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*Editors*

# Fundamentals of Tissue Engineering and Regenerative Medicine

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Ulrich Meyer · Thomas Meyer  
Jörg Handschel · Hans Peter Wiesmann  
(Eds.)

# Fundamentals of Tissue Engineering and Regenerative Medicine

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## Preface

The man-made creation of tissues, organs, or even larger organisms was for a long time a matter of myth and dream throughout the history of medicine. It now comes into clinical reality. Tissue engineering and regenerative medicine are the terms that are nowadays used to describe the approach to generate complex tissues and organs from simpler pieces. Both are multidisciplinary, young and emerging fields in biotechnology and medicine, which are expected to change patient treatment profoundly, generating and regenerating tissues and organs instead of just repairing them. There is much promise and expectation connected to this biomedical discipline regarding improved treatment possibilities, enhanced quality of the patient's life, and the ability to overcome in a future perspective the need for major grafting procedures. It is anticipated that this biotechnology has also a high economical impact on clinical medicine. To fulfil these expectations several challenges concerning scientific, technological, clinical, ethical, and also social issues need to be met. Basic research still requires the evaluation and elaboration of fundamental processes and procedures in multiple research fields. However, first bioengineered products have already been introduced in the markets, and much more are in the preclinical stage, and many companies are involved in this area.

In addition to having a therapeutic application, where the tissue is either grown in a patient or outside the patient and transplanted, tissue engineering can have diagnostic applications where the tissue is made *in vitro* and used for testing drug metabolism and uptake, toxicity, and pathogenicity. The foundation of tissue engineering/regenerative medicine for either therapeutic or diagnostic applications is the ability to exploit living cells in a variety of ways. Whereas tissue engineering is a more technical concept of tissue and organ reconstruction by the use of cells, scaffolds, and biomolecules, the term regenerative medicine is more focused on the support of self healing capabilities and the use of stem cells. Medicine-oriented stem cell research includes research that involves stem cells, whether from human, non-human, embryonic, fetal, or adult sources. It includes all aspects in which stem cells are isolated, derived, or cultured for purposes such as developing cell or tissue therapies, studying cellular differentiation, research to understand the factors necessary to direct cell specialization to specific pathways, and other developmental studies. In this sense it does not include transgenic studies, gene knock-out studies, nor the generation of chimeric animals.

Both concepts (tissue engineering and regenerative medicine) of cell, tissue, or organ regeneration and reconstruction are based on an multidisciplinary approach bringing together various scientific fields such as biochemistry, pharmacology,

material science, cell biology, and engineering and clinical disciplines. The promising biotechnology, now introduced as a new clinical tool in the restoration of lost tissues or the healing of diseases, is assumed to change treatment regimes and to contribute significantly to clinical medicine in future decades. A lot of current limitations seem most likely to be overcome in the near future, suggesting that tissue engineering as well as regenerative medicine strategies will replace other therapies in routine clinical practice.

The fast growth of the tissue engineering and regenerative medicine discipline is mirrored by the high number of excellent research papers covering all aspects of these fields. Additionally, numerous high quality books are available describing in detail different aspects of tissue engineering or regenerative medicine. Despite the fact that such literature is already available, we decided to edit a book on tissue engineering and regenerative medicine. There were three reasons for this decision: during our experimental and clinical work on tissue regeneration and reconstruction, with our main focus on bone and cartilage engineering, which we have done for more than a decade in our clinics as well as in our interdisciplinary biomineralization and tissue engineering research group, we observed that many specialists of the different fields, involved in approaching this area, had difficulties in overviewing the complexity of the field. We therefore intended to edit a comprehensive book covering all major aspects of this field. Secondly, during the last decade a shift and, at the same time, interdentation was seen between the tissue engineering field and the field of regenerative medicine (with a main focus on stem cell research). In recent years stem cell research and use was applied with tissue engineering techniques and the border between both areas therefore blurred. This fusion is mirrored also by the emergence of new societies (for regenerative medicine) or the renaming of the most influential society (Tissue Engineering and Regenerative Medicine Society, formerly the Tissue Engineering Society International). Therefore, there was a need to integrate both aspects in one book. Thirdly, as tissue engineering brings together basic researchers, mainly having a biological, biophysical, or material science-oriented background, with clinically oriented physicians, we found that they differed in the used “language.” In this text book the contributors tried to use a uniform terminology as a common platform for discussions across the borders of medical subspecialities.

*Fundamentals of Tissue Engineering and Regenerative Medicine* is intended not only as a text for biomedical engineering students and students in all fields of tissue engineering and cell biology, and medical courses at basic and advanced levels, but also as a reference for research and clinical laboratories. In addition, a special aim of this book was to define the current state of tissue engineering and regenerative medicine approaches which are applied in the various clinical particular specialities. We have therefore conceptualised the book according to a methodological approach (social, economical, and ethical considerations; basic biological aspects of regenerative medicine; classical methods of tissue engineering (cell, tissue, organ culture, scaffolds, bioreactors); and a medical discipline-oriented approach (application of these techniques in the various medical disciplines). Since during the last years these therapeutic options have been introduced in clinical treatment decisions, this book gives profound basic tissue engineering information (as how to generate and regenerate tissues and organs) and at the same time the medical specialist will find detailed information on the state of regenerative medicine in his/her discipline. The text of this book is supported by numerous

tables, schematic illustrations, and photos in order to provide a better understanding of the information offered in this book. As the recent detailed knowledge in tissue engineering and regenerative medicine far exceeds the content of a book, we have tried to find a compromise between a comprehensive depiction of this new biomedical field and one that is manageable for the reader.

The expertise required to generate this book far exceeded that of its editors. No single expert, to date, is able to have detailed insight into all aspects of this fast growing and complex biomedical field. The content of the book represents the combined intellect and experience of more than one hundred researchers and clinicians, all of them outstanding specialists in their field. Their fundamental work has not only set the basis for the tremendous advances in this biotechnology field but has also given patients new and fascinating treatment options in clinical medicine.

Finally, we believe that, especially today, it is important to understand and reflect the current limitations of the field. The expectations must be aligned with scientific and, perhaps more importantly, ethical considerations and reflections. Given that stem cell use is a mainstay in regenerative medicine, a special focus is given to ethical as well as theological considerations. In addition to the impressive speed with which the advances in tissue engineering and regenerative medicine during the last decade have made a clinical impact on the treatment of many diseases, a fascinating aspect of this area of biotechnology is that it is a model of how basic biology is closely connected with and directly transferred to clinical medicine.

We hope this book will add further stimulus for all basic researchers and clinicians who are involved in investigating and applying tissue engineering and regenerative medicine techniques and will contribute to make this an attractive and reliable alternative treatment option in medicine.

*Ulrich Meyer*  
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