as opposed to 0.2 between α's. Not surprisingly, Cody's interpretations at this juncture become highly intuitive, reinforcing my impression that his intuition, derived from his extensive field experience, is actually much better than the theory he is able to employ. This is probably a general state of affairs in contemporary ecology. The intuition of capable field ecologists exceeds their abilities to express the often subtle notions in analytical form, and the higher-order interactions that most of us believe are central to competition among species in nature are exasperatingly difficult to treat formally and are almost universally ignored in theory. Nevertheless, the role of theory in the development of Cody's book has clearly been substantial. It was the source of most of the questions Cody asked, and it guided the selection of things to measure in the field. Without the theory many of the questions that now occupy the attention of field ecologists would not be asked, and this is probably the greatest value of contemporary theory. The proper attitude, paradoxically, is to know and to use theory whenever possible but not to take it too seriously.

Cody has amassed a large body of information on the behavior and morphology of birds living together and shows that these patterns for the most part can be explained on the basis of long-term competition for resources during the breeding season. Other interpretations are not necessarily precluded by the data, but Cody has developed a number of ingenious ideas about patterns of divergence and overlap. These patterns and the interpretations offered for them should be challenging to all ecologists, even those who dislike "natural experiments" of the kind employed by Cody. One can quibble with some analytical techniques and be frustrated by the illustrations whose captions are not complete enough or are too small to be read easily, but in general the book is free of errors (though the author has committed the unpardonable sin of misspelling the scientific name of the yellowheaded blackbird). This important book, standing as the most complete attempt to date to integrate several aspects of recent theory with field data, can be a valuable source of stimulation to ecologists of many persuasions and deserves to be widely read and digested.

GORDON H. ORIANS
Department of Zoology,
University of Washington, Seattle

How Pictures Work

A Psychology of Picture Perception. JOHN M. KENNEDY. Jossey-Bass, San Francisco, 1974. xvi, 174 pp., illus. $10.75. Jossey-Bass Behavioral Science Series.

Whether or not one agrees with the old adage that a picture is worth a thousand words, it can hardly be disputed that pictures can provide rich and generally veridical representations of visual objects and events. Moreover, various forms of pictorial representation—from high-fidelity photographs to unembellished line drawings—are all successful in conveying information concerning actual or potential scenes and activities. In this short, provocative book Kennedy explores the fundamental issue of how it is that pictures can be so informative. He discusses pictorial representation from the point of view of a perceptual psychologist. Esthetic considerations, though acknowledged, are intentionally ignored.

Kennedy's basic thesis is that pictures are informative because they present to the viewer the same elements of optical information that are available in the ordinary visible environment. In his words, "pictures work because light is informative, [and] pictures make use of the laws of naturalistic light" (p. 159). Kennedy begins by analyzing the operation of light in the natural environment and establishes that the structure of the optic array (the pattern of illumination available at a point of observation or station point) can provide unambiguous information concerning its real-world origins. Before extending this analysis to pictorial representations, Kennedy evaluates four "theories" (the basis for the selection of which he does not make clear) of the nature of pictures, this evaluation constituting nearly one-third of the book.

The first theory Kennedy discusses, which views pictorial representations as successful communication devices because they somehow "resemble" the scenes they depict, is swiftly and rightly rejected as being circular and, at best, vague. A second definition of depiction, according to which pictures are artificially treated surfaces providing light to a particular station point which is isomorphic to light provided by the appropriate real-world scene, is found incapable of explaining such representations as line drawings and caricatures. The third position views pictures as arbitrary learned symbols, much like words, which bear no significant structural relation to the objects and scenes they represent. By this "arbitrary convention" account, picture perception should depend strongly upon developmental and cultural factors, and Kennedy marshals considerable experimental evidence against this claim. By reinterpreting cross-cultural, developmental, and infrahuman perceptual research, he successfully argues that the ability to perceive pictorial representations is present at a very early age, is common to Western and non-Western culture, and is evident in a variety of nonhuman organisms, from chimps to pigeons.

The position Kennedy finally adopts holds that pictures provide the same basic features of optic structure as the aspects of the visible environment they represent. (This is to be distinguished from the view that pictures yield the same point-by-point elements of light as the objects and scenes they depict.) The remainder of the book is devoted to gathering support for this position. The role of figure and ground in picture perception is examined, some basic elements of optic information that must be provided by pictures are enumerated, and an argument that these fundamental features of optic structure are available in relatively impoverished line drawings is advanced. Unfortunately, Kennedy's own experimental work provides only weak support for his major conclusions.

Throughout, Kennedy's analysis of picture perception is limited by his adherence to a particular theory of ordinary visual perception, the "passive registration" theory. Stated simply, this position views perception of the visible environment as direct and unmediated. In the opening chapter, Kennedy contrasts the "registration" theory of perception, an approach originally advanced by James Gibson, with the "constructive" theory of perception, a position often identified with information-processing approaches and modern cognitive psychology. His presentation of the constructive theory and his arguments against this position are surprisingly naive. To Kennedy, the constructive theory holds that information impinging on the sensory receptors is generally incomplete and ambiguous and that, therefore, "the observer is forced, willy-nilly, to guess and deduce" (p. 8). His dissatisfaction with this position is twofold. (i) Our everyday perceptual experience of the world seems effortless and direct. Rarely, if ever, do we need to guess or deduce. (It is strange that such an objection should be made,

for Kennedy's own interpretation of the constructive theory holds that such inferences are unconscious in nature.) (ii) It can be demonstrated that properties of the optic array can be unambiguously informative about their environmental origins. What more is needed for effortless, generally veridical perception?

