

Contents

<i>Acknowledgements</i>		xi
<i>Introduction</i>		xiii
<i>About the Companion Website</i>		xix
PART I: PLANT GENOMES AND GENES		
Chapter 1	Plant genetic material	3
	1.1 DNA is the genetic material of all living organisms, including plants	3
	1.2 The plant cell contains three independent genomes	8
	1.3 A gene is a complete set of instructions for building an RNA molecule	10
	1.4 Genes include coding sequences and regulatory sequences	11
	1.5 Nuclear genome size in plants is variable but the numbers of protein-coding, non-transposable element genes are roughly the same	12
	1.6 Genomic DNA is packaged in chromosomes	15
	1.7 Summary	15
	1.8 Problems	15
	References	16
Chapter 2	The shifting genomic landscape	17
	2.1 The genomes of individual plants can differ in many ways	17
	2.2 Differences in sequences between plants provide clues about gene function	20
	2.3 SNPs and length mutations in simple sequence repeats are useful tools for genome mapping and marker assisted selection	22
	2.4 Genome size and chromosome number are variable	28
	2.5 Segments of DNA are often duplicated and can recombine	30
	2.6 Some genes are copied nearby in the genome	31
	2.7 Whole genome duplications are common in plants	34
	2.8 Whole genome duplication has many effects on the genome and on gene function	37
	2.9 Summary	41
	2.10 Problems	42
	Further reading	42
	References	42
Chapter 3	Transposable elements	45
	3.1 Transposable elements are common in genomes of all organisms	45
	3.2 Retrotransposons are mainly responsible for increases in genome size	46
	3.3 DNA transposons create small mutations when they insert and excise	52
	3.4 Transposable elements move genes and change their regulation	57
	3.5 How are transposable elements controlled?	60

	3.6 Summary	60
	3.7 Problems	61
	References	61
Chapter 4	Chromatin, centromeres and telomeres	63
	4.1 Chromosomes are made up of chromatin, a complex of DNA and protein	63
	4.2 Telomeres make up the ends of chromosomes	66
	4.3 The chromosome middles – centromeres	71
	4.4 Summary	77
	4.5 Problems	77
	Further reading	77
	References	77
Chapter 5	Genomes of organelles	79
	5.1 Plastids and mitochondria are descendants of free-living bacteria	79
	5.2 Organellar genes have been transferred to the nuclear genome	80
	5.3 Organellar genes sometimes include introns	82
	5.4 Organellar mRNA is often edited	82
	5.5 Mitochondrial genomes contain fewer genes than chloroplasts	84
	5.6 Plant mitochondrial genomes are large and undergo frequent recombination	87
	5.7 All plastid genomes in a cell are identical	91
	5.8 Plastid genomes are similar among land plants but contain some structural rearrangements	93
	5.9 Summary	95
	5.10 Problems	95
	Further reading	95
	References	95
PART II: TRANSCRIBING PLANT GENES		
Chapter 6	RNA	99
	6.1 RNA links components of the Central Dogma	99
	6.2 Structure provides RNA with unique properties	102
	6.3 RNA has multiple regulatory activities	105
	6.4 Summary	108
	6.5 Problems	108
	References	109
Chapter 7	The plant RNA polymerases	111
	7.1 Transcription makes RNA from DNA	111
	7.2 Varying numbers of RNA polymerases in the different kingdoms	112
	7.3 RNA polymerase I transcribes rRNAs	114
	7.4 RNA polymerase III recruitment to upstream and internal promoters	116
	7.5 Plant-specific RNP-IV and RNP-V participate in transcriptional gene silencing	117
	7.6 Organelles have their own set of RNA polymerases	117
	7.7 Summary	118
	7.8 Problems	118
	References	118

