Cell Instructive Polymers

Takuya Matsumoto · David J. Mooney (✉)

Division of Engineering and Applied Sciences, Harvard University, 29 Oxford Street, Cambridge, MA 02138, USA
tmatsu@deas.harvard.edu, mooneyd@deas.harvard.edu

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Abstract Polymeric materials used in tissue engineering were initially used solely as delivery vehicles for transplanting cells. However, these materials are currently designed to actively regulate the resultant tissue structure and function. This control is achieved through spatial and temporal regulation of various cues (e.g., adhesion ligands, growth factors) provided to interacting cells from the material. These polymeric materials that control cell function and tissue formation are termed cell instructive polymers, and recent trends in their design are outlined in this chapter.

Keywords Cells · External stimuli · Growth factors · Synthetic extracellular matrix

Abbreviations
BMP bone morphogenetic protein
CAD/CAM computer-aided design/computer-aided manufacturing
CT computer tomography
DDS drug delivery system
ECM extracellular matrix
EGF epidermal growth factor
FDM fused deposition molding
FGF fibroblast growth factor
G α-L-guluronic acid
GAG glycosaminoglycan
1 Introduction

A new research field in which cells are seeded into materials in order to build new biological tissues was started in the 1980’s [1, 2], and this approach has since come to be recognized as one of the major strategies in the new field of tissue engineering [3]. Success in this approach to tissue engineering is based on advances in both life sciences (e.g., cell biology) and engineering (e.g., biomaterials science), as both are crucial to the strategy. Initial tissue engineering efforts typically utilized materials solely to carry cells to the desired anatomic location and/or to control the gross size and shape of the engineered tissue, and these efforts were highly successful in forming several new tissues and providing insight into the process of tissue formation [4, 5]. However, controlling this process to achieve the desired tissue structure and function, and adapting this approach to the construction of complex organs comprised of multiple cell types and tissues remain major challenges.

Tissues are typically built from several types of cells with tissue specific composition and alignment in both two and three dimensions, and contain a similarly tissue-specific extracellular matrix (ECM). For example, cells lin-