not likely that angiosperms arose directly within the eastern United States.

On the basis of the new information, Doyle and Hickey present a speculative model for the origin of angiosperms. The angiosperm ancestor may have been a xeromorphous derivative from the cycadopsid gymnosperms, which developed "weedy" tendencies in a variable, probably xeric-temperate, environment. In a riparian setting the weedy early angiosperms may have diversified rapidly into nymphaeoid (monocot) and magnolioid (dicot) alliances, with subsequent facile development of different habits of growth and environmental preferences. The period for these important developments is almost entirely Albian. It appears from this that a critical time for the rapid diversification of angiosperms extended over about 8 million years at the end of the Early Cretaceous.

"Neoteny" is the process whereby essentially juvenile, developmental phases are prolonged and projected in ontogeny into mature stages of a life cycle. Armen Takhtajan discusses many such occurrences that may have been involved in the origin of angiosperms. Neoteny may be induced by stress of environmental conditions, like the seasonal arid regime and disturbed habitats postulated by Doyle and Hickey.

Although many have supposed that chromosome records can contribute little to solving general problems in evolution, F. Ehrendorfer has been able to draw general conclusions about angiosperm evolution from the patterns of chromosomal differentiation in gymnosperms and angiosperms. Karyological patterns favor a common origin for all angiosperms, as well as a common origin of Coniferophytina and Cycadophytina. The association of smaller chromosomes in angiosperms has facilitated polyploidy and was conducive to their greater evolutionary versatility.

The pollen morphology of 230 genera assigned to 35 families of plants in nine modern orders of angiosperms, treated informally as a "ranalean complex," has been examined by James W. Walker. He gives a concise, thorough review of the principal pollen characters that are phyletically useful, followed by data systematically presented on geographic distribution and pollen morphology, remarks, and assembled references for each of the 35 families. About 65 beautiful scanning electron micrographs of pollen, magnification various, but chiefly ranging from 300 to 5000, illustrate variation for each family. All data are vouchered for possible future reference. This extensive survey provides a basis for discussion of evolutionary trends and conclusions about the ancestral type determinable from modern angiosperm pollen.

Walker believes pollen evolution progressed from large grains to small; the primitive pollen coat may have resembled neither the alveolate exine of gymnosperms nor the tectate structure of modern angiosperms but might be better described as "atectate." The fossil pollen of *Clavatipollenites*, cited as the oldest tricolpate angiosperm pollen (Barremian) by Doyle and Hickey, probably is not close to the ancestral type (its closest alliance may be with the Chloranthaceae). Walker insists the most primitive angiospermous pollen grains were boat-shaped and large, anasulcate with a long sulcus, atectate, and more or less psilate. This agrees with the suggestion made by Brenner, and also conforms with the Albian evolutionary sequence proposed by Doyle and Hickey. Walker's most interesting suggestion is that the earliest primitive angiospermous pollen may have been confused as fossil "cycadophyte pollen" by palynologists. If this should be the case, the most primitive angiosperm pollen might be somewhat older than the Barremian.

G. Ledyard Stebbins has contributed an article "Seeds, seedlings, and the origin of angiosperms" that also reflects the consensus, although he does not preclude much earlier origin. Paraphrasing Stebbins only slightly, one may say that, from about the end of the Paleozoic until the early part of the Cretaceous, the evolutionary line leading to the angiosperms passes through a dark tunnel of ignorance. The important characters of angiosperms, such as the pollen tube, stigma and style, carpel or ovary, double-integumented anatropous ovule, reduced gametophyte, double fertilization, triploid endosperm, intercalary vegetative growth, and overall physiologic versatility, seem designed to provide for rapid response to selective environmental pressures such as drought, seasonal variation, and growth in disturbed habitats like talus slopes and eroded stream banks. Thus far, fossil evidence has shed little light within the tunnel, although caytonian fruiting structures may suggest an origin for the second integument. Stebbins thinks, however, that no really significant fossils have been found that can be related to the origin of angiosperms.

Character correlation designed to indicate general evolutionary status (degree of primitiveness or advancement) within the angiosperms is treated by Kenneth R. Sporne. Although the concept is simple, the statistical proof of it is not clear to me—one can appreciate the difficulty in avoiding circular argument. Twenty-four carefully chosen characters have been utilized for evaluation in dicots, and 12 in monocots. One objective has been calculation of an "advancement index" which would provide a numerical basis for relative evaluation for taxonomic groups. The data lend themselves to excellent diagrammatic representation, but it is difficult to evaluate the degree of generalization that is required for mathematical treatment. Sporne appreciates the importance of the fossil record, particularly fossil pollen, but it is difficult to incorporate the available fossil information for comparison with selected characters determinable in the extant flora.

The collection of papers in this volume must be of interest to anyone concerned with the derivation of our angiospermous flora. There is now a great revival of interest in this subject, which I can attribute only to the greatly enhanced fossil record that has recently become available through the serious botanical study of palynomorphs. Explanation of why modern plant distribution provides few answers that bear directly on angiosperm origin is provided by Schuster, but I am just as sanguine as Hughes is that fossil studies will eventually fully elucidate the origin and early evolution of angiosperms.

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Glacial Geomorphology

Glaciers and Landscape. A Geomorphological Approach. DAVID E. SUGDEN and BRIAN S. JOHN. Arnold, London, 1976 (U.S. distributor, Halsted [Wiley], New York). viii, 376 pp., illus. Cloth, £12; paper, £5.95; U.S. prices, $30 and $12.50.

Sugden and John, geographers from the Universities of Aberdeen and Durham, have produced an unusual and striking textbook about glaciers and their effects on the landscape beneath them. The book is divided into five almost equal parts, with three chapters in each. It treats glaciers and glacier dynamics, glacier distribution in space and time, glacial erosion and deposition and their effects on landforms and landscapes, and the meltwater system within, but not beyond, the confines of the glaciers.

