for atomic collision data from other fields (such as plasma physics and astrophysics) has increased. In the subfield of energetic atomic collisions, positively charged ions from small as well as large accelerators with energies from KeV's to hundreds of MeV's are now used to explore the inner region of atoms. In such collisions, hot atoms with inner-shell vacancies are produced. The de-excitation of these hot atoms, with the emission of electrons and photons, is detected with increasingly high resolutions, from which the excited states of these atoms can be identified.

Compared to the impact by electrons, positrons, and photons, energetic ion-atom collisions can cause great distortion of the electronic charge clouds, which not only can change size but can also change shape and rotate. Measurements of excitation, ionization, and charge transfer cross sections, which are illustrated in this book, provide information about the response of the electronic clouds to the changing Coulomb fields of the collision system. When the incident particles are light projectiles, the distortion of the charge cloud is small and the standard perturbation theory (first Born approximation and its variants) has been proved to be able to predict excitation and ionization processes quite well. The situation for charge transfer is different. Identification of charge transfer mechanisms at high energies has shown that the first Born approximation is completely inadequate and that a correct description requires at least a second Born approximation (and its variants). Simple perturbation theory is no longer applicable for collisions with heavier projectiles. In the special case of lower collision velocities, the time evolution of the charge cloud can be approximated as following the molecular orbitals of the collision system. This general model, which was first proposed in the 1930's, has now been used to interpret many experimental data. Recent progress lies in our ability to isolate a few important molecular orbitals for specific collisions and for quantitative predictions.

Although quantum mechanical scattering theory is in principle a well-documented subject, extensive theoretical development is still needed for implementation of the various working models associated with the various collisional mechanisms. This proceedings volume starts with a brief and excellent review of the formal scattering theory by Massey. The chapters that follow survey a coherent selection of interesting topics in energetic ion-atom collisions. Most of these overview chapters are thoughtful and stimulating, and the experimental and theoretical papers complement each other.

The last third of the book contains papers on coherence and correlation in atomic collisions and on new aspects in the study of atomic collisions. The papers on coherence and correlation report progress toward "complete" (in the quantum mechanical sense) experiments where scattering amplitudes and phases are determined in coincidence experiments. The papers on new aspects cover the use of polarized particles in atomic experiments. This third of the book is concerned with highly sophisticated techniques that are expected to be the driving forces in providing detailed information about atomic collisions in the future.

All in all, the book provides a lucid, enjoyable overview of energetic ion-atom collisions. It will be valuable to anyone who is seriously interested in doing research in accelerator-based atomic physics and to researchers in other fields who want to get an overview of the considerable progress that has been made in this field. The book provides less insight into the collisions of atoms with electrons, positrons, and photons because of the limited space allocated to these subjects, and those who would consider them are advised to look elsewhere.

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Sedimentary Particles

Coated Grains. TADEUSZ M. PERYT, Ed. Springer-Verlag, New York, 1983. xiv, 655 pp., illus. $58.

Coated grains are sedimentary particles with concentric (usually) layers. Some are less than 0.5 millimeter in diameter, and others are many centimeters in diameter. Most consist of calcium carbonate, but iron-rich or even volcanic-ash coated grains also occur. Some coated grains form chemically in shallow water, others precipitate in vadose zones, and still others are formed by a variety of living organisms.

The laminated nature of most coated grains implies episodic deposition and precipitation, but the diversity of structure and composition of the grains has led to confusing terminology and classifications that ultimately have hindered conclusions concerning their origin. One person's ooid is another's oolith or oolite or pisolith. More seriously, rhodoliths (calcified by red algae) on occasion have been termed oncolites (generally formed by blue-green algae). Travertine coated grains at various times have been considered freshwater ooids, vadose precipitates, or biochemically formed grains, and in fact any of these explanations could apply in the proper circumstances.

In an attempt to bring order to this chaos, Peryt has edited a multiauthored discussion of the types, occurrences, and origins of coated grains. The book is divided into six sections containing a total of 52 chapters. There are more than 60 authors, the majority from Europe, but also from North America, Australia, China, South Africa, Sri Lanka, and Israel. The first section deals with general aspects of coated grains. The next four sections discuss ooids (chemically or biochemically precipitated in the phreatic zone), rhodoids (precipitated by red algae), oncoids (formed by green algae or cyanophytes), and vadoids (chemically precipitated in the vadose zone). The final section deals with occurrences of multiple types of coated grains. Each section begins with one or more unifying reviews discussing general characteristics, classification, ecology, and formation of the type of coated grain under consideration. The rest of the papers in each section deal with specific occurrences in both modern and ancient environments. Most examples come from Europe and North America, but examples from Africa, South America, Australia, and Asia are also discussed.

Despite Peryt's attempt to unify the description and classification of these diverse grains, the book contains a number of problems. One concerns terminology: under the classification proposed by Peryt, where does one place a bryozoa- or foraminifera-coated grain, for example, and why should the term "rhodoid" necessarily replace the commonly used "rhodolith"? In a more constructional sense, many papers read as descriptions and lack adequate conclusions; other papers resemble extended abstracts. The inclusion of such papers detracts from the book, which is unfortunate, for it also contains a number of excellent summary papers, many of which should be used for years as standard references.

One can question the premise that coated grains need a unifying discussion. Because differences in morphology, structure, and origin often outweigh the similarities of these layered grains, many readers probably will only read parts of the book. Readers concerned with rhodoids, or rhodoliths, for example, may

choose to ignore the chapters dealing with vadoids. Still, by incorporating discussions of these various grains into a single volume, Peryt has provided a basis for solving some of the potential terminological and conceptual problems in dealing with coated grains. For that alone he is to be congratulated.

