

XVIII. NEUROPHYSIOLOGY*

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RESEARCH OBJECTIVES

Relaying of information between neurons may occur either through direct nervous conduction at the junctions or by means of some intermediate chemical agent emitted by one to act on the other. Evidence for both processes can be found among invertebrates. Which is the case in any set of vertebrate synapses cannot be decided on present data. Since direct transmission would allow relating of function to structure, we wish to test for its existence in the central nervous system.

Coding of various senses in the nerve fibers attached to end-organs is distributed and filtered at their junction with the subsequent set of neurons. What the laws for transformation and distribution are cannot be determined with gross electrodes; rather, it is obtained statistically from impulse patterns in single neurons. We are now engaged in making the necessary records.

There is experimental evidence for believing that whatever the type of nervous relay, it is sensitive to delicate variations in spike height and membrane potential. The physical chemistry underlying nerve membrane phenomena is still obscure, and we are devising special electrodes to measure different ionic activities within a cell.

A. RECENT WORK

Work done this past summer and fall on motoneurons of the spinal cord in the cat has established profound doubt that intracellular records are interpretable. First, the very presence of the electrode seems to produce artefacts which are indistinguishable from the supposed normal activity – and the artefacts can be proved to be artefacts. Second, the position of the electrode within the cell cannot be determined, and the interpretation depends on knowing that position. Third, the sign of small, slow transients within the cell does not have univocal relation to the threshold of the cell, as has commonly been supposed. We have also found that the so-called Renshaw cells seldom occur except with physical damage to the circulation or in the presence of barbiturates, since they only appear in our experiments after deliberate tearing of vessels or injection of the drugs. We suspect that they are sometimes dendritic oscillations of the motoneurons. Despite this nihilism, we can show that the origins of different fractions of an antidromic response are more probably those given by Lloyd rather than those given by Eccles, and that the locus of inhibitory action seems to be a part of the

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cell other than that involved in facilitation. A paper concerning the details of this work and certain other findings of more specialized interest is being prepared for publication.

In addition to this work, there are three items which are now in process of publication. First, a chapter has been completed for a book to be published in Britain for the layman. The book deals with the general problem of brain and behavior and is written by a group of zoologists, ecologists, and other specialists. The chapter briefly summarizes the present state of neurophysiology in relation to the behavior of the whole animal. Next, a paper on the post-tetanic potentiation of the mono-synaptic reflex is being submitted for publication. This paper shows that it is possible to explain the great exaggeration of a reflex after a burst of impulses has passed over the afferent fibers. There is a change in the size of the impulse being delivered to the effector cell. Last, work is now completed and ready for publication on the effects of a single volley over afferent nerve fibers on the excitability of the terminals of those fibers and neighboring inactive ones. This work has shown that there are at least two different types of ending. The first is on the motoneurons, where the proprioceptive fibers produce a short disturbance in their endings and no effect on their neighbors. Further, it can be shown that the antidromic firing of the cells on which the afferents end does not affect their excitability, so that they are effectively isolated from some events in the cells on which they end and isolated from their neighbors. In contrast, the endings of sensory nerves on internuncial cells set up a disturbance which does affect neighboring inactive endings. This disturbance appears to be the origin of the slow potential recorded electrotonically from the spinal cord. It can be shown not to result from the actual production of impulses in the internuncials. It is probably a prolonged depolarization of part of the cell membrane. This work has clarified the origin of two components of the slow wave and has located two different types of relationship between nerve fibers and the cells on which they end.

Of the new work arising from these procedures, one project deals with the simultaneous recording from two cells in the spinal cord which are responding to a peripheral touch on the leg. It is found that the relative pattern of firing of pairs of cells varies as the peripheral location of the stimulus is changed. We need to move closer to the actual coding mechanism by which peripheral localization of the stimulus is transmitted. We hope to get away from the indeterminacy resulting from single-unit recording and the poor resolution resulting from massed recording of the simultaneous action of thousands of cells.

B. INSTRUMENTATION

For Mr. O. G. Selfridge's amusement we have made an artificial neuron (Fig. XVIII-1) to be used in artificial nerve nets. The neon tube oscillator, bootstrapped by the triode, generates output pulses of approximately 80 volts. A positive signal on input A increases, and on input B decreases, the rate of firing. The low impedance of the output allows one neuron to supply the input for many others.

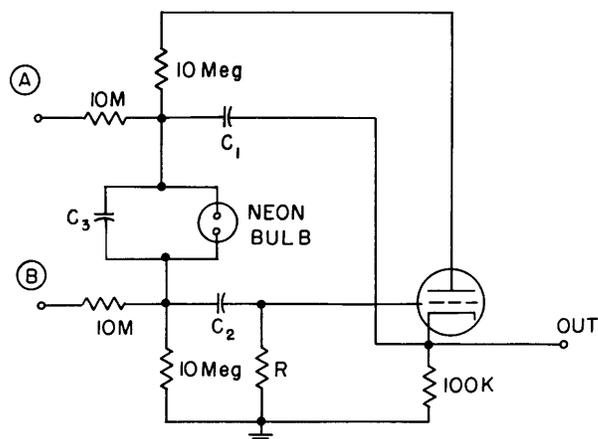


Fig. XVIII-1. Artificial neuron.

Description of an electrometer circuit developed in this laboratory was presented at the IRE Symposium on Electrodes and Amplifiers and Biological Research at the University of Pennsylvania. It was also submitted for publication in the Transactions of the IRE (PGME) under the title "Footnotes on a Headstage."