

The results just described made it seem probable that *Bartonella bacilliformis* was the cause of both Oroya fever and verruga, and it was desirable that parallel cultural and experimental investigations be made with human verruga tissues. Such studies were rendered possible through the kind intermediation of Dr. E. Campodónico, of Lima. Subcutaneous nodules were excised under aseptic conditions from verruga patients in Lima, and portions were forwarded to New York for bacteriological and experimental study by one of us (N.), the clinical and pathological work being carried out by the other (H.) in Lima. What has been accomplished thus far may be summed up as follows:

(1) Two young monkeys (*Macacus rhesus*), inoculated with a saline suspension of nodular tissue from Case P. 5, manifested fever (104° F.) within 1 to 3 weeks after inoculation, and from the blood in each instance was isolated in pure culture a microorganism indistinguishable from the strain of *Bartonella bacilliformis* previously cultivated from the blood of an Oroya fever patient. (2) In one of the monkeys a hard nodule about the size of a walnut developed within seven weeks near the middle portion of the tail. The lesion consisted of highly vascular granulomatous tissue, rich in endothelial cells, and containing a considerable amount of fibrous connective tissue. Pure cultures of the same organism which had been isolated from the blood were obtained from the nodular tissue. (3) *Rhesus* monkeys inoculated with the cultures developed verruga lesions at the sites of intradermal injection and showed marked anemia. Characteristic bacilliform microorganisms were found in the red blood corpuscles, and pure cultures of what appears to be *Bartonella bacilliformis* were obtained from both skin lesions and blood. (4) Serological tests showed the verruga strain and the strain from Oroya fever to be closely related.

Clinical and pathological reports will be presented later, together with full details of the experimental work just outlined.

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ON THE EXTENSION OF THE DEBYE- HÜCKEL THEORY OF STRONG ELEC- TROLYTES TO CONCENTRATED SOLUTIONS

THE Debye-Hückel theory¹ explains the observed deviations of a solution of a strong electrolyte from the ideal solution by the electrostatic forces between

¹ Debye and Hückel, *Physik. Z.*, 24, 185 (1923).

the dissolved ions, which give rise to an additional term in the expression for the free energy of the solution. This free energy term depends, among other things, upon the dielectric constant of the solution. In the original theory, which applies only to dilute solutions (up to about 0.3M), the dielectric constant is assumed to be independent of the concentration of the solution. Hückel² has given an extension of the theory to concentrated solutions, assuming that the dielectric constant decreases linearly as the concentration increases. Through a faulty application of the so-called charging process,³ Hückel's expression for the electrostatic free energy term is erroneous, and his further results, which are all derived from this expression, are therefore invalid.

The writers have shown that the correct expression for the electrostatic free energy is the same as in the original Debye-Hückel theory, the only difference being that the dielectric constant is no longer assumed to be independent of the concentration. The writers have furthermore developed methods for calculating, from experimental data (freezing point and vapor pressure lowering, electromotive force, solubility) not only the free energy term referred to, but also the ionic radius and the change in the dielectric constant with changing concentration.

It is found that the ionic radius varies rapidly with the temperature, the radii for LiCl, NaCl, KCl at 0° calculated from freezing points being roughly twice those at 20° determined from vapor pressures.

The dielectric constant also varies markedly with the temperature. Moreover, at any fixed temperature, but with increasing concentration, the dielectric constant begins by decreasing much more (from 50 to 100 times) rapidly than Hückel's expression indicates. It soon reaches a minimum and starts to increase more slowly, until in very concentrated solutions it is considerably larger than in pure water. This behavior of the dielectric constant is in entire qualitative agreement with the direct measurements of Walden and his collaborators⁴ of the dielectric constant of non-aqueous solutions of electrolytes.

It is also found that certain salts, for instance, KNO₃, do not conform to the theory, the probable explanation being that in addition to its electric charge, the NO₃ ion also carries an electric dipole moment. Theoretical investigations in this direction are now in progress.

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² Hückel, *Physik. Z.*, 26, 93 (1925).

³ Debye, *Physik. Z.*, 25, 97, (1924).

⁴ Walden, Ulich and Werner, *Z. Phys. Chem.*, 116, 261, (1925).