stellation, faceting, and compounding. Each photograph is accompanied by a set of instructions and diagrams for constructing the model and suggestions for decorating it with colors. The coloring schemes are mostly consistent with the rules of color symmetry, although the color symmetries are often much lower than the purely geometrical symmetries of the figures.

Commentaries on the histories and interesting mathematical properties of the solid figures occur here and there in the text, and add greatly to its educational value. There are also occasional inspirational remarks to encourage model builders. These last are especially appropriate in connection with the extremely complicated figures toward the end of the book; for instance, the "small inverted retrosnub icosicosidodecahedron," a beautifully spiny, partially concave, and very intricate symmetrical figure, of which the author says, "You will need unusual patience and perseverance to complete a model."

The general effect of this book is to create a desire in the reader to become involved with these gracefully symmetrical figures; it is very pleasant reading indeed.

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## For Morphologists

**Microreconstruction.** W. A. GAUNT. Pitman Medical, London, 1971. xii, 108 pp., illus. £2.25.

A few months ago (3 Dec. 1971, p. 993) I explained in *Science* how three-dimensional structure often can be identified from single sections if only a few simple rules on dimensional reduction are kept in mind. For many people this commonsense approach would appear too primitive. They need to be convinced by the more sophisticated approach of stereology. Like all stereology (of which it is only a very small part), stereological shape determination is a matter of geometrical probability. Simple shapes can be identified stereologically by measuring the length and width of each profile of a feature in section, classifying the quotients length/width of many profiles, and applying mathematical rules elaborated by the reviewer, to a large extent in association with August Hennig.

These two methods are applicable only when the particles are numerous enough so that axial ratios of sections through them can be classified in a statistically significant manner, when the particles are randomly distributed in space or their distribution can be randomized by proper sampling procedures, and when the particles are of a fairly simple shape. When we are dealing with a single object of complicated shape, the shape can be determined only by reconstruction from serial sections. That is, the solid in which the object is contained must be disassembled into a succession of thin slices images of which, traced on plates of appropriate thickness, can be stacked. The result is a magnified replica of the object. Gaunt's posthumous little book *Microreconstruction* gives an excellent account of the history of such reconstruction and thorough instructions on how to do it.

The technique of serial reconstruction was invented in 1883 by Born and subsequently perfected by him and many others. Born devised a method by which plates of wax are produced whose thickness is controlled so that the magnification in height equals the magnification in width. The contour of the feature is traced from successive sections on the wax plates and cut out. The plates are stacked and welded together, and the layered edge can be smoothed out with a hot spatula. Accurate reconstructions can be produced only if the "sections" cut with the microtome are perfectly smooth and uniform.

Gaunt gives instructions on how to produce optimal serial sections. He also describes various techniques of graphical reconstruction, including perspective reconstruction and photographic reconstruction.

As a descriptive embryologist Gaunt confines himself almost exclusively to the use of reconstruction in that field and does not report on the advances or numerous new uses of reconstruction from serial sections in such fields as adult anatomy, pathology, and metallurgy. Even in his own field he overlooks a great step forward that was achieved by Hegre and Brashear in 1947 and was soon extended to use in botany by Postlethwait. This is the technique of block-surface cinematography, where a motion picture camera is mounted over the paraffin-embedded specimen and a frame is exposed after the removal, by the microtome knife, of the previous section. Thus there is no distortion or displacement of the successive images, and from them one can produce plastic or graphical reconstructions of greater perfection than was possible before this technique was introduced.

In other fields, serial sectioning serves less for the faithful representation of an individual structure than for the elucidation of such matters as the spatial interrelations of various components of a tissue or a material. Immediate tracing on glass plates for future stacking has been extensively used to follow the progress of a disease process. This technique and its advantages are not discussed sufficiently in the book.

The use of serial sections to investigate problems of continuity or discreteness in metallurgy is not mentioned. One important method in metallurgy is serial section photography, in essence similar to the Hegre method. As successive layers are removed with a diamond knife or by grinding, the block surface is photographed after polishing and etching. The elucidation of topological parameters is especially facilitated by serial section photography, particularly on motion picture film, which not only permits the production of well-superimposed models but makes it possible visually to "travel" through a specimen, directly observing continuities and discontinuities.

Also not mentioned in Gaunt's book is the extensive use of reconstructed models for volumetry. This method, of course, has now been superseded by the point counting and intercept methods of mathematical stereology.

An important innovation in the field was presented only recently by M. Yamada and S. Yoshida. This is stereoscopic reconstruction. The images of successive serial sections are traced directly with a ball-point pen on transparent paper. With the use of carbon paper two identical sets of contour maps are produced. The sets are then separated, and in one of them the successive tracings are displaced laterally by a specified distance. Thus two contour maps, one as seen by the right eye, the other as seen by the left, are obtained, and each is laid on a light box and photographed. The result is a pair

of pictures which, when viewed in a stereoscope, gives a great deal of three-dimensional information.

