BIOREACTORS FOR TISSUE ENGINEERING

Bioreactors for Tissue Engineering

Principles, Design and Operation

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Legend for front cover photographs:
Upper left: Fibroblast cells growing on a collagen matrix
Upper right: Schematic of the pulsatile tissue engineered heart valve bioreactor
Lower left: Minibioreactor perfusion chamber
Lower right: Scanning electron micrograph of a poly(lactic acid-co-glycolic acid) hollow fiber

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PREFACE

The emerging field of tissue engineering represents the integration of concepts and ideas from the biological sciences, engineering disciplines, material science and clinical procedures. Therapies are being developed and tested in clinical trials, with the potential to help patients suffering from the loss of tissue or its function. Engineering tissues, for example bone, cartilage, blood vessels and liver, involves three key factors. Firstly, the cell source is of paramount importance. Although there has been much interest in the use of autologous cells to treat individual patients, the field has recently refocused on the potential inherent in the use of progenitor or stem cells, and their application in many forms of regenerative medicine including tissue engineering. A second factor is the design of appropriate scaffolds to mimic the role of the extracellular matrix. This is a burgeoning field where both natural and synthetic materials are being developed with enhanced cell adhesion and proliferation properties. Finally, tissue engineering relies on appropriate cell and tissue cultivation methods – at the core of which lies the bioreactor.

To date, engineered tissues have been made possible through innovations in cultivation technology and bioreactor engineering. These new therapies will need to utilise the achievements made in the last few decades in developing high performance bioreactors for the production of pharmaceutical products, particularly those derived from mammalian cell culture, which in turn demands understanding of the hydrodynamic and biochemical factors in the cell and tissue environment. In tissue engineering, the situation is made more complex by the need to generate the correct three-dimensional architecture of the tissue in order to restore function.

Bioreactor design, control and operation are well established in engineering disciplines, but they are relatively new to biology and medicine. Hence, an engineering approach to the development of functional tissue equivalents will require a new breed of interdisciplinary researchers well trained at the biology/engineering interface. While many of the obstacles to the development of 3D functional tissue construct appear formidable, none are insurmountable provided an appropriate approach to the design, characterisation and operation of the bioreactor environment is used.

This book brings together the knowledge and experience of researchers who are applying engineering principles of bioreactor cultivation of cells/tissues to the in vitro generation of functional tissue constructs. The aim of this book is to provide the reader with a number of contributions that map out the breadth of topics that are being considered with respect to providing advanced culture systems for regenerating tissue. Individual chapters discuss concepts that will be important in the development of reactors that can be use for production of clinical scale tissue. Some chapters are general in that they provide state of the art reviews of specific reactors that can be applied to several tissue types. Other chapters focus on individual tissues and describe innovations being made towards growing functional tissue. A key feature of tissue bioreactors that is represented in this volume is the use of mechanical forces during tissue culture to condition the nascent tissue, thereby giving rise to in vivo-like function. Finally, the breadth of the bioreactor field is illustrated through the use of MRI techniques for evaluating tissue during growth,

and also the cryopreservation of the cultured tissue so it can be stored and transported for clinical use.

The material is addressed primarily to those interested in tissue engineering, but many topics will also be of interest to cell culture technologists and biochemical engineers, in both academia and industry. It is hoped that this book will stimulate the development of new ideas emerging from this exciting interface between engineering and the life sciences. Finally, the editors are grateful for the support of all the contributors and the publisher who have made this book possible.

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Mohamed Al-Rubeai