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Edited by Wenguo Cui, Xin Zhao, and Shen Liu

Biofabrication for Orthopedics

Methods, Techniques, and Applications

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Volume 1

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Volume 1

Foreword from Prof. Changsheng Liu

I would like to thank Profs Wenguo Cui, Xin Zhao, and Shen Liu for inviting me to write this foreword. I am honored to take part in the knowledge exchange of our scientific culture, as well as to promote training of our students and professionals.

With the rapid development of biomaterials and biofabrication technologies, a variety of biomaterials have been made for the repair and regeneration of bone, muscle, tendon, and other orthopedic tissues and organs. This book focuses on the current state of biofabrication technologies and materials in orthopedics biomedical applications. The various highlights of this book include a comprehensive analysis of different biofabrication methods for constructing relevant biomaterials in the orthopedics field, with an emphasis on the recent developments of technologies involving 3D printing, bioceramic, electrospinning, microfluidics, bioactive glass, etc. A detailed look into these biofabrication techniques using different biomaterials is also included in terms of functional performance, advantages, and disadvantages for repairing and regeneration in orthopedics, of which the choices of biomaterials are especially critical since their applications must be based on a thorough knowledge of the anatomy and physiology of the bone, muscle, and adjacent tissue. With the content being organized clearly, practically, rigorously, and most importantly, up to date with current knowledge, this review will therefore provide the research community a reference source for current approaches to biomaterials and scaffold preparation in orthopedics, as well as to reinforce our readers' understanding of materials' biomedical applications in orthopedics.

In essence, this book is clear and well written in a way that provides highly useful and relevant content to support trained orthopedic doctors and biomaterial researchers. This helps give the readers the basis of the preparation of a variety of biomaterials and thus enhance the understanding of their

application in orthopedics. Through this book, the authors have faith that the readers and researchers can generate next-generation biomaterials for orthopedic applications.

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Foreword from Prof. Yingze Zhang

In the past decades, traditional orthopedic metal implants such as plates and rivets have benefited many patients with orthopedic diseases. However, problems such as mechanical failure and poor efficacy always exist, which need to be solved through innovation. Nowadays, interdisciplinary convergence and cross-border integration of several technologies are becoming the norm and will continue to give birth to the forefront of new disciplines. Thanks to the development of tissue engineering and regenerative medicine, a large number of new materials and technologies with great application prospects in orthopedic medicine have emerged, providing new opportunities for the diagnosis and treatment of orthopedic diseases.

This book systematically demonstrates the widely popular and eye-catching biomaterials and biofabrication technologies, explains in detail their advantages and disadvantages in orthopedics, and lists their applications in the repair of bone, muscle, ligament, tendon, and other orthopedic organs.

Each chapter of this book emphasizes the impact of advanced materials and biofabrication technologies in the field of orthopedics, including how biofabrication affects all substances used in bone implants (from 3D printing to electrospinning and microfluidic technology). One of the highlights of this book is apparently to cover the most innovative biomaterial manufacturing technologies and emphasizes the safety of biofabrication that we have not fully understood and need to develop solutions. It also provides concise reasons on why we should consider using these materials to complete the regeneration and repair of orthopedic systems, discussing in-depth beyond the typical trial-and-error thinking of traditional orthopedics.

The editors and authors of this book hope to enrich readers and researchers in the field of orthopedics, orthopedic biomaterials, and their clinical applications, and in my opinion, this book is certainly a must-have for all those who want to create new solutions to the most stubborn problems in orthopedics, so that we can improve the quality of life for patients of implants with novel biofabrication technologies. We believe that new orthopedic biofabrication technologies for bone tissue regeneration and a better understanding of the interface between biomaterials and

adjacent tissues will be an important part of orthopedic biomaterials and implants in the future for better orthopedic surgery.

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Foreword from Prof. Lianfu Deng

With the rapid development of medical science and engineering technology, the field of orthopedics has also made great progress. In recent years, biomaterial implants have been widely used in the replacement treatment or adjunctive therapy of injured bones to replace, support localization, or repair human bones, joints, and soft tissues. The clinical demand for orthopedic implanted medical devices has been maintaining a rapid growth rate. However, due to the differences in disease or injury types, the demand for personalized design and fabrication of biomaterials and biomaterials with specific functions is also increasing. This also greatly promoted the development of orthopedic materials through biofabrication technology.

