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3772

Resistance and Capacity of Stimulated and Unstimulated Muscle at Varying Electric Current Frequency Related to Chronaxie.

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The relation of chronaxie to the frequency of alternating electric currents capable of stimulating muscle is shown in the following table. The alternating current was derived from a General Radio Company oscillator, No. 377, and silver pin electrodes 5 mm. apart coated with AgCl by electrolyzing 1% NaCl with 6 volts for 10 seconds. These were stuck into the muscle and the chronaxie was determined by the condenser method.

TABLE I.

$\sigma = 0.001$ second. Kilocycle = 1000 cycles per second.

	Chronaxie σ	Duration of oscillator current in 1 direction σ	Maximum No. of kilocycles capable of stimulating
Fish	0.20	0.010	50
Frog	0.25	0.013	40
Crab	10.00	0.025	20
Scallop	30.00	0.050	10

The above table indicates that the threshold of duration of current from oscillator is about 0.05 of the chronaxie in case of fish and frog. With the crab and scallop the results are uncertain owing to the uncertainty of the determination of such long chronaxies by the condenser method. Since the energy required to stimulate is at a minimum at the chronaxie, it seems best to use muscles with short chronaxies for measuring the conductivity of the muscle with the stimulating current (using telephone for detection), so that the muscle will become stimulated in a small fraction of a cycle.

Lapique has shown that chronaxie varies rapidly after excision of tissue, and similar results are obtained for the highest frequency capable of stimulating the muscle. The gastrocnemius of the green frog was excised at 4:50 P. M. and immediately placed in moist chamber and stimulated at 70 kilocycles; at 4:55, 60 kilocycles was the highest frequency that would stimulate it; at 5:20, 30 K. C., 5:30, 28 K. C., and 5:45, 20 K. C.

No great difference in chronaxie was observed between bony fish and elasmobranch (dogfish) and the absence of bones in the latter made it convenient. No difference was observed between the green frog and bull frog. The muscle was pressed between silver electrodes. It was found that a film of AgCl did not lower the impedance. The measurements were made with a Wheatstone bridge with equal ratio arms. By balancing the tissue against a circuit that would remain in balance with change of frequency, the type of circuit in the muscle was imitated and was: a capacity (C) in parallel with a resistance r and the whole in series with another resistance R. Green frog thigh muscles (unstimulated) balanced (with equal ratio arms) against a circuit with r = 226 ohms, C = 0.145 microfarads and R = 125 ohms at 1 K. C., 2 K. C. and 3 K. C., whereas if C was increased or decreased and r and R changed to balance at one frequency it did not balance at another. For instance if C is set at 0.070 mf. at 1 K. C., r = 300 ohms and R = 15 whereas at 3 K. C. r = 290 and R = 20. If C is set at 0.245, at 1 K. C. r = 200 and R = 200, but at 3 K. C. r = 225 and R = 210.

TABLE II.

Animal	Kilocycles	Physiological State	Microfarads C	Ohms R
Dogfish	2.5	u	—	500
		s	—	489
Bullfrog	0.9	u	3.24	285
		s	3.60	267
,,	1	u	2.45	309
		s	2.50	299
,,	1	u	2.50	300
		s	3.00	290
,,	2	u	0.935	286
		s	0.935	262
,,	2	u	0.930	318
		s	0.960	272
,,	3	u	0.500	270
		s	0.550	250
Green frog	2	u	1.00	317
		s	1.10	300
,, ,,	2	u	1.10	300
		s	1.14	297

u = unstimulated. s = stimulated.

In another experiment with bull frog muscle at all 3 frequencies $r = 198$, $C = .195$ and $R = 98$.

If r is made zero a balance may still be obtained but varies with frequency as shown in the following table (together with the change in resistance and capacity with stimulation).

It may be seen from the table that the resistance invariably decreased on stimulation. Change of shape may have an effect on resistance. Since the muscle placed between the electrodes had muscle fibers extending in various directions, it was thought that the effects of change of shape of the different fibers might tend to neutralize one another. The fact that there was always a decrease in resistance is considered as indicating that there was a decrease in resistance of the individual muscle fibers. The changes in capacity are not so regular.

3773

The Effect of Hypercalcemia on the Creatin Output in Myasthenia Gravis.

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The discovery by Fiske and Subbarow[1] of muscle phosphocreatine as a labile compound with a definite relation to the functional condition of the muscle, again awakened the interest in those diseases of the (neuro)muscular system, which are characterized by creatinuria, *viz.*, progressive muscular dystrophy and myasthenia gravis. The occurrence of acute attacks of muscular incompetence in myasthenia gravis versus the more steadily yet slowly progressive course of the muscular dystrophy made us choose the former disease for our experiments. The question whether the escape of the creatine from the muscle is due to an error of metabolism of the sarcoplasm or to an abnormal permeability of the sarcolemma presents itself. Through the parathyroid hormone preparation by Collip it has become possible to influence the blood calcium level sufficiently for the carrying out of cell-membrane permeability experiments in human subjects.

We report briefly an experiment designed to demonstrate the effect of hypercalcemia on the creatin output in myasthenia gravis. The patient was 45 years, with myasthenia gravis of one year's duration, the diagnosis having been made in the neurological divi-