

Contents

Preface XIII

List of Contributors XV

1	Development of Functional Materials from Rod-Like Viruses	1
	<i>Zhongwei Niu, Jianhua Rong, L. Andrew Lee, and Qian Wang</i>	
1.1	Introduction	1
1.2	Overview	2
1.2.1	TMV	2
1.2.2	M13 Bacteriophage	3
1.3	Programmable Protein Shells	4
1.3.1	Chemical Modifications	5
1.3.2	Genetic Modifications	5
1.3.2.1	Genetic Modification of TMV	7
1.3.2.2	M13 Genetic Modification	7
1.3.3	Chemical Modification in Combination with Genetic Mutation	8
1.4	Templated Syntheses of Composite Materials	9
1.4.1	Synthesis of Inorganic Materials Using TMV as the Template	9
1.4.2	Bacteriophage M13 as the Template	11
1.5	Self-Assembly of Rod-Like Viruses	12
1.5.1	Controlled 1D Assembly	14
1.5.1.1	TMV Head-to-Tail Assembly	14
1.5.1.2	Conductive 1D TMV Composite Fibers	16
1.5.1.3	Weaving M13 Bacteriophage into Robust Fibers	16
1.5.1.4	Nanoring Structure	17
1.5.2	Fabrication of Thin Films by 2D Self-Assembly	17
1.5.3	Controlling the 3D Assembly of TMV and M13	19
1.6	Virus-Based Device and Applications	20
1.7	Outlook	22
	References	23

2	Biomimetic Nanoparticles Providing Molecularly Defined Binding Sites—Protein-Featuring Structures versus Molecularly Imprinted Polymers	31
	<i>Kirsten Borchers, Sandra Genov, Carmen Gruber-Traub, Klaus Niedergall, Jolafin Plankalayil, Daniela Pufky-Heinrich, Jürgen Riegler, Tino Schreiber, Günter E.M. Tovar, Achim Weber, and Daria Wojcikiewicz</i>	
2.1	Introduction	31
2.2	Core Materials and Functionalities	34
2.2.1	Inorganic Core Materials	34
2.2.1.1	Inorganic Crystalline Nanoparticles	34
2.2.1.2	Particles with Silica Cores	35
2.2.1.3	Metals and Metal Oxides	36
2.2.2	Organic Core Materials	37
2.2.2.1	Polymers, Lipids and Fullerenes	37
2.3	Functional Shells	42
2.3.1	Organic Shells	42
2.3.2	MIPs	44
2.3.2.1	Tools for MIP Development	44
2.3.2.2	Bulk MIP and Proteins	45
2.3.2.3	Nanospheric MIPs in General	47
2.3.2.4	Nanospheric MIPs and Proteins	48
2.4	Applications	49
2.4.1	Biopurification	49
2.4.1.1	Magnetic Nanoparticles	49
2.4.1.2	MIPs with Magnetizable Cores	50
2.4.2	Drug Delivery and Drug Targeting	51
2.4.2.1	Nanoparticle Systems for Drug Delivery	51
2.4.2.2	Ligands on Nanoparticle Surfaces	53
2.4.2.3	Targeting of Specific Cells	53
2.5	Products	55
2.5.1	MIPs—Applications and Products	55
2.5.2	Luminex Assay	55
2.6	Conclusions	56
	References	57
3	Interaction Between Silica Particles and Human Epithelial Cells: Atomic Force Microscopy and Fluorescence Study	69
	<i>Igor Sokolov</i>	
3.1	Interaction of Silica with Biological Cells: Background	69
3.2	Interaction of a Silica Particle with the Cell Surface: How It Is Seen with AFM	70
3.2.1	AFM	70
3.2.2	AFM on Cells	72
3.2.2.1	Cell Culture	72
3.2.2.2	AFM	72

