Functional biomaterials

Cite as: APL Bioeng. 6, 010401 (2022); https://doi.org/10.1063/5.0078930
Submitted: 16 November 2021 • Accepted: 22 November 2021 • Published Online: 03 January 2022

Wenguo Cui, Hélder A. Santos, Boyang Zhang, et al.

COLLECTIONS

Paper published as part of the special topic on Functional Biomaterials
This paper was selected as Featured

ARTICLES YOU MAY BE INTERESTED IN

Skin-on-a-chip models: General overview and future perspectives
APL Bioengineering 5, 030901 (2021); https://doi.org/10.1063/5.0046376

Roadmap on organic–inorganic hybrid perovskite semiconductors and devices
APL Materials 9, 109202 (2021); https://doi.org/10.1063/5.0047616

A scalable 3D tissue culture pipeline to enable functional therapeutic screening for pulmonary fibrosis
APL Bioengineering 5, 046102 (2021); https://doi.org/10.1063/5.0054967
INTRODUCTION

A biomaterial is generally defined as "a substance that has been engineered to take a form which, alone or as part of a complex system, is used to direct, by control of interactions with components of living systems, the course of any therapeutic or diagnostic procedure, in human or veterinary medicine.” While the field as a whole has existed for over half a century, it is really in the past couple decades that we have witnessed an exciting growth in the development of various functional biomaterials. These biomaterials are designed to possess intended functionalities, showing enhanced capacities for tackling numerous human health-related problems. Such advances in the field have also suggested that the concept of biomaterials is likely an evolving subject that should be dynamically refined. Many substances that were excluded from the definition of biomaterials may later, on the contrary, be included due to these new developments, in particular with the evolution of functional biomaterials.

Some examples of functional biomaterials span from those that are traditional, such as structural biomaterials serving as scaffolds for engineering tissue constructs, mechanically modulated biomaterials for enhancing biomaterial–tissue interactions, and nanobiomaterials allowing disease theranostics, to the more recently trending biomaterials that enable three-dimensional (3D) bioprinting, organ-on-a-chip applications, immunomodulation, extracellular vesicle research, vaccine delivery, and anti-viral performances, among others.

The Functional Biomaterials Special Topic in APL Bioengineering is therefore intended to focus on the latest advancements in functional biomaterials featuring a collection of 15 articles in total, as detailed below.

TUNING PHYSICOCHEMICAL PROPERTIES OF BIOMATERIALS

The collection starts with the older concepts of mechanobiological modulations and topographic controls of cellular functions. Boghdady and colleagues highlight the role of tensegrity in tissue dynamics across multiple scales of homeostasis, morphogenesis, and pathological dysfunctions. Subsequently, the review by Cui and colleagues summarizes how hydrogel surface patterning-induced topographic features may affect their physicochemical and biological properties, and accordingly, the cellular interactions. Specific applications of mechanotransduction were demonstrated by Marinval and Chew and by Shi and colleagues, respectively, surrounding neuronal tissue and cardiac tissue.

ENGINEERING BIOMATERIALS AT MULTIPLE SCALES

Properly engineering biomaterials to endow them with functions at the desired scales or across multiple scales is a long-investigated subarea of the field yet is full of challenges. The selection of papers continues with an overview of biomaterials-engineering platforms, including but not limited to bioprinting, microfluidic devices, and biostimulatory systems, for enhanced cell-based therapeutics when used in combination with cellular reprogramming technologies, provided by Jin and Cho. Song and colleagues follow with another comprehensive review on enzyme-mediated crosslinking to fabricate hydrogels that feature improved biological functions. Two specific exemplary tissue types bioengineered using advanced biomaterials and biofabrication methods then ensue, by Blake and colleagues on bioprinting for muscular...
tissue engineering\textsuperscript{17} and by Kim and Jang on recreating the 3D micro-environmental niches for modeling the diabetes mellitus.\textsuperscript{19}

Beyond macroscale and microscale manipulations of biomaterials, nanobiomaterials, as an enabling class of biomaterials, are also instrumental in healthcare applications. To this end, Aronson and colleagues summarize peptide-functionalized liposomes towards receptor-targeted cancer therapy.\textsuperscript{18} This is followed by the review by Ma and colleagues detailing functional biomanomaterials for cellular surface engineering put forward to utilities in cancer immunotherap.\textsuperscript{19} Xu and colleagues subsequently showcase the possibility of non-invasive remote neuro-stimulation with physical fields enabled by nanomaterials.\textsuperscript{20} Beyond therapeutic capacities, nanobiomaterials can also serve as facile contrast agents to facilitate better theranostics, such as with the use of photoacoustic imaging, as reviewed by Park and colleagues.\textsuperscript{21}

**FUNCTIONAL BIOMATERIALS USED TOWARD WOUND DRESSING**

Wound-dressing has been an important area of biomaterials research due to its prevalence in the treatment of injuries or diseases. Zhu and colleagues provide a critical analysis on the complicated tissue reactions and tissue–biomaterial interactions following implantation, which is hoped to help the readership understand these cascades of events, allowing the development of better grafts possessing promoted biocompatibility and functions.\textsuperscript{22} Pan and colleagues then, in another review, discuss polymer-based hydrogel biomaterials utilized towards hemostasis-control and wound-dressing.\textsuperscript{23} Gao and colleagues further narrow down the scope by specifically describing stimuli-responsive and multi-functional hydrogels that are suitable for the management of diabetic wounds,\textsuperscript{24} concluding the Special Topic.

**CONCLUSIONS**

In summary, the Special Topic on Functional Biomaterials collects a diverse selection of articles to provide a glimpse into both the histories of many aspects of the field and the most recent advancements of how these different areas might have been evolving in the past few years. These insights will hopefully allow the readership to gain a better understanding of functional biomaterials as a whole and inspire readers to carry out additional exciting research around the topic, further pushing its boundaries.

**ACKNOWLEDGMENTS**

We would like to express our sincere appreciation to all the authors who have contributed to this collection of articles. Gratitude also goes to our journal editors, staff, and reviewers, who have truly made the collection possible in the first place while ensuring the quality of all the papers included.

**DATA AVAILABILITY**

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

**REFERENCES**

\textsuperscript{1}D. F. Williams, \textit{Biomaterials} \textbf{30}(30), 5897 (2009).
\textsuperscript{4}W. L. Murphy, T. C. McDevitt, and A. J. Engler, \textit{Nat. Mater.} \textbf{13}(6), 547 (2014).
\textsuperscript{13}L. Cui, Y. Yao, and E. K. F. Yim, \textit{APL Bioeng.} \textbf{5}(3), 031509 (2021).
\textsuperscript{17}W. Song, J. Ko, Y. H. Choi, and N. S. Hwang, \textit{APL Bioeng.} \textbf{5}(2), 021502 (2021).