

Contents

Section I Basics

I.1	The Principle: Identification and Application of Molecular Markers	3
	P. LANGRIDGE and K. CHALMERS	
1	Introduction	3
2	Status	4
3	Molecular Markers	5
4	Identifying Marker/Trait Associations	6
5	Application of Molecular Markers	12
6	Directions	17
7	Conclusions	20
	References	20
I.2	Genotyping Tools in Plant Breeding: From Restriction Fragment Length Polymorphisms to Single Nucleotide Polymorphisms	23
	V. MOHLER and G. SCHWARZ	
1	Introduction	23
2	Restriction Fragment Length Polymorphisms	23
3	Microsatellites	25
4	Random Amplified Polymorphic DNAs	25
5	Amplified Fragment Length Polymorphisms	26
6	Single Nucleotide Polymorphisms	28
7	Conclusions	33
	References	34
I.3	A Model Crop Species: Molecular Markers in Rice	39
	D.J. MACKILL and K.L. McNALLY	
1	Introduction	39
2	Gene Mapping with Molecular Markers in Rice	41
3	Positional Cloning	42
4	Array-Based Markers	45
5	Candidate Genes as Markers	47
6	Conclusions	48
	References	49

I.4	From Markers to Cloned Genes: Map-Based Cloning	55
	W.-R. SCHEIBLE, O. TÖRJEK, and T. ALTMANN	
1	Introduction	55
2	Outline of the General Map-Based Cloning Strategy	56
3	Map-Based Cloning in a Model Species with a Fully Sequenced Genome (<i>Arabidopsis thaliana</i>)	70
4	Map-Based Cloning in Crop Species	76
5	Conclusions	80
	References	81

Section II Specific Crops

II.1	DNA Markers in <i>Brassica</i> : Use of Genetic Information from <i>Arabidopsis</i> and Development of Sequence Tagged Site Markers . .	89
	T. SAKAI, H. FUJIMOTO, R. IMAI, and J. IMAMURA	
1	Introduction	89
2	Characterization of DNA Markers in <i>Brassica</i>	90
3	Application of <i>Arabidopsis</i> Genome Information to <i>Brassica</i> DNA Markers	96
4	Developing Random Amplified Polymorphic DNA Sequence Tagged Site Markers Linked to the Radish-Derived Fertility Restoration (<i>Rf</i>) Locus in <i>B. napus</i>	97
5	Conclusions	100
	References	101
II.2	Genomics as Efficient Tools: Example Sunflower Breeding	107
	A. SARRAFI and L. GENTZBITTEL	
1	Introduction	107
2	Linkage Mapping	107
3	Quantitative Trait Loci Identification	111
4	Sunflower Genomics: Towards Genes and Functions	114
5	Conclusions	116
	References	116
II.3	Genome Analysis: Mapping in Sugar Beet	121
	C. JUNG	
1	Introduction: The Species of the Genus <i>Beta</i>	121
2	Resources and Techniques	121
3	Repetitive DNA Classes	126
4	Genetic Relationships Between Species of the Genus <i>Beta</i>	128
5	Genetic Mapping of Mendelian Traits	129
6	Mapping of Quantitative Trait Loci	132
7	Conclusions	133
	References	133

II.4	Molecular Markers in Genetics and Breeding: Improvement of Alfalfa (<i>Medicago sativa</i> L.)	139
	I.J. MAUREIRA and T.C. OSBORN	
1	Introduction	139
2	Characterization of Alfalfa Germplasms	140
3	Development of Genetic Maps and Identification of Regions Affecting Traits of Interest	142
4	Additional Uses of Molecular Markers in Alfalfa Breeding	148
5	Conclusions	149
	References	150
II.5	Localization of Important Traits: The Example Pea (<i>Pisum sativum</i> L.)	155
	W.K. SWIECICKI and G. TIMMERMAN-VAUGHAN	
1	Introduction	155
2	The <i>Pisum</i> Genetic Map and Loci for Agronomic Characters	156
3	Resistance to Powdery Mildew (<i>Erysiphe pisi</i> Syd.)	158
4	Resistance to Fusarium Wilt (<i>Fusarium oxysporum</i> f. sp. <i>pisi</i> (van Hall) Snyder & Hans)	159
5	Plant Virus Resistance	159
6	Flowering Genetics	161
7	Quantitative Trait Loci	162
8	Conclusions	166
	References	166
II.6	Molecular Markers in <i>Vigna</i> Improvement: Understanding and Using Gene Pools	171
	A. KAGA, D.A. VAUGHAN, and N. TOMOOKA	
1	Introduction	171
2	Application of Molecular Markers to Understand the <i>Vigna</i> Crop Gene Pools	171
3	Linkage Maps	174
4	Syteny	176
5	Gene Mapping	178
6	Transformation Systems	181
7	Conclusions	183
	References	183
II.7	Molecular Markers for Genetics and Breeding: Development and Use in Pepper (<i>Capsicum</i> spp.)	189
	V. LEFEBVRE	
1	Introduction	189
2	Molecular Markers	190
3	Genetic Diversity	190
4	Variety Identification and Hybrid Purity	191

