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Understanding of essential hydrogel in Medicine

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Abstract

Hydrogels have been extensively investigated as biomaterials because of their excellent biocompatibility, and recent developments such as 3D printing and the incorporation of dynamic crosslinks have advanced the field considerably. However, the next step of in vivo translational biomedicine requires an understanding of essential hydrogel properties so that they can be designed to overcome the challenges of the living environment. In this review, the stringent design criteria required for in vivo applications are highlighted and recent advances in the repair of organ tissues (heart, bone, eye, etc.) and the therapeutic delivery of bioactive molecules are described. Technological innovations and advances in scientific understanding have created an environment where data can be collected, analyzed, and interpreted at scale, ushering in the era of personalized medicine.

Introduction

The ability to isolate cells from individual patients offers tremendous promise if those cells can be used to generate functional tissue replacements or used in disease modeling to determine optimal treatment strategies. Here, we review recent progress in the use of hydrogels to create artificial cellular microenvironments for personalized tissue engineering and regenerative medicine applications, as well as to develop personalized disease models. Continued progress in the development of engineered hydrogels, in combination with other emerging technologies, will be essential to realize the immense potential of personalized medicine.

Analysis

The field of regenerative medicine has tremendous potential for improved treatment outcomes and has been stimulated by advances made in bioengineering over the last few decades. The strategies of engineering tissues and assembling functional constructs that are capable of restoring, retaining, and revitalizing lost tissues and organs have impacted the whole spectrum of medicine and health care. The high water content of hydrogels can provide an ideal environment for cell survival, and structure which mimics the native tissues. Hydrogel systems have been serving as a supportive matrix for cell immobilization and growth factor delivery. This review outlines a brief description of the properties, structure, synthesis and fabrication methods, applications, and future perspectives of smart hydrogels in tissue engineering. Understanding cell behavior within the extracellular matrix is essential for the implementation of biomaterials in medical applications. Conjugation of bioactive molecules to hydrogel scaffolds imparts the materials with biological cues necessary for controlling cell behavior such as adhesion, growth and migration. Photo-induced ligation is a powerful tool to precisely control when and where such bioactivity can be initiated. In this approach, reactive groups such as thiol, amine and aldehyde are masked with photolabile moieties, which can be photo-released to participate in click reactions, such as Michael addition and oxime ligation. New chromophores with long wavelength visible light absorption are also examined for potential employment in light-induced bioconjugation.

Conclusion

In tissue engineering, i.e., in combined advanced technologies to replace damaged or missing parts of living tissues, emerging strategies strongly point toward the use of hydrogels also for their ability of being vehicles for local controlled drug delivery. The investigation of drug release mechanisms in such matrices thus plays a key role in the design of smart system but literature is still very controversial on theoretical interpretations and understanding of available data. The proportion of this effect was directly linked to hydrogel mesh size, thus carrying intrinsic novelty, but also complexity, and suggesting that not only strictly hydrodynamic effects should be considered but also electrostatic interactions between polymer chains and drug molecules might be key players in avoiding fluorescein aggregation and also affecting diffusivity.