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Drug delivery technologies for autoimmunity therapies

Autoimmune diseases represent a major burden on healthcare, yet treatment options for autoimmunity therapies remain limited.[1–3] Current clinically-approved autoimmunity therapies largely result in global immunosuppression, which hinders both pathogenic and homeostatic immune interactions and leaves the body susceptible to other ailments such as infection or cancer.[4–6] Thus, current therapies result in management of disease symptoms rather than reversal and subsequent cure of autoimmune disease. To achieve the latter and develop next-generation autoimmunity therapies, emphasis should be put on restoring the loss of central and peripheral tolerance that is observed in autoimmune disease.[7,8] This could be accompanied by a better understanding of fundamental immune mechanisms, identifying key cellular players, and employing tissue- and cell-specific strategies for targeted therapeutic drug delivery. Here, we seek to address these current gaps in the literature to provide drug delivery scientists, engineers, immunologists, and clinicians with strategies to formulate novel technologies that enable therapeutic delivery for autoimmune disease.

This special issue contains 13 contributions highlighting smart, novel and translatable strategies for therapeutic drug delivery in autoimmune disease. Experts in the fields of nanotechnology, cell and gene therapy, drug delivery, tissue engineering, and immunoengineering describe how to leverage cutting-edge therapeutic strategies from adjacent fields of study to mitigate autoimmune diseases and develop next-generation autoimmunity therapies.

Kim et al. highlight the use of vaccination strategies to induce immune tolerance against autoantigens in several key autoimmune disorders including multiple sclerosis, type 1 diabetes, rheumatoid arthritis, inflammatory bowel disease and systemic lupus erythematosus. Important methodologies in eliciting tolerogenic responses and key gaps in the field for future development are also described.

Scotland et al. discuss cell-based and biomaterial-based strategies to achieve both innate and adaptive immune cell modulation for the treatment of autoimmune disorders. A deeper discussion of the current challenges in and future considerations for engineering novel cell- and biomaterial-based therapies are also provided.

Diwan et al. provide an overview of the disease pathology, the current in vitro and in vivo experimental models, and emerging treatment options to tackle pulmonary fibrosis. An emphasis on developing clinically relevant treatments is showcased through a thorough breakdown and analysis of currently ongoing clinical trials.

Mehta et al. expand upon cell-based therapies that enable reversal of a self-destructive phenotype in several prevalent autoimmune and autoinflammatory disorders. An in-depth discussion of the barriers to clinical translation and potential solutions is also included.

Lansberry et al. identify key challenges in the implementation of cellular transplants in type 1 diabetes and provide detailed guidelines for improving therapeutic outcomes. Specifically, various drug delivery strategies that can be employed for combatting the grand challenge of transplant rejection are highlighted.

Thatte et al. describe nanomedicine-based strategies that can be employed to avoid global suppression, balance immune interaction with immune evasion, and achieve delivery of complex cargoes that can multimodally tackle autoimmune disorders. Key areas for future development of nanomedicine-based autoimmunity therapies are also emphasized.

Kioulaphides et al. discuss avenues to enhance the therapeutic effect of islet cell transplants in type 1 diabetes. Strategies employing macro-, micro-, and nano-scale biomaterials encapsulating cells from traditional as well as novel, alternative cellular sources are discussed.

Chapa-Villarreal et al. expand upon the utility of hydrogels as versatile drug carriers in the treatment of rheumatoid arthritis. Considerations for determining the most optimal combination of type of hydrogel, therapeutic cargo and route of administration on a case-by-case basis are provided.

Bonadio et al. discuss the role of fibronectin in fibrosis and autoimmunity and highlight its potential as a therapeutic target for the treatment of both. Tuning the interaction of fibronectin with several key immune cells is highlighted as a promising therapeutic strategy.

Shah et al. identify key immune cells residing in the skin as therapeutic targets for biomaterial-based control of immune responses in infection, cancer, allergy and autoimmunity. An extensive list of biomaterial-based strategies currently in clinical trials as well as considerations for effective clinical translation of pre-clinical therapies is included.

Kupor et al. highlight neutrophils as an important therapeutic cell target for the treatment of autoimmune and autoinflammatory disorders. Several nanoparticles of synthetic and cell-derived origins are highlighted as effectively delivery vehicles for neutrophil transfection and engineering.

Smith et al. emphasize the concept of immune tolerance and how antigen-presenting cells (APCs) can be leveraged to therapeutically restore lost tolerance in autoimmune disease. Key mechanisms of APCs in maintaining normal and aberrant immune homeostasis along with strategies for engineering APCs for therapeutic effect are described.

Kim et al. describe the use of hydrogels for targeting of hypersensitivity mechanisms implicated in autoimmune diseases, including systemic lupus erythematosus, rheumatoid arthritis, type 1 diabetes, and multiple sclerosis. Design considerations for developing safe and effective therapeutic hydrogels for autoimmune diseases are provided.

Together, this special issue is intended to provide important

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background and novel insights into recent advances in drug delivery strategies for autoimmunity therapies. Overall, the development of novel delivery technologies that effectively target cells of interest and facilitate a balanced and tolerogenic immune response will promote the development of next-generation therapies that address the fundamental sources of autoimmune disease.

Declaration of Competing Interest

The authors declare no competing interests.

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