

Contents

<i>Preface</i>	v
<i>List of Contributors</i>	xix
Chapter 1 Adult Stem Cells: From Bench-Top to Bedside	1
<i>Henry E. Young, Lee Hyer, Asa C. Black Jr</i> <i>and Joe Sam Robinson Jr</i>	
1. Introduction	2
2. Classification of Stem Cells	6
3. Stem Cell Isolation and Cultivation	19
3.1. Isolation.....	19
3.2. Cultivation.....	19
3.3. Replating	20
3.4. Cryopreservation	21
3.5. Assaying for cell type.....	22
4. Parkinson Disease and Potential of Stem Cell.....	26
4.1. Bench-top animal model for Parkinson disease	35
4.2. Bedside phase-0 efficacy trial for Parkinson disease	38
5. Future Perspective	50
6. Concluding Remarks.....	54
Acknowledgments.....	55
References	56
Chapter 2 Preparation of Tissue Development — Mimicking Matrices and Their Applications	61
<i>Guoping Chen, Takashi Hoshiba</i> <i>and Naoki Kawazoe</i>	

1. Introduction	62
2. Cell-Derived Matrices	62
3. Stepwise Osteogenesis-Mimicking Matrices	65
4. Stepwise Adipogenesis-Mimicking Matrices	68
5. Comparison of Stepwise Osteogenesis-Mimicking and Stepwise Adipogenesis-Mimicking Matrices on Stem Cell Differentiation	71
6. Conclusions	73
References	73
 Chapter 3 Decellularized Scaffolds: Concepts, Methodologies, and Applications in Cardiac Tissue Engineering and Whole-Organ Regeneration	
<i>Sourav S. Patnaik, Bo Wang, Benjamin Weed, Jason A. Wertheim and Jun Liao</i>	
1. Introduction	78
2. History and Current State of Decellularized Approach	81
3. Methodologies in Decellularization Approaches	83
3.1. The balance between cell removal and ECM preservation	83
3.2. Current state of decellularization methodologies	84
3.2.1. Chemicals methods	84
3.2.2. Enzymatic methods	86
3.2.3. Physical methods and preservation methods	87
3.2.4. Combinations of various decellularization methods	87
3.2.5. Scaffold treatment — Sterilization, stabilization, coating, and storage/handling	88
4. Application of Decellularized Scaffolds in Cardiac Tissue Engineering	89
4.1. Cardiac tissue engineering	89
4.2. Acellular myocardial scaffolds and applications	92
4.3. Biomechanics of acellular myocardial scaffold and its implications	93

5. Application of Decellularized Scaffolds in Whole-Organ Tissue Engineering	97
5.1. Demands for whole-organ tissue engineering	97
5.2. Whole-organ decellularization and its applications	98
5.2.1. Heart	99
5.2.2. Lung	99
5.2.3. Liver	100
5.2.4. Kidney	101
6. Discussions	102
6.1. 3D structural integrity	102
6.2. Recellularization and provision of oxygen and nutrients	103
6.3. Concluding remarks	107
Acknowledgments	108
References	108

Chapter 4 Recent Advances on Three-Dimensional Electrospun Nanofiber Scaffolds for Tissue Regeneration and Repair	125
<i>Bing Ma, Matthew R. MacEwan, Franklin D. Shuler, Matthew K. Wingate and Jingwei Xie</i>	
1. Introduction	126
2. Fabrication of 3D Electrospun Nanofiber Scaffolds	128
2.1. Nanofiber bundles and yarns	128
2.2. Tubular nanofiber structures	131
2.3. Microspherical nanofiber structures	134
2.4. Heterogeneous structures	135
2.5. Regular structures formed by layer-by-layer stacking	138
2.6. Regular structures formed by direct fiber writing	139
2.7. Regular structures with dimpled feature	140
2.8. Regular structures with patterned hexagonal features	141
2.9. Regular structures formed by noobing and weaving	142
3. Utilization of 3D Nanofiber Scaffolds for Tissue Regeneration and Repair	144

