resolution of the Oedipus complex, but extends throughout life. Each stage of life builds upon the stage that precedes it, synthesizing and integrating what went before. Human development, then, is more than the working-out of infantile experience and fantasy (although it is that); and it is more than the transaction between man and his environment (although it is that too). Life is a continual process of inner reintegration in which the life-historical and the actual are repeatedly resynthesized.

Individual life is historical in a second sense. Influenced by modern concepts of evolution and studies of animal ethology, Erikson continually asks, How does man transmit culture (knowledge, symbols, concepts of self, and ways of dealing with the world) from generation to generation? Freud's discussion of the relationship of the generations was largely exhausted by his concept of the Oedipus complex. Erikson sees the Oedipus complex as but one aspect of the intergenerational dialectic that not only reenacts man's primitive drives and libidinal nature, but rehearses the time when children will become the parents to the next generation. In the dialectic of the generations on which history is built, Erikson therefore sees not only discontinuity, rebellion, envy, and hatred, but—in any society that survives —signs of a more orderly succession that permits each new generation to reassert what is valid from the past while creating what is appropriate to its present.

Finally, Erikson is acutely aware of how historical possibilities, demands, and settings affect the very structure of life and of the theories we spin around it. Freud hoped to arrive at a universal theory of personality on the basis of his self-analysis and his work with Viennese patients at the turn of the century. Erikson points to the cultural and the historical in Freud's work to argue that the most basic symbols and forces in personality are affected by the individual's historical involvement and position.

The very concepts by which man attempts to understand himself in any historical era—including such concepts as "identity"—come out of and pass quickly back into the elusive historical process they seek to capture. Thus, Erikson can view the work of Freud simultaneously as a special product of the Victorian, Viennese ethos from which it grew, as a lasting contribution to human understanding, and as itself a powerful force in the shaping of the "post-Freudian" world.

But to those devoted to other concepts of science, Erikson often seems inexact, elusive, rhetorical, and even mystical. Erikson is a clinician, not a behavioral scientist. And clinical empiricism, which seeks understanding through intensive studies of a few individuals, seems maddeningly "unscientific" to those committed to a methodology of exact measurement and statistical significance. Erikson deliberately eschews the operational definitions, precise formulations, and testable hypotheses that define most scientific work today. Collecting 20 years of writing on the subject of identity, he provides no definition of the concept, preferring illustration, the case histories of gifted men, example and allusion. As a result, the concept of identity, despite its usefulness to political theorists, historians, literary critics, and sociologists, has inspired remarkably little work by research psychologists. To some, this will indicate the limits of Erikson's views. To Erikson, it would simply indicate that a sense of identity is elusive, difficult to identify with specific operations and exact indices, and completely related to individual motives, social opportunities, and historical positions.

But if Erikson's clinical empiricism is not that of the behavioral scientist, this fact too makes him very much a part of the psychoanalytic tradition. Although Erikson is in many respects highly critical of certain of Freud's basic assumptions, he remains true to the original effort of Freud—by the intensive study of a few men and women, in all of their depth, ambiguity, and historicity, to do justice to the complexity of man. In Erikson's hands, psychoanalysis as a theory of man—a theory grounded in clinical observation, open to change and correction, self-conscious and self-critical—demonstrates its continuing vitality.

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Seeking Tractable Neural Analogues

Models of the Nervous System. SID DEUTSCH. Wiley, New York, 1967. x + 266 pp., illus. $9.95.

It is a brave man indeed who attempts such a Herculean task as that of constructing adequate functional models of the brain. Twenty years ago there was apparently considerable optimism, mainly a result of the advent of cybernetics and of information theory, that there would be major theoretical breakthroughs toward an understanding of how brains work. Today, those neural theorists who have survived the transition seem to be, if not sadder, certainly considerably more sophisticated in their approach to neural modeling. It is now generally accepted that the payoff diminishes rapidly as the range and complexity of the neural problem that is posed increase. It is also generally accepted, by theorists as well as experimentalists, that the chief weakness of most theorizing about the nervous system has been oversimplification, due largely to lack of an immediate acquaintance with raw experimental material and problems. Now there is continued emphasis on biological veridicality, and most theoretical work is concerned with the classical questions of neurophysiology: the generation and propagation of the action potential in myelinated and unmyelinated fibers, synaptic transmission, electrotonic effects in somatodendritic membrane, potential changes in inhomogeneous and anisotropic volume conductors, and so on. Since 1954 there has been considerable work done on the statistical analysis of the firing patterns of individual neurons, but only now is there work in progress on the two-point correlation functions associated with interacting neurons. Since 1954 there has also been a considerable development in what are now called bioengineering and bionics, an interweaving of biology and electronics. Here again, after an initial trauma, current neural work is focused on the synthesis and analysis of small nets of model neurons, serving to represent, for example, various insect or arthropod ganglia. And of course considerable work has been done, both analytic and synthetic, on the image-forming nets of peripheral sensory systems.

