THE RELATION OF PERMEABILITY TO ADAPTATION IN UNSTRIATED MUSCLE

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Danielli (1941) has explained accommodation in nerve produced by calcium as due to increase in permeability. Such an explanation would explain adaptation in unstriated muscle (Singh, 1944 *a*). In the present paper some facts are presented which harmonise with such a view.

Results

When unstriated muscle is stimulated continuously with alternating current, the muscle may be completely or incompletely tetanised, or relax during the passage of the current (Figs. 1 *a, b, c*). This suggests that if the

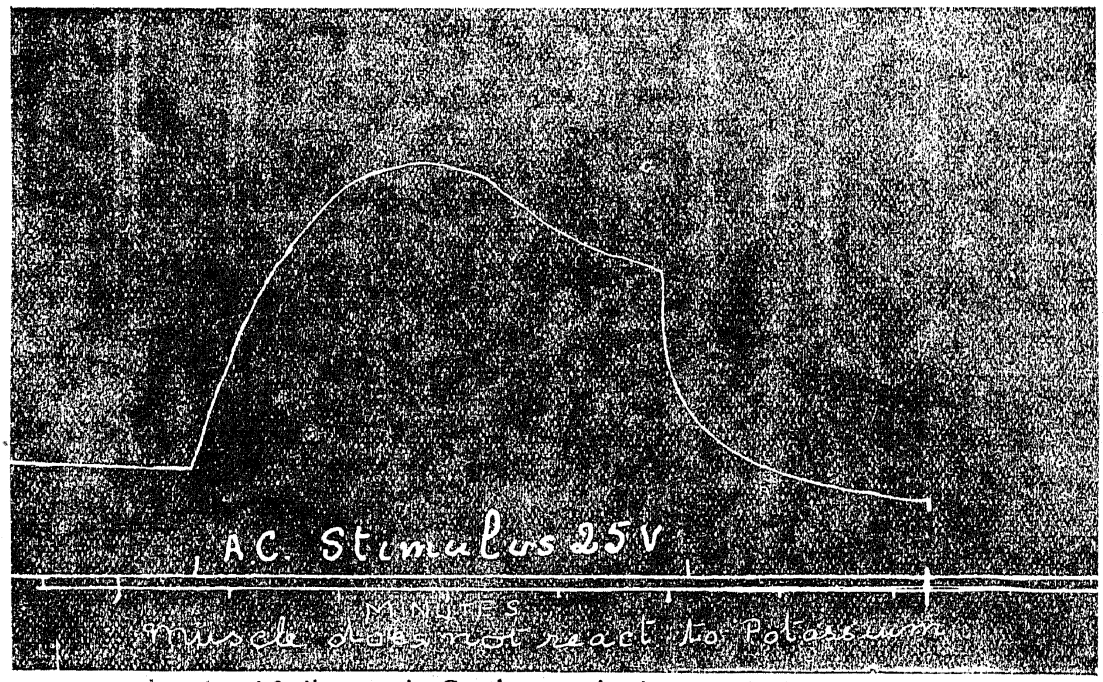

Fig. 1 *a*. *Mytilus* muscle. Continuous stimulation with alternating current

ions had accumulated on one side of the membrane, they had leaked through the membrane. As increase in the osmotic pressure of the saline produces identical contractions, or as the contraction is increased by increase in osmotic

pressure of the saline, the ions accumulate inside the muscle membrane, and the resulting inexcitability is probably due to their leakage through the

