Meetings

Information and Control Processes in Living Systems

The operating languages or codes in which processes of biological communication and control are formulated was the theme at the fourth of a series of conferences on information and control processes in living systems held in Pacific Palisades, California, 25–28 February 1968. Similar to other conferences in the series, the emphasis was on informal discussion of the present state of our knowledge and possible future directions of investigation rather than on formal presentation of recent research results.

The conference began with a consideration by Gardner C. Quarton (Massachusetts Institute of Technology) of some of the premises that might underlie realistic physiological models of molecule-to-molecule and cell-to-cell communication and control. In expanding on these notions Murray D. Rosenberg (University of Minnesota) pointed out that time structure is as important as physical structure in models of the enzymatic readout process. Morphological difficulties in such models were discussed by Jerome Y. Lettvin and Francis O. Schmitt (M.I.T.) from the point of view of ambiguities that arise in intracellular recordings attributable to such phenomena as vacuole formation around the tip of a microelectrode immediately following its penetration into such organisms as *Stentor*. It was suggested that the microstructuring of subcellular fields could produce "communication structures" with very small energy exchanges. Thus, molecules arranged in a helix might have a defect which could propagate down the helical chain. This phenomenon is analogous to "hole" conduction in semiconductors, and, as in semiconductors, may substitute for electron conduction.

It was pointed out that the interaction of actin and myosin in processes of muscular contraction involves side-bridges which project from the myosin molecule. These side-bridges have the enzyme adenosine triphosphatase on the end, and it is the interaction of the adenosine triphosphatase with actin that leads to contraction. It is also possible to spin label compounds and to follow very fast changes in muscles associated with contraction and the gating of ions.

The discussion of transductive and transponsive languages, in which an organism conducts its internal communication and control processes, was introduced by Manfred Clynes (Rockland State Hospital, Orangeburg, New York). He described his experiments in which evoked potentials from brain activity were recorded from scalp electrodes in response to patterned visual and auditory stimulation. He suggested that recognition of particular patterns rested on a comparison with stored traces and emphasized the transient nature of the response, which declines even if the stimulus persists. Clynes named these finely graded evoked potential response patterns "actons" and compared them with gestures and dance steps in that they all are intimately related to task performance.

Neuroendocrine and humoral factors in the timing of control mechanisms in food and water intake and in respiration were described by David G. Fleming (Case Western Reserve University). Functional connectivity in tissue taken from preweanling mice could be demonstrated 6 to 8 hours after explantation of a cerebellar folium. He described pacemaker patterns in these preparations, with a comparison of different units in simultaneous recordings that were turned on in one case and off in the other by the same stimulus. Stimulation was typically by the extracellular field from a 500-nanoampere source. Similar effects were also produced by acetylcholine which induced firing and by gamma aminobutyric acid which produced inhibition.

Lettvin reviewed some of his studies of frog optic nerve in which distribution diagrams were drawn of firing rates in resting preparations and after a flash of light. The resultant distribution curves showed that the majority of fibers exhibited short interspike intervals in the resting condition and a sharp transition to much longer intervals after the flash. He concluded that the fiber firing rates were determined by the axonal terminal arborizations and were thus susceptible to a failure rate of conduction induced by changed sensitivities at branch points in the terminal arborization. He had also tested this behavior in the spinal cord with fibers from stretch receptors and had shown that branchings of the entering dorsal root fibers with diameters of 0.1 mμ or less were apt to fail to conduct by reason of activity in adjacent regions and that the occurrence of failure in these arborizations was probably widespread. Lettvin proposed that one can postulate functional states of excited terminals. If the conditions at the bifurcation are examined, there will be fluctuations in this "state function" for long periods after a single pulse. The following pulse will invade with a different pattern. By the second or third pulse, firing will be determined by the history of activation of this arborization.

The conference then turned its attention to the vocalization, linguistic, and behavioral codes in which an organism conducts its communication and control processes. John J. Dreher (McDonnell-Douglas Corp., Huntington Beach, California) discussed mathematical techniques for recognizing identifiable patterns in spoken Chinese and English. An elementary form of analysis involves detection of periodicity in speech by simple audio intensity measuring devices. More elaborate analysis techniques include optical correlation, autocovariance calculations, and spectral analysis. With these techniques it is possible to identify individual speakers and to investigate the disputed authorship problem in public speeches.

Keith Nelson (University of Maryland) then described the temporal patterning of behavior in the stickleback fish. There are set periods that the fish devotes to such activities as digging, placing, boring, and fanning; these activities overlap each other in a definite sequence. Employing a transition matrix of sequential events and the notion of dependency as used in information theory, it is possible to show that there is as much variation in behavior within individual fish as between several sticklebacks.

Howard A. Baldwin (University of Arizona) discussed his physiological studies of free-roaming animals in their natural environments. By measuring blood flow in the ear with special sensors and radiotelemetry, it was possible

to show that there are large diurnal shifts in the thermal status of lions, as much as 8° or 9°C between resting and active states. Baldwin described studies on the green turtle in the South Atlantic; the turtle regularly migrates to Ascension Island and appears to be sensitive to certain olfactory gradients. Other studies using radiotelemetry with water buffalo have shown ways in which the dominant male in a group preserves his territorial rights. The territorial movement of water buffalo has been successfully followed at distances as far as 20 miles from the radio receiver.

