

human) begin to close as the scientist (the molecular biologist, the neurophysiologist, the ethologist) supplies increasingly detailed descriptions and the informed philosopher looks from science to science for common patterns. Such a unitarian view cannot be sustained either by a teleology or by a simple mechanical model of the 18th-century variety; Langer is impatient with both. What is called for is a radically revised conception of the nature of the reality which all sciences are trying to describe.

The key concept in this revised conception of reality is the "act." Most of us in our everyday thinking are thing-minded; we accept the world about us as an array of essentially inert structures which may be pushed and pulled about in space in a multitude of ways, even to the point at which they seem to be generating power, but in the last analysis it is the structure (the atom, the molecule, the bone, the nerve) which is accepted as real; an event is merely what happens to things in time and is essentially secondary. When we found our philosophy on "things" we have the various forms of classical materialism, in which physics becomes the queen of the sciences and the machine (the spring clock, the combustion engine, the electronic computer) becomes the prototype of mind. In protest against this kind of machine theory it is often claimed that there must be "something more": a *deus ex machina*, a guiding purpose, a vital principle; a mere machine, it is asserted, can never replicate the phenomena of growth and reproduction, of feeling, choosing, and reasoning.

Langer agrees that the machine models are inadequate, and she is particularly contemptuous of the computer analogy, with its deceptive jargon of inputs, information processing, and outputs. She is skeptical of model building in general and especially of those models of mind which obsequiously borrow their terms from the physical sciences. The proper alternative, however, is not a retreat into teleology but rather a fresh and critical look at the phenomena themselves. The distinctive phenomena of life and mind are not thing-like but event-like, and the true element is not the particle but the act. To conceive of mind as a matrix of acts within acts requires a suspension of our physicalistic bias. To conceive of life in the same way requires the further suspension of the assumption that for every act there must be an

agent. Life processes are directive, but we need postulate a director only if we cling to the analogy of the machine and its driver. It is difficult to get rid of the agent-action-object paradigm, for it is rooted in the grammar of our language; yet we must do so if we are to recognize that the concept of act belongs in physics as well as in biology and psychology. "The study of living functions as acts," Langer insists, "leads us backward into the physical sciences without coming to any dividing line that has to be crossed by a *saltus naturae*" (p. 274). Similarly there is no sharp break between the activity of simple living tissue and the more complex physiological processes which render possible the emergence of the "psychic phase."

In stressing the primacy of the act Langer lays no claim to originality. She recognizes kindred spirits among recent and contemporary writers, and the Aristotelian doctrine of formal causality (minus the final cause) is roomy enough to accommodate the act as the unifying principle. Her treatment is distinctive, however, in two ways. In the first place, no contemporary philosopher has combed the literature of the sciences more painstakingly and interpreted it with greater insight. The very contemporaneity of the discussion is fraught with danger, of course, for today's research may be exposed tomorrow as faulty; but the risk was worth taking. It is a pleasure, to repeat, to encounter a philosopher who actually reads and thinks about the work of the scientists.

In the second place—and this is perhaps truly distinctive—Langer approaches the theory of mind from the esthetic rather than from the cognitive angle. Those who are familiar with her earlier work, especially *Philosophy in a New Key* (1942) and *Feeling and Form* (1953), have an advantage, but nearly half the present volume is devoted to the esthetic thesis. Mind in its most elementary form is not *res cogitans* but rather feeling. Feeling is an aspect of evolving reality which emerges gradually within the system of nature, becomes progressively differentiated and articulated, and achieves its fullest expression in the rhythms, patterns, and symbols of art. If we are to find the key to the understanding of mind we must consequently look first at artistic expression in all its forms. By according the esthetic problem such a central position Langer is indeed challenging some age-old prejudices. Mind has tra-

ditionally been regarded as that which thinks, and above all as that which thinks rationally; and esthetics has consequently tended to become a luxury item, if not a downright nuisance. If, however, mind in its elemental form is feeling rather than knowing, then not only does esthetics become central in a philosophy of mind but the sciences which purport to study mind, the so-called behavioral sciences, must undergo a drastic reorientation. This promises to be healthy.

We shall have to await volume 2 for Langer's attack on the problem of mind in its specifically human contexts, and this is where the real battle must be fought. Her references in the first volume to psychological, sociological, and anthropological sources are scanty, but it is evident that she does not count on much solid support. Behaviorists are too slavish in their imitation of physical science and technology, Gestaltists too restricted in the fields they have explored, Freudians too muddled in their conceptualizations, and social theorists too eager to dehumanize social man; and one has the impression that she will be impatient with the existentialists and with those who for want of a better name are now calling themselves humanists. The sciences of man are indeed in a muddle. Perhaps the time is ripe for a fresh appraisal by a philosopher who is fully aware of the central problems, who is not afraid to challenge implicit assumptions, and who can think with clarity and discipline. Toward the end of the last century William James attempted such an appraisal, with only partial success. Perhaps Langer will do better. One hopes so; but even if she too is only partially successful, the world of science will still be in her debt.

