
CONTENTS

PREFACE	xix
CONTRIBUTORS	xxiii
ACRONYMS AND ABBREVIATIONS	xxix
1 AN INTRODUCTION TO PROTEOMICS: APPLICATIONS TO PLANT BIOLOGY	1
<i>Ralph A. Bradshaw</i>	
1.1 Proteomics Defined	2
1.2 Proteomics Applied	5
References	6
PART I TECHNOLOGIES	
2 GEL-BASED PROTEOMICS	11
<i>Pier Giorgio Righetti, Paolo Antonioli, Carolina Simò, and Attilio Citterio</i>	
2.1 Introduction and Brief Bibliographic Review	11
2.2 SDS-PAGE	12
2.3 IEF	17
2.4 2D Maps	22
2.5 Conclusions	28
2.6 Five-Year Viewpoint	29
References	30
3 MASS SPECTROMETRY-BASED PROTEOMICS: IDENTIFYING PLANT PROTEINS	33
<i>Eveline Bergmüller, Sacha Baginsky, and Wilhelm Gruissem</i>	
3.1 Introduction and Brief Bibliographic Review	33
3.2 Instrumentation	34
3.3 MALDI	35

3.4	ESI	36
3.5	Mass Analyzers	36
3.6	Ion Detectors	38
3.7	Sample Preparation	39
3.8	Protein Identification	40
3.9	Conclusions	44
3.10	Five-Year Viewpoint	44
	References	44
4	CHEMICAL PROTEOMICS	47
	<i>Miriam C. Hagenstein, Olaf Kruse, and Norbert Sewald</i>	
4.1	Introduction	47
4.2	Strategies For Activity-Based Protein Profiling (ABPP)	47
4.3	Case Study: Development of Molecular Tools Targeting Plant Kinases	53
4.4	Conclusions	57
4.5	Five-Year Viewpoint	58
	References	58
5	THE ARABIDOPSIS LOCALIZOME: SUBCELLULAR PROTEIN LOCALIZATION AND INTERACTIONS IN ARABIDOPSIS	61
	<i>Georgios Kitsios, Nicolas Tsesmetzis, Max Bush, and John H. Doonan</i>	
5.1	Protein Compartmentalization in Plant Cells	61
5.2	Experimental Determination of Protein Localization	66
5.3	<i>In Vivo</i> Imaging Approaches to Protein Localization and Interaction	69
5.4	Plant Cell Cultures for Studying Protein Localization	73
5.5	Protein-Protein Interaction <i>In Vivo</i> : FRET	74
5.6	Perspectives: Integrating Predictive and Experimental Protein Localization Data	77
	References	77
6	SECRETOME: TOWARD DECIPHERING THE SECRETORY PATHWAYS AND BEYOND	83
	<i>Young-Ho Jung, Ganesh Kumar Agrawal, Randeep Rakwal, and Nam-Soo Jwa</i>	
6.1	Introduction and Brief Bibliographic Review	83
6.2	Methodology and Strategy	86
6.3	A Case Study: <i>In Planta</i> and <i>In Vitro</i> Protein Profiles of Soluble and Secreted Proteins in Rice	87

6.4	Conclusions	87
6.5	Five-Year Viewpoint	89
	References	89

7 PEPTIDOMICS 91

Peter Schulz-Knappe

7.1	Introduction and Brief Bibliographic Review	91
7.2	Separation Technology	93
7.3	MS Technology	95
7.4	Bioinformatics and Data Mining	97
7.5	Differential Peptide Display	98
7.6	ID LC-MALDI	99
7.7	2D CA-RP-LC-ESI-MS	100
7.8	Applications	100
7.9	Peptides and Proteases	101
7.10	Conclusions	102
7.11	Five-Year Viewpoint	103
	References	103

PART II COMPUTATIONAL PROTEOMICS

8 BIOINFORMATICS IN GEL-BASED PROTEOMICS 107

Åsa M. Wheelock and Craig E. Wheelock

8.1	Introduction and Brief Bibliographic Review	107
8.2	Methodology and Strategy	112
8.3	Experimental Results and Applications	120
8.4	Conclusions	122
8.5	Five-Year Viewpoint	123
	References	124