The book is encyclopedic, clearly written from a geographical viewpoint, and profusely illustrated with good drawings and photographs. The authors draw heavily on the recent literature on Iceland, Greenland, and Antarctica. They incorporate observations and principles from over a thousand references, and although many of these involve theoretical physics and mathematics as applied to glaciers, the book has few formulas. It does not just describe glaciers and their effects, however, but attempts to provide an understanding of the processes involved. It is not a complete treatment of the subject because it does not go beyond the limits of present or past glaciers in its treatment of topics. Moreover, because of its focus on landforms and landscapes, it is weak in stratigraphy and correlation or chronology.

An impressive list of colleagues is acknowledged as having read parts of the manuscript. Most are Europeans and members of the International Glaciological Society; none works in the classical glacial stratigraphy of the midwestern or northwestern United States. Perhaps as a result, many major papers from those areas are not cited.

The authors remind us that a third of the land area of the earth has at one or more times been covered with glaciers. Historically, geomorphology started in Europe and was expanded in North America—these being areas that were heavily glaciated. The status and traditions of geomorphology differ from one country to another, as do those of what we call glacial geology. There has been a tendency for geologists in the United States to emphasize glacial stratigraphy and chronology and for geomorphology to be taught in geology departments. In most other countries geomorphology is most often taught in geography departments, and the emphasis is on landforms and landscapes. In recent years there has been a strong surge of interest in the subject on the part of glaciologists—those concerned with the physics of ice—and paleoclimatologists—those investigators from any field who can aid in the reconstruction of former climates. Because of the diversity of the disciplines involved in all these approaches, close cooperation and exchange of information have not always been achieved. The authors hope to unify these different approaches in their book, providing something for everyone, but retaining a focus on glacial geomorphology. Their success will have to be judged by the individual reader, but this reviewer considers their performance creditable indeed. No introductory textbook can satisfy everyone. Still, even though the glacial geologists of central North America may feel shortchanged by the discussion of stratigraphy, I warrant that they can benefit from the synthesis of the many views of others on the characteristics and dynamics of glaciers and on glacial landforms and landscapes.

In dealing with matters of scale, a major theme, the authors use a modified version of a terminology set out by Tricart. For the most part SI units are used. Numerous models are used to simplify and portray graphically the authors' systems approach to the subject. Many students and specialists alike will find them helpful, but, as the authors admit, they are simplistic.

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Heterogeneous Catalysis

Catalysis by Electron Donor-Acceptor Complexes. Their General Behavior and Biological Roles. KENZI TAMARU and MASARU ICHIKAWA. Kodansha, Tokyo, and Halsted (Wiley), New York, 1976. viii, 208 pp., illus. $19.

Since the first striking experimental observation of a specific physical consequence of weak donor-acceptor interaction (the Benesi-Hildebrand observation of the benzene-iodine charge-transfer absorption band) and the first careful exposition of the nature of donor-acceptor interactions (by Mulliken in the 1950's), the concept of donor-acceptor interaction has been widely applied in the explanation of physical and chemical properties of interacting molecules. Indeed, since even rather strong interactions, such as the formation of hydrogen bonds, ion pairs, or highly ionic molecules such as lithium fluoride, can be discussed in terms of electron donor-acceptor interactions, the concept is potentially so broad as to be vague—all chemical bonding implies some charge transfer.

The core of Tamaru and Ichikawa's book is the fourth chapter, which provides a detailed summary of recent experimental work, very largely Japanese, on heterogeneous catalysis by donor-acceptor complexes. In this chapter, the term "donor-acceptor complex" is used quite carefully to refer to systems such as sodium-anthracene in which the interaction is specifically and clearly of charge-transfer type. The chapter describes work on a wide range of processes (ammonia synthesis, hydrogenation, butene isomerization, carbon dioxide reduction) for which catalysis by donor-acceptor complexes has been demonstrated and makes some cogent arguments about possible mechanisms. This work is important and highly specialized, and the present review by leaders in the field is timely and helpful.

In a certain sense, it is obvious that such solid materials as the phthalocyanines and certain aromatics, in which the number of carriers and other electronic properties, such as work function, can be varied within large limits simply by doping the materials with metal, could be employed to make highly selective catalysts. Tamaru and Ichikawa provide examples of cases for which such selectivity has indeed been demonstrated. They fail, however, to provide either an overview of or a general hypothesis regarding the actual means by which this selectivity can be achieved—too often the chapter reads like a compendium of what has been done, and little effort is made to rationalize the separate experimental data within even a phenomenological model of the causes of the processes. This undifferentiated exposition of fact is the major strength of the book, but also its major weakness. One would have hoped that the authors would provide a conceptual framework for their experiments.

The book also has several minor weaknesses. The second chapter, which discusses donor-acceptor complexes in general, is perfunctory and quite inferior to many similar presentations. Much of chapter 3, on homogeneous catalysis, fits rather badly with the subject of donor-acceptor catalysis. There are numerous minor errors (missing electrons in the equation on p. 2, confusion of donor with acceptor on p. 8, confusion over hydrogen bond lengths on p. 26, confusion of sigma bond with sigma complex on p. 138) and many misprints. There are also some confusing sections, such as that on the notion of localization energy on specific atoms, a nonstandard concept that is used but not defined. Also a book published in 1976 should not still claim that alkali and ammonium salts of tetracyanoquinodimethane show the highest conductivities of any organic material. Despite these drawbacks, this book is a useful review of important work and should be read by anyone concerned with heterogeneous catalysis.

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