Book Reviews

The History of Maize

Corn. Its Origin, Evolution, and Improvement. PAUL C. MANGELSDORF. Belknap (Harvard University Press), Cambridge, Mass., 1974. xvi, 262 pp., illus. $20.

In 1939 Mangelsdorf and Reeves postulated that cultivated maize arose from a wild pod corn, that teosinte (*Zea mexicana*) is the derivative of natural hybridization of *Zea mays* and a species of *Tripsacum*, and that modern maize is the product of the introgression of primitive maize with teosinte or *Tripsacum* or both. Since the development of this "tripartite hypothesis," most of Mangelsdorf's research and that of his students has been directed toward the testing of it. The results of this research form the basis of the present volume. Its 20 chapters, ranging in subject from archeological maize to modern maize breeding, provide an up-to-date, detailed account of the theories of the origin and evolution of maize and its close relatives. The book also gives insight into the career and scientific philosophy of the author.

The book is an admirable summary of what is known about the evolution of one of our most important cultivated plants. It is written in lucid and lively language and will leave no doubt in the mind of the reader about the position of the author on a number of controversial topics. Among its many interesting chapters, the most engaging is that dealing with prehistoric wild corn and fossil pollen. Herein are described the prehistoric remains of corn recovered from rock shelters of the Tehuacán Valley of Mexico, the oldest specimens of which date back to about 5200 B.C. The reader cannot help sharing in the excitement of the author as he pieces together the evolutionary sequence of maize as revealed in the more than 12,000 recovered prehistoric cobs covering a period of about 6,000 years. Equally intriguing is the account of the recovery and examination of fossil pollen, thought to be that of maize, from drill core depths of almost 70 meters below Mexico City. The earliest of the Mexican fossil pollen is estimated to be at least 80,000 years old. Although some have questioned the authenticity of the Mexico City pollen, its discovery has led to palynological studies that have contributed significantly to a better understanding of the relationships between maize, *Tripsacum*, and teosinte.

The most controversial part of the tripartite hypothesis is the postulated hybrid origin of teosinte. Maize and *Tripsacum* have been hybridized numerous times, yet nothing closely resembling teosinte has been recovered from the F_2 or backcross progeny of the cross. Opponents of the theory of the hybrid origin of teosinte have all used this evidence in support of their arguments. Mangelsdorf, however, has not been influenced by this kind of negative evidence. He has correctly pointed out that the chances of reconstituting teosinte would be slight indeed in the absence of knowledge of the species of *Tripsacum* or kinds of maize that might have been the parents of such a hybrid. Recent studies by Elso Barghoorn and others on the fine structure of the exines of pollen grains of maize, *Tripsacum*, and teosinte have shown that teosinte is not a hybrid of maize and *Tripsacum*, however, so, apparently, this part of the tripartite hypothesis has finally been laid to rest. The implications of the pollen studies are fully accepted by Mangelsdorf, who adds in a footnote, "Perhaps I may be permitted to enjoy some degree of satisfaction in the fact that it is my colleagues and not my critics, who have shown that this part of our tripartite hypothesis is no longer tenable."

While giving up the hybrid origin of teosinte hypothesis, Mangelsdorf is as firm as ever in rejecting teosinte as the ancestral form of maize. He argues that in many morphological characteristics maize is more primitive than teosinte, that the changes from polystichous to distichous spikes, from paired to solitary spikelets, and from herbaceous to indurated glumes are all in the direction of evolutionary specialization. For these and other reasons, he suggests that teosinte should be considered a descendant of maize rather than its ancestral form. This is just the reverse of the old but recently revived proposal that maize is derived from teosinte through a series of mutations accompanied by selection by primitive agriculturists. Mangelsdorf's new hypothesis, in the reviewer's opinion, will probably receive no greater acceptance than did the hybrid origin theory. It is no more amenable to experimental test than is the theory that teosinte is the ancestral form of maize. Since neither theory can reasonably be expected to be proven or disproven, it is unlikely that either will contribute much to our knowledge of the role of teosinte relative to the origin of maize.

Perhaps the most speculative chapter of the book is that entitled "The concept of lineages," in which the author attempts to assign the more than 300 described races of maize from the Western Hemisphere to six "lineages," each descended from a presumed wild race. The six postulated lineages are: Palomero Toluqueño of Mexico, the Chapalote-Nal Tel complex of Mexico, Pira Naranja of Colombia, Confite Morocho of Peru, Chullpi of Peru, and Kculli of Peru. Although this is a justifiable attempt to simplify the classification of maize and to reduce to a reasonable number the numerous named races, many of which are duplicates, the author appears to have erred in the direction of oversimplification. Few will agree, for example, that all sweet corns trace their origin to Chullpi of Peru. Indeed, except for the single recessive gene su_1 on chromosome 4, Chullpi differs from most varieties of sweet corn of the northeastern parts of the United States in practically every diagnostic characteristic. Also, those familiar with the eight-rowed corns of the Western Hemisphere will have difficulty in accepting Confite Morocho, a mid- to high-altitude popcorn of Peru, as the ancestral form of the widely distributed and highly variable eight-rowed corns of South, Middle, and North America.

