cussions—as is exemplified by the intriguing hints given by Denizot and Lugardon for a homology between the centripetally deposited laminated layer that makes up the bulk of the exine (minus perispore) in many bryophytes and pteridophytes and the inner exine layer (endexine) of gymnosperms and angiosperms. Similarly, Huynh's careful analysis of developmental relationships between positions of apertures and tetrad symmetry in angiosperms belongs to a tradition that has had generally recognized evolutionary implications. On the other hand, although Laing summarizes recent studies on Cretaceous fossil pollen that provide important evidence concerning early evolutionary trends in angiosperms, and Chaloner and Heslop-Harrison present arguments about the functional significance of characters in fossil and modern spores and pollen that promise to help explain exine evolution as one facet of the evolution of more basic reproductive adaptations, the dearth of references to the fossil record and the adaptive bases of trends elsewhere in the book (partial exceptions being papers by Köhler, Walker, and Muller and Leenhouts) suggests that these new aspects of palynology have not yet attracted the attention they deserve from systematic palynologists.

Some of the systematically oriented papers are rather narrow in focus and will be of interest primarily to taxonomic specialists. Many, however, are of considerable general interest because they discuss trends in large or phylogenetically important groups (for example, Lugardon on exine structure in pteridophytes, Walker on living "primitive" angiosperms, Hideux and Ferguson on the Saxifragaceae sensu lato, Van Campo on patterns of aperture and symmetry variation within angiosperm taxa) or because they illustrate especially well trends or methodological approaches that are relevant to other groups (for example, Köhler on pollen dimorphism in Sterculiaceae, Le Thomas and Lugardon on exine structure in Annonaceae, Muller and Leenhouts on Sapindaceae). The paper by Hideux and Ferguson, though too preliminary to do full justice to the subject, is of special interest not only because of the key phylogenetic position of the Saxifragaceae, but also for its pioneering attempts to systematize exine structure and sculpture features as seen with the scanning electron microscope and to apply multivariate techniques to analysis of pollen morphological variation and trends. Also of broad evolutionary interest is evidence presented by Walker and by Le Thomas and Lugardon that stages in the origin of the typical "columellar" exine structure of most angiosperms are preserved within living primitive dicots. In the light of comparative and fossil evidence that nonalveolar exines in modern gymnosperms are more advanced than alveolar ones, however, I find Walker's hypothesis that the columellar structure of angiosperms and the "alveolar" structure of many gymnosperms arose as divergent specializations from a homogeneous "atectate" exine of the sort seen in some modern Magnoliales unconvincing. The lack of critical discussion of evolution in gymnosperm pollen is indeed one of the most conspicuous lacunae in this book as a whole.

Although usually plausible and internally consistent, many of the evolutionary schemes proposed by the contributors suffer somewhat from the widespread tendencies toward insufficient justification of assumptions about directions of evolutionary trends and toward "one-character phylogeny" based on the stringing together of modern pollen types without enough consideration of the fossil record, correlation with characters of other organs, or alternative schemes (for example, Chanda and Ghosh's suggestion of a relationship between the dicot family Berberidaceae and the monocot family Xanthorrhoeaceae). Methodological assumptions used in reconstructing evolutionary history are most clearly stated by Muller and Leenhouts, who are refreshingly candid in their emphasis on the limitations of arguments based on comparative morphology, where ambiguities often arise owing to parallelism or mosaic evolution. The repetition of similar series of pollen morphological types in different groups gives the impression that it may sometimes be better to consider groups as characterized by particular "patterns of variation" defined by a limited number of geometric rules, as is argued by Van Campo and illustrated by cases of pollen dimorphism (Köhler, Mattsson) than to search for irreversible, unidirectional "trends."

In sum, *The Evolutionary Significance of the Exine* is an excellent introduction to the successes, limitations, and potential of research on pollen and spore morphology and evolution, and an essential reference for students of pollen morphology and plant systematics.

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Surfaces and Catalysis

The Physical Basis for Heterogeneous Catalysis. Proceedings of a colloquium, Gstaad, Switzerland, Sept. 1974. EDMUND DRAUGLIS and ROBERT I. JAFFEE, Eds. Plenum, New York, 1975. xxvi, 596 pp., illus. $45. Battelle Institute Materials Science Colloquia.

This book is the report of a meeting of 53 persons classifiable into three groups: chemists concerned with heterogeneous catalysis, experimental chemists or physicists working in surface chemical physics, and theoreticians, mainly solid state theoreticians. The second group predominated. The object of the meeting was to evaluate what the last two groups had done and could do for the first. Since the last two groups have only recently interested themselves in applications to heterogeneous catalysis, the meeting was a timely one.

In order to make the colloquium "narrow enough that all the viewpoints could be brought together" it was restricted to catalysis on group VIII metals. Necessarily, then, there are only occasional references to coordination chemistry and organometallic chemistry, which so far have contributed more to the understanding of heterogeneous catalysis than has surface chemical physics. But, the restriction was a wise one because it is in studies of group VIII metals that surface chemical physics has made contributions and has the prospect of making important contributions.

Most of the 26 papers in the volume are related to the core problem of the meeting, but some are rather removed from it. The surface chemical physicists talked to each other and respectfully posed questions to the theoreticians. The theoreticians seemed to try to talk to all groups. On the evidence of the discussion sections, the seven papers on catalysis had little impact, perhaps because most of the surface chemical physicists and the theoreticians are studying chemisorption and do not yet feel ready to go very far into reactions among chemisorbed species.

The concerns of surface chemical physicists reflect the fact that historically their discipline evolved from research in ultrahigh vacua (the U.S. club of the surface chemical physicists is the American Vacuum Society). In their research they employ ultrahigh vacua and probes nec-

essarily limited thereto, such as moving electrons and far-ultraviolet photons. Their aim is to arrive at an understanding of the microscopic properties of and processes on surfaces, and they are therefore happiest when working with single crystals. One might have thought that electron paramagnetic resonance, infrared, or visible spectroscopy would be as suitable for the elucidation of microscopic details as the current techniques of surface chemical physics, but spectroscopy, which does not involve ultrahigh vacua and is not readily applied to the surfaces of single crystals, by tradition belongs to the province of physical chemists. The results obtained in chemical physics at pressures less than 10^{-5} torr cannot immediately be applied to heterogeneous catalysis, in which the pressure usually exceeds 10^{2} torr. There was considerable discussion at the meeting of this "pressure gap." There are a number of researches aimed, and with some success, at closing it. The papers of Ertl and Somorjai provide examples. Another sign of progress in the application of surface chemical physics to heterogeneous catalysis is the fact that most of the papers by chemical physicists deal with metals other than tungsten, the touchstone of surface chemical physics but of only slight interest in the study of heterogeneous catalysis.

The reports of the general discussions that followed groups of papers are among the most interesting items in the book. The interest in chemisorption shown by a rather large group of theoreticians is of very recent origin. Exact mathematical solutions are out of the question, and it is not yet clear what approximations will prove to be the most suitable for various purposes. The discussion of the theoretical papers involved most of the leaders in that area of research. The other discussions are also good, and they address many currently important problems in heterogeneous catalysis, such as the effect upon chemisorption and heterogeneous catalysis of steps and kinks on otherwise plane surfaces and the question whether the active catalytic sites in various reactions involving hydrocarbons on group VIII metals are directly on the metal surface or on overlying carbonaceous layers.

In a day of photoreproduced typescripts, it is a pleasure to see a book so handsomely printed.

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