It is quite obvious that reconstruction from serial sections is a very active field of endeavor. Had Gaunt not died before his manuscript was completed he would probably have included all the new methods and fields of application that have been mentioned in this review. In spite of its omissions, the book is of great value for scientists in various disciplines. In my opinion, it should be on every morphologist's bookshelf. And by "morphologist" I mean anyone concerned with the three-dimensional structure of sectionable objects.

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# Mammals Presumed Most Useful

**The Origin of the Domestic Animals of Africa.** H. EPSTEIN. Revised in collaboration with I. L. Mason. Africana, New York, 1972. Vol. 1, xii, 574 pp., illus. Vol. 2, xii, 720 pp., illus. $85.

This work is a curiously old-fashioned one to be published in the latter third of the 20th century; it is old-fashioned in language ("wither," "brisket," "gaskin," "hock," "thurl," "hook-bone," "pin-bone," and "stop" for anatomical terms), old-fashioned in its discursiveness (1158 pages of text and figures unmarred by graphs or statistics), welcomely old-fashioned in its wealth of illustrations (1297 figures), old-fashioned in its thoroughness (44 pages of bibliography and 85 pages of indexes), old-fashioned in the assumption that the reader is educated and thus will be thoroughly familiar with multiple names of places, tribes, archeologic sites, and historical personages, and old-fashioned in a reliance on flowing anatomical description to a degree of detail that most readers will find skippable. The very title is old-fashioned; "animals" here means mammals, and then only those presumed to be most useful to man. The dog is included, but cats are mentioned only in passing and do not receive the discussion which they deserve as one of the two native domestic mammals of Africa.

Is there merit in such a compendium? Indeed there is, because for each of the domestic mammals included (dog, cattle, water buffalo, sheep, goat, pig, ass, horse, and camel) Epstein reviews the Quaternary history of the wild ancestors and the early history of domestication. For all the species except the Nubian ass, the wild ancestors were Eurasiatic, not African, so that, as a necessary part of the discussion of their origins, a full history emerges of early domestication in the Old World. This side of the treatment is much more complete than that of Zeuner (*A History of Domesticated Animals*, 1963), so complete in fact that in Epstein's present volumes we have for the first time in English a source to which a student can be sent to acquire the historical background for his studies in mammalian domestication. To have immediately available, for instance, an outline of Studer's classification of breeds of prehistoric dogs is a great help, for European writers use this terminology consistently, without sufficient explanation of its meaning. Whereas many Europeans have regarded Studer's breeds as subspecies, complete with trinomial names, Epstein realizes that these are but types, and not breeds or subspecies, but he keeps the names for their descriptive and historical usefulness. Indeed, with regard to sheep and pig, he believes that the well-known turbary type, first described from Swiss "lake-dwellings," is a natural product of malnutrition and poor care and so may appear in any human culture, thus negating former ideas of movements of domestic animals over long distances to appear subsequently in the archeologic record.

Cattle, as befits their importance in African economy and culture, receive the greatest attention, two-thirds of volume 1. Since this one section is as long as many books, and illustrates well Epstein's treatment of each of the species, I will let the cattle serve as an example for the other sections, all shorter. The chapter begins with basic taxonomy, and then Epstein outlines the history of a series of subspecific names, as based on morphology of the skulls, offered by several authors in the 19th century. All these names are shown to represent morphological types, not subspecies, since the skull grows to conform to the stresses put upon it by the increasing size and weight of the growing horns. Size of horns depends in turn upon sex, genotype, and availability of food.

Genetic change, by artificial selection for short-horned cattle, seemingly began before 3000 B.C. No mention is made of any genetic studies on shapes of horns in cattle; a knowledge of such genetics would seem important for further understanding of the early history of cattle.

The zebu is then discussed historically and morphologically; considering the great success of the descendants of zebus in Africa, one would expect some introductory discussion of physiological adaptations to heat, but we find a short summary on this topic toward the end of the section on cattle. (In most sections, physiology receives little or no attention.) The anatomy of the humps of zebus and part-zebu cattle is described and figured in considerable detail; mixed cattle have the hump placed more anteriorly and it tends also to be fattier and less muscular than in pure-bred zebus. Epstein considers the hump of a zebu to be as much a result of artificial selection as is the fat of a fat-tailed sheep.

Epstein then treats in detail all of the known African breeds of cattle, present and past (the past being mostly Egyptian, as recorded pictorially), under four phenotypes: humpless longhorns, humpless shorthorns, zebu, and sanga; these last are crosses between zebus and non-humped cattle. The situation is complicated by the fact that two major introductions of zebu stock have occurred in the history of Africa, once by or before 2000 B.C., and again after A.D. 670, following the invasion of Africa by Arabs. Possibly in both instances, but certainly in the later one, the cattle were introduced via southern Arabia into East Africa; these later immigrants, marked when relatively pure-bred zebu by the thoracic position of the hump (as contrasted with a cervicothoracic position on sanga), have spread widely across the central part of Africa south of the Sahara. Humpless cattle are now mostly limited to West Africa, Egypt, and the areas north of the Sahara. Most of Africa's famous large-horned cattle are of sanga stock.

In places in the section on cattle, as