when he states that studying the fly's eye convinced Cajal of the existence of God. Actually that lifelong agnostic only remarked that it "weakened his faith in Darwinism"—a more modest lapse to which Darwin himself was occasionally prone.

Genes get scant attention in the rest of the book, most of whose contributors are neuroanatomists and physiologists. Even so, one can't help being impressed by the ingenuity of current experimental techniques, which include lineage analysis with retroviral vectors (Altshuler, Turner, and Cepko), observation of growing axons *in vivo* (Fraser; Holt; Stuermer), NMDA-receptor blockade (Cline; Daw and Fox), and various types of transplants, reroutings, or selective ablations (Reh; Harris; Fraser; Shatz *et al.*; Sur). Development plasticity in the ocular dominance system, first described by Hubel and Wiesel almost 30 years ago, is still a hot topic—the attention has largely shifted from the physiology and anatomy to an analysis of the synaptic mechanisms involved (Daw and Fox; Cynader *et al.*; Stryker). Michael Stryker even throws in for good measure a (nondevelopmental) explanation for that other Hubel and Wiesel conundrum, orientation tuning.

The main message that seems to be emerging from this work is that, even more than in the fly's eye, the vertebrate visual system depends for its development on interactions between cells, regulation, and plasticity, rather than rigid cell-autonomous programming. The role of the "subplate"—a small, transient population of neurons that sits under the developing visual cortex and that seems to influence the formation of the permanent connections of the cortex—is an especially interesting example of this (Shatz *et al.*). Indeed, this kind of interactive development seems the only conceivable way to go if one has to put together a brain vastly larger than a fly's with a genome that is only modestly expanded. These interactions are probably mediated by a fairly small box of molecular tricks that are used over and over again: diffusible and cell-surface markers, receptors, second messengers, transcription factors, and so on. The trick that seems closest to being pinned down is the NMDA receptor and its potential role in the generation of activity-dependent patterns of connectivity. As to the mechanisms that operate earlier to convert multipotential postmitotic cells into the highly specialized neuron types of the mature visual system, this book gives some idea of their general character, but their actual identity remains obscure. Let us hope that Benzer is right.

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Special Kinds of Knowledge

What Engineers Know and How They Know It. Analytical Studies from Aeronautical History. WALTER G. VINCENTI. Johns Hopkins University Press, Baltimore, MD, 1990. viii, 326 pp., illus. $45. Johns Hopkins Studies in the History of Technology.

Over the years there has been a widespread belief, especially among some scientists, that modern engineering is a subdiscipline of science that does nothing more than apply the results and discoveries generated by pure science without making any fundamental contributions to those discoveries. Recently many scholars, particularly historians of technology, have come to challenge this belief. They argue that engineering generates its own form of knowledge in the form of concepts and methodologies that cannot be simply reduced to scientific knowledge. As Herbert Simon has observed, science deals with how things are whereas engineering deals with how things ought to be. This difference is reflected in the fact that engineering knowledge, unlike scientific knowledge, is not about the natural world but about humanly designed objects such as structures and machines.

In this book, Walter G. Vincenti draws on his background as both an aeronautical engineer and a historian of technology to investigate the nature of engineering knowledge. Through five case studies in aeronautical engineering, he examines how problems arising from normal design requirements have complex epistemological consequences that distinguish engineering knowledge from applied science.

The study of Consolidated Aircraft's decision during the 1930s to use David R. Davis's unconventional airfoil design for its B-24 shows how engineering design grows in the face of incomplete and uncertain information. Empirical tests done with small-scale models at the wind tunnel at the California Institute of Technology indicated that the Davis wing had superior characteristics compared with more established designs, but engineers were unsure how such tests would relate to actual performance. This uncertainty was compounded by Davis's inability to provide an acceptable theoretical basis for his airfoil design. Vincenti argues that attempts to decrease such uncertainties through a complex interaction between theory and experiment became a significant factor in the growth of engineering knowledge.

Vincenti's discussion of early aircraft design illustrates how design requirements grew out of a conflict between the preference of one group of engineers for a plane that had inherent stability and another group's preference for a plane that had a high degree of maneuverability. In this case the subjective needs of pilots helped to shape the debate. The eventual conclusion that airplanes should be stable but not too stable represents how an entire community of engineers and pilots played a role in the generation of engineering knowledge.

A study of control-volume analysis provides an example of how a subject is approached differently by engineers and scientists. Engineering textbooks treat problems in fluid mechanics and thermodynamics in terms of an imaginary control volume or control surface, but such concepts are absent in physics textbooks. Vincenti argues that the mathematical formalism of control-volume analysis arose from the demands of design and the economic constraints that faced engineers. They must design artifacts, and control-volume analysis lends itself better to a concern for overall results. Scientists, on the other hand, are concerned with understanding the workings of nature and usually need a detailed point-by-point description of phenomena.

