Stem Cell Biology and Regenerative Medicine

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Fetal Stem Cells in Regenerative Medicine

Principles and Translational Strategies

Springer

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To the patients and their families,
who may benefit from the developments
discussed in this book

To our mentors and colleagues,
who share our quest for such developments

To our families, who enrich our lives
through love, care, and understanding
amid our quest

Dario O. Fauza and Mahmud Bani

Foreword

This book brings together two important fields of science and engineering with roots in the latter part of the twentieth century and propels them into the twenty-first century. Fetal biology and fetal therapy are interwoven into the disciplines of regenerative medicine and tissue engineering. The marriage is logical from many standpoints. Developmental biology has undergone explosive growth in new knowledge and understanding. The gene programs and signaling pathways in many ways overlap with the signaling of successful regeneration of tissues. Much of this knowledge can be harnessed into new strategies to improve patient care. Engineering science stands at this nexus in many circumstances.

Fauza and Bani have carefully assembled experts in the key areas of these fields and have put together a thoughtful sequence of chapters which brings the reader through sophisticated science and technology in a coherent and readable way. New populations of stem cells including fetal stem cells, embryonic stem cells, amniotic stem cells, and placental and umbilical cord stem cells are all described and discussed. As well, their potential use in human therapy is a fundamental part of the book.

In short, this book provides a readable summary of an area in science and medicine that has the potential to transform the way we think about improving patient care and a paradigm shift in the way we approach future studies to understand developmental biology and apply that knowledge to improve the human condition.

August 25, 2015 Joseph P. Vacanti

Preface

Despite significant experimental advances, much promise, and excessive publicity, most cell-based therapies have yet to deliver meaningful impact to patient care. Conspicuous exceptions have been therapies based on amplifying the biological role played by cells in their natural environment. Evident examples are variations of blood transfusions and bone marrow transplantation. These long-established cell-based therapies have had unparalleled impacts in health care, to a large extent due to the fact that the cells involved fulfill the very same roles that they already perform in nature. Therein lies much of the appeal of fetal stem cell-based regenerative medicine, particularly as it applies to the perinatal period, during which the normal biological activities of these cells are regulated within the distinctive environment in which they already operate, aiming at therapeutic benefit. As much as fetal stem cells have shown to possess unique characteristics compared with other stem cells, so do the fetus and neonate when compared with any other age group, converging into a perfect storm that enables unparalleled biomedical discoveries, original therapeutic paradigms, and ultimate translational significance. Although fetal stem cells have been increasingly used in recipients of all ages, this book is focused on their perinatal applications, exploring the exceptionality of their fundamental roles in fetal development, arguably the purest form of regeneration. This relationship lends overt biological validation to the use of these cells in therapeutic strategies within this specific period, confirmed by prolific advances in the field. It also allows for the establishment of select service-based models of on-demand individualized stem cell processing, while validating fetal stem cell banking as clinically relevant.

In light of such tangible biological and therapeutic correlations, it is perhaps surprising that fetal regenerative medicine is still in its infancy, even when compared with its parent field. Therefore, expectedly, much of the nomenclature used has yet to be properly standardized. This is reflected in some of the chapters, which expose terminology overlaps typical of an emerging discipline, while we deliberately avoided attempts to arbitrarily systematize it. Also typical of a burgeoning field is its fluidity. This has led us to favor basic principles and general translational

strategies, as opposed to multiple, as of yet unwarranted fragmented chapters devoted to narrower specific applications, conferring a more universal nature to the book. This should appeal to a broader readership of physicians, scientists, and trainees.

We were fortunate to have attracted contributions from esteemed, highly prominent colleagues in their respective areas of expertise, to whom we are greatly obliged. We are also grateful to Michael Griffin at Springer for his patience and precious assistance throughout the preparation of this volume. Special thanks from MB to the late Andree Gruslin, a kind, passionate, and cheerful clinician-scientist who will be always remembered for her devotion to promoting regenerative medicine. A personal, deep expression of gratitude from DOF goes to Kevin and Kate McCarey for their sustained generous support, without which a number of the developments discussed herein would not have taken place.

Boston, MA, USA — Dario O. Fauza, MD, PhD
Ottawa, ON, Canada — Mahmud Bani, PhD

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Dr. Dario Fauza received his M.D. from the University of São Paulo Medical School, in São Paulo, Brazil, where he also received a PhD-equivalent degree. There, he attended an internship and residencies in both general and pediatric surgery. He then moved to the United States, where he completed postdoctoral training in different clinical and research fellowships at Boston Children's Hospital and Harvard Medical School. He is currently an Associate in Surgery and Associate Professor of Surgery at these two institutions, respectively. Dr. Fauza serves as a member of various professional organizations, including the American Academy of Pediatrics, the International Fetal Medicine and Surgery Society, the Society of University Surgeons, and the Royal College of Surgeons of England, where he received a Fellowship *ad eundem*. He has an extensive bibliography as well as a patent portfolio. His research is directed at developing original, more effective ways to repair birth defects, both pre- and postnatally. To that end, he has pioneered and explored a variety of approaches, including fetal tissue engineering and transamniotic stem cell therapy.

Dr. Mahmud Bani received his Ph.D. in neurodevelopment from the Department of Anatomy and Cell Biology at the University of Western Ontario in Ontario, Canada. Following the completion of his doctoral training, he took a postdoctoral fellowship in the Neural Stem Cell Laboratory at the Robarts Research Institute, studying neural cell fate and signaling pathways. In 2002, Dr. Bani joined the National Research Council (NRC) Canada in Ottawa, where he has established his research on the applications of stem cells in the brain. He is currently a Team Leader and Senior Research Officer in the Department of Translational Bioscience at NRC, and an Adjunct Professor in the Department of Cellular and Molecular Medicine at the University of Ottawa. Dr. Bani serves as a member of several scientific organizations and committees, including the Natural Sciences and Engineering Research Council of Canada, Ontario Institute for Regenerative Medicine, and the University of Ottawa Brain and Mind Research Institute. Dr. Bani's primary research interests are cellular and molecular mechanisms of neurogenesis and developing neuroprotective and neuroregenerative strategies for brain injury.

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