3.2.3	AFM Probe Preparations	73
3.2.4	Models to Analyze the Cell Surface: Need for a Two-Layer Model	74
3.2.5	Experimental Data	78
3.2.5.1	Surface Brush on Cancer and Normal Cells	78
3.2.5.2	Measurement of Adhesion: Silica Particle–Cell Interaction	80
3.2.5.3	Can the Difference in Adhesion Be Used to Detect Cancer Cells?	83
3.3	Ultra-Bright Fluorescent Silica Particles to Be Used to Study Interaction with Cells	84
3.4	Ultra-Bright Fluorescent Silica Particles to Distinguish Between Cancer and Normal Cells	85
3.4.1	Methods and Materials	86
3.4.1.1	Spectrofluorometric and Optical Measurements of the Particles Attached to Cells	86
3.4.1.2	Detection of Affinity of Fluorescent Silica Particles to Cells	87
3.4.2	Experimental Results: Spectrofluorometric and Image Analysis of Cancer and Normal Cervix Cells	87
3.5	Conclusions	89
	References	89
4	Chiral Molecular Imprinting as a Tool for Drug Sensing	97
	<i>Sharon Marx</i>	
4.1	Introduction	97
4.2	Electrochemical Drug Sensors	101
4.3	Optical Drug Sensors	103
4.4	Mass Drug Sensors	106
4.5	Conclusions and Summary	107
	References	107
5	Catalytic Antibodies for Selective Cancer Chemotherapy	111
	<i>Roy Weinstein and Doron Shabat</i>	
5.1	Introduction	111
5.2	Catalytic Antibodies Designed for Prodrug Activation	111
5.3	Catalytic Antibody 38C2 and Cancer Therapy	114
5.3.1	General Approach for Prodrug Activation with Antibody 38C2	114
5.3.2	Bifunctional Antibodies for Targeted Chemotherapy	116
5.3.3	<i>In Vitro</i> and <i>In Vivo</i> Evaluations of Antibody 38C2-Catalyzed Prodrug Activation	118
5.3.4	Polymer Directed Enzyme Prodrug Therapy: An Approach to Target Antibody 38C2 to a Tumor Site	120
5.3.5	Chemical Adaptor Concept	123
5.3.6	Self-Immulative Dendrimers Concept	125
5.3.7	Prodrugs of Dynemicin and Doxorubicin Analogs	126
5.4	Chemically Programmed Antibodies	128
5.5	Outlook	134
	References	134

6	Natural and Synthetic Stimulators of the Immune Response	137
	<i>Marine C. Raman and Dominic J. Compopiano</i>	
6.1	Introduction	137
6.2	Lipopolysaccharide Endotoxin—A Potent Immunostimulatory Molecule	137
6.3	LPS Recognition	138
6.4	Septic Shock	139
6.5	LPS Biosynthesis	140
6.6	Minimal, Modified Lipid A	140
6.7	Isolation of "Natural" Kdo ₂ -Lipid A	143
6.8	Synthetic LPS, Lipid A and Their Uses	144
6.9	Structural Studies	147
6.9.1	LBP, CD14 and FhuA	147
6.9.2	MD-2/Lipid IVa Complex	149
6.9.3	TLR4—MD-2 Complex	151
6.10	Bacterial LPS-Binding Proteins	153
6.11	Sphingolipids—Essential Membrane Components of Mammals, Plants, Fungi, Yeast and Bacteria	153
6.12	Natural Killer T Cells and GSLs	158
6.13	GSL Antigens	159
6.14	Structure—Activity Relationships	161
6.15	Saccharide Modification	161
6.16	Ceramide Modification	163
6.17	High-Resolution Structural Analysis of Receptor—GSL Complexes	163
6.18	Conclusions	168
	References	169
7	Supramolecular Assemblies of Polydiacetylenes for Biomolecular Sensing: Colorimetric and "Turn-On" Fluorescence Approaches	177
	<i>Guangyu Ma and Quan Jason Cheng</i>	
7.1	Introduction	177
7.2	Vesicular PDA Sensors for Colorimetric Signaling of Bacterial Pore-Forming Toxin	179
7.3	Fabrication of "Turn-On" Fluorescence Vesicle Sensors with PDAs	181
7.4	"Mix-and-Detect" Type of "Turn-On" Fluorescence Sensor for Bacterial Toxin	186
7.5	Conclusions	189
	References	190
8	Multivalent Synthetic Receptors for Proteins	193
	<i>Jolanta Polkowska, Peter Talbiersky, and Thomas Schrader</i>	
8.1	Aminopyrazoles for β -Sheet Capping in Protein Misfolding Events	193
8.2	New Mechanisms of Enzyme Inhibition by Molecular Clips and Tweezers	202