The continuous innovation and development of biomaterial fabrication technologies (3D (three-dimensional) bioprinting, electrospinning, and microfluidic) have improved the utilization of biomaterials, including the fabrication of complex 3D structures, the improvement of biomaterial interface and cell interaction, and the development of controlled drug-release systems. The development and biofabrication of advanced biomaterials in orthopedics field covers the interdisciplinary study of materialogy, tissue engineering and regenerative medicine, cell and molecular biology, and clinical medicine. The biofabrication techniques bridge basic research and clinical treatment, help to accelerate the orthopedic basic scientific research to the engineering application of the industrialization process, and promote the development of targeted treatment strategies for different orthopedics diseases or injuries. It is meaningful to advance the development progress of translational medicine.

It is timely to compile this book on advanced fabrication technology of biomaterials and its application in orthopedics. This book summarizes the latest scientific research progress and development trend of orthopedics worldwide, aiming to track the frontier of the discipline, introduce advanced theories and technologies, and promote the development of orthopedics and orthopedics technology. This book will help doctors, researchers, and students of medical specialty to

have a good command of the design, fabrication, and application of biomaterials as well as the regulatory mechanism of bone regeneration process and better understand the development direction of biological fabrication and orthopedic technology.

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Foreword from Prof. Cato T. Laurencin

It is always a great privilege to be invited to write a foreword for a book. Moreover, when the book enlarges our scientific knowledge and viewpoints while promoting the training of our students and professionals, it is even more welcome. I am therefore more than happy to provide my insights regarding such books.

The convergence of the life, physical, and engineering sciences has led to the creation of a new multidisciplinary field, which I have termed as "regenerative engineering." Orthopedic surgery is a prominent field that stands to gain from the insights of regenerative engineering. In particular, biofabrication techniques developed in this field applying the principles of regenerative engineering have the potential of bringing revolutionary treatments to clinical practice. This book summarizes important aspects of biofabrication techniques for orthopedic surgery and offers valuable information of state-of-the-art technological advancements that can ultimately become a practical toolbox for physicians, scientists, and engineers. While traditional orthopedic surgery books cover conventional strategies, this book focuses on newer biological strategies such as bioprinting, stem-cell therapy, and organ-on-a-chip technology. The chapters encourage readers to examine and embrace novel technologies to address clinical challenges. The content is well organized while covering a wide range of related fields. The knowledge and information provided by all the contributors are up to date, covering comprehensively technological aspects as well as clinical applications involved in orthopedic surgery practice.

The editors of this book, Profs Wenguo Cui, Xin Zhao, and Shen Liu, have assembled an excellent team and have created an important contribution to our field. The contributors to this book are respected scholars and professionals that come from a broad background including orthopedic surgery, biomedical engineering, stem-cell biology, and physics. This allows the book to have insights regarding the current status and future trends of this field.

Scientific books must evolve to capture important aspects of the corresponding fields. This book is published at the right time when many exciting new biofabrication technologies have arisen, many of them inspired by the field of regenerative

engineering. I congratulate again the editors of the book. This well-organized contribution to the world's literature will be relevant to scientists, engineers, and clinicians everywhere.

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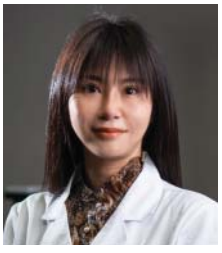
Preface

Wenguo Cui



Xin Zhao

Shen Liu

Bone, as one of the most essential organs in the body, not only supports the stability of body along with protection of other organs, but also provides hematopoietic function and stores minerals such as calcium and phosphorus. Unfortunately, when some damages/diseases, such as fracture, osteoarthritis, and osteoporosis, appear in the bones, these functions will be disrupted, leading to the systemic responses as seen clinically. Researchers are therefore proposing to develop techniques to remodel the damaged/diseased bone functions. Last decades, biofabrication techniques, including three-dimension (3D) bioprinting, 3D printing, electrospinning, microfluidics, and stem-cell therapy, have been widely applied in tissue regeneration. Some products of these biofabrication techniques were even commercialized, such as Absorb GT1 and XinSorb. *Biofabrication for Orthopedics – Special Topic* in Wiley mainly focuses on the development of biofabrication and applications in orthopedics, comprising 20 chapters in total, as detailed below.

Areas Covered in the Special Topic

The book starts with the two popular biofabrication techniques in the recent decades, namely, translational 3D bioprinting and 3D printing, which are comprehensively reviewed by Xiao and colleagues in the choice of bioink, cell types, the