5	Genetic Maps	192
6	Maps Position and Markers of Loci Governing Traits of Interest ..	198
7	Genomic Resources	206
8	Marker-Assisted Selection	208
9	Conclusion	209
	References	210
II.8	Potato Genetics: Molecular Maps and More	215
	C. GEBHARDT	
1	Introduction: The Potato as an Object of Genetic Analysis	215
2	Reference Molecular Maps of Potato	216
3	Synteny of Potato With Other Plant Genomes	216
4	Potato Function Map for Pathogen Resistance	218
5	Potato Function Map for Tuber Traits	221
6	Potato Function Maps as Basis for Innovative Approaches to Breeding	223
7	Conclusions	224
	References	224
II.9	Molecular Marker Maps of Barley: A Resource for Intra- and Interspecific Genomics	229
	R.K. VARSHNEY, M. PRASAD, and A. GRANER	
1	Introduction	229
2	Molecular Markers	230
3	Construction of Molecular Maps	230
4	Comparative Mapping and Synteny	236
5	Conclusions	238
	References	239
II.10	Genomics in Rice: Markers as a Tool for Breeding	245
	Y. KISHIMA, K. ONISHI, and Y. SANO	
1	Introduction	245
2	Conventional Markers	246
3	The Beginnings of Molecular Marker Analysis	246
4	Molecular Markers Currently Used in Rice Breeding	247
5	Amplified Fragment Length Polymorphism Analysis in Rice	248
6	MITE-Transposon Display in Rice	248
7	Transposable Elements as Markers for Major Genes	250
8	Conclusions: Quantitative Trait Loci and Future Prospects	251
	References	252
II.11	Wheat Microsatellites: Potential and Implications	255
	M.S. RÖDER, X.-Q. HUANG, and M.W. GANAL	
1	Introduction	255
2	Development of Microsatellite Markers	255

3	The Bridge to Practical Applications	257
4	Diagnostic Markers for Traits of Interest	257
5	Analysis of Genetic Diversity	261
6	Conclusions	261
	References	262
II.12	Comparative Genetic Mapping in Trees: The Group of Conifers ..	267
	D.B. NEALE and K.V. KRUTOVSKY	
1	Introduction	267
2	Conifer Genomes	268
3	Loblolly Pine Reference Genetic Map	269
4	Genetic Markers for Comparative Mapping in Conifers	269
5	Comparative Mapping in <i>Pinus</i>	270
6	Comparative Mapping in Pinaceae	273
7	Conclusions: Needs of Linking the Genetic Map to Chromosomes	275
	References	275
II.13	Markers in Fruit Tree Breeding: Improvement of Peach	279
	E. DIRLEWANGER and P. ARÚS	
1	Introduction	279
2	Use of Molecular Markers for Fruit Quality Improvement	285
3	Use of Molecular Markers for Disease Resistance	289
4	Marker-Assisted Selection for Tree Architecture Characters	291
5	Syteny Among <i>Prunus</i> Species	292
6	Development of Peach Molecular Markers, Their Use for Fingerprinting and for the Evaluation of Genetic Resources	296
7	Conclusions	297
	References	297

Section III Breeding Strategies and Silviculture Based on Markers

III.1	General Considerations: Marker-Assisted Selection	305
	V. MOHLER and C. SINGRÜN	
1	Introduction	305
2	Requirements of Markers for Marker-Assisted Selection	305
3	Present Status of Validated Molecular Markers for Molecular Breeding of Important Crops	307
4	Marker-Assisted Selection for Quantitative Trait Loci	307
5	Marker-Assisted Selection in Gene Pyramiding	310
6	Marker-Assisted Selection in Backcross Breeding	311
7	Conclusions	313
	References	313