8.3	Protein Surface Recognition by Tailor-Made Polymers	210
8.4	Conclusions and Outlook	214
	References	215
9	Analysis of Biological Interactions and Recognitions by Surface Plasmon Resonance	219
	<i>Sang Jun Sim and Cuong Cao</i>	
9.1	Introduction to Surface Plasmon Resonance Technology	219
9.2	Working Principle of SPR	220
9.3	Sensor Surface Chemistry and Its Fabrications	222
9.4	Important Factors Impacting on the Performance of SPR-Based Analyses of Biological Interactions on the Nonbiological Transducer Surface	227
9.4.1	Nonspecific Interactions	227
9.4.2	Recognition Elements	230
9.4.3	Detection Formats	230
9.4.3.1	Direct Binding Assays	230
9.4.3.2	Sandwich Detection Assays	232
9.4.3.3	Competitive Detection Assays	232
9.4.3.4	Inhibition Detection Assays	232
9.4.4	Several Approaches for Sensitivity Enhancements of the SPR Bioassays	233
9.5	Localized SPR of Inorganic Nanoparticles for Analyses of Biological Interaction	236
	References	239
10	Membrane-Active Natural and Synthetic Peptides and Peptidomimetics	247
	<i>Regine Willumeit</i>	
10.1	Introduction	247
10.1.1	Structure of Cell Membranes	247
10.1.2	Biophysical Properties of Phospholipids	248
10.2	Mode of Action of Membrane-Active Peptides	249
10.2.1	Carpet Model	249
10.2.2	Barrel Stave Model	250
10.2.3	Toroidal or Wormhole Model	250
10.2.4	Two-State Model	251
10.2.5	"Detergent-Like" Model	251
10.2.6	Molecular Mechanism of Membrane Disruption	251
10.3	Natural Peptides	252
10.3.1	α -Helical Peptides	253
10.3.2	β -Sheet Peptides	254
10.3.3	Cyclic Peptides	254
10.4	Synthetic Peptides	254
10.5	Peptidomimetics	255

10.6	Conclusions	256
	References	258
11	Luminescent Quantum Dot Fluorescence Resonance Energy Transfer-Based Probes in Cellular and Biological Assays	265
	<i>Lifang Shi, Nitsa Rosenzweig, and Zeev Rosenzweig</i>	
11.1	Introduction	265
11.2	Luminescent QDs	266
11.3	FRET	268
11.4	QD FRET-Based Protease Probes	269
11.5	Summary and Conclusions	273
	References	274
12	New Proteins for New Sensing Methodologies: The Case of the Protein-Binding Family	281
	<i>Vincenzo Aurilia, Maria Staiano, Mosè Rossi, and Sabato D'Auria</i>	
12.1	Introduction	281
12.2	Galactose/Glucose-Binding Protein from <i>Escherichia coli</i>	282
12.3	Glutamine-Binding Protein from <i>Escherichia coli</i>	285
12.4	Trehalose/Maltose-Binding Protein from the Hyperthermophilic Archaeon <i>Thermococcus litoralis</i>	287
12.5	Lipocalins and Odorant-Binding Protein	289
12.5.1	Structural Characterization of Pig OBP	291
12.5.2	Functional Characterization and Biotechnological Application of pOBP	292
12.6	Conclusions	294
	References	294
13	Methods of Analysis for Imaging and Detecting Ions and Molecules	299
	<i>Sung Bae Kim, Hiroaki Tao, and Yoshio Umezawa</i>	
13.1	Fluorescent and Luminescent Proteins	299
13.1.1	GFP and Its Variants	299
13.1.2	Luciferases	308
13.2	Functional Peptides	312
13.3	Representative Technologies for Molecular Imaging	313
13.3.1	Classical Methods for Sensing Bioactive Small Molecules	313
13.3.2	Fluorescence (or Förster) Resonance Energy Transfer	317
13.3.2.1	Probes for Determining Protein Phosphorylation	319
13.3.2.2	Probes for Determining Steroid-Activated Protein-Protein Interactions	319
13.3.2.3	A "Flip-Flop"-Type Indicator	319
13.3.3	Bioluminescence Resonance Energy Transfer	321
13.3.4	Protein-Fragment Complementation Assay	323
13.3.5	Intein-Mediated Protein-Splicing Assay	326

13.3.6	Circular Permutation of Fluorescent and Luminescent Proteins	331
13.4	Conclusions and Perspectives	332
13.4.1	Frontier Research in Analysis	332
13.4.2	Analytical Achievements Inspired by Nature	332
13.4.3	Future Directions	333
	References	334
	Index	339