Book Reviews

Ancient Metals Trade

Copper and Tin. The Distribution of Mineral Resources and the Nature of the Metals Trade in the Bronze Age. JAMES DAVID MUHLY. Connecticut Academy of Arts and Sciences, New Haven, 1973 (distributor, Archon Books Shoe String Press, Hamden, Conn.). ii pp. + pp. 155–536. Paper, $15. Transactions of the Connecticut Academy of Arts and Sciences, vol. 43.

James D. Muhly is a member of a team of scientists and archeologists who are exploring the evidence for the earliest metallurgy in the Near and Middle East. The present book "represents an attempt to combine geological, archaeological, and textual evidence in order to place the study of the Bronze Age metals trade upon a more secure basis" (p. 170). This is an ambitious proposition and one that takes the reader through an inspection tour of such a variety of sources, data, and theories that he may wonder if "a more secure basis" is indeed within reach.

The problems belong to the realm of geology and mineralogy (sources and nature of ores), technology (the earliest use of copper, the methods of use, the introduction of arsenic and tin alloys), economic history (the development of trade in metals, the impact of metal supplies and trade on the rise and decline of early communities), and literature (the analysis of written history, pseudohistory, and mythology concerning early metal trade and metallurgy). Nobody but a very learned man could undertake to discuss all these aspects of early metallurgy in one volume. Muhly is learned; his apparatus of footnotes and bibliography is formidable, and a great many by-products of his research are presented as fringe benefits in text and notes. The exposition is not particularly systematic; chapter headings and captions do not rigidly correspond to factual contents.

What keeps the study manageable to the reader is the geographical order of discussion in the basic chapters dealing with copper and tin resources, respectively. The examination starts in the West (Cornwall, Iberia) and moves gradually east as far as India, including Egypt in the consideration of the Near East. For each region there is a summary of ancient literary sources and a discussion of mineral deposits, of archeological evidence, and of modern interpretations, with comments by the author, some constructive, quite a few cheerfully polemic.

One of the problems of copper resources and copper trade (chapter 2) is the date of the earliest availability of West Mediterranean resources. Muhly objects to theories that Iberian copper would have been known to East Mediterranean traders in the Bronze Age; his reason is the absence of archeological evidence for such trade. Similar reservations are expressed concerning Sardinia and Corsica. This negative evidence is however not absolute, and in the case of Sardinia Muhly has to admit that copper ox-hide ingots found on the island are evidence of some kind of trade with the East Mediterranean, indirect though it may be, by the middle of the second millennium B.C. The major known copper providers of the Bronze Age are Cyprus, Anatolia, and Iran. For each of these regions archeological evidence is amply available, and through the study of ancient metals trade the history of individual areas can often be better understood, as for example in the case of Cyprus. The exploitation of the copper deposits on Cyprus (which gave its name to the metal in a late and incidental way) started in the course of the third millennium B.C. The contacts of the island with Anatolia and with the Aegean world were stimulated by its copper trade. The great prosperity of Cyprus (Alashiya) in the Late Bronze Age was based on its active role as a shipper of copper ingots.

Muhly's longest chapter is devoted to the tin trade in the Aegean and Mesopotamia. Here again the question of Western and Eastern sources arises. There is much modern discussion concerning the date of the earliest exploitation and trade of the tin from Cornwall and Brittany. Muhly considers it possible that the Mycenaeans of the Shaft Grave era (around 1600 B.C.) received this tin via European middlemen at a time when they also began to enjoy the benefits of the European amber trade. The European provenance of their tin is, however, more difficult to prove than that of their amber, especially in view of the solid documentation of the Near Eastern side of Aegean trade. Crete-Kaptara drew on the tin trade of Syria and Mesopotamia as early as the 18th century B.C. (p. 293), as we now know from records recently published by Dossin. The city of Mari on the upper Euphrates transshipped large quantities of tin, and among the recipients a man from Kaptara is listed, as is a Carian (West Anatolian); both of these merchants apparently received the tin in Ugarit on the North Syrian coast. Muhly gives a detailed and up-to-date account of the Old Assyrian and Old Babylonian textual evidence for tin trade in the early second millennium B.C., all of it pointing to an elaborate trade mechanism drawing on sources in northwest Iran and probably also in India and Afghanistan.

In the historical and well-documented period of the second millennium B.C. there is no doubt about the Eastern origin of Mesopotamian and Anatolian tin imports; for the third millennium B.C. we are short of economic texts and have to hypothesize similar trade channels and a similar provenance of the tin used to make the bronze objects excavated in central and western Anatolia (Troy), Cyprus, Crete, and the Cyclades. Muhly's survey and analysis are useful and solid for the Eastern provenance of the tin essential to the great historical Near Eastern economies. The texts are not explicit about the specific origin of the tin, because the trade records are concerned with transactions at hand, not with the long chain of transmission. Even the geographical terms quoted in the texts are not always identifiable through internal or archeological analysis. Archeology has added considerable evidence through the excavation of specimens of tin bronzes and metal working establishments in stratigraphic and datable contexts in the Near East, and is moving in the direction of the ancient caravan and shipping routes. The final answers will have to be found through explorations now in progress in Iran, along the shores and on the islands of the Persian Gulf, and elsewhere in the field. The ore deposits have to be identified and evidence for ancient exploitation must be examined. In other programs, the analysis of trace elements in excavated metal objects is

systematically pursued and coordinated with the results of the field searches.

