

Contents

Contributors		xi
Preface		xvii
Section I	Genomics of Hybrids	1
1	Yeast Hybrids and Polyploids as Models in Evolutionary Studies	3
	Avraham A. Levy, Itay Tirosh, Sharon Reikhav, Yasmin Bloch, and Naama Barkai	
	Introduction	3
	Experimental Advantages of Budding Yeasts	3
	Yeast Hybrids	4
	Yeast Polyploids	5
	Paleopolyploidy and Duplicated Genes Retention	5
	Ploidy and Evolution—Theory and Experiments	6
	Genomic Response to Polyploidy and Hybridity	8
	Yeast Hybrids as a Tool for Studying Genomic Regulation	9
	Conclusions	10
	Acknowledgments	11
	References	11
2	Transcriptome Profiling of <i>Drosophila</i> Interspecific Hybrids: Insights into Mechanisms of Regulatory Divergence and Hybrid Dysfunction	15
	José M. Ranz, Shu-Dan Yeh, Kevin G. Nyberg, and Carlos A. Machado	
	Introduction	15
	Gene Expression	16
	<i>Drosophila</i> Hybrids as a Model to Study Transcriptome Divergence	19
	Outlook	31
	References	32
3	<i>cis</i>- and <i>trans</i>-Regulation in <i>Drosophila</i> Interspecific Hybrids	37
	Joseph D. Coolon and Patricia J. Wittkopp	
	Introduction	37
	Distinguishing between <i>cis</i> - and <i>trans</i> -Regulatory Changes Using eQTL, GWAS, and ASE	39
	Methods Used to Quantify ASE	41
	Studies of <i>cis</i> - and <i>trans</i> -Regulation in Interspecific Hybrids of <i>Drosophila</i>	43

	Insights into Regulatory Evolution	46
	<i>cis</i> - and <i>trans</i> -Regulatory Evolution in <i>Drosophila</i> : A Look Ahead	53
	References	54
4	Gene Expression and Heterosis in Maize Hybrids	59
	Mei Guo and J. Antoni Rafalski	
	Introduction	59
	Gene Expression in Maize Hybrids—Transcript Abundance Relative to Inbred Parents	60
	Allele-Specific Gene Regulation in the Maize Hybrid	64
	Modes of Gene Regulation in the Hybrid	68
	Genetic and Structural Diversities That Contribute to Regulatory Variation	75
	Understanding Heterosis—Various Models	77
	Perspectives	78
	Acknowledgments	79
	References	79
5	Integrating “Omics” Data and Expression QTL to Understand Maize Heterosis	85
	Camille Rustenholz and Patrick S. Schnable	
	Introduction	85
	Experimental Design and eQTL Analysis	87
	eQTL and the Mechanisms Underlying Gene Regulation	90
	Building Networks and Integrating “omics” to Understand How Variants, in Particular eQTL, Can Result in Phenotypic Variation	94
	Conclusion and Future Prospects	98
	Acknowledgments	99
	References	99
6	Genomics and Heterosis in Hexaploid Wheat	105
	Zhongfu Ni, Yingyin Yao, Huiru Peng, Zhaorong Hu, and Qixin Sun	
	Introduction	105
	Genetic Dissection of Wheat Heterosis	105
	Transcriptome and Proteome Analysis between Wheat Hybrids and Parents	106
	Some Differentially Expressed Patterns are Correlated with Wheat Heterosis	106
	Function Analysis of Differentially Expressed Genes between Wheat Hybrids and Their Parental Lines	110
	Possible Regulatory Mechanism Contributing to Differential Gene Expression in Wheat	110
	Physiological Basis of Heterosis for Grain Yield in Wheat	113
	Concluding Remarks	113
	Acknowledgments	113
	References	114
7	Progress of Genomics and Heterosis Studies in Hybrid Rice	117
	Lei Zhang, Yonggang Peng, Yang Dong, Hongtao Li, Wen Wang, and Zhen Zhu	
	Introduction	117
	Progress in the Study of Rice Genomics	118

