ical physicists occurred in 1933 with the founding of the *Journal of Chemical Physics* by Harold Urey. The increasing mathematization of quantum mechanical theories of electronic structure of molecules and crystals, the problems of chemical binding, and the statistical mechanical treatments of systems seemed to convey confidence in a deeper, more abstract understanding of chemistry, which, paradoxically, would lead to an almost visual perception of chemical entities, such as the chemical bond. Yet, as C. Coulson aptly warned: "That will never be, for a bond does not really exist at all: it is a most convenient fiction . . . both to experimental and theoretical chemists" (p. 261).

Nye's splendid account of scientists braving the often tortuous path between chemistry and physics is a story about how individuals have sorted out their views, even feelings and "aesthetic preferences" about the natural world, in building ever-changing disciplinary and professional identities.

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Categorization

Classification and Cognition. W. K. ESTES. Oxford University Press, New York, 1994. xii, 282 pp., illus. $49.95. Oxford Psychology Series, no. 22.

A full model of concept learning and categorization remains one of the most sought-after prizes in cognitive psychology. It is not hard to adopt a perspective whereby almost all cognition boils down to learning how to partition objects into useful groups. Concepts allow us to treat different objects equivalently, communicate, draw inferences, reason, and explain our world. To recognize a handwritten character as a *B* is to categorize it into the class of *B* letters. To remember reading an article is to categorize the article as belonging to the class of familiar things. To make a clinical diagnosis is to place a patient into a disease category. Although special-purpose routines will be needed to subserve these quite different categorizations, there is also guarded optimism that a unified model of categorization will be able to provide at least a partial explanatory account across many domains. The excitement and promise of this approach stem from its astoundingly wide sphere of application.

Categorization research has undergone several transformations. Before the 1970s, much of the work on concept learning began with the assumption that concepts are determined by necessary and sufficient defining features. In the 1970s, the prototype theory developed out of discontent with this rule-like, clear-cut approach. It assumed that concepts are organized around a best example that summarizes the most common or typical features of a concept's instances. The work summarized by Estes's book adopts a third, more recent, theory, which differs from the preceding theories in that concepts are not represented by summary or abstract descriptions. Rather, they are represented by their individual instances (called exemplars). In deciding whether an item belongs to a concept, the item is compared with the concept's exemplars. If the item is more similar to the concept's exemplars than it is to other concepts' exemplars, then it will be placed in the concept.

One of the primary attractions of exemplar models is that, even though they do not explicitly create abstract category representations, they can produce behavior that mimics behavior from models that force abstractions to occur. In the same way in which a prototypical man's face will spontaneously emerge when 50 photographs of different men's faces are superimposed, exemplar models can predict that category prototypes will emerge when many exemplars are combined. Even though only category instances are stored, previously unfamiliar prototypes may be categorized quite accurately (sometimes even more accurately than the exemplars themselves) because they are highly similar to many exemplars.

Estes's basic approach is to apply a relatively simple, mathematically formalized exemplar model to a wide variety of empirical results that have been obtained in human research laboratories including his own. He assumes that events are represented in terms of independent features (for example, *dog* might be represented by *four-legged, barks, furry,* and *tail*). When an event occurs and is effectively stored in memory, a trace of its features, including its category label, is laid down. Estes also presents a neural network implementation of his theory in which the influence of instance traces is altered with learning. Although Estes is one of the foremost researchers in mathematical psychology and his exemplar model is mathematically formalized, the equations that govern categorization behavior require only knowledge of simple algebra and are intuitively easy to grasp.

Estes applies his simple model to an extraordinarily wide array of results. He first applies it to standard empirical findings in human categorization. He provides formal accounts of how instances within a category vary in their typicality and categorization accuracy; how categories that are defined by different rules are learned with different degrees of efficiency; how concepts are combined; and how categorization is influenced by variables such as category size, presentation order, frequency, and featural similarity. However, Estes is not content merely to apply his model to traditional categorization results. True to his thesis that categorization is a core cognitive process, he subsequently applies it to work in memory, induction (for example, Given that an object has certain properties, what other properties is it likely to have?), pattern completion, and causal reasoning (for example, Is X, Y, or Z the cause of A?).

Not all readers will care about the fine details of Estes's accounts. Still, the research presented here is important for three reasons. First, it sets a standard for rigor, parsimony, and theoretical elegance in cognitive modeling. Second, in the study of human behavior, where truly general laws are rarities, it offers a coherent and predictive system for tackling both specific and general issues. Third, it provides formal tools for quantitative modeling of complex systems that researchers in many fields could effectively borrow. Although there must be more to cognition than remembering instances and generalizing from them, Estes makes a compelling claim for the broad and effective application of this process.

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Books Received

Abemama. An Atoll. Latitude 0° 24' North, Longitude 173° 52' East. Charles J. Flora. Jero, Everson, WA, 1994. xvi, 233 pp., illus. Paper, $33.

Adaptive Optics for Astronomy. D. M. Alloin and J.-M. Mariotti, Eds. Kluwer, Norwell, MA, 1994. xviii, 338 pp., illus. $127 or £84 or Dfl. 222. NATO Advanced Science Institutes Series C, vol. 423. From an institute, Cargèse, Corse, France, June 1993.

Addictive Behaviors in Women. Ronald R. Watson, Ed. Humana, Totowa, NJ, 1994. x, 526 pp., illus. $69.50. Drug and Alcohol Abuse Reviews, vol. 5.

Bachanalia. The Essential Listener's Guide to Bach's *Well-Tempered Clavier*. Eric Lewin Altschuler. Little Brown, New York, 1994. xvi, 254 pp. $22.95.

Bacterial Adhesion to Cells and Tissues. Itzhak Ofek and Ronald J. Doyle. Chapman and Hall, New York, 1994. xii, 578 pp., illus. $79.

Becoming a Scientist in Mexico. The Challenge of Creating a Scientific Community in an Underdeveloped Country. Jacqueline Fortes and Larissa Adler Lomnitz. Pennsylvania State University Press, University Park, 1994. x, 225 pp., illus. $35 or £32. Translated from the Spanish by Alan P. Hynds.

A Calendar of the Correspondence of Charles Darwin, 1821–1882, with Supplement. Frederick Burkhardt *et al.*, Eds. Cambridge University Press, New York, 1994. Variously paged, illus. $150. Corrected augmented reprint, 1985 ed.