3.1. Putting tubular nanofiber scaffolds to work for artificial blood vessels	144
3.2. Putting tubular nanofiber scaffolds to work for nerve regeneration	146
3.3. Putting layer-by-layer stacked nanofiber scaffolds to work for annulus fibrosus regeneration	149
3.4. Putting 3D nanofiber scaffolds to work for bone regeneration	151
4. Conclusion and Remarks.....	153
Acknowledgments.....	155
References	155
Chapter 5 Nanofibrous Scaffolds for Tissue Engineering Applications: State-of-the-Art and Future Trends	163
<i>Masoud Mozafari, Vahid Shabafrooz, Mostafa Yazdimamaghani, Daryoosh Vashaei and Lobat Tayebi</i>	
1. Nanotechnology	164
2. Electrospinning.....	166
2.1. Processing parameters	166
2.1.1. Applied voltage	167
2.1.2. Flow rate.....	167
2.1.3. Collector distance.....	167
2.1.4. Types of collectors	168
2.2. Solution parameters	169
2.2.1. Polymer concentration	169
2.2.2. Solution conductivity	170
2.3. Polymeric blends.....	170
2.3.1. Blends of natural polymers	170
2.3.2. Blends of natural and synthetic polymers	172
2.4. State-of-the-art and new trends.....	175
2.4.1. Need of electrospinning for tissue engineering	175
2.4.2. Novel approaches in electrospinning.....	177
2.4.3. Combined therapy with drug loaded scaffolds	196
3. Conclusion	199

Acknowledgments.....	199
References	199
Chapter 6 Extra Cellular Matrix and Its Application as Coating on Synthetic 3D Scaffolds for Guided Tissue Regeneration	205
<i>Qing Liu and Marika K. Bergenstock</i>	
1. Introduction	206
2. Scaffold-Guided Tissue Regeneration.....	206
3. ECM as Naturally Derived Scaffolds	208
4. Synthetic 3D Scaffolds Coated with Cell Culture Derived ECM for Bone Regeneration	209
5. Conclusion Remarks	213
References	214
Chapter 7 Nanodimensional and Nanocrystalline Calcium Orthophosphates.....	219
<i>Sergey V. Dorozhkin</i>	
1. Introduction	220
2. General Information on "Nano".....	223
3. Micron- and Submicron-Sized Calcium Orthophosphates vs. the Nanodimensional Ones	227
4. Nanodimensional and Nanocrystalline Calcium Orthophosphates in Calcified Tissues of Mammals.....	230
4.1. Bones.....	230
4.2. Teeth	232
5. The Structure of the Nanodimensional and Nanocrystalline Apatites.....	233
6. Synthesis of Nanodimensional and Nanocrystalline Calcium Orthophosphates.....	239
6.1. General nanotechnological approaches	239
6.2. Nanodimensional and nanocrystalline apatites	240
6.3. Nanodimensional and nanocrystalline TCP	252
6.4. Other nanodimensional and nanocrystalline calcium orthophosphates	253

6.5. Biomimetic construction using nanodimensional particles	257
7. Biomedical Applications of Nanodimensional and Nanocrystalline Calcium Orthophosphates	258
7.1. Bone repair	258
7.2. Nanodimensional and nanocrystalline calcium orthophosphates and cells	262
7.3. Dental applications	266
7.4. Other biomedical applications	268
8. Non-Biomedical Applications of the Nanodimensional and Nanocrystalline Calcium Orthophosphates	276
9. Summary and Perspectives	276
10. Conclusions	280
11. Post-Conclusion Remarks	281
References	282

Chapter 8 Nano-Bioceramics as Coatings for Orthopedic Implants and Scaffolds for Bone Regeneration 343
Yongxing Liu Mohamed N. Rahaman and B. Sonny Bal

1. Nanotechnology in Orthopedic and Dental Implants	344
1.1. Nanoscale topography	346
1.2. Nanostructured coatings of bioactive ceramics	350
1.2.1. Calcium phosphate-based (CaP) coatings	351
1.2.2. Nanocomposite and doped HA coatings	353
1.2.3. Reinforcement of HA coatings with nanoscale phases	356
1.2.4. Non-CaP ceramic coatings	358
1.3. Outlook for nanostructured ceramic coatings	360
2. Three-Dimensional Macroporous Scaffolds of Nanostructured Bioceramics	360
2.1. Bioactive glass scaffolds	361
2.2. CaP scaffolds	364
2.3. Surface coating	367
2.4. Polymer-ceramic nanocomposites	369

2.4.1. Nanophase bioactive ceramic coating on macroporous biopolymer scaffolds.....	370
2.4.2. Organic-inorganic composites	371
2.5. Outlook for nanocomposite scaffolds	375
References	376

