Materials Advances

ROYAL SOCIETY OF CHEMISTRY

EDITORIAL

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Cite this: *Mater. Adv.*, 2024, 5, 4539

Introduction to Biomaterials in Innate Immunity

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DOI: 10.1039/d4ma90056a

rsc.li/materials-advances

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Erika Moore

Dr Erika Moore is an Assistant Professor within the Fischell Department of Bioengineering at the University of Maryland, College Park. Her academic journey began with a Bachelor's degree in Biomedical Engineering from Johns Hopkins University in 2013, followed by a PhD in Biomedical Engineering from Duke University in 2018. As the Principal Investigator of the Moore lab, Dr Moore is dedicated to engineering biomaterial models that harness the regenerative potential of the immune system, particularly focusing on the pivotal role of macrophage immune cells in tissue repair and regeneration. Her research focuses on health inequities, spanning age-associated macrophage function, macrophage-vasculitis mediation in lupus, and macrophage integrin ligand interactions with the extracellular matrix. Beyond her scientific endeavors, Dr Moore is a fervent advocate for professional development and financial literacy, especially for underrepresented minorities in STEM. She co-founded #BlackInBME, a support group for black trainees and faculty in biomedical engineering, and established Moore Wealth Inc., a non-profit organization aimed at empowering students with financial literacy skills. Recognized as a Forbes 30 Under 30 awardee in Healthcare and a TED Fellow, Dr Moore's contributions have also been acknowledged through prestigious grants and awards, including the N.I.H. R35 Maximizing Investigators Research Award, Lupus Research Alliance Career Development Award, BMES Rita Schaffer Award, 3M Non-Tenured Faculty Award, and NSF CAREER Award.

Shreya A. Raghavan

Dr Shreya Raghavan is an Assistant Professor in the Department of Biomedical Engineering and a Project Leader in the Regional Excellence Center for Cancer at Texas A&M University. She has a PhD in Biomedical Engineering from the joint program between Wake Forest University and Virginia Tech and was an NIH Postdoctoral Fellow at the University of Michigan. At Texas A&M, the Raghavan lab engineers mechanically competent, biomaterial microenvironments to study innate immune function in cancer and regeneration. Her approaches integrate mechanobiology and immunology to decode how immune processes aid cancer metastasis or impede functional regeneration. Her work is funded by the NIH/NCI through an R37 MERIT award, the Department of Defense, and the Cancer Prevention and Research Institute of Texas. In recognition of her creativity and innovation, Dr Raghavan is the recipient of the BMES Rita Schaffer Young Investigator Award, the CMBE Young Innovator Award, as well as the Texas A&M Dean of Engineering Excellence Award. In addition to research, Dr Raghavan serves as the Vice-Chair of the Immune Engineering Special Interest Group in the Society for Biomaterials, as well as several roles within the Biomedical Engineering Society. Dr Raghavan is also an award-winning teacher, recognized for her inclusive pedagogy in the undergraduate classroom by the Montague Scholars Award from Texas A&M University. Dr Raghavan is an advocate for accessibility and equity, working actively towards dismantling systemic processes that hold academics behind in STEM.

Biomaterials in innate immunity: a knowledge-driven approach to immune-modulation

We are delighted to present this comprehensive issue on "Biomaterials in Innate Immunity". Modulation of innate immunity is an attractive therapeutic target, be it to improve outcomes in pathological contexts like cancer or boosting tissue regeneration following injury and inflammation. Wide-spread adoption of innate immunomodulation, however, requires the intersection of biomaterials engineering and immunobiology.

The collection of articles in this themed issue focus on how biomaterials can be harnessed to decode and modulate the behavior of innate immune cells in the contexts of regeneration and disease. In our selection of articles, specific attention is drawn to biomaterial design and formulations, while integrating newer spectroscopic and bioinformatics techniques. These diverse biomaterials strategies ultimately converge into a knowledge-driven approach to modulate innate immune activity.

First, Galindo *et al.* review various biomaterial formulations to modulate inflammation and promote functional tissue repair within the central nervous system (**https://doi.org/10.1039/D3MA00736G**). The article highlights the versatility of biomaterials, delivered as nanoparticles, hydrogels, implantable scaffolds or even used as neural probe coatings. The ultimate goal is to use biomaterials to control local neuro-inflammation and promote axonal elongation and mitigate glial scarring. Complementing this notion of local control, Sosnik *et al.* demonstrate that a drug-free polymer-polysaccharide nanoparticle can actively reprogram innate immune cells like macrophages engaged in inflammation (**https://doi.org/10.1039/D3TB01397A**). Combining *in vitro* approaches and bioinformatics, they demonstrate that the nanoparticle biomaterial has the potential to actively reprogram macrophages *via* local delivery producing local anti-inflammatory effects. This work underscores the intricate relationship between material structure informing cell function which could pave the way for their application in the therapy of different inflammatory conditions, especially by local delivery.

Evers *et al.* lay the groundwork for how cellular mechanics of macrophages are altered as they traverse through different environments in the body from bone marrow through circulation to inflamed tissues like tumors (**https://doi.org/10.1039/D3MA01107K**). The article presents single-cell mechanical characterization of tumor-associated macrophages and offers insight into underlying mechanical regulation in tumor-associated macrophages. Building off this theme that materials can be used to guide biophysical responses as well, Davis *et al.* review the importance of structural design in delivering immunomodulatory cargo to innate immune cells for cancer therapy (**https://doi.org/10.1039/D3TB01677C**). The article highlights the potential of biomaterials in enhancing therapeutic outcomes through targeted design strategies.

Complementing this theme strongly, Boboltz *et al.* engineer a synthetic immune-inspired biomaterial based on neutrophil extracellular traps (NETs) combined with viscoelastic mucin hydrogels (**https://doi.org/10.1039/D3TB01489D**). With careful characterization of mechanical properties of their synthetic immune inspired hydrogel, the work investigates immunity-mediated airway dysfunction in cystic fibrosis.

Conclusion

This issue serves as a comprehensive amalgam of cutting-edge research at the intersection of biomaterials and innate immunity. By elucidating the mechanisms underlying biomaterial–immune cell interactions and exploring their therapeutic implications across diverse disease contexts, these articles pave the way for transformative advancements in leveraging the innate immune system for therapeutic impact. We hope that this collection inspires further exploration, collaboration, and innovation, ultimately leading to improved diagnostics, therapeutics, and patient outcomes.

Acknowledgements

This work was supported by the Cancer Prevention and Research Institute of Texas award RP230204 (SAR), and the NIH NCI R37CA26922 (SAR), NSF Career Grant #2237741 (EM) and NIH R35GM147048 (EM).