III.2	Breeding Strategies: Optimum Design of Marker-Assisted Backcross Programs	319
	M. FRISCH	
1	Introduction	319
2	Introgression of One Dominant Gene	319
3	Introgression of a Recessive Gene	327
4	Introgression of Two Dominant Genes	330
5	Length of the Intact Donor Chromosome Segment Around the Target Gene	331
	References	333
III.3	From Theory to Practice: Marker-Assisted Selection in Maize ...	335
	D.A. HOISINGTON and A.E. MELCHINGER	
1	Introduction	335
2	Practical Examples of Marker-Assisted Selection	342
3	Economics of Marker-Assisted Selection	348
4	New Marker-Assisted Selection Strategies	349
5	Conclusions	349
	References	350
III.4	Molecular Markers for Disease Resistance: The Example Wheat ..	353
	C. FEUILLET and B. KELLER	
1	Introduction	353
2	Development of Molecular Markers	354
3	Use of Molecular Markers in Marker-Assisted Selection for Disease Resistance	362
4	Conclusions	363
	References	364
III.5	Application of DNA Markers: Soybean Improvement	371
	M.J. IQBAL and D.A. LIGHTFOOT	
1	Introduction	371
2	Choice of Markers	373
3	Identification of Polymorphism	378
4	Marker-Assisted Recovery of Recurrent Parent Genome	378
5	Marker-Assisted Selection in Recurrent Cross Populations	379
6	Marker-Assisted Selection for Targeted Genes/Traits	379
7	Methods for Marker-Assisted Selection	380
8	Conclusions	382
	References	383

III.6	Forest Management and Conservation Using Microsatellite Markers: The Example of <i>Fagus</i>	387
	Y. TSUMURA, M. TAKAHASHI, T. TAKAHASHI, N. TANI, Y. ASUKA, and N. TOMARU	
1	Introduction	387
2	Development and Evaluation of Microsatellite Markers in <i>Fagus</i>	388
3	Spatial Analysis of Genetic Structure Within Forests by Microsatellite Markers	390
4	Genetic Management of <i>Fagus</i> Forests for Conservation and Sustainable Use	393
5	Conclusions	395
	References	395
III.7	Molecular Markers in Tree Improvement: Characterisation and Use in <i>Eucalyptus</i>	399
	M. SHEPHERD and M.E. JONES	
1	Introduction	399
2	Base Population Characterisation – <i>Eucalyptus globulus</i> is geographically structured with chloroplast haplotypes coincident with quantitative genetic variation	400
3	Effect of Utilisation on the Base Population Resource – Influence of Silvicultural and Harvesting on <i>Eucalyptus sieberi</i> Genetic Diversity	401
4	Defining the Gene Pool for Breeding – Hybridisation	402
5	Direct Measures of Gene Flow – Implications for Orchard Design	403
6	Genetic Architecture of Commercial Traits – Quantitative Trait Loci and Candidate Gene Mapping	405
	References	409
III.8	DNA Markers for Identification and Evaluation of Genetic Resources in Forest Trees: Case Studies in <i>Abies</i> , <i>Picea</i> and <i>Populus</i>	413
	B. ZIEGENHAGEN and M. FLADUNG	
1	Introduction	413
2	Which DNA Marker at Which Scale and for Which Purpose?	415
3	Case Studies with Fir (<i>Abies</i> sp.), Norway Spruce [<i>Picea abies</i> (Karst.) L.] and Poplar (<i>Populus</i> sp.)	417
4	Conclusions	425
	References	426

Section IV Legal Aspects

IV.1	Intellectual Property Rights in the Field of Molecular Marker Analysis	433
	P. JORASCH	
1	Introduction	433
2	What is a Patent?	434
3	Microsatellite or Simple Sequence Repeat Markers	434
4	The Selection of Microsatellite Primers and the PCR Reaction ...	436
5	Analysis of PCR Products	437
6	Marker-Assisted Breeding Methods	437
7	Conclusions	438
	References	471
	Subject Index	473