entific research as they varied with political change. Development was hindered, for instance, by mistrust and restricted budgets during the Bourbon Restoration and the Second Empire. Zwerling, however, in his paper on the Ecole Normale Supérieure, where future lycée teachers were trained, rejects accepted explanations for a decline in French science. Rather than seeing over-centralization and political instability as fundamental, he relates changes in the French scientific community to the emergence of an industrial society in France during the 19th century. He also points out that mathematics could adjust to changing circumstances because of the lesser need for financial support and research facilities.

Zwerling's contribution provides useful new evidence of the role of the Ecole Normale in scientific development. During its early years, the teaching of science was not emphasized at the Ecole Normale, but in the 1830's this situation began to change and, according to Zwerling, *normaliens* played an increasingly important role in scientific teaching and research. Reforms in the 1850's stressed the need for science in the lycées with consequent effects on the Ecole Normale. Zwerling provides useful comparisons with the Ecole Polytechnique, with respect not only to scientific research but also to the social backgrounds and ambitions of the students. He provides evidence that the *polytechniciens* came increasingly from the upper levels of the bourgeoisie and the *normaliens* from the lower levels; this is interesting in view of the democratizing aims of the founders of the Ecole Polytechnique. He illustrates the support of developing industry for provincial faculties of science. While *polytechniciens* could envisage top careers in the civil service, new types of scientific career were open to *normaliens* in an expanding French economy. However, according to Zwerling, the economy itself dictated the type of career possible, and he sees in its slow expansion relative to that of Germany an explanation for what has been considered to be the decline in French science.

In comparing the scientific achievements of the Ecole Polytechnique and the Ecole Normale, Zwerling's stress on the output of scientific papers is not wholly convincing. Merely to compare numbers of papers is inadequate, since quality is not assessed and, moreover, the number of papers published by *normaliens* increased sharply, according to Zwerling's statistics, with the foundation of the *Annales Scientifiques de l'Ecole Normale Supérieure* in 1864, publishing almost exclusively the works of *normaliens*. However, Zwerling's thorough research throws interesting new light on the history of the Ecole Normale.

Weisz's paper on medical education concentrates on the period from 1870 to 1914. Some mention of the earlier years, linking development in hygiene with public works, would have been interesting. There is scant reference to the *officiers de santé*, and their role is not explained. As regards the organization of medical teaching and the political struggles involved, however, the work is full and comprehensive, as is Crawford's study of the effects on scientific progress of the prizes of the Academy of Sciences and the increasing importance of their material rather than symbolic value. Limoges describes the decline and growing isolation of the Muséum d'Histoire Naturelle during the 19th century but rather neglects the earlier part of the period, apart from providing interesting comparisons of its budgets with those of other institutions.

Shinn provides an excellent analysis of the changing concept of the "engineer" and the barrier between the state engineering corps and the growing needs of industry. He claims that participation in industry was considered socially degrading, but he does not mention the role of *polytechniciens* in the Saint-Simonian movement for the advancement of industry. He claims that the power of the state corps exists today in France because of the entrenched values of the privileged classes, but attitudes began to alter with the growth of industry and the need for highly educated technical and scientific personnel. His contribution is most useful in assessing changes in engineering education and the role of the engineer in French society. Day stresses the political motivation for changes in technological education. He throws new light on *Université* attitudes and the emergence of technical education, as does Paul when he describes the increasing stress on applied science, the failure of the *grandes écoles* to meet the needs of industry, and the changing funding of education, with subsidies from local authorities and regional industry.

What emerges most forcibly from this collection is a picture of entrenched traditions. Though studies of French scientific research have usually resulted in unfavorable comparisons with Germany, the two countries were in fact, according to Lundgreen, developing in similar ways, with strong bureaucratic attitudes influencing the recruitment of manpower and favoring systematic learning and training. The requirement of formal education and qualifications on both sides of the Rhine gave rise to or enforced the rule of meritocracy, but industry and the economy dictated change according to prevailing needs. In Germany and Switzerland, first-class scientists were harnessed to laboratories whose research was directly related to expanding and powerful industry. France's development was different, but the most successful French industries were, according to Paul, directly linked to institutes or had their own laboratories for pursuing the industrial application of scientific research.

MARGARET BRADLEY
Department of Combined Engineering, Coventry (Lanchester) Polytechnic, Coventry CV1 5FB, England

The Brain

The Organization of the Cerebral Cortex. Proceedings of a colloquium, Woods Hole, Mass. FRANCIS O. SCHMITT, FREDERIC G. WORDEN, GEORGE ADELMAN, and STEPHEN G. DENNIS, Eds. MIT Press, Cambridge, Mass., 1981. xxii, 592 pp., illus. $50.

The cerebral cortex is perhaps the most uniform of all mammalian brain regions in its anatomical organization. Everywhere it can be subdivided tangentially from pial surface to white matter into more or less six cell and fiber layers. Such uniformity even at this gross cytoarchitectural level implies that many of the underlying neural computations must be rather similar throughout. This is a hopeful view, one that means that by studying the structure and function of even a small portion of this immense collection of neurons it may be possible to gain insight into the functioning of the whole. In *The Organization of the Cerebral Cortex*, a collection of papers presented at a 1979 Neurosciences Research Program Colloquium, many different regions of cortex (motor, visual, somatosensory, frontal-association) are examined from almost every point of view (chemistry, physiology, ultrastructure, development, cytoarchitecture, and more). The result: an up-to-date affirmation of the view that a number of broad principles underlie the organization of the cerebral cortex.