Kennedy's analysis of the richness and completeness of the information available in the optic array, undertaken in the service of defending the registration theory of ordinary perception and extending this theory to picture perception, is a valuable contribution. But his oversimplified interpretation of the constructive theory blinds him to the fact that he has in no sense refuted the constructive theory blinds him to the the heart of the constructive theory is not so much the contention that inferences about the visual world must be made on the basis of impoverished and hopelessly ambiguous sensory information (though ambiguity and incompleteness are sometimes encountered, to be sure), but rather the idea that perception is a *selective process* by which incoming sensory information is integrated and encoded. The task, then, becomes one of specifying not only the stimulus variables that influence these selective mechanisms—such as Gestalt principles of organization and "figural goodness"—but also the nature of the internal processes that transform sensory input, as complete and informative as it may be, into perceptual experience.

The selective and constructive nature of perception is evident at a variety of levels, from the neural mechanisms for information reduction and recombination known to exist in the primate visual system, to higher-order mechanisms such as attention and expectancy. Moreover, viewing perception as a constructive process provides a framework for understanding other internal, constructive processes—such as mental imagery, which can occur in the absence of any appropriate external stimulus.

While the constructive theory portrays the perceptual process as actively and selectively building an internal representation of the visual environment, the registration theory, championed by Kennedy, ascribes to the perceiver no more than the ability to be "tuned to the invariants of structure" in the optic array (p. 45). Kennedy's view of ordinary perception prevents his analysis of picture perception from considering such matters as the possible effects of expectancy and context on perception of pictorial representations. Missing, also, is any mention of the relevant work on scene analysis and picture grammars emerging from the field of artificial intelligence. Yet despite these shortcomings, Kennedy's book, as an attempt to extend a unified theoretical position to the perception of a variety of pictorial displays, may stimulate other perceptual psychologists to consider and explore the fascinating problem of pictorial representation.

LYNN A. COOPER
Department of Psychology, University of California, San Diego

Neuroscience

Essays on the Nervous System. A Festschrift for Professor J. Z. Young. R. BELLAIRS and E. G. GRAY, Eds. Clarendon (Oxford University Press), New York, 1974. viii, 512 pp., illus. $43.50.

More than a decade has passed since we faced the challenge of writing a discussion of an article by J. Z. Young addressed to the problem of the twinned brain. We can still recall the excitement—and the anguish—as we read his closely reasoned arguments, drawn with equal grace from data on structure, on function, and on behavior. His stimulus led us into constructions that we had not previously considered, and although our effort is disappointing, even embarrassing, to us on current rereading, it is at least indicative of Young's enduring capacity to stir ferment in younger minds.

The volume under review appears to provide another example of this phenomenon. In celebration of Young's 67th birthday, Bellairs and Gray have put together a bound document which fulfills almost all the potentialities of "festschriftery" with virtually none of its drawbacks. Here is a pride of talented neuroscientists, all marked by their present, or past association with Young, giving status reports of the fields they know best. Unlike most contributors to volumes of this kind, the majority show commendable restraint in quoting their own work, draw broadly on the work of others, and come close to offering us a handbook in microcosm. Most of the classic handbooks in neuroanatomy and physiology, and their modern counterparts, seem cut from similar goods; attempting to be definitive, they end up being interminable. Not so here, where excellent judgment on the part of the contributors, or sensible editorial control, or both, have made most of the chapters broad as to sampling, rich in content, concise in form, and sometimes audacious in conclusions.

As might be expected, the material is varied, ranging from ontogeny and differentiation, through synaptic morphology in a half dozen different systems, to respiratory neurons, the eternal problem of pain, and the possible central sites for learning. We found Wall's reformulation and extension of the gate theory of pain and Nadel and O'Keefe's discussion of hippocampal function in terms of cognitive mapping courageous if speculative. Similarly Colonnier weaves an ever-enriching fabric in cortical synaptology and spatial relations, and Boycott performs similar functions for the retina. Knowles recreates the early excitement over the concept of neurosecretion, and Merrill not only finds a function for medullary respiratory neurons but describes hitherto uncertain details of reticular axonal pathways with rather elegant antidromic microelectrode methodology.

It is necessary only to add that the editors have done the reader the courtesies of providing more than adequate indexes at the end and a businesslike history of the Anatomy Department at University College London, both before and during Young's stewardship, at the beginning. The Oxford University Press has performed its usual workmanlike job of supporting the project with solid binding, good typography, and satisfactory photographic reproduction. Unquestionably, this most satisfying volume does honor to Young, both in word and in deed.

MADGE E. SCHEIBEL
ARNOLD B. SCHEIBEL
Departments of Anatomy and Psychiatry, University of California Medical Center, Los Angeles

Honoring Dirac

The Physicist's Conception of Nature. Proceedings of a symposium, Trieste, Italy, Sept. 1972. JAGDISH MEHRA, Ed. Reidel, , 1973. xxiv, 840 pp., illus. $85.

To celebrate Dirac's 70th birthday in 1972, a mammoth conference was organized at the International Center for Theoretical Physics in Trieste. Dirac himself was there, together with the