The discussion of corresponding codes and languages in which larger systems of organisms carry out their communication and control processes was initiated by William J. Horvath (University of Michigan). He described studies of war models which were based on a Markov process. Using such a model to study 315 wars, it was found that the ending of a war is related to the number of deaths; the model predicts size of the war rather than duration. Similar models have also been applied to the chronicles of the Department of Labor on the duration of industrial strikes. There are approximately 3300 recorded strikes in the United States each year. They show the same slow falloff as in the case of wars. The decrement resembles the failure rate in vacuum tubes, in that the longer they perform, the longer will be the time to failure. There is a similar finding in characteristics of marriage and divorce. The longer one remains with a spouse, the longer one is likely to remain.

The final session of the conference dealt with the feasibility of machine codes, structures, components, and languages designed for compatibility with biological systems and the features of a mathematics deliberately developed for such systems. Horst Mittelstaedt (Max-Planck Institut, Seewiesen, Germany) discussed gravity orientation in fish and the philosophic questions of causality versus information flow. He defined information as a causal relation between input and output variables. A "transferer" can be described just by input-output characteristics. Thus, for example, in the orienting to light by the drone fly, the turning moment in the legs relates to the angle between the fly and the light source. In this case no changes can occur within the central nervous system by feedback to the source of the stimulus. Mittelstaedt then went on to describe the intercausal nets composed of transferers that simultaneously receive and transfer different sets of inputs. Fractional approaches to understanding the behavior of a multicausal net can be made by looking at the effects of the input from different receptors. He suggested a disjunction and division of the net into many classes so that one can proceed until a complete understanding of the behavior of the net is fully specified. In this way it should be possible to determine if the organism acts as a transferer or as a simple cybernetic system.

Leon D. Harmon (Bell Telephone Laboratories, Murray Hill, New Jersey) discussed the types of codes that could elicit patterned output in the nervous system. He noted that codes could be classified into two generic coding categories: spike trains and continuous slow transactions. He cited three levels of coding: (i) codings that arise in sensory transducers, (ii) codings that arise in the central processor, at which point memory storage may be involved, and (iii) codings involved in motor outputs. In all of these, parallel or serial processing may be involved.

Rosenberg discussed cell-to-cell interaction, pointing out that transmitter substances may be bidirectional and that their effects would then be reciprocal. In this case there would be a limited degree of transmitter mobility and a range in its specificity. There probably is a hysteresis loop in the time course of typical transmitter substances. During differentiation of cells, one cell may exercise an inductive influence on another cell until there is ultimately a condition of irreversibility. Lettvin considered that the effects of individual elements may be parochial rather than global. He noted that if one removes half the retina of a frog, the remaining fibers spread over the whole of the colliculus. It is very difficult to explain the further finding that, if one removes a square of the colliculus, rotates it 180 degrees, and reinserts it, no changes in visual performance can be detected after 90 days.

Jerome R. Cox, Jr. (Washington University School of Medicine, St. Louis, Missouri) described a method for computer recognition of electrocardiographic patterns by the use of a string of cascaded processors employing successive data reduction.

Y. V. L. Rao (United Nations Educational, Scientific & Cultural Organization, Paris, France) discussed some of the problems of mass communication. In their projects they have studied the dynamics of small and large group interaction. Their conclusion is that since there are many variables involved, it is impossible to predict the characteristic reaction of an individual without knowing those elements of his behavior which he contributes to the group interaction. He cited several examples of propaganda films that had either the opposite of the effect intended or no effect at all on audiences. The most persuasive films encouraging dental hygiene were those that employed fear.

The conference, chaired by Otto H. Schmitt (University of Minnesota), was organized under the auspices of the Interdisciplinary Communications Program of the New York Academy of Sciences (Dr. Frank Fremont-Smith, director) and was supported by the National Aeronautics and Space Administration and the Smithsonian Institution. An edited transcript of the proceedings is scheduled for publication. Ensemble dynamics within and between living organisms is planned as the subject of next year's conference.

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Calendar of Events

October

1–4. American **Roentgen Ray** Soc., New Orleans, La. (Secretary, The Society, c/o Mayo Clinic, Rochester, Minn. 55902)

2–3. **Health Quackery**, 4th natl. congr., Chicago, Ill. (American Medical Assoc., Dept. of Investigation, 535 N. Dearborn St., Chicago 60610)

2–4. Symposium on **Materials for Radioisotope Heat Sources**, Gatlinburg, Tenn. (Chairman, Metallurgical Soc. of AIME, 345 E. 47 St., New York 10017)

3–4. **Fiber** Soc., Washington, D.C. (L. Rebenfeld, Box 625, Princeton, N.J.)

3–5. Canadian Soc. of **Immunology**, Toronto, Ont., Canada. (H. Z. Movat, Dept. of Pathology, Univ. of Toronto, 100 College St., Toronto 2)

4. **Industrial Pharmaceutical Technology**, Philadelphia, Pa. (R. S. Joslin, William H. Rorer, Inc., Fort Washington, Pa. 19034)

4–5. American **Physical** Soc., Hanover, N.H. (The Society, Executive Secretary, 528 W. 120 St., New York 10027)

4–6. National Conf. on **Marine Sciences in Education**, Catalina Island, Calif. (R. B. Linsky, Coordinator, Marine Sciences and Director, Floating Lab Program, 1104 W. 8 St., Santa Ana, Calif. 92701)

4–8. American College of **Chest Physicians**, 10th, Washington, D.C. (M. Kornfield, 112 E. Chestnut St., Chicago, Ill. 60611)

5–6. National Congr. on **Medical Ethics**,