Handbook of Maize: Its Biology

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Editors

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Preface

Soon after the rediscovery of Gregor Mendel's work about a century ago, maize became the first plant to undergo detailed genetic analysis, resulting in the first evidence of linkage in plants and the first fragmentary genetic map. The great ease of maize genetics stems largely from the vigor of the plant, its numerous morphological types, its abundant seed set from easily separated gametophytic lineages, and the collections of fascinating mutants detected and used by Native American and immigrant farmers over the last several thousand years. For these reasons - and for its role as one of the world's most productive crops, maize remains a model for the genetic analysis of plant biology. As genetics has become the universal tool for biological study in fields as wide-ranging as biochemistry, developmental biology, ecology, evolutionary biology, pathology, physiology and taxonomy, understanding maize has become even more important. In the last decade, comparative genomics has uncovered the many genetic commonalities between plant taxa, demonstrating that model plants like maize will become the foundation species for understanding the shared common biology within any plant lineage, and a site of examination for rarer changes that make each species unique.

In *Handbook of Maize*, we attempt to capture a significant portion of the great diversity of high quality research in the maize scientific community. Given the history of maize research, it is not surprising that many of these studies have a strong underpinning of genetics and are conducted by scientists who view themselves as maize geneticists. The field has matured to a point, however, where the pursuit of purely genetic questions like recombination or mutation constitutes a significantly smaller portion of the maize genetics portfolio than do investigation into development biology or physiology, for instance. *Handbook of Maize* covers much of the breadth of research within the Maize community, but cannot possibly capture the entire depth of skill and achievement among this group of researchers. To provide even a minimal sampling of the best work and major achievements in this field would require a much larger opus. Having said this, it should be noted that no other book, monograph series or other publication format has succeeded in capturing the state-of-the-art in maize research in a single resource. With the great renaissance in plant science initiated by the genomics era, and the near-completion of a maize genome reference sequence, now is an apt time to assemble this first comprehensive treatise on the biology of maize.

Volume I addresses the basics of maize biology, starting with development and covering a great span of study leading to the final applied goal of crop research, namely, understanding and improving economic traits. The first ten chapters focus on the plant and its parts, with an emphasis on genetic mutants that are informative for growth and development. Chapter 1 examines the vegetative meristem and establishment of patterning in the maize plant. Chapter 2 focuses on inflorescence meristems and elaboration of ears and tassels, while Chapter 3 focuses on genes that regulate flowering time. Chapters 4 and 5 examine the male and female gametophytes, respectively. The activity of the haploid gametophytic stage of development is crucial for double fertilization, leading to embryo and endosperm. Next, Chapter 6 looks at patterns of gene expression in the embryo with a discussion of the differences between maize and another important model plant, *Arabidopsis thaliana*. Chapter 7 concerns development of the kernel including the endosperm, embryo and the maternally derived outer tissue. An enormous number of mutations affecting kernel development has been discovered, thanks, no doubt, to the large and easily observed kernels held together on an ear. Chapter 8 discusses the anatomy and morphology of maize roots, and chapter 9 looks at leaf development and mutants that inform us about patterning in the leaf. Chapter 10 focuses on cell biology, in particular, division, expansion and differentiation of epidermal cells in the leaf.

The following ten chapters examine plant responses to the environment and the utilization of quantitative trait loci in maize improvement. Chapter 11 addresses photobiology in maize, the phytochromes in particular. Chapters 12 through 14 focus on the genetics of the resistance of maize to fungal and bacterial disease, virus infection and insect damage, respectively. Chapters 15-17 examine maize responses to key abiotic stresses, cold, drought and submergence. Chapters 18, 19 and 20 inspect breeding efforts to produce corn that tolerates aluminum or prospers with fewer inputs of phospate and nitrogen. Chapter 21 looks at seed phosphate composition and chemistry while Chapter 22 discusses the regulation of seed starch biosynthesis. Much of the current understanding of the enzymatic steps required for starch synthesis in all plants has been acquired using maize as a model organism. The next five chapters describe the employment of plant breeding to improve corn. Chapters 23 and 24 discuss breeding for yield and heterosis, while Chapter 25 focuses on a specific experiment that demonstrates the long-term effects of breeding. Chapter 26 discusses QTL for a number of important agronomic traits such as lodging and architecture, and Chapter 27 outlines cultural practices and breeding efforts of maize in China. Finally, Chapter 28 describes the diversity of maize in its originating home, Mexico, with implications for how the Mexican landraces can be mined for further improvement of maize.

In its entirety, Volume I of *Handbook of Maize* describes what we now know, what we will soon know, and where we are headed for a great variety of questions concerning plant form, development, growth and responses to the environment. The last few chapters illustrate how the exceptional genetic diversity and genetic tools available in maize have been and are being used to improve this crop. They also help provide an excellent transition to Volume II, which details the history of maize as a crop and genetic model in the context of the great range of modern genetic tools currently available to the maize research community.

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