A discussion of the aircraft propeller tests conducted by W. F. Durand and E. P. Lesley from 1916 to 1926 shows how engineers acquire the quantitative experimental data they need to carry out design. Through a process of parameter variation, Durand and Lesley conducted wind-tunnel tests on a large number of propellers. Vincenti argues that such testing represents an important methodology used by engineers that differs from the experimental method used in science. Experimental parameter variation could provide design data needed by engineers when they were faced with the lack of a useful quantitative theory.

The development of the techniques of flush riveting in the American airplane industry between 1930 and 1950 provides an example of engineering knowledge that did not involve any dependence on science. Rather, flush riveting reveals a different kind of technological knowledge that could be called prescriptive knowledge, or knowledge of procedures and operations. This type of knowledge differs from descriptive knowledge, or knowledge of facts, which is more closely associated with science.

These examples provide the basis for a model of engineering knowledge. Vincenti identifies the knowledge-generating activities in engineering as theoretical tools and data transferred from science, invention, theoretical engineering research, experimental engineering research, design practice, production, and direct trials. He concludes by exploring the idea that such knowledge grows by way of a blind-variation–and–selective-retention model put forward by the psychologist Donald Campbell. Such a model, along with the case studies, provides important insights into the distinctiveness and complexity of engineering knowledge.

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Some Other Books of Interest

Psychology at Iowa. Centennial Essays. JOAN H. CANTOR, Ed. Erlbaum, Hillsdale, NJ, 1991. xii, 178 pp., illus. $34.50. Based on a symposium, Iowa City, Oct. 1988.

Among the early developments important in establishing psychology as a discipline in the United States was the founding of the Psychology Laboratory at the University of Iowa. Associated with the laboratory and other institutional arrangements that succeeded it have been such eminent figures in the field as Carl Seashore, Kurt Lewin, and Kenneth Spence. In the opening chapter of this collection celebrating the laboratory's centennial Howard Kendler traces the intellectual lineages and orientations of these and other principal figures and describes the interplay of ideas and approaches that have gone into "the Iowa tradition" in psychology, which he sums up as representing "the strivings for a mutually beneficial relationship between experimental and applied psychology, a close and intimate bond between research and comprehensive theorizing, and a constant concern with the methodological foundations of psychology." After this introduction ten other Iowa alumni or former faculty further expound matters bearing on the tradition. I. E. Farber discusses the course "History and systems of psychology" taught by Gustav Bergmann at Iowa for over 30 years and Bergmann's assessments of British associationism, Gestalt theory, Freudianism, and various forms of behaviorism. Ernest Hilgard then presents recollections of faculty, students, and facilities up to about 1938, and Leonard Goodstein of the American Psychological Association takes note of roles Iowa faculty and graduates have played in that organization. The remaining papers deal with more specific research areas within psychology. Judson Brown, chairman of the Iowa department from 1965 to 1972, discusses definitional and experimental issues that have emerged in his studies of motivation, and Leonard Eron describes laboratory studies of aggression he conducted there. Research in developmental psychology at Iowa dates back to the establishment of the Iowa Child Welfare Research Station in 1917, and Tracy Kendler gives a "retrospective and prospective view" of that field. Norman Garmezy then offers some observations bearing on research in psychopathology; Albert Bandura discusses "the changing icons in personality psychology"; and Abram Amsel discusses the study of frustration ("experimental neurosis" in one formulation) as related to stimulus-response theory and learning theory more broadly. In a more broadly focused paper Janet Spence offers some observations on current directions, including organizational issues, in psychology generally, concluding that "the challenge we currently face is to resist the balkanizing tendencies that have come with" the advances that have been made. The book ends with subject and author indexes.—**K.L.**

Science, American Style. NATHAN REINGOLD. Rutgers University Press, New Brunswick, NJ, 1991. x, 429 pp. $42; paper, $18.

In this volume Nathan Reingold, one of the first historians trained to take American science as his research subject, presents a collection of his essays published between 1958 and 1987. After an introduction in which he distinguishes his approach to the subject from the once-conventional "top-only. . .fixation on great ideas, great scientists, and great revolutionary events" and expresses his avocation for analyzing archival collections as material for "detective stories," Reingold presents a total of 17 essays under five headings. The group headed The National Stage includes a bicentennial assessment (De Tocqueville to Gerald Ford) and discussion of the professionalization of American science up to about 1900 and the supposed initial "American indifference to basic research." There follow five papers specifically focused on the 19th century, dealing with the Navy Department in the Civil War, activities in Russia of the meteorologist Cleveland Abbe, the influence of Alexander Dallas Bache, a "founder of the American scientific community," and the concerns of Joseph Henry. A further three papers consider institutions—the relations between American graduate schools and their European models and the early days of the Carnegie Institution of Washington, the National Academy of Sciences, and the Rockefeller Institute. The group headed The Perils of Maturity is a miscellany considering refugee mathematicians from Nazi Germany, Vannevar Bush's "new deal for research," and a Hollywood representation of the atomic bomb program. A final trio deals with historiographic issues: the relation of the history of science to the other disciplines—sociology and philosophy—concerned with science, a 1980 indictment of trends in the field by Charles Gillispie (relevant references here being *Science* **207**, 389 and 934), and the formulations of Thomas Kuhn. The essays have not been updated for the collection; rather, the author provides for each an introduction expounding the concerns that motivated him at the time of writing. A 19-page index concludes the volume.—**K.L.**