Chapter 8	Making mRNAs – Control of transcription by RNA polymerase II	121
	8.1 RNA polymerase II transcribes protein-coding genes	121
	8.2 The structure of RNA polymerase II reveals how it functions	121
	8.3 The core promoter	123
	8.4 Initiation of transcription	125
	8.5 The mediator complex	127
	8.6 Transcription elongation: the role of RNP-II phosphorylation	128
	8.7 RNP-II pausing and termination	129
	8.8 Transcription re-initiation	130
	8.9 Summary	130
	8.10 Problems	130
	References	130
Chapter 9	Transcription factors interpret <i>cis</i>-regulatory information	133
	9.1 Information on when, where and how much a gene is expressed is codified by the gene's regulatory regions	133
	9.2 Identifying regulatory regions requires the use of reporter genes	134
	9.3 Gene regulatory regions have a modular structure	135
	9.4 Enhancers: <i>Cis</i> -regulatory elements or modules that function at a distance	137
	9.5 Transcription factors interpret the gene regulatory code	138
	9.6 Transcription factors can be classified in families	138
	9.7 How transcription factors bind DNA	139
	9.8 Modular structure of transcription factors	143
	9.9 Organization of transcription factors into gene regulatory grids and networks	146
	9.10 Summary	146
	9.11 Problems	146
	More challenging problems	147
	References	147
Chapter 10	Control of transcription factor activity	149
	10.1 Transcription factor phosphorylation	149
	10.2 Protein–protein interactions	151
	10.3 Preventing transcription factors from access to the nucleus	155
	10.4 Movement of transcription factors between cells	156
	10.5 Summary	158
	10.6 Problems	158
	References	158
Chapter 11	Small RNAs	161
	11.1 The phenomenon of cosuppression or gene silencing	161
	11.2 Discovery of small RNAs	162
	11.3 Pathways for miRNA formation and function	163
	11.4 Plant siRNAs originate from different types of double-stranded RNAs	166
	11.5 Intercellular and systemic movement of small RNAs	168
	11.6 Role of miRNAs in plant physiology and development	170
	11.7 Summary	171
	11.8 Problems	171
	References	172

Chapter 12	Chromatin and gene expression	173
	12.1 Packing long DNA molecules in a small space: the function of chromatin	173
	12.2 Heterochromatin and euchromatin	173
	12.3 Histone modifications	174
	12.4 Histone modifications affect gene expression	175
	12.5 Introducing and removing histone marks: writers and erasers	175
	12.6 'Readers' recognize histone modifications	177
	12.7 Nucleosome positioning	177
	12.8 DNA methylation	178
	12.9 RNA-directed DNA methylation	179
	12.10 Control of flowering by histone modifications	180
	12.11 Summary	181
	12.12 Problems	181
	References	181
PART III: FROM RNA TO PROTEINS		
Chapter 13	RNA processing and transport	185
	13.1 RNA processing can be thought of as steps	185
	13.2 RNA capping provides a distinctive 5' end to mRNAs	185
	13.3 Transcription termination consists of mRNA 3'-end formation and polyadenylation	189
	13.4 RNA splicing is another major source of genetic variation	192
	13.5 Export of mRNA from the nucleus is a gateway for regulating which mRNAs actually get translated	194
	13.6 Summary	196
	13.7 Problems	196
	References	196
Chapter 14	Fate of RNA	199
	14.1 Regulation of RNA continues upon export from nucleus	199
	14.2 Mechanisms for RNA turnover	199
	14.3 RNA surveillance mechanisms	201
	14.4 RNA sorting	202
	14.5 RNA movement	203
	14.6 Summary	204
	14.7 Problems	204
	Further reading	205
	References	205
Chapter 15	Translation of RNA	207
	15.1 Translation: a key aspect of gene expression	207
	15.2 Initiation	209
	15.3 Elongation	209
	15.4 Termination	210
	15.5 Tools for studying the regulation of translation	211
	15.6 Specific translational control mechanisms	211

15.7	Summary	213
15.8	Problems	214
	Further reading	214
	References	214
Chapter 16	Protein folding and transport	215
16.1	The pathway to a protein's function is a complicated matter	215
16.2	Protein folding and assembly	215
16.3	Protein targeting	218
16.4	Co-translational targeting	218
16.5	Post-translational targeting	219
16.6	Post-translational modifications regulating function	220
16.7	Summary	222
16.8	Problems	223
	Further reading	223
	References	224
Chapter 17	Protein degradation	225
17.1	Two sides of gene expression – synthesis and degradation	225
17.2	Autophagy, senescence and programmed cell death	225
17.3	Protein-tagging mechanisms	226
17.4	The ubiquitin proteasome system rivals gene transcription	228
17.5	Summary	231
17.6	Problems	231
	Further reading	231
	Reference	231
	<i>Index</i>	233