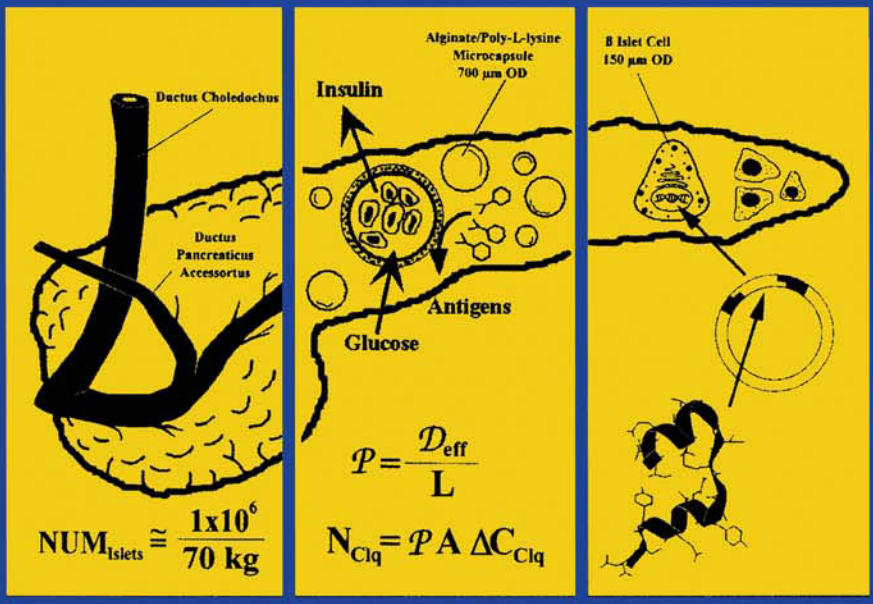
FRONTIERS IN TISSUE ENGINEERING



Edited by
Charles W. Patrick Jr, Antonios G. Mikos and Larry V. McIntire

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Cover Illustration: Tissue engineering involves a synergistic coupling of the disparate fields of engineering, life science, and clinical science. The illustration depicts a pancreas viewed from each field's vantage point in the following order, left to right: clinical science (anatomy and transplantation of pancreas), engineering (encapsulated islets releasing insulin), and life science (upregulation of insulin secretion via genetic engineering). Illustration by C.W. Patrick Jr.

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Preface

The beauty of the human form has been the subject of countless artistic masterpieces through the ages, the focus of exquisite poetry and central to every art form. However, it can also be considered the most elegant and sophisticated of machines. As with all machines, wear and tear occurs with aging and accidents can happen. With living machines, disease processes can also occur which can lead to destruction of tissues. It is the role of reconstructive surgeons to help patients who are afflicted with disease, trauma, or malfunction due to aging. Reconstructive surgical procedures have been developed over the last century to replace human tissues and organs so that people can return to a good quality of life or, in the case of many operations, to save life. Current reconstructive strategies include replacement of defective body parts with totally prosthetic devices, transfer of one tissue to another site or transplantation of organs and tissue from one individual to another when that becomes necessary. These techniques have improved and saved countless lives. However, all have limitations.

The fundamental roadblock to future improvements is the lack of sufficient tissue for ideal structural replacement to produce functional normalcy. It has been estimated that in the United States alone, the care of patients with tissue malfunction and loss can exceed one-half of a trillion dollars annually. It is this need that has driven the emergence of the field of Tissue Engineering. The concept of the rational design and fabrication of living tissues and organs for repair and replacement is relatively new, emerging within the last quarter of this century. The field has brought together diverse scientific and clinical areas. Clinical physicians and surgeons are working hand-in-hand with basic scientists in the fields of molecular and cell biology, biochemistry and the engineering fields of chemical engineering and materials science. This unique grouping has produced dramatic experimental examples that are shedding knowledge in the areas of new tissue fabrication, implantation and function. From its inception, the field has also brought the business community in contact with the academic community. As well, the regulatory agencies have been involved with the rigorous design and safe implementation of clinical trials. This broad representation of the medical, scientific, industrial and regulatory community is detailed in this book. The book is divided into three parts including the fundamentals and the methods of tissue engineering, tissue engineering applied to specialized tissues and tissue engineering applied to organs. The book has taken on an enormous task of providing a comprehensive overview of this emerging field and communicating the excitement felt by its many participants. No one can predict the future of any new scientific endeavor at its early stages, but if enthusiasm were an

important component, then this field promises to bring hope to many people who are afflicted with serious disease or injury.

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SECTION I

PROSPECTUS OF TISSUE ENGINEERING

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CHAPTER I

Prospectus of Tissue Engineering

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1 Tissue engineering defined

Tissue engineering is a relatively new and emerging interdisciplinary field that applies the knowledge of bioengineering, the life sciences, and the clinical sciences towards solving the critical medical problems of tissue loss and organ failure. It involves applying engineering principles of transport and reaction phenomena as well as methods of analysis towards understanding the complex biological processes that occur in tissue development and repair. Frequently, knowledge of molecular phenomena and cellular interactions with surface, biochemical, and mechanical environments are employed. Tissue engineering has been formally defined as 'the application of the principles and methods of engineering and the life sciences toward the fundamental understanding of structure-function relationships in normal and pathological mammalian tissues and the development of biological substitutes that restore, maintain, or improve tissue function' [1]. Implied in the above is the essence of tissue engineering: the use of living cells,