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## Electromagnetic Waves

**Radiation Processes in Plasmas.** G. BEKEFI. Wiley, New York, 1966. 391 pp., illus. \$15.75.

The way in which Bekefi has organized and elucidated the material he has brought together, mostly from the periodical literature, makes this monograph an excellent tutorial instrument as well as research reference. For the latter use it may have no more than a five-year half-life, as is often the case with

research-oriented monographs, but its usefulness in teaching should extend much longer.

The reason for my delight in reading over the work is the many connections Bekefi makes between the subjects he discusses and physics at large. Research workers in any field—and plasma physics is no exception—easily fall into using a lingo which insulates their work from their colleagues in adjacent fields; here this pitfall has been skillfully avoided.

The treatment centers mainly on the production, transport, scattering, and reception of self-generated plasma radiations. Interactions of the plasma with externally generated signals are discussed insofar as they can illuminate the main subject. Thus, careful development of radiative transport theory is provided, with particular attention to the problems associated with the anisotropy of many interesting plasmas.

Kirchoff's radiation law is carefully discussed and its important generalizations to nonequilibrium steady states are developed. At about this point, material subject to straightforward experimental test is introduced, and—setting the tone for most of the remainder of the monograph—the experiments are nicely woven in with the theory.

Careful discussions follow on the emission processes in plasmas—both single-particle and collective. The relevance of the cyclotron emission mechanism, in particular, to both laboratory and cosmic plasmas is stressed. The influence of weak microinstabilities on the emission spectrum is also discussed. Chapters on scattering from plasma fluctuations and on experimental techniques round out the work.

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## Cognitive Paradigms and Real Minds

**The Psychology of Communication.** Seven Essays. GEORGE A. MILLER. Basic Books, New York, 1967. 207 pp., illus. \$4.95.

Six of the essays in this volume have appeared before in various sources, dating from 1956 to 1964. With the exception of the fourth (Concerning Psychical Research) the essays are semi-popular expositions of the problem area in which the author has been an outstanding investigator. Specifically, Miller's concern is with man as an information-processing and information-gathering system.

The enthusiasm with which the mathematically oriented psychologists greeted information theory is understandable on philosophical grounds. A science matures when it acquires a "skeleton" in the form of a paradigm, that is, a conceptual framework on which pieces of theory can be hung so that the science can develop as an organic whole. If a living process involves, in addition to transformations of matter and energy, the processing of information, then the "quantification of information" could well presage a paradigm for psychology analogous to that provided for physics by the quantification of energy. However, the information-theoretical method in psychology has not fulfilled some of the sanguine expectations, for it has shed little light on *how* the processing of

information takes place. (Conservation laws would not have been of much help in physiology, if the physiologists had not made use of advanced biophysical and biochemical techniques to discover the details of matter and energy transformations within the organism.) The quantification of information-processing in an actual situation depends not only on the "objective" features of the situation but also, and essentially, on the inherent abilities or previous experiences of the processor. To take a simple example: since an octal digit carries three times as much information as a binary digit, one might think that three times as many binary digits as octal digits could be stored in the immediate memory. It turns out, however, that there is little difference, unless the subject learns to recode the binary into octal digits. Generally speaking, the amount of information that can be stored in the immediate memory and the amount that can be "pumped" through an individual depend crucially on the coding procedures. Nevertheless, the information concept did serve a useful purpose in experimental psychology by bringing this problem into focus.

Miller's first three essays are devoted to this and related problems. Particularly illuminating is the second essay, the justly famous *The Magical Number Seven Plus or Minus Two*. The

third essay, *The Human Link in Communication Systems*, brings out the "glaring result . . . man's inadequacy as a communication channel." Specifically, the capacity of this "channel," as revealed in experiments designed to measure it, is not more than 25 bits per second, a rate attained by skilled typists and pianists. The lesson is clear: the use of human beings as a "link" is not, as Norbert Wiener would have put it, a human use of human beings. Miller implies the same when he says that "man's peculiar gift . . . is his ability to discover new ways to transform, or to recode, the information which he receives. . . . The search is something we call 'thinking'; if we are successful, we call it 'understanding.'"

The last three essays are devoted to another "modern" paradigm of communication science, namely the approach suggested by the theory of formal grammars. This paradigm rests on a categorical rejection of the conditioned-response model of verbal behavior. An elementary calculation shows that, aside from clichés, the overwhelming majority of sentences which we "understand" and produce have never been heard or uttered before. To invoke the "generalization" of a conditioned response is to evade the problem. The crucial question is *how* we generalize. The psycholinguists of the formal grammar school postulate an inherent sentence-producing and sentence-recognizing apparatus, unique to our species. Psycholinguistics, as defined by that school of thought, is the study of the *modus operandi* of the presumed apparatus. In this way a link is made between a theory of verbal behavior and the theory of automata, where a grammatical sentence corresponds to an output produced (or an input accepted) by an automaton and grammar to the rules governing the behavior of the automaton. The experimental techniques in psychology suggested by this model are used to investigate the degree of comprehensibility, acceptability, and reproducibility of sentences as these depend on the complexity of their structure.

In the last essay, the new one in the volume, *Project Grammars* is described. This is an experimental program aimed at discovering to what extent subjects are able to infer the rules according to which sequences of symbols are produced, that is, the rules of an artificial grammar. These are experiments in concept attainment analogous to those reported by Bruner, Goodnow, and Austin in *A Study of*