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Handbook of maize: its biology

Jeff L. Bennetzen, Sarah C. Hake.
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This book is the first of four volumes forming the new *Handbook of maize*. It encompasses 28 chapters contributed by 56 well-known authors/co-authors. As outlined in the preface, the book is a conceptual round-up of what we

know now, what we will know soon, and where the maize researchers are headed for a great variety of questions concerning plant form, development, growth and responses to the environment. The book shapes the current bigger picture of the maize plant and puts its biology back into the minds of maize geneticists and breeders. In the post-genomics era, this well-written and excellently structured book sets the tone for the technological opportunities to come in using the near-completed maize genome reference sequence. The book links basic molecular research with breeding applications and sets cultivars and experimental lines in the wider context of population behaviour and responses to environmental impacts. This is welcome because it puts the focus on the plant, rather than just on the DNA sequence knowledge itself (which of course is otherwise one of the great accomplishments of the maize research community) – but after all, livestock feeds on maize pellets and silage, and we eat its flour and not the letters of the DNA sequence from the computer screen. Thus the book points the interested reader towards current questions in maize biology beyond pure molecular genetics, setting the topic in a broad context and giving a snapshot of research efforts towards improving the maize crop.

The book is structured into three main parts. The first comprises the ten chapters that describe the basics of maize morphology, anatomy and those functions that can be well interpreted from the analyses of the abundance of maize mutants available. Chapter 1 describes vegetative shoot meristems and their developmental patterning, in particular the molecular mechanisms of the function of the shoot apical meristem. Chapters 2 and 3 focus on a description of inflorescence meristems, the development of the ear and tassel, and the genetic regulation of flowering time as part of the floral transition, including its sex determination process. Chapters 4 and 5 review current knowledge on male and female gametophyte development, respectively, including transcriptomic changes, mainly known from pollen and embryo sac mutants. Chapter 6 describes embryo patterning from an evolutionary perspective by comparing the regulatory networks involved with those of the model plant *Arabidopsis thaliana*. Based on the fundamental process of

double fertilization in angiosperms, Chapter 7 is dedicated to maize kernel biology. This chapter describes the structure and development of the kernel, the abundance of informative mutants, and the cell-genetic basics of the embryo–endosperm interactions. Chapter 8 is dedicated to the morphology, anatomy and genetics of the root system, including a review of the recently cloned genes for shoot-borne root and root hair formation. Chapters 9 and 10 describe the structure and function of the maize leaf from cytological and histological points of view, which include cytokinesis, cell expansion, intracellular compartmentation, control of vesicle trafficking and cytoskeletal dynamics.

The following chapters form the next part of the book, which examines the plant responses to different abiotic and biotic stress factors, and explains the opportunities of using mapped QTLs for crop improvement. Chapter 11 reviews current knowledge on light signal transduction networks. This very detailed chapter summarizes modern understanding of light responses in maize and discusses some strategies for enhancing agronomic performance through manipulation of the light signal transduction pathways. Chapters 12 to 14 are dedicated to the genetics and biochemistry of resistance against diseases, viruses and pests, respectively. Chapters 15 to 20 give a broad overview on maize tolerance to abiotic stresses, including chilling, drought, flooding and oxygen deprivation, aluminum surplus, and phosphate limitation. Chapter 20 covers all physiological and genetic aspects of nitrogen use efficiency, this being one of the main agronomic traits as soil-N deficiency is amongst the most serious constraints of maize production worldwide. Chapter 21 reflects on the seed content and chemistry of phosphate, as these traits are important in relation to maize end-use quality, and on the genetic opportunities for breeding and engineering in order to improve grain quality and to reduce environmental pollution as well. Chapter 22 is devoted to the seed content and chemistry of starch and the entire process of regulation of its biosynthesis, which has delivered much of our current general knowledge of these processes, making maize a model plant species.

The last part of the book describes different tactics of plant breeding for crop improvement. Chapter 23 reviews current knowledge regarding theories and models for explaining the phenomenon of heterosis, and Chapter 24 describes physiological and breeding aspects for yield improvement, both with perspectives towards technological progress to enhance the rate of genetic gain. Chapter 25 describes a long-term selection experiment with a focus on QTL analysis and Chapter 26 is also committed to QTL research; both are excellent examples of how, throughout the last decade, breeding has become an application field for QTL mapping and QTL marker-based selection, and both benefit from very extensive and well-selected reference lists. Chapter 27 describes and classifies the diversity of Mexican landraces. This review also details the current situation regarding the conservation of germplasm and the genetic erosion of diversity of Mexican maize, and has some implications for mining Mexican landraces for further crop improvement. The last chapter outlines cultural practices and breeding efforts of

maize in China, the second-largest maize producer in the world, just behind the USA.