9 BIOINFORMATICS IN MS-BASED PROTEOMICS 127

Jacques Colinge

9.1	Introduction	127
9.2	Database Searching	128
9.3	Peptide <i>De Novo</i> Sequencing	135
9.4	Conclusions and Five-Year Viewpoint	138
	References	139

PART III EXPRESSION PROTEOMICS

10	AN OVERVIEW OF THE <i>ARABIDOPSIS</i> PROTEOME	143
	<i>Jacques Bourguignon and Michel Jaquinod</i>	
10.1	Introduction and Brief Bibliographic Review	143
10.2	Methodology and Strategy	146
10.3	Experimental Results and Applications	147
10.4	Conclusions	160
10.5	Five-Year Viewpoint	160
	References	161
11	RICE PROTEOME AT A GLANCE	165
	<i>Ganesh Kumar Agrawal and Randeep Rakwal</i>	
11.1	Introduction and Brief Bibliographic Review	165
11.2	Methodology and Strategy	167
11.3	Experimental Results and Applications	172
11.4	Conclusions	177
11.5	Five-Year Viewpoint	177
	References	178
12	PROTEOMICS OF LEGUME PLANTS	179
	<i>Satish Nagaraj, Zhentian Lei, Bonnie Watson, and Lloyd W. Sumner</i>	
12.1	Introduction and Brief Bibliographic Review	179
12.2	Proteomics of Model Legume <i>Medicago truncatula</i>	180
12.3	Proteomics of Model System <i>Lotus japonicus</i>	183
12.4	Proteomics of Soybean, <i>Glycine max</i>	183
12.5	Proteomics of Alfalfa, <i>Medicago sativa</i>	184
12.6	Conclusions	186
12.7	Five-Year Viewpoint	187
	References	187
13	PROTEOME OF SEED DEVELOPMENT AND GERMINATION	191
	<i>Julie Catusse, Loïc Rajjou, Claudette Job, and Dominique Job</i>	
13.1	Introduction	191
13.2	Proteomics of Developing Seeds	192
13.3	Proteomics of Mature Seeds	196
13.4	Proteomics of Germinating Seeds	198
13.5	Proteomics of Somatic Embryogenesis	201
13.6	Metabolic Control of Seed Development and Germination	203

13.7	Conclusions	204
13.8	Five-year Viewpoint	205
	References	205
14	ENDOSPERM AND AMYLOPLAST PROTEOMES OF WHEAT GRAIN	207
	<i>William J. Hurkman, William H. Vensel, Frances M. DuPont, Susan B. Altenbach, and Bob B. Buchanan</i>	
14.1	Introduction	207
14.2	Fractionation and Analysis of Endosperm Proteins	208
14.3	The Endosperm Proteome	210
14.4	The Amyloplast Proteome	215
14.5	Conclusions	219
14.6	Five-Year Viewpoint	219
	References	220
15	ROOT PROTEOME	223
	<i>Kuo-Chen Yeh, Chyi-Chuann Chen, and Chuan-Ming Yeh</i>	
15.1	Introduction	223
15.2	Application of Proteomics in the Study of Root Development	225
15.3	Proteome Analysis of Response to Plant Hormones	232
15.4	Proteome Analysis of Gravity Response	233
15.5	Action to Microbe-Plant Symbiosis	233
15.6	Proteome to Cope With Environmental Stresses	234
15.7	Conclusions and Five-Year Viewpoint	236
	References	237
16	LEAF PROTEOME	239
	<i>Bin Kang, Shuyang Tu, Jiyuan Zhang, and Siqi Liu</i>	
16.1	Introduction	239
16.2	Proteomics Studies in Plant Leaf	240
16.3	Conclusions	247
16.4	Five-Year Viewpoint	247
	References	248
17	ANTHER PROTEOME	249
	<i>Nijat Imin</i>	
17.1	Introduction and Brief Bibliographic Review	249
17.2	Methodology and Strategy	251
17.3	Conclusions	258

17.4 Five-Year Viewpoint	258
References	259

18 POLLEN PROTEOME **261**

Sandra Noir

18.1 Introduction	261
18.2 Bibliographic Review: Pollen Development and Function	262
18.3 Methodology and Experimental Results	264
18.4 Conclusions	271
18.5 Five-Year Viewpoint	272
References	272

