portant area contributions, they may turn out to be the basis for much future research and analysis.

As a final caveat it must, at the same time, be pointed out that the colloquium and its synthesizer, Gordon Willey, did not give enough emphasis to a thread that connects reconstructions of complex societies. The distinguishing feature of such reconstructions is not methodology; regional approaches, sampling techniques, and broadly based research designs are required for the study of both complex and noncomplex societies. Nor is it the use of anthropological theory, which is also not necessarily limited to the study of advanced societies. It is the fact that in reconstructing truly complex societies the archeologist usually must deal with internal documentary histories or, as in the case of the Inca, an external equivalent. It is the appearance of extensive documentation that clearly sets off complex from noncomplex society. This crucial factor is only dimly perceived in most of the papers in this volume because of the manner in which the colloquium was organized.

The exceptions are the papers by Morris and Adams. Morris calls for a continuous interdigitation of archeological and ethnohistorical sources during the actual fieldwork phase of a project rather than a post-hoc attempt to fuse two separate syntheses. Such an approach can readily be endorsed and will lead to a much fuller cultural reconstruction, but it is Adams who comes closest to the more crucial point. In his discussion of Mesopotamia he warns that much of that region's written history was produced by an urban elite whose values and commitments would eliminate and distort certain ranges of data. It is only the appearance of documents that enables a researcher to approach values and belief systems directly. Both an emic and an etic analysis are thus possible. Written sources may, of course, be used to gain insights into human behavior and so greatly enhance the etic level, which is also directly approachable in archeology. At the same time an emic interpretation based on the beliefs and concepts associated with such behavior, irrespective of what causal relationship is espoused, is also available and interpretable for the first time.

Deetz's brief (4 pp.) and reprinted article is thus the most significant paper in the monograph. It is interesting that Willey in his concluding remarks did not know what to do with this offering. How to classify it? Was it even science? Willey was not convinced. "A cognitive historical model for American material culture" is not, as Willey puts it (p. 152), the work of "a poet who is willing to submit his vision to the computer"; it is a scientific study of the ideological subsystem of American society and its three major transformations between 1620 and 1835. It is just as empirically based as Morris's investigation of the Inca economic subsystem or Adams's proposal for a total patterning of Mesopotamian culture. It is true that Deetz's theoretical perspective is different from that of most of the symposium participants; he is not a materialist. However, it is research such as his, which clearly could be materialistic in orientation, that will give a total cultural view of past societies. It is when archeologists combine recent advances in methodology and theory with the recognition of the true potential of documents that the research design for the study of complex societies will be complete. This completion will in turn be an important force in the reunification of all the subfields of general archeology.

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Archeological Methodology

Mathematics and Computers in Archaeology. J. E. DORAN and F. R. HODSON. Harvard University Press, Cambridge, Mass., 1975. xii, 382 pp., illus. $18.

The substantial increase in the importance and prominence of quantitative procedures in archeological research over the past two decades, in the form of statistical methodology and model building, makes the appearance of *Mathematics and Computers in Archaeology* timely. The plethora of analytical procedures that have been introduced to archeology in recent research papers has created a need for a text that discusses their utility to the archeologist critically and at a level understandable to the reader with little training in statistics and mathematics. This book should help fill that need even though the authors do not attempt to cover all the procedures that have been suggested, but limit themselves to those appropriate at the level of the attribute and the item.

Quantification, it should be noted, is not new to archeology. Rather, in the last few years there has been an explicit linking of quantification with scientific archeology stemming from the emphasis of the "new archeologists" on a Hempelian-based covering law model of explanation. This book provides a counterargument to that position: it explicitly rejects the primacy of the covering law model in archeological reasoning and in its place develops an approach to the use of quantification that gives primacy to description in the form of data analysis and to common sense.

The book begins with two chapters giving an overview of what constitutes mathematical and statistical reasoning. Though a single chapter each cannot do justice to these two topics, the chapters are sufficient for making the point, repeatedly stressed by the authors, that proper mathematical modeling and statistical inference demand a degree of understanding and conceptual precision not yet existing in archeology. Models that are mathematically tractable are too simplified to be of use (or at least their utility has not yet been demonstrated), and more complex models require simulation procedures that depend on a level of detail and accuracy not yet available in archeological data (p. 315). The usefulness of statistical significance testing is also questioned, since the archeologist generally does not, or cannot, define populations to which meaningful statistical inference can be made, or is so constrained by data acquisition procedures that the notion of random sampling is meaningless except with reference to uninteresting populations.

In the place of statistical analysis, Doran and Hodson argue for *data* analysis—analytical procedures whose aim is to discover patterning in data—leaving the inferential part of the analysis to the archeologists (p. 57). Their argument is not so much a rejection of the utility of statistical inference as a pragmatic realization that the link between the populations of interest—the target populations, that is, the society that produced the artifacts—and the data available to the archeologist is not statistical. The linkage is via a series of not yet well-formulated relationships that are specific to each situation (pp. 94–95), and statistical significance testing is thus an exercise without any substantive meaning. The exception is those situations in which a random sample is drawn from a population such as a collection of all shards recovered from a site or all survey units in a region.

Neither the inferential process itself nor the criteria for its validity are discussed, other than to put emphasis on common sense (pp. 101, 341). The new archeologists may not be happy with this position—what is common sense to one person may be anathema to another. Doran and Hodson nonetheless are properly providing a counterweight to the appeal to a covering law model of explanation that does not come to grips with the procedure for constructing an explanation, as opposed to determining whether a given argument can be accepted as explanatory. The hypothetico-deductive approach, they write, "fails to recognize that all reasoning, be it scientific,

inductive, deductive or whatever is much more complex even than philosophers of science generally allow" (p. 343).