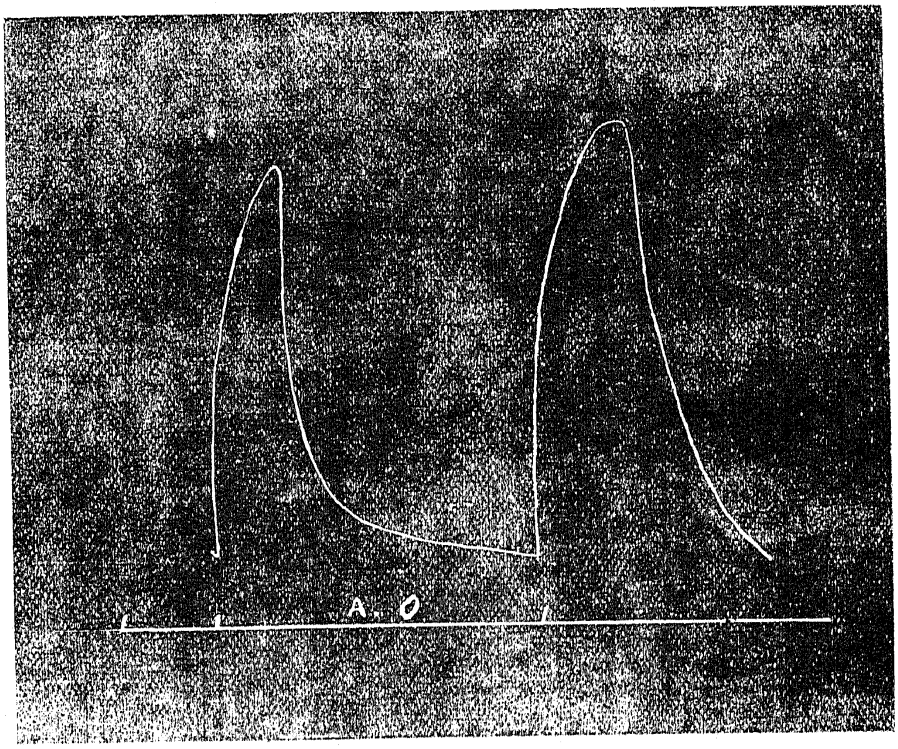

FIG. 1 *b*. Same as Fig. 1 *a*.

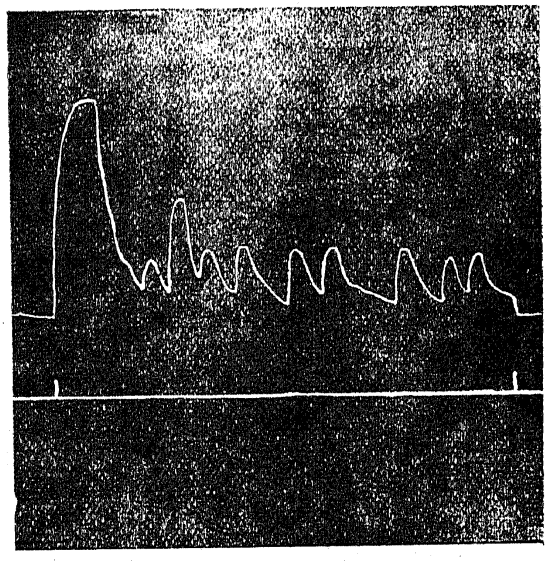

FIG. 1 *c*. Same as Fig. 1 *a*.

membrane, and the accumulation on the other side just as the inexcitability of the freshly dissected frog skeletal muscle (Duliere and Horton, 1929).

The above conclusion is supported by the following facts:—

(1) On cessation of the current, a contraction occurs, which has the p perties of contractions produced by addition of ions outside the fibres.

(2) Substances which increase the permeability of the muscle, incre the subsidence of the tension and the off-contracture. Thus the latte increased in the absence of the calcium and if the chloride of the saline replaced by bromide, iodide, nitrate, thiocyanate and cyanide.

(3) During stimulation there is gain of sodium, which implies leak of potassium (Singh, 1939). Thiocyanate and absence of calcium increa the leakage of potassium (Gokhale and Singh).