19 MICROTUBULE-BINDING PROTEINS **275**

Lori A. Vickerman and Douglas G. Muench

19.1 Introduction	275
19.2 Brief Bibliographic Review	276
19.3 Strategies and Methodologies	277
19.4 Experimental Results and Applications	280
19.5 Conclusions	286
19.6 Five-Year Viewpoint	287
References	287

PART IV ORGANELLE PROTEOMICS

20 CELL WALL **293**

Elisabeth Jamet, Hervé Canut, Cécile Albenne, Georges Boudart, and Rafael Pont-Lezica

20.1 Introduction	293
20.2 Brief Bibliographic Review	296
20.3 Specific Methodology and Strategies	296
20.4 Experimental Results and Applications	300
20.5 Conclusions	304
20.6 Five-Year Viewpoint	304
References	306

21 PLASMA MEMBRANE: A PECULIAR STATUS AMONG THE CELL MEMBRANE SYSTEMS **309**

Geneviève Ephritikhine, Anne Marmagne, Thierry Meinel, and Myriam Ferro

21.1 Introduction and Brief Bibliographic Review	309
21.2 Specific Methodologies and Strategies (Box 21.1)	310

21.3	Experimental Results and Applications: Toward an Informative Database of the Plant PM Proteome	319
21.4	Conclusions	323
21.5	Five-Year Viewpoint	324
	References	325
22	NUCLEUS	327
	<i>Subhra Chakraborty, Aarti Pandey, Asis Datta, and Niranjana Chakraborty</i>	
22.1	Introduction and Brief Bibliographic Review	327
22.2	Methodology and Strategy	328
22.3	Experimental Results and Discussion	330
22.4	Conclusions	335
22.5	Five-Year Viewpoint	336
	References	337
23	CHLOROPLAST	339
	<i>Thomas Kieselbach and Wolfgang P. Schröder</i>	
23.1	Introduction	339
23.2	Brief Bibliographic Review	341
23.3	Methodology and Strategy	341
23.4	Experimental Results and Applications	344
23.5	Conclusions	348
23.6	Five-Year Viewpoint	348
	References	349
24	ETIOPLAST	351
	<i>Anne von Zychlinski, Sonja Reiland, Wilhelm Grissem, and Sacha Baginsky</i>	
24.1	Introduction	351
24.2	Etioplast Proteome Analysis	352
24.3	Conclusions	358
24.4	Five-Year Viewpoint	359
	References	359
25	THE PLANT MITOCHONDRIAL PROTEOME AND THE CHALLENGE OF HYDROPHOBIC PROTEIN ANALYSIS	361
	<i>Yew-Foon Tan and A. Harvey Millar</i>	
25.1	Introduction	361
25.2	Brief Bibliographic Review	363
25.3	Methodology and Strategy	364
25.4	Experimental Results and Applications	369

25.5	Conclusions	373
25.6	Five-Year Viewpoint	373
	References	374
26	PEROXISOME	377
	<i>Yuko Arai, Youichiro Fukao, Makoto Hayashi, and Mikio Nishimura</i>	
26.1	Introduction	377
26.2	Brief Bibliographic Review	379
26.3	Specific Methodologies and Strategies	379
26.4	Experimental Results and Applications	383
26.5	Conclusions	386
26.6	Five-Year Viewpoint	387
	References	388
27	UNRAVELING PLANT VACUOLES BY PROTEOMICS	391
	<i>Songqin Pan and Natasha Raikhel</i>	
27.1	Introduction	391
27.2	Bibliographic Review: Role of Proteomics in Understanding Biology of Plant Vacuoles	393
27.3	Methodology and Strategies	395
27.4	A Case-Study of Label-Free Quantitative Proteomics	401
27.5	Conclusions	402
27.6	Five-Year Viewpoint	403
	References	404
28	OIL BODIES	407
	<i>Pascale Jolivet, Luc Negroni, Sabine d'Andréa, and Thierry Chardot</i>	
28.1	Introduction and Brief Bibliographic Review	407
28.2	Methodology and Strategy	408
28.3	Conclusions	413
28.4	Five-Year Viewpoint	414
	References	416
PART V MODIFICATION PROTEOMICS		
29	PHOSPHOPROTEINS: WHERE ARE WE TODAY?	421
	<i>Florian Wolschin and Wolfram Weckwerth</i>	
29.1	Introduction	421
29.2	Phosphoprotein and Phosphopeptide Enrichment	422

