, however, remains remarkably constant when the pressure is held constant. Another striking thing is the absence of vibrations in the rotor when filled with a liquid and the consequent reduction of stirring or remixing to a minimum. The theory of separation by centrifuging should, therefore, hold with good approximation.

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A METHOD FOR COMPARING GROWTH RATES BY MEANS OF A PROTRACTOR

IN growth studies on plants and animals, the investigator, in his examination of the data, wishes to compare not only the growth increments, but also the *rates* of growth. The former may be done by the usual graphs, plotted directly from his records, but when he is contending with large amounts of data the numerous calculations of growth rates are time-consuming and become tedious. The writer has employed a simple and rapid method for the inspection of growth rates directly from the increments graphs. Although the method is not exceedingly accurate, it has proven to be of considerable aid in the general study of growth data.

The procedure is as follows: The customary growth increment graphs are plotted upon standard coordinate paper, being careful to locate each point accurately and sharply, and, in any series to be compared, the distances along the abscissa and ordinate allotted to the units of time and growth must remain constant throughout all sheets of graphs.

The rate of growth is the *slope* of the graph between any two points or observations. The value of this slope in degrees is easily determined by means of an ordinary transparent protractor. One has simply to place the point of origin of the protractor exactly upon one point along the graph, and then to rotate the protractor until its basal axis is directly over the point marking the next observation. The value of the slope between these points is read from the protractor over a line which is the continuation of the ordinate of the first point selected. This value, for convenience, is written beside the particular interval of the graph measured. Unfortunately, for this work, protractors are so numbered that the "90°" mark is at the top and the "0°$_s$" are to the right and left at the bottom, with the result that, the more rapid the growth rate, the smaller is the indicated angle corresponding to the slope. To rationalize this, one may subtract from 90 degrees the value found, and then use the complimentary angle. It is better, however, to renumber the protractor so that

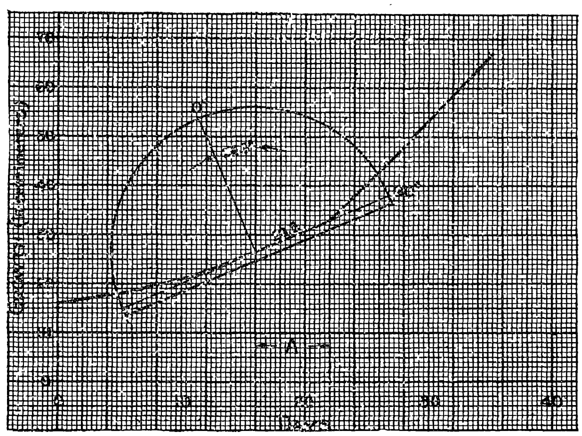

FIG. 1

"0°" occurs at the top, and "90°" at the bottom to the right (the first quadrant only is used). Fig. 1 shows a growth increment graph with protractor in position for measuring the slope of interval "A."

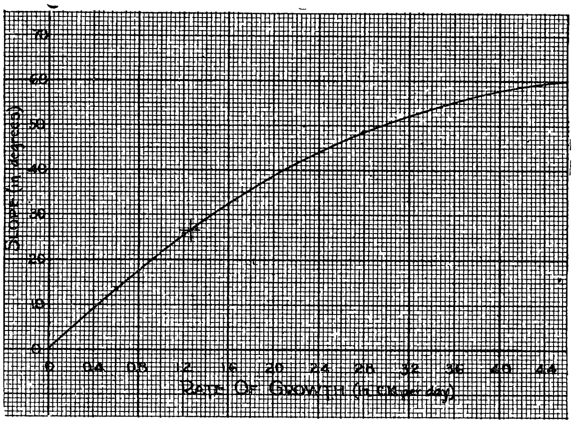

FIG. 2

The values found are arbitrary in any series of graphs, but they are suitable for comparison either by direct inspection or by using them for plotting other graphs showing rates of growth. If it is desired, however, the slope may be translated quickly to absolute rate of growth through reference to a curve, which is obtained by calculating from the growth data the actual rates corresponding to a few representative slopes. Such a curve of reference is shown in Fig. 2. When the slope of 26.5°, as found for interval "A" in Fig. 1, is referred to the curve in Fig. 2, it will be seen that this slope corresponds to a growth rate of 1.26 centimeters per day.

The protractor method for determining growth rates is very simple and rapid, and it should be particularly useful when large quantities of growth records have to be studied.

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SPECIAL ARTICLES

ON MOLECULAR ORGANIZATION IN AMEBAN PROTOPLASM

THE question whether a submicroscopic organization exists in protoplasm has been considered with increasing frequency during the past several decades. Among the more recent discussions come to mind those of H. Przibram, R. G. Harrison, L. J. Henderson, J. Needham, E. J. Lund, C. V. Taylor, G. H. Parker, W. T. Bovie and others. The wide-spread and persistent interest in this subject is presumably due to the belief that the proof of the existence of submicroscopic organization would not merely add a new series of facts to science concerning the nature of protoplasm but would, in addition, serve to bring many observations on the form and behavior of organisms into relation which now stand by themselves. And as a consequence, it would also serve as a good tool for further investigation in a number of lines of work.

The data presented herewith seem to me to constitute evidence in support of the hypothesis of molecular organization in the protoplasm of four species of amebas. Other data will also be presented as presumptive evidence tending to show that similar organization may be general among organisms and that certain large groups of hitherto unrelated observations fall into a coherent system under this generalized hypothesis. Since the entire argument is based ultimately on molecular movements and displacements, a statistical treatment is probably the most appropriate method of handling the data.

I. When an ameba is placed on a thin glass rod or within a fine capillary tube of suitable size, the path which the ameba makes on the rod or within the tube is a helical spiral of greater or less regularity, depending somewhat upon the individual, the species and other factors. The direction of the path may be to the right or to the left, for varying lengths of time, and may alternate frequently during the course of a few hours. Of the four species investigated, three are predominantly *left,* making each about 1.4 left turns to 1 right; the other species, which readily hypertrophies, is predominantly *right* to a slightly greater degree.

Now if one takes a convenient, small unit of measurement, such as one half turn around the rod or tube, and then measures all the right and left sections of path to the nearest half turn and arranges the sections in a frequency series based on length, a characteristic distribution is obtained for each species. Thus for the 4 species: *Rugipes bilzi, Mayorella conipes, Trichamoeba schaefferi, T. sphaerarum,* the distribution in the higher categories closely approximates the exponential series represented, respectively, by the formulas:

$$2^{-\left(\frac{y-1}{2}\right)},\ 2^{-(y-\frac{1}{2})},\ 3^{-(y-\frac{1}{2})},\ 4^{-(y-\frac{1}{2})},$$

where y is the length of any section. The data, representing 316, 3250, 322 and 615 sections respectively, of the above named amebas, are shown graphically in the figure. (The points representing the lower categories on the figure, which have drifted off the theoretical curve and are believed to represent the operation of an added factor, will be discussed in a more extended paper to be published soon.) For convenience of graphic representation the observed number of sections are proportionated so that the highest category, y^o, equals 1,000 and the log of the