Biopolymer Methods in Tissue Engineering

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Preface

There is an urgent need to develop new approaches to treat conditions associated with the aging global population. The surgeon's approach to many of these problems could be described as having evolved through three stages:

Removal: Traditionally, diseased or badly damaged tissues and structures might simply be removed. This was appropriate for limbs and non-essential organs, but could not be applied to structures that were critical to sustain life. An additional problem was the creation of disability or physical deformity that in turn could lead to further complications.

Replacement: In an effort to treat wider clinical problems, or to overcome the limitations of amputation, surgeons turned to the use of implanted materials and medical devices that could replace the functions of biological structures. This field developed rapidly in the 1960s and 1970s, with heart valve and total joint replacement becoming common. The term "biomaterial" was used increasingly to describe the materials used in these operations, and the study of biomaterials became one of the first truly interdisciplinary research fields. Today, biomaterials are employed in many millions of clinical procedures each year and they have become the mainstay of a very successful industry.

Renewal: Although there were impressive results associated with the use of biomaterials and medical devices, problems remained. The human body did not always accept the presence of a foreign substance, and this could ultimately cause the failure of a medical device. Despite extensive research, long-term failure of medical devices and the need for subsequent revision surgery is a major problem. Throughout the entire history of biomaterials research and development, we have always known that the best materials in the body are healthy human tissues. This has in turn encouraged a reappraisal of our approach to the treatment of trauma and the general degeneration of the aging individual. Surgeons would now like to use healthy living tissues to replace diseased ones, a process best described as "renewal." The emerging field of tissue engineering, in which living tissue is grown in a laboratory before subsequent therapeutic application, is one area of great promise in the search of a solution. Most tissue engineering research, along with the current first generation products, requires some form of biomaterial support or scaffold during culture and/or delivery to the patient.

The scientific discipline of tissue engineering could therefore be described as having originated from (and is still dependent on) the application of biomaterials in medicine. What is perhaps less obvious is that the future of the biomaterials and medical device industry has become closely intertwined with the growth of tissue engineering as a viable therapeutic concept. Tissue engineering has the potential to reduce the need for traditional biomaterials, and may ultimately render many medical devices obsolete.

The recent shift in emphasis away from biomaterials and towards tissue engineering is illustrated by changing patterns of research output. Figure 1 shows a simple analysis of papers published during the last 40 yr of the 20th century. There was a steady growth over that period in the annual number of papers with "biomaterials" as a key word or title word. The phrase "tissue engineering" was not cited in the literature until the mid-1980s and during the 1990s there was an explosion of interest in this emerging field. Indeed, by the dawn of the new millennium there were more papers being published using the term "tissue engineering" than "biomaterials." If research activity provides an insight into the future of technology, then tissue engineering will undoubtedly revolutionize the treatment of disease in the near future.

The application of biomaterials in tissue engineering is a truly interdisciplinary endeavor, involving experts in chemistry, chemical engineering, cell biology, matrix biochemistry, biomechanics, and clinical medicine. In many cases, scientists with a highly focused expertise in one discipline are having to cross boundaries into completely new areas.

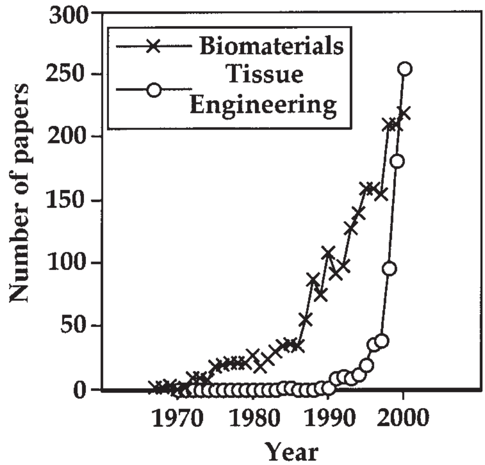

Fig. 1. Publication rates in biomaterials and tissue engineering.

Biopolymer Methods in Tissue Engineering constitutes a major consolidation of the basic methodologies from many of the scientific fields investigating biomaterials into a single volume. Different accounts of several of the approaches included here may be available in other forms elsewhere in the literature, however we hope that our book will serve as a basic laboratory manual allowing tissue engineering scientists not only to access a wide range of techniques in one place, but also to have them described using a standard format.

The chapters are organized into three clear groups. There are nine chapters dealing with the synthesis, processing, and characterization of specific biomaterials. The next four chapters provide details on the successful use of some of these scaffolds for the engineering of tissues. The last six chapters provide a range of techniques that can be used to evaluate the biological quality of tissues that have been engineered on scaffolds. We consider the rigorous assessment of tissue quality to be particularly important since it is often neglected in published accounts of tissue engineering.

We hope that readers of *Biopolymer Methods in Tissue Engineering* will find it a valuable reference manual for day-to-day use in their laboratories. We are indebted to all the international experts included among the chapter authors who have taken enormous trouble to prepare their important contributions to this volume.

Anthony P. Hollander
Paul V. Hatton

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Color Plates

Color plates 1–4 appear as an insert following p. 112.