29.3	Detection of Protein Phosphorylation and Determination of Phosphorylation Sites	427
29.4	MS-Based Approaches	432
29.5	Biological Implications of Protein Multisite Phosphorylation in Plants	434
29.6	Large-Scale Proteomics Studies	437
29.7	Conclusions and Five-Year Viewpoint	438
	References	438
30	PROTEOME ANALYSIS OF THE UBIQUITIN PATHWAY	443
	<i>Junmin Peng</i>	
30.1	Introduction	443
30.2	Brief Bibliographic Review	444
30.3	Specific Methodologies and Strategies	445
30.4	Experimental Results and Applications	448
30.5	Conclusions	451
30.6	Five-Year Viewpoint	452
	References	452
31	ANALYSIS OF THE N-GLYCOSYLATION OF PROTEINS IN PLANTS	455
	<i>Willy Morelle</i>	
31.1	Introduction	455
31.2	Brief Bibliographic Review	456
31.3	Methodology and Strategy	458
31.4	Conclusions	465
31.5	Five-Year Viewpoint	466
	References	467
32	FUNCTIONAL ANALYSIS AND PHOSPHORYLATION SITE MAPPING OF LEUCINE-RICH REPEAT RECEPTOR-LIKE KINASES	469
	<i>Steven D. Clouse, Michael B. Goshe, Steven C. Huber, and Jia Li</i>	
32.1	Introduction and Brief Bibliographic Review	469
32.2	Specific Methodologies and Strategies	473
32.3	Experimental Results and Applications	477
32.4	Conclusions and Five-Year Viewpoint	481
	References	482
33	TIME TO SEARCH FOR PROTEIN KINASE SUBSTRATES	485
	<i>Birgit Kersten</i>	
33.1	Introduction and Brief Bibliographic Review	485
33.2	Methodology and Strategy	486

33.3	Experimental Results on Plant MAPK Downstream Signaling and Applications	49
33.4	Conclusions	49
33.5	Five-Year Viewpoint	49
	References	4

34 TYROSINE PHOSPHORYLATION IN PLANTS: EMERGING EVIDENCE

Andrea Carpi, Valeria Rossi, and Francesco Filippini

34.1	Introduction	49
34.2	Brief Bibliographic Review	50
34.3	Methodology and Strategy	50
34.4	Experimental Results and Applications	50
34.5	Conclusions	51
34.6	Five-Year Viewpoint	51
	References	52

35 14-3-3 PROTEINS: REGULATORS OF KEY CELLULAR FUNCTIONS

Peter C. Morris

35.1	Introduction and Brief Bibliographic Review	51
35.2	Methodology and Strategy	51
35.3	Experimental Results and Applications	51
35.4	Conclusions	52
35.5	Five-Year Viewpoint	52
	References	53

PART VI MULTIPROTEIN COMPLEX

36 TAP-TAGGING SYSTEM IN RICE FOR PROTEIN COMPLEX ISOLATION

Jai S. Rohila and Michael E. Fromm

36.1	Introduction	52
36.2	Methodolgy and Strategy	52
36.3	Experimental Results and Applications	53
36.4	Conclusions	54
36.5	Five-Year Viewpoint	54
	References	54

37	TAP STRATEGY IN <i>ARABIDOPSIS</i> PROTEIN COMPLEX ISOLATION	543
	<i>Vicente Rubio and Xing Wang Deng</i>	
37.1	Introduction and Brief Bibliographic Review	543
37.2	Specific Methodology and Strategies	546
37.3	Experimental Results and Applications	552
37.4	Conclusions	554
37.5	Five-Year Viewpoint	555
	References	555
38	BLUE-NATIVE PAGE IN STUDYING PROTEIN COMPLEXES	557
	<i>Holger Eubel and A. Harvey Millar</i>	
38.1	Introduction	557
38.2	Brief Bibliographic Review	560
38.3	Methodology and Strategy	561
38.4	Experimental Results and Applications	566
38.5	Conclusions	567
38.6	Five-Year Viewpoint	567
	References	568
39	PROTEIN-PROTEIN INTERACTION MAPPING IN PLANTS	571
	<i>Joachim F. Uhrig</i>	
39.1	Introduction and Brief Bibliographic Review	571
39.2	Methodology and Strategy	574
39.3	Experimental Results and Applications	578
39.4	Conclusions	580
39.5	Five-Year Viewpoint	581
	References	581