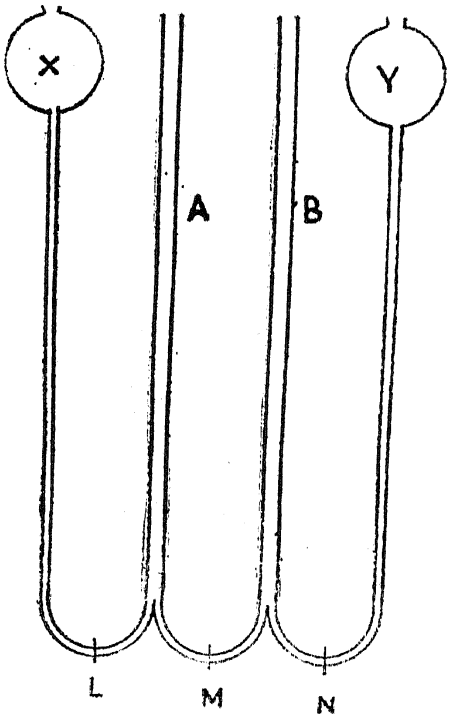

FIG. 2 *a*

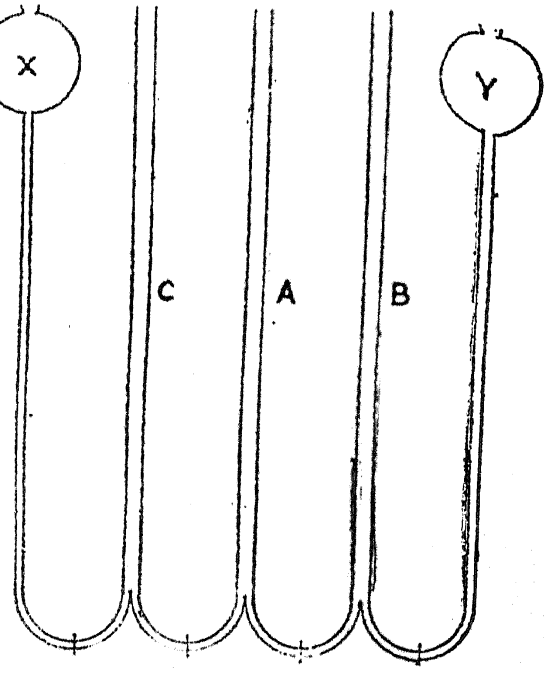

FIG. 2 *b*

The above phenomena can be represented by a simple hydrostatic mode (Fig. 2*a*). It consists of a U-tube, with limbs A and B; each limb can be fille with mercury by means of reservoirs X and Y respectively. Excitation i presumed to occur when there is difference in levels of fluid in the two limbs A and B. The limb B represents the interior of the muscle fibres and the limb A, the exterior, L, M and N are variable constrictions. Raising of X implies additions of ions outside the fibres, and that of B stimulates excitation by electric current or increase in osmotic pressure of the saline producing an increase in the concentration of ions inside the fibres.

If X or Y are raised slowly then no contraction occurs, depending upon the permeability of M. The subsidence of the excitation process by electric current would be simulated by subsequent lowering of Y. This would result in a contraction similar to that produced by raising of X.

The occurrence of the off-contraction would be favoured by (i) increase of permeability, permitting leakage of ions. Thus it is favoured by the absence of calcium, and by bromide, nitrate, iodide, thiocyanate and cyanide, (ii) at the end of the stimulation, by decrease of permeability. Thus it is occasionally favoured by calcium. Excitation will be abolished if the permeability is too much increased.

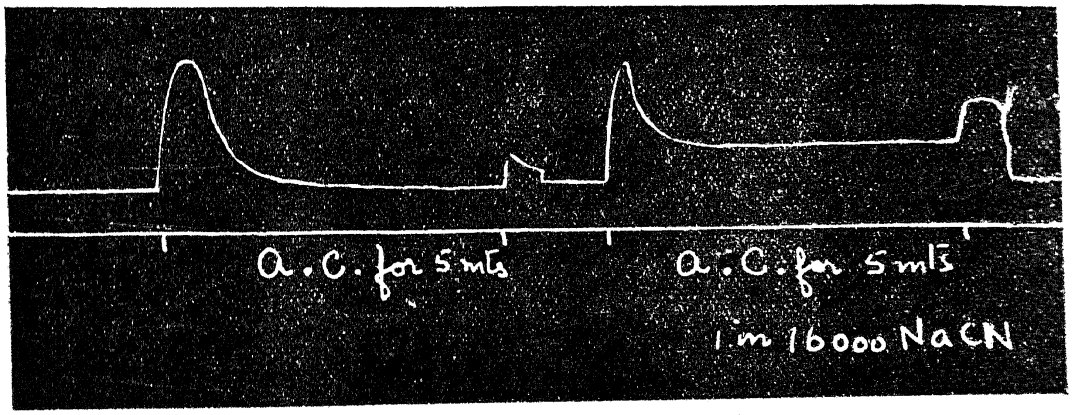

FIG. 3½*a*. Same as Fig. 1 *a*. Effect of cyanide

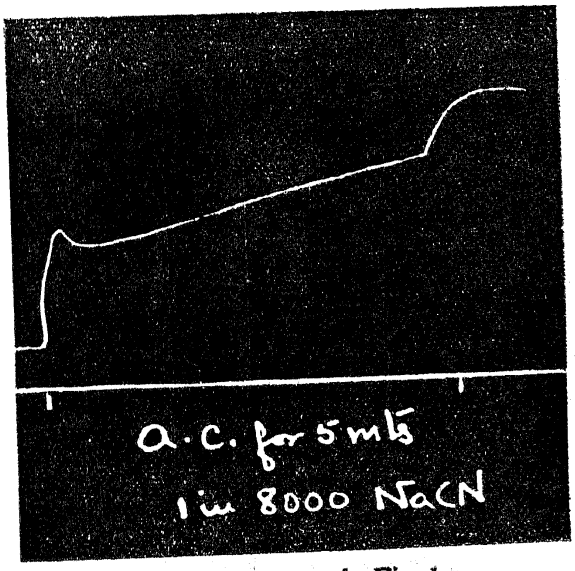

FIG. 3 *b*. Same as in Fig. 1 *a*

In the above model, an increase of permeability should lessen the excitability to electrical current, and to potassium. But the excitability to