Chapter 9 Cell Behavior on Electrospun Scaffolds:

Factors at Play on Nanoscale	393
<i>Parthasarathy Madurantakam and Gary Bowlin</i>	
1. Introduction	394
2. Cell Sensing of the Micro-Environment	395
2.1. Cell-biomaterial interface	396
2.1.1. Integrins	397
2.1.2. Integrin mediated adhesions.....	398
2.1.3. Intracellular signaling pathways	400
2.2. Electrospinning.....	401
2.3. Nano-topologies in electrospun scaffolds.....	403
2.3.1. Fiber diameter	403
2.3.2. Fiber alignment	405
2.3.3. Pore size and porosity	407
3. Biological Response to Electrospun Scaffolds	411
4. Physical Substrate for Stem Cell Differentiation	412
5. Effect of Fiber Diameter and Scaffold Porosity.....	415
6. Effect of Fiber Alignment	417
7. Effect of Chemically Modified Electrospun Scaffolds.....	419
8. Conclusion	424
References	425

Chapter 10 The Convergence of Biomimetic Nanofibers

and Cells for Functional Tissue Formation.....	435
<i>Xuening Chen, Licheng Wang and Hongjun Wang</i>	
1. Introduction	436
2. Fabrication of Nanofibers with a Diverse Chemistry.....	438
2.1. Synthetic polymer fibers	438

2.1.1. Polycaprolactone	438
2.1.2. Poly(lactic-co-glycolic acid)	442
2.1.3. Other synthetic polymers	443
2.2. Natural polymer fibers	443
2.2.1. Collagen	444
2.2.2. Chitosan	445
2.2.3. Silk fibroin	446
2.2.4. Other natural polymers	447
2.3. Composite nanofiber	448
2.3.1. Synthetic polymers with natural polymers	448
2.3.2. Polymers with ceramics	450
3. Fiber Dimension and Spatial Arrangement	450
3.1. Fiber diameter	450
3.2. Spatial arrangement of electrospun nanofibers	452
4. Cell-Electrospun Fiber Interaction	455
4.1. Cell morphology	455
4.2. Cell migration and proliferation	456
4.3. Cell phenotype	457
4.4. Underlying mechanism	459
5. Future Perspective and Challenge	460
6. Conclusion	461
Acknowledgment	462
References	462

Chapter 11 Surface Structure of Nanocomposites and Its Properties: A Practical Example

*Davide Barbieri, Joost D. de Bruijn
and Huipin Yuan*

1. The Importance of the Surface in Biomaterials	474
2. Nano-Composites with Active Surfaces	478
2.1. Synthesis of nano-sized calcium phosphate apatite	480
2.2. Preparation of composites having various surface roughness levels	482
2.3. Characterization of the surface of composite discs (i.e. roughness and hydrophilicity)	486

2.4. <i>In vitro</i> degradation	489
2.5. <i>In vitro</i> surface mineralization	492
2.6. Serum protein adsorption	495
2.7. rhBMP-2 adsorption from enriched culture medium	496
2.8. hBMSCs cell culture	497
2.9. <i>In vivo</i> tissue response	499
3. Discussion	501
Acknowledgments	507
References	508
Index	517

Columbia, MO 65212, USA
Chapter 8

Davide Barbieri
Xpand Biotechnology BV
Prof. Bronkhorstlaan 10, 3723 MB
Bilthoven, The Netherlands
Chapter 11

Marika K. Bergenstock
3D Biotek, LLC
North Brunswick
NJ 08902, USA
Chapter 6

Asa C. Black Jr
Regeneration Technologies
Macon, GA 31201 (HEY)
Georgia Neurological Institute
Macon, GA 31201 (LH, JSR)
Memorial General Hospital
University of South Carolina
Medical School
Greenville, SC 29605 (ACB), USA
Chapter 1

Chapter 9

Guoping Chen
Tissue Regeneration Materials
Unit
International Center for
Materials Nanoarchitectonics
National Institute for Materials
Science
1-1 Namiki, Tsukuba
Ibaraki 305-0044 Japan
Chapter 2

Xuening Chen
Chemistry, Biological Chemistry
and Biomedical Engineering
Stevens Institute of Technology
Hoboken, NJ 07030, USA
Chapter 10

Joost D. de Bruijn
Xpand Biotechnology BV
Prof. Bronkhorstlaan 10
3723 MB
Bilthoven, The Netherlands and