

Synthetic Immunology: Approaching a Turning Point in the Treatment and Prevention of Disease

Synthetic immunology, an innovative field of research which could lead to fundamentally new approaches and methods in the treatment of infectious diseases and cancer, is the topic of an article in the “Perspectives” section of the journal “Nature Nanotechnology”. Herein, Heidelberg researchers Prof. Dr Kerstin Göpfrich, Prof. Dr Michael Platten, Prof. Dr Friedrich Frischknecht, and Prof. Dr Oliver T. Fackler describe a so-called bottom-up approach that uses the toolbox of nanotechnology and synthetic biology to construct systems from molecular building blocks and specifically equip them with immune functions. The experts in the fields of synthetic biology, neuroimmunology, parasitology, and virology conduct research at Heidelberg University, the Heidelberg and Mannheim University Hospitals, the German Cancer Research Center, and the Max Planck Institute for Medical Research.

In the new bottom-up approach in synthetic immunology, complex immune functions are no longer created by modifying existing cells or molecules, but rather originate from molecular building blocks like nanoscale components or artificial cells assembled into complex systems. The process is based on technologies and techniques from synthetic biology such as the design of proteins and peptides, polymer synthesis as well as DNA/RNA modification and DNA/RNA origami – the three-dimensional “folds” of DNA or RNA strands – to produce functional nanostructures.

As the authors discuss in their article in the “Perspectives” section of “Nature Nanotechnology”, the new bottom-up approach in synthetic immunology is expected to allow for unparalleled precision and control in shaping immune functions. By manufacturing immune components from the ground up, immune responses can be custom-engineered with great specificity and efficiency. This opens up groundbreaking approaches in the development of new therapies and vaccines that circumvent the constraints of traditional approaches, like unwanted side effects or time-limited efficacy.

The Heidelberg researchers believe that the bottom-up approach not only promises improved therapeutic approaches and methods but can also push the future boundaries of what is possible in the treatment of complex illnesses. The further development of this research field could lead to the development of completely synthetic immune effectors that, according to the vision, could then prevent and treat diseases. “We are facing a turning point in the treatment and prevention of infectious diseases and cancer. The synergies between synthetic biology and immunology open up a number of possibilities that could one day create a completely new basis for how we deal with disease,” states Prof. Göpfrich.

Molecular biologist Kerstin Göpfrich, who was appointed as a professor to Ruperto Carola in 2022, heads the “Biophysical Engineering of Life” research group at the Center for Molecular Biology of Heidelberg University (ZMBH); it is also based at the Max Planck Institute for Medical Research. Michael Platten is the Medical Director of the Neurological Department of University Hospital Mannheim and Director of the Mannheim Center for Translational Neuroscience at the Medical Faculty Mannheim of Heidelberg University, where he has been a professor since 2016. At the German Cancer Research Center, he heads the Clinical Cooperation Unit Neuroimmunology and Brain Tumor Immunology. Parasitologist Friedrich Frischknecht and virologist Oliver T. Fackler conduct research at the Center for Integrative Infectious Disease Research (CIID) located at the Department for Infectious Diseases of Heidelberg University Hospital. Prof. Frischknecht has been a professor of integrative parasitology since 2014; Prof. Fackler, likewise a professor at the Medical Faculty Heidelberg of Heidelberg University, has led the integrative virology research area since 2007.

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