potassium is oppositely affected. When *Mytilus* muscle is stimulated continuously with alternating current, a second contraction may occur (Fig. 3 *a*, *b*), which has the properties of the potassium contraction. Such curves resemble those in the striated muscle (Briscoe, 1938). In the model of Fig. 2, such a process would be simulated by raising of X, during raising of Y, so that the effect of Y may be neutralised or exceeded by that of X.

The above phenomena can be reproduced in the model by addition of another limb C on the side of X (Fig. 2*b*). C will represent the intercellular space instead of A and A a zone between B and C. With increase of permeability, ions will leak out into A both from B and C. With great increase in permeability the leakage of C may entirely mask the leakage from B, so that alternating current will produce a tonic contraction from the outset (Fig. 4).

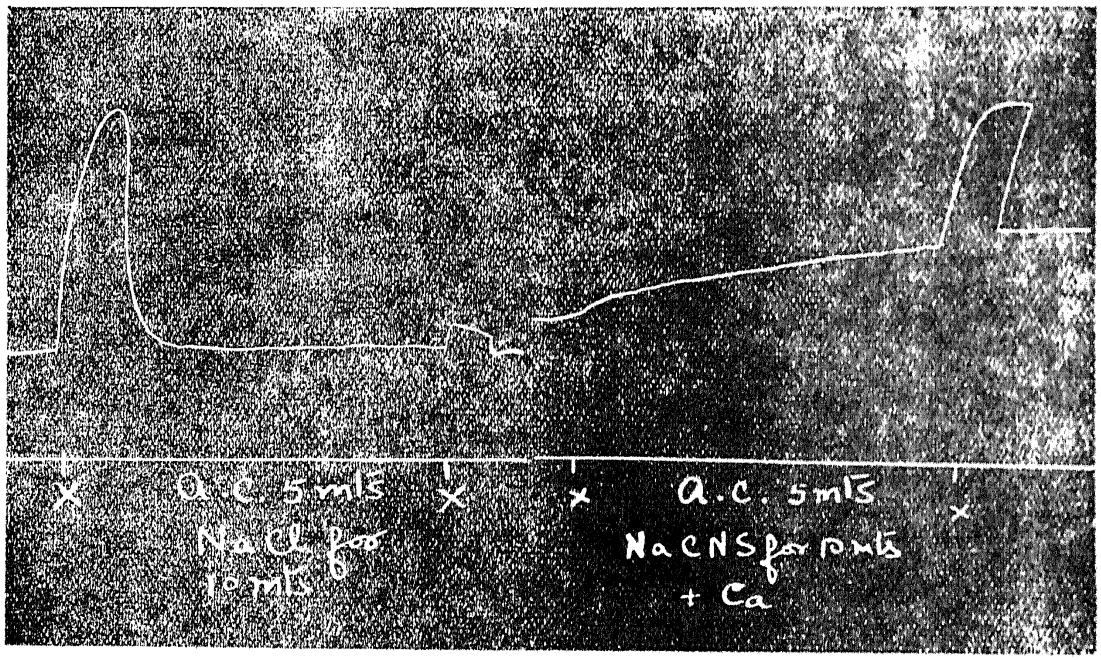

FIG. 4. Same as Fig. 1 *a*. Effect of the thiocyanate

The initial contraction has disappeared, but a tonic contraction has developed. The disappearance of the initial contraction and development of the tonic contraction can be traced by successive replacing the chloride of the saline with bromide, nitrate, iodide, and thiocyanate respectively (Singh, 1945).

At the end of the stimulation there will be an off-contracture due to leakage of the ions not only from B but also from C. Increase in permeability, therefore, will increase the excitability to chemical and diminish that to electrical stimulation. Adaptation to electric current would thus be due to two causes. As mentioned previously, the movement of the ions are not only conditioned by permeability changes but also by colloidal affinity (Singh, 1944 *b*).

Permeability has probably similar effect on chemical stimulation (Gokhale and Singh, 1945). It is possible however that adaptation may also be produced by the development of opposite excitatory states, which will produce a contraction of the opposite kind on cessation of stimulation.

SUMMARY

A hydrostatic model is described to explain adaptation in unstriated muscle.

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