	Heterosis and Transcriptomics in Hybrid Rice	121
	Epigenetic Modification and Heterosis in Hybrid Rice	126
	Molecular Mechanism behind Heterosis	128
	Perspectives	131
	Acknowledgments	131
	References	131
8	Heterosis: The Case for Single-Gene Overdominance	137
	Katie L. Liberatore, Ke Jiang, Dani Zamir, and Zachary B. Lippman	
	Introduction	137
	Understanding Hybridization: Natural Phenomenon to Genetic Mystery	138
	Hybrid Vigor versus Heterosis	139
	Inbreeding Depression and Heterosis in Breeding	140
	Hypotheses on the Genetic Basis of Heterosis	141
	Overdominance and Quantitative Genetics	142
	Cases for Single-Gene Overdominance	143
	Dosage: An Evolving Heterosis Model	146
	Conclusion	148
	Acknowledgments	148
	References	148
Section II	Genomics of Polyploids	153
9	Genomics and Transcriptomics of Photosynthesis in Polyploids	155
	Jeremy E. Coate and Jeff J. Doyle	
	Introduction	155
	Polyploidy and Photosynthesis	156
	Evolutionary Trajectories of Duplicated Photosynthetic Genes	157
	Transcriptomic Responses to Allopolyploidy in Relation to Photosynthesis	160
	Polyploidy and Photoprotection	166
	Conclusions	167
	Acknowledgments	167
	References	167
10	Chromosomal and Gene Expression Changes in <i>Brassica</i> Allopolyploids	171
	Eric Jenczewski, A.M. Chèvre, and K. Alix	
	Introduction	171
	Recurrent Polyploidy in the Brassicaceae and the Brassiceae	172
	Chromosomal Changes in Natural and Synthetic <i>Brassica</i> Polyploids	173
	Gene Expression Changes	178
	Impact on the Phenotype	181
	Conclusion and Perspectives	182
	Acknowledgments	183
	References	183
11	Dynamics of Duplicated Gene Expression in Polyploid Cotton	187
	Keith L. Adams and Jonathan F. Wendel	
	Origin of Polyploid <i>Gossypium</i>	187

	Homoeologous Gene Expression	187
	Developmental and Environmental Effects on Homoeologous Gene Expression	188
	Global Genome Biases in Homoeologous Gene Expression	190
	Temporal Dynamics of Duplicate Gene Expression Evolution	191
	Proteomic Studies	191
	Why Is Gene Expression Altered in Cotton Allopolyploids and Hybrids?	192
	Acknowledgments	193
	References	193
12	Reprogramming of Gene Expression in the Genetically Stable Bread Allohexaploid Wheat	195
	Dominique Arnaud, Houda Chelaifa, Joseph Jahier, and Boulos Chalhouh	
	Importance of Polyploidy and the Wheat Polyploid Model	195
	Structural Changes That Follow Wheat Allopolyploid Formation	197
	Transposable Element Modifications	198
	Reprogramming of Gene Expression in Allohexaploid Wheat	200
	Concluding Remarks	208
	References	209
13	Nucleocytoplasmic Interaction Hypothesis of Genome Evolution and Speciation in Polyploid Plants Revisited: Polyploid Species-Specific Chromosomal Polymorphisms in Wheat	213
	Bikram S. Gill and B. Friebe	
	Introduction	213
	Nucleocytoplasmic Interaction Hypothesis of Genome Evolution and Speciation	213
	Evidence for Adverse Nucleocytoplasmic Interactions and a Bottleneck	
	Chromosomal Change, Restoring Fertility and Cytoplasmic-Nuclear	
	Compatibility in an Alloplasmic Wheat- <i>Elymus</i> Hybrid	214
	Chromosomal Polymorphisms during Wheat Speciation by Polyploidy, Adaptive	
	Radiation, and Domestication-Driven Evolution	216
	Future Outlook	219
	Acknowledgments	220
	References	220
Section III	Mechanisms for Novelty in Hybrids and Polyploids	223
14	Genes Causing Postzygotic Hybrid Incompatibility in Plants: A Window into Co-Evolution	225
	Kirsten Bomblies	
	Introduction	225
	Genes Causing Intrinsic Postzygotic Incompatibility in Plants	225
	Functional and Evolutionary Insights	233
	References	235
15	Meiosis in Polyploids	241
	Graham Moore	
	Introduction: General Meiotic Process	241

