

## ADAPTATION OF CUTANEOUS TACTILE RECEPTORS

### IV. ELECTROLYTE CONTENT OF FROG SKIN

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Hoagland (1934, 1935 *a*, *b*) has presented evidence indicating that the failure of response of the tactile axon endings in frog's skin to mechanical stimulation of the skin may be due to reduction of the excitability of the endings by the release of potassium from surrounding epithelial cells when they are pressed upon. To test this hypothesis it was desirable to obtain information concerning the electrolyte content of the skin areas used in these experiments. Up to the time of the present investigation there seemed to be no available data describing the electrolyte content of the skin of the back and sides only of *Rana pipiens*.

A sample of freshly removed skin (approximately 0.2 gm.) from the back or sides was blotted lightly on smooth filter paper, placed in a porcelain crucible, and weighed. The sample was dried to a constant weight in a desiccator and reduced to a white ash in a muffle furnace. Except in the case of the chloride analyses, the ash was taken up in 50 cc. of 0.1N HCl. For chloride analysis the ash was dissolved in hot water to which was added a few drops of concentrated H<sub>2</sub>SO<sub>4</sub>. The following colorimetric procedures were employed with but slight modifications as conditions required: *potassium*—Jacobs and Hoffman (1931); *sodium*—Salit (1932); *calcium*—Roe and Kahn (1929); *phosphate* (inorganic)—Bell and Doisey (1920); *sulfate* (inorganic)—Wakefield (1929); *magnesium*—Yoshimatsu (1929–30); *chloride*—McClendon (1934).

Table I shows the results obtained by the analyses. The values are typical for both the back and the sides, since no significant difference was observed between them. Only a few analyses were performed on some of the constituents since the purpose of this investigation was merely to obtain relative concentrations, and especially to see if potassium were concentrated in the skin in such a way as to be in harmony with the proposed adaptation hypothesis.

From the table it is evident that there is considerable variation in the electrolyte content from animal to animal, especially of Ca and P. The averages of these values give relationships which are useful for our purpose.

The ratio of K in the skin to the K in frog plasma is of the same order of magnitude as that found by Fenn, Cobb, Hegnauer, and Marsh (1934) between frog nerve and plasma;  $\frac{\text{Skin K}}{\text{Plasma K}} = \text{about } 14$ , and  $\frac{\text{Nerve K}}{\text{Plasma K}} = \text{about } 19$ . If, among other things, the excitability

TABLE I

The following values are expressed in milligrams of electrolyte per hundred grams of wet tissue. Experimental errors as follow K  $\pm 2$  per cent; Na  $\pm 2$  per cent; Ca  $\pm 7$  per cent; Mg  $\pm 3$  per cent; Cl  $\pm 1$  per cent; S  $\pm 5$  per cent; P  $\pm 2$  per cent.

K	Na	Ca	Mg	Cl	S	P
<i>mg. per cent</i>	<i>mg. per cent</i>	<i>mg. per cent</i>	<i>mg. per cent</i>	<i>mg. per cent</i>	<i>mg. per cent</i>	<i>mg. per cent</i>
136.0	86.9	340.0	3.8	182.2	36.3	341.9
124.0	94.3	310.5	5.0	178.1	29.9	319.0
128.5		205.0		187.6		271.2
131.6		354.9		139.5		318.7
141.8		328.4				438.1
		258.6				410.3
		419.2				310.5
		440.9				307.5
		262.5				321.1
Average . . 132.4	90.6	302.2	4.4	171.9	33.1	337.6

of the axon endings is dependent on the ratio of potassium inside the axon to that outside in the plasma ( $K_i/K_o$ ), then the release of K from the epithelial cells surrounding the endings would decrease their excitability by reducing the ratio  $K_i/K_o$ . The amount of K present in the skin is consistent with such an hypothesis.

The amount of Na present in the skin indicates that probably an insignificant amount of it would be released from the skin on mechanical stimulation, because it would be opposed by an appreciable concentration gradient. The Na concentration of the plasma is about 2.6 times as great as is that in the skin. The Ca, although

present in considerable amounts, is probably present in the skin in an indiffusible form ( $\text{Ca}_3(\text{PO}_4)_2$ ). As will be shown in a subsequent paper, Ca is not expressed from the skin under pressures used in Hoagland's adaptation experiments. Mg is present in very small amounts, and, if anything, might be expected to increase the excitability (Schaefer, 1934). The anion Cl and the S present would not be expected to have any effect on the excitability of the axon endings.

## SUMMARY

The potassium content of the skin of *Rana pipiens* is found to be 132 mg. per cent. This is roughly of the order of magnitude of the content of potassium in nerve.

Analyses were also made of the skin for Na, Ca, Mg, Cl, S, and P.

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