In effect, theirs is an argument for a return to fundamentals. If archeology is to be scientific, the archeologist must first be able to describe accurately and classify objectively the material remains that are his or her primary data (p. 5). The need for accurate description justifies the emphasis on quantification and the need for objective classification the use of mathematical techniques.

The themes of description and classification provide the framework for Doran and Hodson's discussion of data analysis techniques. They cover a series of univariate and multivariate procedures that have been tried on archeological data, ranging from the traditional scattergram plots and histograms to numerical taxonomy in the form of *k*-means cluster analysis, principal component analysis, discriminant analysis, and a relatively new technique, constellation analysis. The presentation is at a general level, emphasizing the goals and assumptions of the various procedures. Doran and Hodson also provide examples of application of the several techniques to the same data sets to give the reader a sense of the kind of results that can be expected. The amount of technical detail, though insufficient for a manual of procedures, is appropriate for giving the statistically naive reader a sense of the utility and limitations of the procedures. Examples from the literature are also given illustrating the misuse of statistical techniques.

Unfortunately, in their exuberance to show the inappropriateness of much of the statistical work in archeology, Doran and Hodson sometimes end up guilty of the same oversimplification for which they chide their colleagues. For example, they properly argue against first converting metric variables to nominal ones and then proceeding to search for types at the level of nominal variables with chi-square tests of significance. But the fact that the chi-square test was introduced to determine the existence of types in data as defined by the nonrandom association of nominal variables (strictly speaking) is lost, and the authors' alternative procedure for discovering types, the *k*-means clustering algorithm, does not address that issue.

And chide their colleagues they do: For example, they refer to Sackett's "misguided results" (p. 171); express "doubts about [Hill's] understanding of exactly what a significance test is" (p. 341); state that Binford's "method intended to simplify data has resulted in greater and unnecessary complication" (p. 205) and that it is "unfortunate that Spaulding's formulation [of a type] has had such an influence in New World Archaeology" (p. 168); and write, with reference to Clarke, "Alas, it is so much easier to make theoretical play with exciting, if imprecise, general concepts than to get down to actual mathematics or to solid and detailed practical application!" (p. 339). While such comments may be ego-bruising, they are primarily arguments "for archaeological procedures and reasoning to be made more systematic, more exhaustive and more objective" (p. 346), certainly one of the avowed goals of the new archeology.

Mathematical techniques are seen by Doran and Hodson not as a solution to all of the methodological and interpretative problems of the archeologists but as adding "new diversity and colour to what is already one of the most varied, attractive and significant areas of human investigation" (p. 347).

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Photoreactions

Concepts of Inorganic Photochemistry. ARTHUR W. ADAMSON and PAUL D. FLEISCHAUER, Eds. Wiley-Interscience, New York, 1975. xvi, 440 pp., illus. $22.50.

Although the photosensitivity of transition metal coordination compounds has been known for over a hundred years, systematic investigation of the photoreactions did not begin until the 1950's. The investigations can be conveniently differentiated into two types: synthetic and mechanistic. The synthetic studies, devoted to producing new compounds, have been dominated by work on metal carbonyl and organometallic compounds. The high photosensitivity and the diversity of the photoproducts of these compounds have combined to make synthetic photochemistry an extremely active field. The growth of mechanistic studies, on the other hand, paralleled the advances in characterization of excited states, particularly by ligand field theory and molecular orbital theory. Mechanistic studies are generally concerned with the primary photochemical step, the photophysical processes competing with the photochemical change, and the relationships between molecular excited states and photoreactivity. To facilitate such studies, the inorganic systems generally chosen are thermally stable transition metal complexes with classical ligands for which detailed spectroscopic analyses can be made.

Concepts of Inorganic Photochemistry is primarily concerned with the mechanistic aspects of transition metal photochemistry. The feature that distinguishes this book from the continually appearing review articles and the existing monograph on the subject (Balzani and Carassiti, *Photochemistry of Coordination Compounds*) is the intention, stated in the preface, of critically organizing "the idea as well as the data content" of the field. In keeping with this goal, the first two chapters provide a pedagogically useful survey of the important photophysical and spectroscopic background of inorganic systems. The background helps to unify the book and in addition clearly reveals the differences and similarities between inorganic and organic systems. The remaining chapters cover solution photochemistry of metals classified according to the type of metal (first-row transition metals, heavy metals), the type of ligand (carbonyl, diketonate), and a type of excited state (charge transfer), and in addition treat aspects of solid state photochemistry and solution photochemistry of nonmetallic inorganic ions. Topics omitted from the book include the photographic process, photoelectric and photogalvanic effects, and experimental technique. Omission of the last is consistent with the level of the book. Knowledge of the fundamentals of photochemistry and of specific techniques such as flash photolysis is assumed.

The primary theme running through the majority of the chapters is that interaction of metal coordination compounds with light causes replacement of coordinated ligands by molecules in the surrounding medium. The chapter on first-row transition elements summarizes the ligand photosubstitution arising from internal *d-d* transitions in cobalt (III) and chromium (III) complexes. The mechanistic aspects of charge-transfer excited state chemistry are less well studied and understood. A thermodynamic model is discussed that, although it is nonstandard and still untested, may provide focus to future studies. The spectroscopy of the heavy metals and the carbonyl complexes is currently being extensively investigated. The chapter on the former is primarily a summary of data collected up to 1974, while that on the latter is an evaluation of the knowledge gained from the numerous synthetic and the few mechanistic studies. The details of the behavior in solution of photogenerated nonmetallic fragments are summarized in a chapter that deserves the attention of everyone studying solution photochemistry. The final half of the last chapter (entitled "Photochromism and chemiluminescence") discusses the intriguing speculation that a molecule in an excited state may be regarded as an "unstable isomer" of the ground state.

Use of this book as a textbook or a