was used, sufficient amounts of this product being generously furnished by Dr. I. Harris.

Intravenous injections of a neutral aqueous solution of this product into dogs showing severe nervous symptoms (clonic spasms, etc.) due to a lack of vitamin-B resulted in a complete cessation of such symptoms, in one instance within a half hour, and in another case within three hours after the injection. In a third instance the relief from symptoms occurred after a longer period. An intravenous injection of the vitamin-containing product was also made into an animal which had lost its appetite after subsisting on the vitamin-free food for a period of days but which showed none of the nervous symptoms characteristic of vitamin-B deficiency. The injection was followed by a complete recovery of appetite which lasted six (6) days.

Intraperitoneal injections were also made. Such an injection, while bringing about relief from nervous symptoms in all cases, did not prevent death from supervening from ten (10) to twelve (12) hours later in those instances where large amounts of material were injected. A control injection into a normal animal resulted in phenomena indicating that the fatal outcome in the instances cited was probably due to the too sudden introduction of large amounts of material and the effect of this procedure on the tissues within the peritoneal cavity.

The effect of subcutaneous injections into such animals will be studied shortly.

125 (1872)

The conductance of unicellular organisms.

By S. C. BROOKS.[1]

[*From the Division of Pharmacology, Hygienic Laboratory, U. S. Public Health Service, Washington, D. C.*]

The electrical conductance of bacteria (*B. coli* and *B. butyricus*) unicellular algæ (*Chlorella* sp.) yeasts (*Saccharomyces* sp.) and mammalian red-blood cells has been studied by a method which yields figures for the gross conductance dependable within 1/10 per

[1] Approved for publication by the Surgeon General.

cent. Polarization capacity was compensated for by variable condensers in parallel with the variable resistance. While most of the studies here reported were made on the alga, *Chlorella*, there is apparently no fundamental difference between this and the other organisms.

The difference between the conductance of the suspending fluid and that of the suspension of cells is expressed in per cent. of the former and called the net conductance. This will always be negative in sign, because living cells are poor conductors of electricity. Rather large variations in the net conductance are produced by factors, such as irregular distribution of cells in the suspension, which it is impracticable to eliminate and which may affect the net conductance of any one sample by several per cent. For this reason enough samples were used in each experiment to make the error of the mean less than three per cent.

It is possible to calculate the limits between which the observed net conductance should fall, the relative conductance of the cells themselves and their volume concentration being known.

If r is the resistance of the suspending fluid and kr that of the cells and n the concentration of the cells in volume per cent., then the total resistance should lie between

$$10r\frac{\sqrt{n}(k-1)+10}{(10\sqrt{n}-n)(k-1)+100}$$

and

$$r\left(1+\frac{n(k-1)}{10\sqrt{n}(1-k)+100k}\right).$$

These formulas give curves convex to the axis of concentrations when they are plotted against resistances as ordinates. But when the cells form less than about 65 per cent. of the total volume the observed curves are nearly linear, possibly because of variations in the relative extent to which the current lines are able to evade the more highly resistant cell material. It is fortunate that this is so, since in case the volume of cells varies during the course of an experiment (*e.g.*, because of osmotic changes) a linear correction may be introduced. Different organisms and even different lots of the same organism differ considerably in their net conductance at any given concentration.

The relation between the conductance of the suspending fluid and the net conductance of the suspension was somewhat unexpected. Perrier's artificial sea-water[1] was diluted to 2, 4 and 8 volumes with distilled water. *Chlorella* which had been grown in a solution somewhat more dilute, was transferred successively to increasing concentrations of this artificial sea-water and the net conductance determined several times in each case until upon further renewal of the solution between each determination no further change occurred. For example, in changing from 1/8 to 1/4 strength sea-water, the net conductance changed from 28.9 to 27.2 per cent. Corrected for the decrease in the volume of cells, the figures would be 28.9 and 28.3 per cent. The change in net conductance is within the limits of error of the method. This shows that if by any chance the conductivity of the surrounding medium is changed during the course of an experiment only the net conductivity in per cent. will normally remain constant. Expressed in any other way the results might easily be misleading. In the above case the net resistance expressed in ohms instead of remaining constant fell from 80 to 45 ohms approximately.

It is also of interest to note that the net conductance of dead cells is relatively greater in those organisms which normally encounter a fluctuating environment. The ratio of the net conductances of dead and living cells is about as follows: red blood cells .45, yeast .65, bacteria .70, Chlorella .80–.90. This fact suggests that the cell walls (or at least some non-living structure), help to protect such cells from extreme fluctuations in electrolyte concentrations, insofar as the changes inside the cell walls would be retarded and therefore less abrupt. Multicellular forms such as *Laminaria* need such protection only at the outer surfaces of the superficial cells, and it is therefore not surprising that such tissues have when dead only about one tenth the electrical resistance that they have when living.

[1] Perrier, E., *Comptes Rendus*, 1890, cx, 1076.