Books Received

The Analysis, Communication, and Perception of Risk. B. John Garrick *et al.*, Eds. Plenum, New York, 1991. xii, 713 pp., illus. $145. Advances in Risk Analysis, vol. 9. From a meeting, San Francisco, CA, Oct. 1989.

The Anatomy of Philosophical Style. Literary Philosophy and the Philosophy of Literature. Berel Lang. Blackwell, Cambridge, MA, 1990. viii, 277 pp. $44.95; paper, $16.95.

Ancient North America. The Archaeology of a Continent. Brian M. Fagan. Thames and Hudson, New York, 1991. 480 pp., illus. Paper, $29.95.

Bioactive Compounds from Plants. Derek J. Chadwick and Joan Marsh, Eds. Wiley, New York, 1990. xii, 242 pp., illus. $63.50. Ciba Foundation Symposium 154. A Wiley-Interscience Publication. From a symposium, Bangkok, Thailand, Feb. 1990.

A Celebration of Colour in Astronomy. David Malin. Current Science Association, Bangalore, India, 1991. ii, 32 pp., illus., + plates. Paper, $15. Current Science, A Special Issue. Vol. 60, no. 1.

Dry Etching for VLSI. A. J. van Roosmalen, J. A. G. Baggerman, and S. J. H. Brader. Plenum, New York, 1991. xviii, 237 pp., illus. $69.50. Updates in Applied and Electrical Technology.

Earthwatch. The Climate from Space. John E. Harries. Horwood (Prentice Hall), Englewood Cliffs, NJ, 1991. 216 pp., illus., + plates. $32. Ellis Horwood Series in Atmospheric Science.

Fundamentals of Ocean Acoustics. L. M. Brekhovskikh and Yu. P. Lysanov. 2nd ed. Springer-Verlag, New York, 1991. xii, 270 pp., illus. Paper, $45. Springer Series on Wave Phenomena, vol. 8.

Genetic Algorithms and Robotics. A Heuristic Strategy for Optimization. Yuval Davidor. World Scientific, Teaneck, NJ, 1991. xvi, 164 pp., illus. $29. World Scientific Series in Robotics and Automated Systems, vol. 1.

Genetically Engineered Organisms. Benefits and Risks. J. R. S. Finchman and J. R. Ravetz. University of Toronto Press, Buffalo, NY, 1991. xiv, 158 pp., illus. $50; paper, $15.95.

A Geostatistical Primer. Peter I. Brooker. World Scientific, Teaneck, NJ, 1991. vi, 95 pp., illus. $32.

Global Change and Relevant Space Observations. J. L. Fellous, Ed. Published for the Committee on Space Research by Pergamon, New York, 1991. vi, 270 pp., illus. Paper, $130. Advances in Space Research, vol. 11, no. 3. From a symposium, The Hague, The Netherlands, June 1990.

Glycogen Phosphorylase b. Description of the Protein Structure. K. R. Acharya *et al.*, Eds. World Scientific, Teaneck, NJ, 1991. viii, 123 pp., illus. $38; paper, $18.

Gossamer Odyssey. The Triumph of Human-Powered Flight. Morton Grosser. Dover, New York, 1991. xxii, 298 pp., illus., + plates. Paper, $9.95. Reprint, 1981 ed.

Governmental Management of Chemical Risk. Regulatory Processes for Environmental Health. Rae Zimmerman. Lewis (CRC Press), Boca Raton, FL, 1990. xxii, 345 pp., illus. $65. Technology and Environmental Health Series.

Gradient HPLC of Copolymers and Chromatographic Cross-Fractionation. Gottfried Glockner. Springer-Verlag, New York, 1991. xvi, 210 pp., illus. $69.

Greek Astronomy. Sir Thomas L. Heath. Dover, New York, 1991. lviii, 192 pp. Paper, $6.95. Dover Books on Astronomy. Reprint, 1932 ed.

Guide to Yeast Genetics and Molecular Biology. Christine Guthrie and Gerald R. Fink, Eds. Academic