Preface

Recent advances in stem cell biology have opened up new therapeutic strategies for a variety of incurable diseases. But the ultimate clinical success of such therapies lies entirely on our ability to efficiently control and manipulate stem cell fate and produce therapeutic cells in large, pharmaceutically relevant scales. This book presents a treatise on the state-of-the-art developments in biomaterials as synthetic niches for engineering stem cells, both for understanding their behavior under 3D biomimetic conditions as well as to develop new strategies for long term maintenance and lineage-specific differentiation into therapeutic cells. Animal and human stem cells of both embryonic and adult origin are discussed with applications ranging from nerve regeneration, orthopedics, cardiovascular therapy, blood cell production and muscle regeneration. Both synthetic and natural biomaterials have been discussed with specific focus on how material–stem cell interactions direct specific cell fate.

Chapter 1 introduces the reader to matrix biology and how dynamic elements of the stem cell extracellular matrix (ECM) can be engineered through biomaterials.

Chapter 2 and 3 provide a detailed understanding of how material properties and three-dimensional (3D) biomaterial scaffolds can be used to alter the stem cell niche with particular focus on surface energy, mechanical properties as well as controlled release of factors from the niche material.

The concept of niche topography and its effect on stem cell fate is thoroughly discussed in Chaps. 4 and 5. Chapter 4 provides particular emphasis on mechanotransduction while Chap. 5 emphasizes on how nanoscale topography of the stem cell niche influences cell proliferation and differentiation. Specifically the authors present ways to mimic these nanoscale features using three-dimensional (3D) nanofiber matrices and how such matrices influence a variety of stem cell behavior.

The use of micropatterning technologies to create synthetic, soft 3D niches is discussed in Chap. 6. Specifically, hydrogel-type biomaterials are presented as a conducive-microenvironment for stem cell growth and differentiation.

Chapter 7 further elaborates on the use of microfabrication technologies along with high throughput approaches on embryonic stem cell research. These are

critical not only in controlling stem cell fate in a precise and deliberate manner but to also study cell–niche interactions in a quantitative and high-throughput way.

Chapters 8–12 focus on use of biomaterial-based niches for lineage-specific differentiation of stem cells. Specifically, Chaps. 8 and 9 discuss cardiovascular differentiation of stem cells while Chap. 10 introduces hematopoietic lineage, specifically T cell differentiation from embryonic and adult stem cells. Chapter 11 provides a review of neural regeneration under hypoxic conditions with specific emphasis on the role of biomaterials. Finally, Chap. 12 provides a unique treatise on the aging stem cell niche in the context of biomaterial-based muscle regeneration.

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