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Editorial overview

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Editorial overview: Reprogramming biology: from biopolymers to complex systems

Giovanni Maglia and Wesley Browne

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For a complete overview see the [Issue](#)

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Giovanni Maglia

Giovanni Maglia completed his PhD at University of Birmingham in 2004 with prof R.K. Alleman. Following postdoctoral positions at Leuven University (prof. Engelborghs) and Oxford University (prof. Bayley), in 2010 he joined the University of Leuven as assistant professor. In 2014 he moved to the University of Groningen where is currently associate professor. The main focus of his group is on the physical and chemical properties of biological nanopores. In particular, he use the available chemical tools to engineer, modify and design nanopores for applications in molecular sensing and single-molecule biophysics.

Wesley Browne

Wesley Browne completed his PhD thesis at Dublin City University (2002), with Prof J.G. Vos. Following postdoctoral positions at Queen's University Belfast and the University of Groningen, in 2008, he joined the faculty at the University of Groningen as assistant professor and is currently full professor at the Stratingh Institute for Chemistry. His research spans the application of spectroscopy, and especially Raman spectroscopy and electrochemistry to (bio)inorganic catalysis and molecular-based materials science.

This issue of current opinion in biotechnology on *reprogramming biology: from biopolymers to complex systems*. The reviews tackle pertinent aspects of the design methods available. The focus is on the control of function in membranes and specifically ion channels, repurposing and augmenting biopolymers, the minimal cell and the design of biobased systems for drug delivery and theranostics.

The fascinating field of biological membranes and especially the control of membrane function including the transport across membranes is introduced by [Henderson *et al.*](#) in a review of 'leak pathways'. During active transport across membranes driven by electrochemical gradients, the energy gradient generated by a concentration difference across a membrane of one solute is used to transport another solute against a concentration gradient. Their review delves into the leak pathways due to imperfect coupling and where protein modification has proven its worth in exploring these processes. [Nenad Bursac and Hung Nguyen](#) explore the world of active control across ion channels using potential, light, small molecules and temperature. Their work evaluates critically the pros and cons of each approach and the lessons that have been learned and applied in controlling the behaviour of whole excitable tissues towards therapeutic uses. [Andrew Ellington and Elizabeth Gardner](#) follow up on the theme of control over channels by delving into the world of neurobiology. Using the emerging genetic tools developed in synthetic biology, they show a potential roadmap to reconstruct the neural connectome and ultimately 'reprogram' neural development.

In the second part of this compilation we move into the world of *de-novo* design of biopolymers, nanoscale structures and cell-like enclosures, and describe efforts in redesigning their structure and function. [Dek Woolfson and Joseph Beesley](#) start by describing the *de novo* design of α -helical peptides for self-assembly with the ultimate goal to control and redesign cellular functions. RNA assembly can also be programmed, and might be used to create nanoscale objects to control cell functions. [Ohno *et al.*](#) describe how the field of RNA nanotechnology is evolving, with a particular eye for *in vivo* applications. The utility of modified fluorescent proteins is key to their application in many aspects of biology and introducing photoswitchable behaviour is a primary example of the demand to develop methods to modify biopolymers. [Peter Dedecker and Sam Duwé](#) provide an overview of recent advances in fluorescent proteins, especially those with photo-transformable behaviour. Of course going beyond reporting to introducing non-natural function in biopolymers brings a myriad of new applications. [Tatjana Parac-Vogt and Laura Van Rompuy](#) describe the addition of inorganic systems such as polyoxometalates for both catalytic and therapeutic uses.

We move from controlling aspects of cell function to the design of a minimal cell in which the key biological processes of transcription and translation are recreated in artificial microenvironments outside the burdens of living organisms. [Dubuc *et al.*](#) distil recent efforts towards synthetic communication networks with a special focus on the microcompartments used and their communication with outside environments. Such cell-free systems can also be used to manufacture biopolymers in a controlled environment. [Hirose *et al.*](#) highlight recent advances for the incorporation of non-standard amino acids into polypeptide chains, hence creating polymers with augmented properties and potential therapeutic use. Cell-free transcription-translation systems have become a versatile technology to implement a variety of biological functions. [David Garenne and Vincent Noireaux](#) describe the possibilities ranging from cell-size compartmentalization to large scale industrial manufacturing.

In the final set of reviews we move to the highly active field of theranostics and drug delivery from multifunctional liposomes, synthetic platelets and supramolecular nanoparticles to interfacing with cell membranes and

biological targets. [Jiang *et al.*](#) describe how the coating with a cell-like membrane can modulate the *in-vivo* interaction of nanoparticles with biological species, while [Lu *et al.*](#) focus their attention on platelets and their use as drug delivery systems. [Yan *et al.*](#) delve into the recent efforts in supramolecular self-assembled scaffolds for teranostic applications, showing how simple building blocks can yield complex functions.

Finally, [Wiktor Szymanski and Friederike Reeßing](#), highlight the rapid increase in complexity of both structure and function that is being achieved in drug delivery systems in which the release of drug cargo can trigger a second life/function for the transport unit itself in both diagnosis and treatment

The collection of reviews in this issue highlight the breadth of chemical and biological handles that we now possess to explore and control the functioning of biological systems. Further than this we now have the tools to build on biology many systems and structures to introduce new function and responsivity for use in all manner of research and medical applications.