Muhly ends his book with the comment that it is only the beginning of his research. Much work indeed is being accomplished each year by him and his scientist-colleagues. It will be useful for the reader of the book to consult some of the recent progress reports and summaries—for example, J. D. Muhly, "Tin trade routes of the Bronze Age," *Am. Sci.* **61**, No. 4, 404 (1973), and T. A. Wertime, "The beginnings of metallurgy: A new look," *Science* **182**, 875 (1973)—as an introduction to and summary of the modern state of the problems. These articles also offer maps which the book does not provide. They could inspire the reader to give up consecutive reading of *Copper and Tin* in favor of selective consultation, to which the book is and will remain especially suitable and through which its valuable contributions will be best discovered.

MACHTELD J. MELLINK
Department of Archaeology,
Bryn Mawr College,
Bryn Mawr, Pennsylvania

Muscle Pigment

Myoglobin. Biochemical, Physiological, and Clinical Aspects. LAWRENCE J. KAGEN. Columbia University Press, New York, 1973. xiv, 151 pp., illus. $10. Columbia Series in Molecular Biology.

Research on myoglobin has been overshadowed by that on its larger cousin, hemoglobin, but this muscle pigment is coming into its own. The transport of O_2 from intracorpuscular hemoglobin in the capillaries to the cellular sites of its reduction is under intense investigation today, stimulated in part by apparent changes in tissue O_2 partial pressure (pO_2) and O_2 delivery produced by changes in the affinity of hemoglobin for O_2. These results have come both from studies on laboratory animals and from a spectrum of clinical findings. Myoglobin is widely distributed in muscle, which represents some 40 percent of vertebrate body mass, and is assumedly involved with O_2 transport. Therefore its respiratory function should be of great significance in total body metabolism, and yet certain critical knowledge about it is lacking today.

This book, one of the Columbia Series in Molecular Biology edited by Ernest Borek, provides an up-to-date synopsis of our knowledge about myoglobin for the reader with basic knowledge in the field. It is weighted in favor of the interest of the author in an immunological approach to the study of myoglobin. Physical chemistry is presented rather briefly; for example there is no mention of the kinetics of the reaction of oxygen and myoglobin, while the amino acid sequences of myoglobin of various species are dealt with extensively. The book contains a brief history of our knowledge of myoglobin, a discussion of its biochemical aspects, including excellent tabular summaries of the amino acid sequences, and of its physiology, including its distribution in the tissues of a variety of animals, its localization in cells, factors altering its concentration in the tissues, and its synthesis and degradation. These are followed by a discussion of immunological studies and a large chapter on clinical aspects such as genetic variants and conditions characterized by myoglobinemia and myoglobinuria. Important matters of present uncertainty such as the existence of fetal myoglobin and the precise localization of myoglobin in the muscle cell are pointed out and the evidence summarized. I would have preferred that more attention be given to the greater question, that of the function of myoglobin.

The book is clearly written, eminently readable, and conveniently small. It represents a practical compromise between an introductory text and a review *in extenso*. The paper is unglazed, to the reviewer's pleasure. In spite of the small size of the book, the bibliography contains more than 500 references.

The book is recommended for the clinician or basic scientist with an interest in the physiology and pathophysiology of muscle. Even the expert will profit.

R. E. FORSTER
Department of Physiology,
University of Pennsylvania School of Medicine, Philadelphia

Symbionts

The Lichens. VERNON AHMADJIAN and MASON E. HALE, Eds. Academic Press, New York, 1973. xiv, 698 pp., illus. $35.

Lichen formers make up about half of the some 50,000 species of the Ascomycetes, the largest group of the Fungi. The Ascomycetes that early took up life with algae abandoned their saprophytic origins and invaded the harshest habitats (bare rock, for example), where competition was low or nil, and there they diversified. Most mycologists cannot name to genus the commonest lichens that they see around them, and textbooks of mycology regularly dismiss the lichens with a page of platitudes on symbiosis. For all its merit *The Fungi: An Advanced Treatise,* edited by Ainsworth and Sussman and with volumes appearing since 1965, also overlooks this conspicuous mass of Fungi, and, aware of this, the publishers commissioned the present book on the lichens, which offers a broad yet scrupulously detailed synthesis of an astonishingly diverse literature.

Nineteen chapters deal with every major area of contemporary lichenology: structure and development, physiology and ecology, chemistry of secondary natural products, symbiosis, and systematics. All the chapters are in English, but strangely no mention is made of the fact that some are translations. The lack of any appreciable overlap among the papers points to a careful collation of the contributions of the 23 authors (representing 11 nationalities) by the editors.

The Lichens is filled with outstanding reviews. For example, an article entitled "Sexual reproduction" becomes Letrouit-Galinou's vehicle for discussing the highlights of 25 years' work on the structure of the ascus and ascocarp by Chadefaud's group in the Sorbonne. The large, convoluted, almost exclusively French literature on this subject has never before been summarized in English. Peveling brings order from the many recent fine-structural studies on the individual symbionts and on the nature of their physical contact. Richardson describes the elegant experiments on carbohydrate movement between symbionts carried out by D. C. Smith and his co-workers at Oxford. The fantastic temperature extremes and water stresses that lichens endure and that account for much of their unique ecology are masterfully summarized by Kappen in one of the book's longest and best chapters. But perhaps most telling of all are the chapters that are not there. There is no "Paleontology," for these ancient double organisms left no fossil record; and there is no "Genetics," reminding us that in this vast group still not even so much as one unequivocal chromosome number is known.

Why have the abundant lichens not been even more extensively studied?