genetic and geographic distance. It is difficult to determine whether the lack of fit between genetic and linguistic patterns of divergence was due to the methodological foibles of glottochronology or whether a comparison of tribal divergence spanning thousands of years and miles produces too much static. The relationship between linguistic and genetic divergence may be observable only for small populations, such as Bougainville or the Yanomama (*4*), that are intimately bound to the land and have little migration.

Friedlaender employs a method, developed by Gower, for measuring the fit between two arrays by the squaring of the summed deviations to produce a statistic called R^2. This statistic indicates that anthropometrics and linguistics give the best fit while dermatoglyphics, male and female, are furthest removed from the pattern of variation observed in the other systems. Friedlaender interprets these results to mean that dermatoglyphic patterns differ little among villages, while varying enormously on the individual level. He is probably correct in that polygenic systems (which experience little environmental influence) tend to be more "conservative" evolutionarily and there has been insufficient time for the villages to diverge significantly. However, if this is the case, why do the dermatoglyphic patterns of the males and females differ so markedly even though they represent a subdivision of the same gene pool?

Although some dermatoglyphic traits exhibit high heritabilities in certain populations, divergences based upon these traits are often at odds with the historical, demographic, and blood-genetic evidence. One of the contributing factors to the lack of fit between dermatoglyphic traits and other genetic variation may be the definition of the traits or units. For example, the number of ridges on a given finger is determined by counting ridges intersected by a line drawn from the triradius to the center of the pattern. If a finger lacks a triradius, that is has an arch, the ridge count is designated 0. The total ridge count (TRC), computed for the individual by the summation of all ridges on all fingers, is commonly employed as a single polygenic trait. This traditional method of ridge counting, used in Friedlaender's study, results in highly distorted variances, which may in turn influence the multivariate measures of divergence. In addition, TRC is not a continuous variable that is normally distributed, but a quasi-discrete variable. However, Friedlaender cannot be criticized for the use of this dermatoglyphic trait, since it has been employed by anthropologists and geneticists in many other studies. In the multivariate statistical analyses of the dermatoglyphic traits, Friedlaender correctly tested for the equality of variance-covariance matrices for individual groups. He found that the H_1 tests were highly significant, prompting him to warn that "it is questionable whether discriminant analysis, or any multivariate technique assuming normality of dispersions, is appropriate." He then proceeds to perform the discriminant function analysis of dermatoglyphics, thus ignoring his own warning. This step may be justifiable, however, since many multivariate techniques are sufficiently "robust" to withstand moderate violations of the normality-of-dispersions assumption.

In two recent publications (*5, 6*) factor and principal components analyses of dermatoglyphic traits suggest that fields, analogous to Butler's dental fields, may exist in finger and palmar configurations. Crawford and associates (*5*) demonstrate that in all the populations contained in their sample certain highly intercorrelated "traits" emerge as likely dermatoglyphic units. To date, these "traits" have been found in Amerindian, European, and African populations and appear to be promising substitutes for the traditional methods of dermatoglyphic analyses.

One of the unique features of this volume is the examination of the secular trend among the men of northeast Siwai, made possible by comparisons between the anthropometric data collected by Oliver in 1939 and Friedlaender's surveys in 1967 and 1970. As expected, there is an increase in stature and weight in the samples from 1939 to 1967. Longitudinally, an unexpected decrease in weight was found in men weighed in 1938 and then reweighed three decades later. In industrial populations, by contrast, there is an increase in weight during the latter years of adulthood. It would have been particularly informative to determine, through factor analysis, if the Siwai became bigger all over or whether certain dimensions or traits were disproportionately affected.

Despite the criticisms and the Monday morning quarterbacking this volume is pioneering and provides a solid foundation for others to build on. However, the relationships of various facets of the genome and the environment can better be understood in future studies in populations with better historical reconstruction and greater demographic stability than are found in Bougainville. It is the absence of this historical perspective that limits Friedlaender's analysis. Ward (*7*) recently concluded in an overview of a similar study:

> Only by understanding how the complex of historical factors interact to influence the distribution of genetic and morphological attributes in populations such as this will we ever understand the diversity of our genetic heritage.

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Alchemy in China

Science and Civilisation in China. Vol. 5, Chemistry and Chemical Technology. Part 3, Spagyrical Discovery and Invention: Historical Survey, from Cinnabar Elixirs to Synthetic Insulin. Joseph Needham, with the collaboration of Ho Ping-Yü and Lu Gwei-Djen. Cambridge University Press, New York, 1976. xxxvi, 482 pp., illus. + plates. $42.

Historians of alchemy have long recognized the decisive Chinese influence which turned the attention first of Islamic and later of Christian alchemists from metallic transmutation to a quest for a drug to confer longevity and cure all diseases. Why that quest should first have begun in China became much clearer in part 2 of Joseph Needham's account of Chinese chemistry and chemical technology. A question seldom asked in specialist histories of alchemy and chemistry arose almost naturally in a study of Chinese science as an aspect of Chinese civilization. It was answered in terms of the distinctive conceptions of death and the afterlife in Chinese culture.

In addition to making use of the term *macrobiotics* to refer to the search for a "drug of deathlessness," Needham introduced a new vocabulary to ease the mental discomfort of travel through the fantastic landscape of alchemy: *aurifiction* for artisan gilding or gold-faking and *aurifaction* for alleged transmutation.

The indispensable metallurgical-chemical and physiological background to alchemical practice in China was painstakingly built up.