In chapter 17 Mangelsdorf discusses an interesting popcorn from the eastern Himalayas which has been referred to in the literature as "Sikkim Primitive." On the basis of published descriptions and illustrations and after having examined some kernels of so-called Sikkim Primitive, but apparently without having seen or studied the plants or ears, he concludes that there is little doubt that the Sikkimese corn is a derivative of the Mexican popcorn race Palomero Toluqueño. A number of popcorns

have been collected in the eastern Himalayas, some of which do have at least a superficial resemblance to Palomero Toluqueño. However, the collections correctly identified as Sikkim Primitive, a number of which have been grown and studied by this reviewer, differ markedly from Palomero Toluqueño in most plant, ear, and tassel characteristics. Furthermore, they appear not to have closely related counterparts among any of the described races of popcorn from the Western Hemisphere. This does not mean, of course, as has been implied by some Indian workers, that Sikkim Primitive was in Asia in the pre-Columbian era.

The criticisms notwithstanding, I consider this book an important contribution to maize literature. It is clearly written and beautifully illustrated. All students of maize, regardless of their specialty, will find in it much of interest. It should also interest ethnobotanists, economic botanists, and students concerned in any way with the evolution of cultivated plants.

WILLIAM L. BROWN
Pioneer Hi-Bred International, Inc., Des Moines, Iowa

Thermoregulatory Mechanisms

Temperature Regulation in Mammals and Other Vertebrates. JOHN BLIGH. North-Holland, Amsterdam, and Elsevier, New York, 1973. xx, 436 pp., illus. $30.50. Frontiers in Biology, vol. 30.

The author's preface of this volume includes John Bunyan's apology at the beginning of *Pilgrim's Progress*, which notes that a modest volume was intended but something else emerged. The apology notwithstanding, most of Bligh's review and discussion is worthy of consideration. Bligh depends primarily upon control theory to expound the thermoregulatory mechanisms, treating previous and new data in the context of functional neuronal models. This is a novel approach, but a tenuous one because this type of representation is still largely conjectural.

The regulation of body temperature is a subject concerning which relatively little has been established as scientific fact. Discrete sensing and efferent mechanisms have been characterized to some extent, and these characterizations are sufficiently described in this volume. Complete understanding of thermoregulation, however, depends upon the study of regulatory mechanisms within a number of organ systems and, especially, of the interactions between these mechanisms. The interdependence of different organ systems receives some, but not enough, attention. The proper attention is given to the derivation of basic principles of thermoregulation. To this Bligh takes an eclectic approach, tending to discount established concepts when necessary and to give credibility to new ideas if they mesh with certain patterns.

The control theory viewpoint focuses attention on the relationships between sensory and motor activities and, in this volume, on postulated events within the regulator, which of necessity has been viewed as a black box. This regulator, after all, operates by comparing intensities or rates of input variables with idealized intensities or rates, directing appropriate signals to efferent end organs so that any error signal is minimized. Among the advantages of approaching thermoregulation by way of a working model such as Bligh has set up is the ease of presentation such a model allows. Pathways and interactions are easy to visualize when placed in flow diagram form. The major drawback is the conjectural nature of the model. To infer neuronal networks from single unit recordings or from administration of neurotransmitter substances is to make a great jump; there is no direct evidence that neurons within the hypothalamus are connected in the way depicted in this book. As Bligh himself is careful to note, his model "may be little more than a pretty piece of fiction based upon scraps of physiological evidence and a great deal of imagination." However, up to now, most discussion of thermoregulation has consisted of making comparisons between responses on a temporal basis, without identifying the important inputs to the regulatory center—that is, previous discussion has been largely descriptive in nature and has contributed little insight into the regulatory processes per se. Bligh's approach may help to place the descriptive approach in its proper bay.

Fully half the volume is devoted to relationships between sensory, integrator, and motor activity. The biophysics of energy exchanges between the animal and its environment is treated in a cursory manner, perhaps on the assumption that anyone who would choose to pick up this volume already has a good appreciation of these phenomena. Bligh's strong suit is the discussion and evaluation of sensory activities and their postulated effects within the central nervous system. He discusses nearly every contribution on these subjects prior to 1971 and attempts to put them into an orderly scheme. This is a difficult task, because a lack of proper controls and the use of pharmacological rather than physiological techniques have often confused issues. Especially provocative are chapters that discuss fever and unorthodox theories of thermoregulation. In the latter of these, Bligh elaborates somewhat on his two-tiered theory, which is based upon differential rates of sensory function and which proposes that there are two distinct thermoregulatory systems, one for fine and the other for coarse, broad-band control. It is an intriguing concept that may explain observations that have otherwise been difficult to account for. Less informative are the chapters on temperature regulation during exercise and on acclimatization to heat and cold. The former is devoid of useful quantitative information and is neglectful of circulatory dynamics. The latter is primarily concerned with cold acclimatization, also neglecting circulatory adjustments in heat acclimatization. The final few chapters, which deal with comparative thermoregulation, detract from the primary message, and the volume would have been tighter and more cohesive had they been omitted.

Bligh correctly admonishes himself along with the rest of us about our persistence in the use of "ancient" terminology. He reminds us that the widely adopted Système Internationale requires the use of joules in the place of calories as the standard energy term (how many of us think in terms of a 6278-kj-per-day diet?). There is no question that conversion to a universally standardized terminology, though it can be painful, is ultimately of great value. SI equivalents could have been included parenthetically so that we might begin adapting.

For the graduate student or researcher in environmental physiology, this is a thorough reference book which offers many stimulating ideas. Its ultimate value may be in the presentation of controversial models and concepts that require testing in the laboratory.

ETHAN R. NADEL
John B. Pierce Foundation Laboratory, Yale University School of Medicine, New Haven, Connecticut