

Preface

Over the past decade, significant advances in the fields of stem cell biology, bioengineering, and animal models have converged on the discipline of regenerative medicine. Significant progress has been made leading from preclinical studies through phase 3 clinical trials for some therapies. This volume provides a state-of-the-art report on tissue engineering toward the goals of tissue and organ restoration and regeneration. Examples from different organ systems illustrate progress with growth factors to assist in tissue remodeling; the capacity of stem cells for restoring damaged tissues; novel synthetic biomaterials to facilitate cell therapy; transplantable tissue patches that preserve three-dimensional structure; synthetic organs generated in culture; aspects of the immune response to transplanted cells and materials; and suitable animal models for nonhuman clinical trials.

Tissue regeneration, and even stem cell therapy, is not a new concept. As discussed in the cautionary first chapter, efforts toward bone and marrow transplantation have been underway for almost half a century. Steady progress has been made in understanding the criteria for successful cell transplantation, and developing a robust structure for clinical oversight. More recently, pluripotent stem cells, with their capacity for self-renewal and tissue-specific differentiation, have become a prime candidate for tissue engineering and regenerative therapies. More than 100 clinical trials have examined the use of mesenchymal stem/stromal cells. Biochemical and mechanical interactions between the extracellular matrix and cell surface receptors, as well as physical interactions between cells, are now recognized as essential for stem cell self-renewal and differentiation. New technologies for scaffold engineering and fabrication have taken advantage of these observations, and hold promise for repairing tissues requiring a highly specialized niche, such as skeletal muscle. These discoveries have led to clinical trials with bioengineered vascular conduits in children with congenital heart disease, complete hollow organs, and complex organs such as bioartificial livers. An evolving understanding of innate and adaptive immune responses, including the foreign body response, has led to novel approaches to modulating the immune system that facilitate tissue repair. Finally, the development of small animal models for discovery, and large animal models for studies of safety and efficacy, has propelled the field of tissue engineering toward the clinic.

The chapters of this book are organized into six sections: Stem Cells, Biomaterials and the Extracellular Environment, Engineered Tissue, Synthetic Organs, Immune Response, and Animal Models. Each section is intended to build upon information presented in the previous chapters, and set the stage for subsequent sections. Throughout the chapters, the reader will observe a common theme of basic discovery informing clinical translation, and clinical studies in animals and humans guiding subsequent experiments at the bench.

I thank the members of my laboratory for their helpful discussion, and my colleagues in Pediatric Cardiology for their support – we all strive to improve the lives of our patients. I appreciate always the encouragement I receive from Tricia Foster, Nathaniel Bernstein, and Katharine Bernstein. I am grateful to the 54 colleagues who have contributed their expertise to this project. We hope that this first edition of *Tissue Engineering and Regenerative Medicine* will serve as an introduction and guide for students of the field at all levels.

San Francisco, CA

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