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6026

Physico-Chemical Mechanism of Cellular Electromotive Force.

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The physico-chemical nature of the intracellular electromotive system is not deducible from electromotive force measurements alone, although many investigators have drawn conclusions from such data. Critical evidence has been provided by Lund and his students[1] that the E.M.F. arises from an oxidation-reduction system. This, and direct evidence by the writer,[2] are interpretable only in terms of a conductor of the first class (plasma membrane, or analogous structure or phase boundary) in electron equilibrium with a dissolved ion or ions. Under these circumstances the effect of electric currents upon cells acquires diagnostic significance. Mast[3] has recently confirmed Kühne's observation that passage of current through the epidermal cells of Tradescantia causes acidity at the cathode end and alkalinity at the anode end. The cells contain a natural pH indicator; the color change begins at the inner boundary of the cell membrane and extends slowly inward. The writer has also confirmed these experiments. The color change is a *qualitative test* of the nature of the electromotive system.

Four physico-chemical systems must be interrogated as to their behavior on electrolysis (the diffusion potential will not explain the facts in Tradescantia). The membrane potential and the phase boundary may be treated together under the Donnan equilibrium. In this system electrolysis causes accumulation of the non-diffusible ion at one membrane and diminution at the other. The non-diffusible ion tends at equilibrium to expel ions of like signs and to attract in ions of opposite sign. If the ion is an ampholyte, *e. g.*, a

[1] For references consult Lund, E. J., *Protoplasma*, 1931, **13**, 236; *Plant Physiol.*, 1931, **6**, 631.

[2] Marsh, G., *Protoplasma*, 1930, **11**, 447.

[3] Mast, S. O., *Z. fur Vergleich. Physiol.*, 1931, **15**, 309.

protein, then on the acid side of the isoelectric point the interior will be alkaline to the exterior; increase in concentration of non-diffusible ion will cause an increase in internal alkalinity, decrease in concentration, an increase in acidity. On electrolysis the non-diffusible ion will accumulate at the cathode membrane, increasing the internal alkalinity; it will diminish at the anode membrane, causing increase in acidity. On the alkaline side of the isoelectric point increase of non-diffusible ion will cause increased internal acidity; this will occur at the anode membrane on electrolysis. The reverse will occur at the cathode membrane. These pH changes can be demonstrated by passing a current through gelatin salts between collodion membranes, using appropriate indicators. Exactly the opposite changes are observed in Tradescantia. A Donnan equilibrium (while probably existing) is not the electromotive system responsible for this phenomenon.

If the mobility of H^+ or of OH^- ions were decreased in the membrane the color changes in Tradescantia would be accounted for. In this event the exterior of the anode membrane should become acid, the exterior of the cathode membrane alkaline. Injured or dead cells occur scattered through the epidermis on both sides of living cells, the dye showing the color corresponding to the pH of the external medium (usually alkaline). Prolonged current flow causes no color change of the dye adjoining either the anode or cathode ends of living cells. The zone of color change in living cells may be greater than 10 times the width of 2 cell walls, so that the reverse pH changes should be visible along the boundary of the adjoining cells. Evidently no marked decrease in mobility of H^+ or of OH^- ions occurs in the membrane.

The pH changes at the surfaces of conductors of the first class on electrolysis are conventionally stated to be alkalinity at the cathode surface and acidity at the anode surface. If, however, the electrolyte is an ion which readily changes valence at the electrodes and water is not decomposed, it is evident that at the cathode cations are destroyed or anions created, at the anode cations are created or anions destroyed, depending upon the sign of charge of the electromotively reversible ion. Simultaneously H^+ and OH^- ions respectively move to and accumulate at the cathode and anode. *Acid* appears at the *cathode* and *alkali* at the *anode*. This may be nicely demonstrated by electrolysing $K_4Fe(CN)_6$ and $K_3Fe(CN)_6$ between platinum electrodes with phenol red.

A conductor of the first class in electron equilibrium with a dissolved ionic species capable of ready valence change is the only physico-chemical system adequate to explain the pH changes in Tradescantia. The conclusion seems inescapable that this is the type of system found in the living cell, for the mechanism of production of E.M.F. is probably common to all forms of living matter. That the cell surface is both a "membrane" and a "solid" conductor of electrons is no real paradox.

6027

The Demonstration of Mycobacterium Tuberculosis in Exudates, Tissues and Body Fluids.

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Five hundred and twenty-seven parallel attempts were made to recover the *Mycobacterium tuberculosis* from various materials taken from lesions suspected of being tuberculous, using guinea pig inoculation and Corper's gentian violet-glycerol-water-potato slants.

TABLE I.

	Tissue	Urine ureteral	Urine voided	Urine bladder	Exudate	Spinal fluid	Sputum	Stool	Gastric content	Cyst fluid	Total
Pig neg. Cult. neg.	48	202	10	10	70	15	5	2		1	363
Pig pos. Cult. pos.	15	17	2		10	3			1		48
Pig pos. Cult. neg.	9	4			11	3			1		28
Pig pos. Cult. inc.		2		1	1						4
Pig neg. Cult. pos.	3	2	1		1						7
Pig inc. Cult. pos.	4				1						5
Pig neg. Cult. inc.	2	13		2	5		1				23
Pig inc. Cult. neg.	9	20		3	8		3				43
Pig inc. Cult. inc.	1	1	2		1					1	6
Total	91	261	15	16	108	21	9	2	2	2	527

Agreement, positive	48	Disagreement, pig negative or incomplete	12
Agreement, negative	363	Disagreement, culture negative or incomplete	32
	411		