curs by a free radical mechanism. This metabolic conversion and the resultant cellular modification, both structural and functional, are one of the central themes of the book by Trevor Slater, himself a product of University College and its environment.

In order to make the discussion of free radical mechanisms in injury understandable, the introductory quarter of the book gives an account of free radicals, their generation and detection. For the chemist, this nonmathematical description may be somewhat disappointing, but its purpose, to introduce free radicals as a potential mechanism for normal cellular processes as well as an agent producing a modified, in fact diseased, cell, is fulfilled. In large part, the text concerns structural and functional perturbations of liver cells following exposure to carbon tetrachloride. The description is extensive, and the emphasis is primarily on the metabolism of carbon tetrachloride, the possible role of the chlorine or chloromethyl groups, and their relationship to the functional distortions. Particular stress is placed on the "self-destructive" role of the microsomal electron transport chain and the role of cytochrome P_{450}. The remainder of the text suggests other possible mediators of cell injury, which could also operate by free radical mechanisms. These include alcohol, light sensitization, and iron deposition states.

The overall intention of providing a timely description of the potential of radical mechanisms in cell injury, as a provocative device for stimulating other investigators to approach this particular subject, is certainly well carried out. Slater has made an extensive survey of the literature. He has selected his data, has support for his case, and has produced a very readable and interesting approach to the biochemistry of disease. If one is to find fault, possibly the absence of discussion of other potential mechanisms of injury that may be involved should be cited, or the fact that the free radical mechanism and lipid peroxidation may be only one of a variety of aberrations produced. Perhaps it should also be mentioned that not all of the changes in the carbon tetrachloride model can be explained by the free radical lipid peroxidation scheme. Nonetheless, this is a novel dissertation, especially so since our changing curricula in medicine and in biology frequently preclude more extensive discussion or understanding of mechanisms from a purely chemical point of view. That pathologists will be exposed to free radicals as a chemical entity with a very significant relationship to cell viability is to be applauded. That this may bring together various approaches to the very real problems of cell injury is more than sufficient justification for the addition of this text to our vast fund of printed information. The particularly pleasant historical account of the progress in biochemical analysis of disease makes the book certainly worth reading.

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Patterning Data

Mathematics in the Archaeological and Historical Sciences. Proceedings of a conference, Mamaia, Romania, 1970. F. R. HODSON, D. G. KENDALL, and P. TĂUTU, Eds. Edinburgh University Press, Edinburgh, 1971 (U.S. distributor, Aldine-Atherton, Chicago). x, 566 pp. + chart. $36.

These proceedings of the Anglo-Romanian conference held in 1970 contain over 50 articles which cover a wide range of topics. There are several strong themes running throughout the volume, however, and the reader will find that on dipping into one article he will be led to others which discuss similar methods applied to different data or different methods applied to similar data. This, of course, gives the whole a welcome unity—a unity that is not normally found in proceedings.

The volume begins with an introductory article by A. C. Spaulding. He points out that archeology, like history, has a commonsense basis of understanding of human dispositions and that very often no explicit theory is needed to explain certain facts.

How far this commonsense approach by itself can take us in the explanation of past events is, of course, unknown, and only time and a great deal of experimentation with it and other approaches will tell. There is much patterning of numerical data that does not need any great analysis, but some does, and in these proceedings we have many mathematical treatments in two large areas, typology and seriation, which deal respectively with clustering and with connected sequences. After discussing artifacts and attributes (as does Moberg in his closing address) Spaulding outlines the basic idea of typology by considering six artifacts $A_1, A_2, \ldots, A_6$ which possess five attributes $V_1, V_2, \ldots, V_5$ among them. In matrix representation it is given by

	V_1	V_2	V_3	V_4	V_5
A_1	0	0	1	1	0
A_2	1	1	0	0	1
A_3	1	1	0	0	1
A_4	0	0	1	1	0
A_5	1	1	0	0	1
A_6	0	0	1	1	0

and from this incidence matrix we can construct a 6×6 symmetric similarity matrix $A = (a_{ij})$ where the similarity coefficient between A_i and A_j is $a_{ij} =$ the number of entries (0 or 1) which A_i and A_j have in common—and so has a maximum of 5 and a minimum of 0. It is obvious that on rearranging the rows and corresponding columns of A we get

	A_1	A_4	A_6	A_2	A_3	A_5
A_1	5	5	5	0	0	0
A_4	5	5	5	0	0	0
A_6	5	5	5	0	0	0
A_2	0	0	0	5	5	5
A_3	0	0	0	5	5	5
A_5	0	0	0	5	5	5

from which we see that we have two clusters of artifacts. Now this is a deliberately simple example, and no mathematical treatment is called for—it could be "seen" in the original matrix. But what if the quantity of data is large both in the number of artifacts and number of attributes? And what if the distribution of 0's and 1's in the original matrix has no "easy to see" pattern? Although, as Spaulding himself points out, artifacts do not exhibit innumerable combinations of attributes—the use of the artifact conditions much of this—we will have areas of contention and more formal techniques are needed. For then the underlying assumptions involved in the clustering will, one hopes, be made explicit. And if they are made explicit the method can be tested on known data and our confidence in the approach thereby increased.

It goes without saying that because of the complexity of the data most formal techniques use the computer.