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Primate Morphometrics

The Order of Man. A Biomathematical Anatomy of the Primates. CHARLES E. OXNARD. Yale University Press, New Haven, Conn., 1984. xiv, 366 pp., illus. $30.

The past several decades of research in biological anthropology and primatology have witnessed a proliferation of complex new investigative and analytical techniques. Perhaps the leading advocate and practitioner of this growing "high-tech" science of biological form is Charles Oxnard, whose career has spanned more than 30 years. In *The Order of Man*, Oxnard has summarized the results of his many studies of extant and fossil primate morphology. This most recent book is the third in a series (the first two being *Form and Pattern in Human Evolution*, 1973, and *Diversity and Uniqueness in Human Evolution*, 1975, both from the University of Chicago Press); although it focuses in detail on studies of nonhuman primates, the author's interpretations of recent discoveries and developments in paleoanthropology are also presented.

Oxnard's book is unusual in that it attempts to bring the results of some rather complex research to the general reader as well as to the professional primate biologist—the goal professed on the dust cover is "animals, anatomies and algebras without tears." The book is handsomely illustrated and contains many background discussions that the nonspecialist will undoubtedly find useful. Anatomists and anthropologists familiar with Oxnard's work will discover little new here—indeed, they may recognize entire pages and passages from earlier publications. The book might have more appropriately been entitled "Oxnard on Primates," as it is largely a compendium of results of the multivariate statistical analyses carried out by Oxnard, his collaborators in Birmingham, Paris, and Hong Kong, and several of his former students. Thus in spite of the title this book is not an attempt to provide a broad summary of our knowledge of primate biology and history.

The volume opens with two chapters discussing new developments in paleoanthropology and recent approaches to the study of primate morphology and evolution. The next two chapters, entitled "Mathematical 'dissection' of anatomies" and "Biological 'meaning' of structures," lay out the methodological and theoretical foundations of Oxnard's approach to understanding animal form. The discussions of multivariate morphometrics here are lucid, although it is unclear exactly what links many of the new techniques reviewed (ranging from optical Fourier transforms to bio-orthogonal grids to Moiré fringes to central axis functions), except for their esoteric nature. It remains to be seen whether Oxnard's pleas for the wider use of such techniques foreshadow productive application of techniques utilized in engineering, physics, and medicine to biological investigations or whether they merely reflect an overemphasis on quantification and an emulation of the "hard" sciences.

Oxnard also (chapter 4) clearly outlines how morphometric studies relate to other approaches in the investigation of animal form and function, such as direct experimental studies of muscle function or bone strain and observational "experimental" field studies that examine morphology and functional behavior in two or more groups selected for certain contrasts and comparisons (for example, arboreal versus terrestrial). The general reader should find this discussion most helpful. Although Oxnard notes the functional significance of many of the primary variables chosen for the multivariate analyses, additional consideration of this topic would have been desirable. How one goes about selecting primary dimensions (or angles or ratios), perhaps the most important step in any morphometric study, is not at all straightforward. Had Oxnard dealt with the issue more fully, he would have informed the general reader and increased the likelihood of productive communication with those (too) many primatologists who are distrustful of multivariate statistical approaches and uncomfortable with the thought of "doughnuts," "dumb-bells," "hyper-sausages," and "signet rings" in n-dimensional space.

The bulk of the book (chapters 5 through 9) summarizes results of the studies of Oxnard and his collaborators on primate morphometrics. Three chapters consider structure-function associations in primate forelimbs, primate hind limbs, and the limbs of catarrhine quadrupeds. Here we most clearly see the potential insights obtainable by the multivariate morphometric approach. These statistical analyses constitute "morphological fishing expeditions," as Oxnard calls them, that may elucidate structure-function relationships and lead to testable hypotheses. A particularly nice example is provided in Oxnard's morphometric study of the hip and thigh in prosimians, which indicated the existence of several distinctive structural configurations in leaping forms. This finding predicts biomechanically different leaping behavior in certain animals—a hypothesis that can be tested by additional field and laboratory investigations. What we know so far appears to support the original morphometric distinctions. Other statistical associations reflecting functional similarities link the arboreal and suspensory gibbons, siamangs, orangutans, spider monkeys, and woolly spider monkeys in the forelimb analyses and the terrestrial vervets, patas monkeys, and baboons in the hind-limb studies.

The major weaknesses of *The Order of Man* emerge when Oxnard attempts to derive systematic and phylogenetic information directly from his multivariate morphometric results. This attempt is made in spite of a long and rather confusing discussion of the reasons why the notion of primitive and derived features is either misleading or simply not applicable to the sorts of data that enter into his multivariate studies. Oxnard bases this argument on the claim that behavioral–adaptive reversals (for example, arboreal to terrestrial to arboreal) may have been quite common in primate lineages; he further argues that particular quantitative measures of bone shape (or ratio, angular, or log transforms) do not define features or character states in the sense traditionally required by cladistic methodology.

Leaving aside this argument and such relevant issues as parsimony, testable hypotheses, and Oxnard's notion that primitive and derived characters must be "uninfluenced by function or anything else," where do his phylogenetic analyses actually lead? Two examples will suffice.

Oxnard's studies of the enigmatic prosimian aye-aye (*Daubentonia*) indicate substantial distance between this genus and other lemurs in morphometric space. On this basis, he argues that "we are bound to infer a much older and more divergent phylogenetic placement [for *Daubentonia*] than generally believed in recent years" (he cites the possibility of a separate lineage since the Paleocene).