	Premeiotic Chromosome Organization	241
	Chromosome Sorting for Pairing	242
	Distribution of Recombination: Factors Affecting Its Distribution	245
	Sites of Recombination	246
	Barriers to Recombination	246
	Chromosome Pairing Loci in Polyploids	247
	Meiotic Observations Connected with the <i>Ph1</i> Locus	248
	<i>Ph1</i> Locus at a Molecular Level	249
	A Model for <i>Ph1</i> Action	250
	Exploitation of Chromosome Pairing Loci	251
	Acknowledgments	252
	References	252
16	Genomic Imprinting: Parental Control of Gene Expression in Higher Plants	257
	Peter C. McKeown, Antoine Fort, and Charles Spillane	
	Introduction: Genomic Imprinting in F1 Seeds	257
	Evidence for Imprinting of MEGs and PEGs	258
	iMEGs and iPEGs with Imprinted Mutant Phenotypes and/or Segregation Patterns	259
	Uniparental Expression of MEGs Caused by Maternal Seed Coat Expression	260
	MEGs or PEGs in F1 Seed due to Deposition of Long-Lived mRNAs from the Gametes	261
	Confirmation of Imprinting through Disruption of an Epigenetic Modifier or Altered Ploidy Level	262
	Use of Imprinting Control Region: Reporter Fusion Constructs	263
	Allele-Specific Imprinting in Plants	263
	Is Genomic Imprinting Restricted to Seed Endosperm in Plants?	264
	Theories for the Evolution of Genomic Imprinting in Plants	266
	Conclusions	267
	Acknowledgments	267
	References	267
17	Seed Development in Interploidy Hybrids	271
	Roderick J. Scott, Julia L. Tratt, and Ahmed Bolbol	
	Introduction	271
	Polyploidy: Causes and Consequences	272
	Hybridization in Plants	273
	Maternal Control of Endosperm Cellularization	283
	References	286
18	Chromatin and Small RNA Regulation of Nucleolar Dominance	291
	Pedro Costa-Nunes and Olga Pontes	
	Ribosomal RNA Loci Organization and Transcriptional Regulation	291
	How Epigenetic Modifications Impact Nucleolar Dominance	296
	Regulation of Nucleolar Dominance by Small RNAs	299

	Road Ahead for Nucleolar Dominance Research: Building Up Parallels in rRNA	305
	Gene Regulation between Plants and Mammals	306
	References	306
19	Genetic Rules of Heterosis in Plants	313
	James A. Birchler	
	Introduction	313
	A Unifying Mechanism	317
	Gene Expression Studies in Hybrids—What Do They Mean?	317
	Mechanistic Propositions	317
	Acknowledgments	318
	References	318
20	Chromatin and Gene Expression Mechanisms in Hybrids	323
	Guangming He and Xing-Wang Deng	
	Introduction	323
	Chromatin States and Gene Expression in Plants	324
	Natural Variation of Chromatin States in Plants	326
	Chromatin and Transcriptional Variation in Hybrids	327
	Future Perspectives	330
	Acknowledgments	331
	References	331
21	Genetic and Epigenetic Mechanisms for Polyploidy and Hybridity	335
	Z. Jeffrey Chen and Helen H. Yu	
	Introduction	335
	Genome Shock: A Consequence of Genetic and Epigenetic Changes in Allopolyploids	337
	Genetic and Nonadditive Gene Expression Models for Heterosis in Allopolyploids and Hybrids	338
	A Molecular Clock Model on Heterosis in Hybrids and Allopolyploids	340
	<i>cis</i> -Regulation and <i>trans</i> -Regulation of Gene Expression in Related Species and Allopolyploids	343
	Gene Expression Changes and Morphological Evolution in Allopolyploids	343
	Posttranscriptional Regulation in Allopolyploids	344
	Translational Regulation in Allopolyploids	345
	Roles for Small RNAs and Transposons in Hybrid Vigor and Hybrid Incompatibility	346
	Acknowledgments	348
	References	348
	Index	355

A color plate is located between pages 174 and 175.