At least three sets of major principles govern the organization of the cerebral cortex: laminar, columnar, and topographic. Until recently, some of the best examples of these have come from studies of the mammalian visual system, and consequently this volume draws heavily on this research. For example, Golgi studies such as those of Lund included here have shown that the neurons residing in each cortical layer give rise to unique patterns of connections. This principle of lamination is examined also at the ultrastructural level, by Colonnier; each layer contains a unique complement of synaptic inputs, and the intrinsic and extrinsic origins of many of these inputs are now known. Not surprisingly, the uniqueness of each cortical layer is also reflected in its neurochemistry, as is discussed by Emson and Hunt. And functionally each layer of the visual cortex can be distinguished on the basis of the response properties of the neurons it contains. Just how such physiological properties might be constructed from the anatomy is the subject of Gilbert and Wiesel's contribution. The cortex can also be subdivided vertically from pial surface to white matter into a system of "columns." Neurons belonging to a given column all share the same functional property—"eye dominance," for example, in visual cortex. The anatomical basis for these particular columns and their development are considered in chapters by Rakic and by LeVay, Wiesel, and Hubel. Finally, cortex is organized topographically. Primary visual cortex, for example, contains an orderly map of the visual field, and, as is discussed by Cowey, this map is repeated (in a more or less orderly fashion) over and over again in nearby visual cortical areas.

In and of themselves, these principles of organization are not news. Columnar organization, for instance, was first proposed by Mountcastle in his 1957 study of the somatosensory cortex. (Sadly, no contribution from Mountcastle is included here, but his work is eloquently summarized in an introduction by Cowan.) Notions of lamination and topography date even earlier. What is news is that the list of cerebral cortical areas now known to conform to these principles is impressive indeed, as exemplified by the numerous fine and exhaustive studies included in this volume. (Studies of auditory cortex have, regrettably, been omitted.)

Just how to piece together from an appreciation of the organization of the cerebral cortex at the structural level an understanding of its function is by no means clear. The problem is bravely attacked in the book's last two sections, one dealing with higher functions of the cerebral cortex and the other with models of cerebral cortical function. At this point, there are no simple answers to be had and no broad conclusions to be drawn. Nevertheless, it is encouraging to note that efforts are in progress to elaborate theoretical frameworks within which this ultimate question might be answered. But a theoretical framework alone is not enough. Perhaps some of the techniques developed recently (and not considered in this volume) for the study of human brain function by means of cerebral blood flow monitoring will be sufficient to bridge the gap between our understanding of local cortical organization and global cerebral cortical function. Or perhaps the wish articulated by the editors in their preface will be granted: that this collection, certainly thought-provoking and timely, will "stimulate and call forth creative new approaches to the study of the neural substrates of behavior."

CARLA J. SHATZ
*Department of Neurobiology,
Stanford University Medical School,
Stanford, California 94305*

Desert Domesticates

The Camel. Its Evolution, Ecology, Behavior, and Relationship to Man. HILDE GAUTHIER-PILTERS and ANNE INNIS DAGG. University of Chicago Press, Chicago, 1981. xii, 208 pp., illus., + plates. $26.

Targets of droll anecdote and poetic allusion, the Camelidae grace the earth with only six species. These species, descendants of Pleistocene emigrants to Asia and South America, are the only remnants of a diverse assemblage of extinct North American camelids that ranged from gazelle-like to giraffe-like forms. The dromedary, domesticated for not less than three millennia, is the focus of this fascinating book, which is based on intermittent research in the western and northwestern Sahara over a 19-year period. In this seemingly boundless land the survival of nomads and camels is intertwined; so neither can be studied without a hard look at the other. The authors of the present book achieve, with clarity, their objectives of describing the camel in its natural habitat and drawing attention to the camel herder's role in desert ecology. The first part of the book considers the camel's evolution, ecology, and behavior and the second considers its relationship to man. Gauthier-Pilters and Dagg, authorities on camels and ungulate locomotion, have successfully synthesized their own findings and an extensive literature. The book has a bibliography of over 500 items, nearly half of which are cited in the text, and it is illustrated with 68 excellent photographs.

The primary habitat of the dromedary is the Sahara desert, "the largest, hottest, driest desert in the world." This is a land of burning winds, sporadic rainfall, and ground temperatures that reach 60°C. The authors' description of Saharan climate, relief, and plant cover will do much to enlighten the stereotyped image the film industry has given most Western readers. Few ungulates are able to exploit the salty, toxic, or thorny plants of the desert, but the camel's water economy allows it to penetrate remote waterless pastures, where it sparingly samples a wide range of foods. Some halophytes may constitute up to 35 percent of the total food intake, and together with dry grass salty plants form a well-balanced regimen. Toxic plants

"Camel feeding on an *Acacia* twig with long thorns." Camels "often first grasp the vegetation between their long, hairy prehensile lips, the upper two halves of which are separated and move independently. . . . The camel may either draw off leaves from a branch or clip off an entire twig, individual fruit, or flowers." [From *The Camel*]