Hodson makes such points, as well as many others, in the introduction to his article "Numerical typology and prehistoric archaeology" and then proceeds to outline the *K-means* method of cluster analysis. He splits the K-means approach into several stages and, since each has its own problem, discusses them stage by stage. In the first stage we choose a certain number of clusters into which the data are to be split. Now we do not usually know at the beginning of the analysis how many clusters to use, so several choices are made and a reasonably formal technique is offered to determine which one is preferable. Let the number of clusters chosen be N and split the data into N clusters. This will be the starting point in a procedure which will lead to the "best" partition of the data into N clusters. Next we need a criterion to tell us how good the clustering is at any stage of the iterative procedure—a function to be minimized. Hodson considers two, one based on Euclidean distance, which has certain disadvantages, and an attractive alternative, the Mahalanobis distance. (This distance criterion is also considered in Rao's paper on "Taxonomy in anthropology" and H. Solomon's on "Numerical taxonomy.")

Clustering characteristics are reported for Fisher's Iris data (data used as a test by other authors), and the whole program is applied to the classification of British hand axes. From this the reader will get a very good idea of its power in dealing with archeological material.

In an earlier paper (*World Archaeology*, 1970) Hodson has used the method on data from graves at the La Tène cemetery at Münsingen-Rain. Two other contributors to the proceedings, Kendall and Doran, also discuss data from this cemetery.

The second mode of patterning considered by Spaulding is seriation, in which one arranges a collection in a patterned series with respect to similarity of components. Spaulding illustrates this by the simple example of Stone/Bronze/Iron Age societies.

Robinson's classic paper of 1951 on seriation has probably made the formal technique needed in handling more complicated data familiar to most archeologists. But the technique has many difficulties associated with it; the well-known Hole and Shaw monograph of 1967 offered much help here. Kivu-Sculy dwells on these problems, as does Sibson in a short and very clear paper entitled "Some thoughts on sequencing methods." In laying bare the foundations of the problem (concerning the dissimilarity coefficient and the measure of discordance) he is able to make a critical analysis of the various methods proposed by Hole and Shaw. He finds a number of their methods wanting at the theoretical level and proposes one of his own (which he tests on the Münsingen grave data). The reader will find the article by Gelfand, "Rapid seriation methods with archaeological applications," very informative.

But for a detailed account of seriation one turns to Kendall's long paper "Seriation from abundance matrices," in which he summarizes much of his earlier work (at some point the reader will want to turn to the theoretical paper of Wilkinson, where seriation is linked with the traveling salesman problem).

It will be recalled that in the Robinson type treatment one forces the data into a linear (that is, one-dimensional) order and afterwards makes some judgment as to whether the resulting order is chronologically significant. Kendall adopts a new procedure based on the multidimensional scaling of Shepard and Kruskal (there is a whole section on multidimensional scaling including one by Kruskal himself). The idea is to plot the given data in *two dimensions* and then see if the resulting plot of points is a *one-dimensional* arc embedded in the plane; if it is we have our seriation. But the beauty of the method, and this Kendall stresses, is that it allows the data to *fail* in the sense that the final output of much computation may be a truly two-dimensional pattern, that is, we have no seriation.

To exhibit how little information one needs to recapture a one-dimensional arc Kendall considers the numbers 1 to 51 plotted as points $0_1, 0_2, \ldots, 0_{51}$ in the plane. Now these points lie in a line, with next neighbors exactly unit distance apart. Throwing most of this information away Kendall adopts the weak similarity σ_{ij} between the points 0_i and 0_j:

$$\begin{aligned} \sigma_{ij} &= 0 \text{ if } |i-j| \geqslant 25; \\ \sigma_{ij} &= 1 \text{ if } 24 \geqslant |i-j| \geqslant 22; \\ \sigma_{ij} &= 2 \text{ if } 21 \geqslant |i-j| \geqslant 19; \\ &\cdots \\ \sigma_{ij} &= 8 \text{ if } 3 \geqslant |i-j| \geqslant 1. \end{aligned}$$

Using multidimensional analysis he shows, after a certain amount of computer work, that the points $0_1, \ldots, 0_{51}$ form a horseshoe in the plane with the correct ordering $1, 2, \ldots.$ along the arc. It is a striking illustration. Then he applies the technique to Hodson's data from La Tène (59 graves containing 70 varieties). Again the results are good and agree well with an ordering previously obtained by Hodson himself.

But there is an impediment in seriation. We generally want the order to be chronological, but the original data contain in them germs of other factors—for example, social factors may influence the contents of a grave. To increase our confidence in the fact that the order obtained is chronological we appeal to other evidence (if it is available); thus in the case cited above the layout of the cemetery is good corroborating evidence. But it is very easy to visualize that there may be cases in which the only way to distinguish the social order of two or more people (referring now to graves and their contents) is in the time scale itself. All contributors are aware of such influences. Thus Kruskal's paper is actually entitled "Multidimensional scaling in archaeology: time is not the only dimension" and Goldmann discusses these problems at some length in his article.

There are two other sections to the volume: Evolutionary Tree Structures in Historical and Other Contexts, and Miscellaneous Applications, the latter subdivided into Archaeology and History. Both contain articles describing formal techniques as applied to archeological, historical, and genetic data. I list some of the titles to give the reader an idea of their scope: "Statistical studies in migration" (Hiorns), "The reconstruction of genealogies from parish books" (Skolnick, Moroni, Cannings, and Cavalli-Sforza), "Mathematical approaches to the study of human evolution" (Edwards), "The measurement of ancient bricks" (Hesse), "On the statistical sorting and reconstruction of the pottery from a Roman-British kiln site" (Orton), "Non-statistical applications of the computer in archaeology" (Wilcock), and "A model of Michael the Brave's decision in 1595" (Malița). There are many other equally interesting articles to read.

The volume ends with an address by C. A. Moberg in which he reviews the conference from an archeological viewpoint, and points to topics not dealt with here which will have to be developed in the near future, among them sampling techniques for archeological situations. Much of the wonderful spirit that must have been present at Mamaia comes through in these proceedings, and the reviewer thoroughly enjoyed reading them. He can but implore others to read them too.

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