Neurophysiology: Evaluating the Comparative Approach

An international conference on comparative neurophysiology was held in Leiden, Netherlands, 5–7 September 1962, prior to the 22nd International Congress of Physiological Sciences. The program was organized by C. A. G. Wiersma (California Institute of Technology), and there were some 60 participants from 14 countries plus 30 official auditors. One objective was to evaluate the comparative approach in the study of basic neurophysiology. At each of six sessions there was an opening address followed by four shorter papers.

The first session, introduced by H. Autrum (Munich), dealt with sense organs. The specificity of individual receptors in an organ was emphasized. For example, the sensory responses from bristles on a neck patch in a bee depend on initial angle, rate of change of angle, and direction of bending. In crabs the phasic myochordotonal receptors respond to velocity of movement with brief bursts of impulses, while tonic receptor cells in the same organs signal position (Cohen, University of Oregon). Generator potentials from chemoreceptors of very high sensitivity to certain organic compounds were described by Schneider (Munich).

The second session, on integration of sensory impulses, presented interesting comparisons among crustaceans, insects, and vertebrates. J. Schwartzkopf (Munich) presented evidence that various vertebrate interneurones perform frequency analysis in audition by responding only within specific frequency ranges, as if individual neurones had a sort of resonant frequency. The paths of phonoreceptor impulses were traced through the cicada nervous system by Y. Katsuki (Tokyo). T. Waterman (Yale) showed that some of the fibers in the optic tract of crabs respond to movement in the visual field and may even indicate direction of movement. The principle that a high degree of integrative selection exists in the retinal neurones of various animals—frogs, octopi, and crustaceans—is emerging.

A session on relations between input and output of central nervous systems presented many new concepts which could come only from study of invertebrates. In crustaceans and insects single interneurones receive sensory input from many segments and even from more than one sense modality (C. A. G. Wiersma; G. M. Hughes, Cambridge; D. Kennedy, Stanford), and in some mollusks similar wide sensory fields for single ganglion cells are indicated (Tauc, Paris). By examining spontaneous and induced activity of many interneurones within a central nervous system, individual ones can be identified by their patterns of firing. Response may be dependent on input frequency, number, bursts, coincidence, or succession from different paths. In *Aplysia* various interneurones were also identified according to their responses to physiologically active compounds (Kerkut, Southampton); certain neurones in isolated ganglia of mollusks show a remarkable circadean periodicity of discharge (Strumwasser, Walter Reed). The use of animals with neurones relatively small in number and large in size reveals the integrative capacity and individuality of single ones.

In a session entitled "Behavior and the neuron" the gap between knowledge of complex behavior and of individual neurones was emphasized in a general way by G. P. Baerends (Groningen) and specifically in papers on coelenterate nets (Horridge, St. Andrews), and on learning in octupus (Wells, Cambridge). Various attempts were made to explain long-lasting effects on neurones in central nervous systems, but modern techniques have not successfully bridged the behavior-neurone gap. The only clue suggested is in the basic difference of coding among different neurones. F. Huber (Tubingen) showed how stimulation of different regions of the cricket brain can evoke different sound patterns—calling, aggression, or courtship. Localized brain stimulation triggers a whole complex of behavior.

In a session on neuromuscular integrative mechanisms, C. L. Prosser (Illinois) presented evidence that contractile systems are more primitive and general, while mechanisms of activation by cell membranes are more varied and specialized. The key problem of coupling between muscle membrane and contractile protein provided a central theme of the session. P. Fatt (London) gave evidence for a new electrical model of striated muscle cell membranes which includes a capacitative shunt across the normal membrane and which might represent the properties of the vesicular membranes in the region of the Z-bands. H. Grundfest (Columbia) suggested that these vesicular membranes which penetrate striated fibers of crustaceans may be specifically permeable to chloride ion (Cl^-). Separation of development of tension from development of stretch resistance in tonic molluscan muscles may provide another clue to a kind of muscle activation (Twarog, New York University). A. Fessard and T. Szabo (Paris) described spontaneous electrical spikes recorded externally from sense cells in the skin of certain electric fish; this sensory firing is markedly altered by very low external electric fields of certain orientation and may provide the basis for detection by these fish of others in the vicinity.

The final session, chaired by J. C. Eccles (Canberra) dealt with transmitter functions. Evidence by L. Tauc (Paris) on single neurones of *Aplysia* indicates that acetylcholine can be either excitatory or inhibitory according to the receptor membrane; some cells are depolarized and excited, others are hyperpolarized and inhibited by the same transmitter. Analyses of ganglia of *Helix* (Kerkut, Southampton) and of crustacean nerves (Florey, University of Washington) show many active organic compounds. The inhibitory transmitter of crustacean nerve appears not to be γ-aminobutyric acid, but to resemble this substance (Florey). Neurosecretory cells of fish show electrical activity which resembles that of motorneurones (Bennett, Columbia).

The value of the comparative approach to basic neurophysiology was clearly shown by this conference. Study of relatively simple nervous systems shows the versatility and uniqueness of individual interneurones, especially in sensory input, spontaneous patterns and effects of transmitter agents. Individual neurones, both in sense organs and as interneurones are capable of surprising amounts of integration and display many degrees of freedom.

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