PART VII PLANT DEFENSE AND STRESS

40	PROTEOMICS IN PLANT DEFENSE RESPONSE	587
	<i>Sun Tae Kim and Kyu Young Kang</i>	
40.1	Introduction	587
40.2	Brief Bibliographic Review	588
40.3	Methodology and Strategies	589
40.4	Experimental Results and Applications	595
40.5	Conclusions	601

40.6 Five-Year Viewpoint	602
References	603
41 PROTEOME ANALYSIS OF CELLULAR RESPONSES TO ABIOTIC STRESSES IN PLANTS	605
<i>Hans-Peter Mock and Andrea Matros</i>	
41.1 Introduction and Brief Bibliographic Review	605
41.2 Summary of Previous Research on Abiotic Stresses in Plants	606
41.3 Comparison of Transcriptomics and Proteomics Data in Analysis of Plant Defense Responses Against Abiotic Stress Factors	621
41.4 Conclusions	624
41.5 Five-Year Viewpoint	624
References	625
42 PROTEOMICS OF BIOTROPHIC PLANT-MICROBE INTERACTIONS: SYMBIOSES LEAD THE MARCH	629
<i>Ghislaine Recorbet and Eliane Dumas-Gaudot</i>	
42.1 Introduction	629
42.2 AM and RNF Symbioses: No Equal Footing for Proteomics	631
42.3 A 2005–2006 Update of the Contribution of Proteomics to AM Symbiosis	634
42.4 A 2005–2006 Update of the Contribution of Proteomics to RNF Symbiosis	637
42.5 Conclusions	640
42.6 Five-Year Viewpoint	640
References	642
43 PROTEOMICS APPROACHES TO CONSTRUCT CALCIUM SIGNALING NETWORKS IN PLANTS	645
<i>Irene S. Day and A.S.N. Reddy</i>	
43.1 Introduction and Brief Bibliographic Review	645
43.2 Methodology and Experimental Results	649
43.3 Conclusions	656
43.4 Five-Year Viewpoint	656
References	657

PART VIII STRUCTURAL PROTEOMICS

44 CELL-FREE EXPRESSION SYSTEM FOR EUKARYOTIC PROTEINS	661
<i>Yaeta Endo and Tatsuya Sawasaki</i>	
44.1 Introduction	661

44.2 Development of Wheat Germ Cell-Free Protein Synthesis System	662
44.3 Application to Functional Proteomics	663
44.4 Application to Structural Proteomics	665
44.5 Conclusions and Five-Year Viewpoint	667
References	668

45 PROTEIN STRUCTURE DETERMINATION 671

Jian-Hua Zhao and Hsuan-Liang Liu

45.1 Introduction	671
45.2 Instrumental Methods for Protein Structure Determination	672
45.3 Computational Approaches for Protein Structure Prediction	678
45.4 Conclusions	687
45.5 Five-Year Viewpoint	687
References	689

PART IX OTHER TOPICS IN PLANT PROTEOMICS

46 PROTEOMICS IN CONTEXT OF SYSTEMS BIOLOGY 695

Serhiy Souchelnytskyi

46.1 Introduction	695
46.2 What Systems Biology Requires	696
46.3 What Proteomics Provides	699
46.4 Representation of Information About Proteins and Their Integration into Systems Biology Tools	706
46.5 Conclusions	708
46.6 Five-Year Viewpoint	708
References	709

47 PROTEOMICS IN DEVELOPING COUNTRIES 713

Nat N. V. Kav, Sanjeeva Srivastava, William Yajima, and Shakir Ali

47.1 Introduction	713
47.2 Proteome Research in the Developing World	719
47.3 Conclusions	725
47.4 Five-Year Viewpoint	726
References	726

INDEX 731