The present book is aimed at bioengineers, and falls naturally into two parts. In the first part, after some preliminary development of the elements of linear systems analysis, a model of the individual neuron is formulated. This model is then used for the analysis of small nets, for example, of the kind that Lorente de Nó found in the spinal cord in 1937. The mathematical model is a cybernetic standard: a discontinuous threshold element receives a weighted linear combination of suitably delayed signals, and in due course emits an impulse for suprathreshold excitation. Propagation down the myelinated axon is represented by the rectangular pulse response of a passive *RC* cable, the pulse being regenerated at nonmedullated nodes. The model does not take account of any of the nonlinearities of function that follow from the spatial organization and time-dependent selective permeability of the neural membrane, save for the existence of a threshold for the emission of an action potential. Even such a simplified model is not sufficiently tractable for the analysis of small nets, and a semilinearized model is used in which the threshold nonlinearity is replaced by a linear ramp function. Nets of such semilinearized model neurons suffer from the defect that they modulate pulse amplitudes and widths, as well as pulse rates. This model is therefore invalid for a single neuron. It is claimed that this doesn't matter because a meaningful response in an organism is generally the algebraic sum of many individual responses. In my view this begs the question. For the analysis of small neural nets, a most precise rendering of the individual neuron is required, for it is details that count: space and time constants for conduction, the changes of threshold that we call adaptation and accommodation, and so on.

The second part of the book is quite different in that large scale models of the sensory and motor cortices are constructed. It is assumed that any cross section of the cerebral cortex that contains many neurons can be regarded as approximately uniform, and the cortex as a whole is taken to be a slab 48 centimeters long, 48 centimeters broad, and from 1.5 to 4 millimeters high, containing 10 billion neurons; that is, the slab is about 40 to 100 neurons thick with a mean spacing between neurons of about 40 microns. The basic idea is that the slab comprises many character-recognizing nets feeding, via reverberatory circuits for short-term memory, into long-term memory stores analogous to conventional digital computer stores. The character-recognizing nets are constructed, again in a standard cybernetic manner, from stimulus-amplitude-matching neurons (first used by W. K. Taylor about ten years ago) feeding into layers of AND-gate matrices followed by OR-gates followed by AND-gates. The signals issuing from such nets are invariant to changes of stimulus amplitude. In the auditory model there are also delay systems so that the output signals carry a representation of the basilar membrane responses, averaged over one or two seconds. In the visual model the final amplitude-invariant signals carry contrast and color information. These signals are then fed into a further net comprising short-line extractor neurons—SLEN's—followed by two more layers of AND-gates, reminiscent of the feature-detectors of Hubel and Wiesel. In such a way are "characters" transmitted to the memory systems. It is conjectured that scale and rotational invariances are obtained either by a transformation from polar to semilogarithmic coordinates or by multiply redundant representations of suitably transformed characters. An interesting feature of these character-recognizing nets is that stimulus-amplitude invariance is obtained by computing the *ratios* of stimulus amplitudes, in the AND-gate matrices that succeed stimulus-amplitude-matching neurons. In the model of the motor cortex, programmed sequences of motions are read out of long-term memory either by a noise generator in infancy or by association fibers from the audio, video, and somatic stores, via suitable decoding nets, into appropriate sequences of skeletal muscle groups. There is, however, no discussion of the role played by the cerebellum in such activity.

It is claimed that the analysis of neural models which are sufficiently simple that they are mathematically tractable can yield insights into the functional mechanisms of the organism, and also that "It may be true that 99% of the models are wasteful mutations, but the 1% that survives is more than sufficient justification for model making. Wild conjecture is a shock front that always accompanies the advance of science." No doubt this is true, but of course what determines the survival of 1 percent of the models is that in addition to providing plausible explanations of the working of neural machinery, they fit the facts of neuroanatomy, of neurophysiology, of neuroembryology, of experimental psychology, and so on. It is no longer sufficient to invent plausible models of possible nervous systems. In my view this is the major weakness of the second part of the book: the model is very far away from contemporary neuroanatomy and neurophysiology. There is no real attempt to connect the postulated structures and their activities with the data that have been obtained from electrode studies. On the other hand it seems likely that sharp predictions could be made concerning, for example, the activities of neurons in the postulated stimulus-ratio-taking matrices.

These caveats notwithstanding, the book as a whole is quite stimulating and should prove of interest to those workers in the neural sciences who are interested in models; but it is not to be recommended as an introduction to neural modeling for those bioengineers who have not had exposure to "wet" neurophysiology and anatomy.

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Gondwanaland

The Precambrian. Vol. 3. KALERVO RANKAMA, Ed. Interscience (Wiley), New York, 1967. viii + 325 pp., illus. $17.50. The Geologic Systems.

This volume is the third in a series which will provide regional summaries of Precambrian geology of the entire world. It offers reviews by six authors on the Precambrian in and around the western Indian Ocean (India, Ceylon, the Seychelles archipelago, and Madagascar) and in the Republic of Congo, Rwanda, and Burundi.

The Precambrian rocks occupy about two-thirds of peninsular India and some parts of the Lesser Himalayas in the extrapeninsular region. The author writing of the Indian shield has spent 40 years in its study. He recognizes five cycles in its geologic history, ranging in date from more than 2605 million to 500 million years ago. The Precambrian of peninsular India continues into Ceylon occupying nine-tenths of the island. Here the Precambrian Khondalite series has produced the variety of precious and semiprecious stones for which Ceylon is famous. The author suggests a new age of 1050 million years for the