High-quality figures, good explanatory colour diagrams and informative tables support the excellent, technically flawless text. The book is delightful to read, mainly due to a good sense for scientific detail and its focus on the bigger picture of general maize biology, which is supplemented with a large selection of literature references. Thus, this book seems to be very useful for teachers, students and non-specialists, in addition to maize researchers and breeders as well. In summary, it is an excellent book, produced at the right time.

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Handbook of maize: genetics and genomics

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This book is the second of four volumes forming the 'Handbook of Maize'. Sixty-eight authors/co-authors have contributed 39 chapters, structured in six parts. The book subsumes the current collective knowledge in the research fields of maize genetics

and genomics by centering on maize as a model for plant genetics in the study of genome structure, function and evolution, as well as for crop improvement. As a logical consequence, the book describes parts of the rich history of maize genetics and the history and contemporary methods of maize improvement. The book depicts the potentials for the development of technological toolkits for classical analysis and modern gene engineering, which deeply root in the progressive knowledge gain on genome dynamics. The book continues with the description of the genetics of some of the most important gene families and gives a short outlook for the future of maize genetics.

The book links the basic research with breeding applications embedded in a historical context. Hence, the first chapter opens by describing the circumstances and opportunities in which maize genetics was founded, featuring the exceptional contributions by E. M. East and R. A. Emerson and their role in developing maize as a pivotal species in genetics. The second chapter is devoted to the pioneering plant geneticist Barbara McClintock and many of her key findings, also including a new look on her early contributions showing her unique perspective, elegant experiments and unprecedented scientific achievements. The chapter includes an annotated chronological list of her publications. The third chapter provides a view on the urgent questions of maize genetics as a driving force on how molecular plant genetics came into existence. The fourth chapter focuses on

mutagenesis. It describes the outstanding collection of maize mutants with their often-dramatic phenotypes associated, and serves to end the first part of the volume.

The second part, consisting of three chapters, describes the improvement of modern maize from the beginnings in the USA during the 19th century, demonstrating the commercial value of heterosis, through the focus on maize as a biotech target, to the current practices of public and private maize breeding.

Chapters 8 to 24 make up the third part of the book, which appears to be the most comprehensive description of nature, biology and evolution of any plant genome so far. Starting from classical cytogenetics and chromosomal structural diversity, through genome anatomy and evolution, genetic diversity and use in linkage disequilibrium mapping, to contemporary insights in the polyploid origin of maize, Chapters 8 to 11 emphasize genome structure and evolution. Chapter 12 focuses on the present understanding of the maize centromere structure, function and origin, as well as the maize-specific knobs. The following four chapters are dedicated to perhaps the most significant biological research achievements: the discovery, characterization and the use of different types of transposable elements. Chapter 17 describes a tool for comparative DNA sequence alignment visualization and research, including a short tutorial for software emphasizing the processes of fractionation of genomic regions and subfunctionalization of genes. Chapter 18 describes current understanding of the process of meiosis and regulating genes. Chapter 19 focuses on homologous recombination, and Chapter 20 is dedicated to the phenomenon of paramutation. Chapters 21 and 22 feature imprinting and epigenetic characterization of maize. Chapter 23 concentrates on all different aspects of the supernumerary B-chromosome and its relation to the regular complement, whilst Chapter 24 provides a far-reaching assessment of the organellar genomes in maize.

Chapters 25 to 34 form the fourth part of the book and illustrate a sample of the major genetic and genomic technologies that are presently available. This part includes tools such as genetic and physical mapping, quantitative chromatin changes, transposon tagging in forward and reverse maize genetics, tilling and point mutation detection, the genome-wide analysis of gene expression, maize transformation and the production and use of doubled haploids. Chapter 33 features databases and data mining, and Chapter 34 describes the process of sequencing genes and gene islands by using gene enrichment techniques.

The fifth part of the book comprises four chapters, which discuss a selection of some of the most important genes in maize, covering transcription factors, the genetics and biochemistry of maize storage proteins, the cytochrome P450 superfamily of monooxygenases, and the genes responsible for cell-wall biosynthesis with the potential for bioenergy production.

The sixth part of the book consists of Chapter 39, which gives a personal prediction on the near-future of maize as a research model for plant biology, as an industrial resource, and as a crop for feed, fuel and energy.

The book is of high quality regarding both text and figures. Very self-explanatory colour diagrams and informative tables complement the technically flawless print. The book continues on seamlessly from its preceeding volume (see previous review) and points the interested reader to the historically evolved symbiosis of maize breeding, genetics and genomics – which ultimately is the strong driver towards scientific and commercial success as well. The book is delightful to read,