Part 3 of the volume traces the history of Chinese alchemy from the first emperor through a "golden age" (end of Chin to late T'ang) and a "silver age" (late T'ang to Sung) to its ultimate decline. A short section sketches the coming of modern chemistry to China, from the Jesuit missions of the 16th century up to the scientific movement of the 19th century.

Two themes, familiar from earlier volumes of the work, recur in Needham's discussion of chemistry and chemical technology in China. One is the skepticism and lack of credulity of the Confucians—which may, at first sight, seem closer to the "scientific spirit." The Confucians consistently derided alchemical enterprises, pointing out (in the words of a treatise of the first century B.C.) that in alchemical arts "everything is vague and formless, like trying to tie up the wind or capture a shadow, and no result is ever achieved." But such skepticism remained part of an attitude that dismissed all inquiries into nature beyond a utilitarian minimum as a distraction from the moral concerns the Confucians placed at the center of culture. Scientific curiosity and achievements remained confined to the credulous but active Taoists.

The other theme is the contrast between gentlemen and sooty empirics. Persistent belief in the possibility of metallic transmutation over the centuries despite a simple and well-known cupellation test for gold puzzled historians of alchemy in the last century. In part 2 of this volume Needham explained it as the result of social barriers between gentlemen theoreticians and metallurgical artisans. More detail is now supplied to support that assertion. In the first century B.C. a Chinese emperor turned over the resources of the imperial workshops to the making of alchemical gold. The project failed. Needham suggests that the very fact that the failure was recognized demonstrates that the alchemical myth could not persist in places where artisans would normally subject it to the cupellation test. Hence the later emphasis on situating alchemical experimentation in recluse environments, away from worldly corruption—and also away from the keen and searching tests of the artisan. How sharply the distinction can be maintained and whether it is just (or complimentary) to place the artisan's understanding of his own work in a theoretical vacuum will no doubt stimulate debate.

With two installments now published and three more to follow, the section on "chemistry and chemical technology" in Needham's massive study vastly increases our knowledge of that aspect of Chinese science. Fascinating cross-cultural comparisons are continually suggested. Information winnowed from Chinese and Japanese sources is supplemented by sources in the principal Western languages, and the bibliography in this part alone occupies 170 pages. An "author's note" contains interesting reflections on the way in which the prevalent view of the place of science in culture has changed radically in the 20 years during which the work has been in progress.

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A Statistical Technique

Discrete Multivariate Analysis. Theory and Practice. YVONNE M. M. BISHOP, STEPHEN E. FIENBERG, and PAUL W. HOLLAND. With the collaboration of RICHARD J. LIGHT and FREDERICK MOSTELLER. MIT Press, Cambridge, Mass., 1975. x, 558 pp., illus. $30.

The analysis of variance, regression and correlation analysis, and contingency tables are among the most commonly used statistical techniques. The analysis of variance is a technique to sort out how a number of factors, often presented in tables whose parts are labeled row, column, and block, affect a response variable, which is usually a measurement. The analysis is designed to find which factors are important and how they interact to produce the observed response. The analysis of variance dates back to the work of Ronald A. Fisher between 1925 and 1935 and reached a height of development with the work of George W. Snedecor between 1930 and 1940. In a sense, the analysis of variance is the workhorse of statistics.

Regression and correlation methods are used to measure the relationship between two or more variables. The term "regression" originated with Francis Galton in his studies on natural inheritance. The practical application of regression and correlation techniques became possible in 1915 when Fisher found the distribution of the correlation coefficient. During the next 20 years much of the classical theory was developed. Recently, activity in this area has revived, primarily because of the availability of computers and programs for multivariate regression models.

The format of some contingency tables may be similar to that of analysis of variance tables, in that there are categories referred to as rows, columns, and blocks. The difference is that there are not measurements in each cell, but only counts of occurrences. In other words, the response variable is now a discrete or counting variable instead of the continuous measurement variable of the analysis of variance. In such cases the analysis of a contingency table is similar to the analysis of variance in that the problem is to sort out the factors and interactions that affect the counts, and similar to a regression and correlation analysis in that the relationship or independence of factors is of interest.

Today the analysis of contingency tables is frequently referred to as the analysis of discrete multivariate data. The book under review is the first extensive exposition of this technique. It is designed for the researcher who is trying to uncover a possible underlying structure that gives rise to the observed cell counts. A recent study dealing with admission of students to Stanford University illustrates the type of data for which such an analysis might be used. There were a number of categories: financial variables, including amount of financial aid; geographical region; ethnicity; sex; previous family affiliation with the university; and, finally, a variable indicating acceptance of Stanford by the student. The problem was to detect the structure of the variables that influence students' choice among the universities to which they have been admitted.

The origins of contingency tables stem from Karl Pearson and Fisher, who did considerable initial work in the early 1900's on the 2×2 table (two rows and two columns). It is indeed surprising how many experiments are amenable to analysis in this format. Tests of independence of two sets of characteristics are explained in many basic textbooks. Even tests for such concepts as complete or partial independence in multidimensional contingency tables, introduced by Yule early in this century, have become standard. In the three-dimensional case, an attempt to define interactions was made as early as 1935 by M. S. Bartlett. The idea behind interactions is as follows. Suppose a number of different items are subjected to different treatments—for instance, different varieties of plants to different fertilizers. When interactions are present, treatment A may be better than treatment B for one