Nanobiotechnology:

Editorial:

It is our pleasure to co-edit this special edition of Current Opinion in Biotechnology with the overall theme of Nanobiotechnology. This is an exciting and growing research area with great relevance to human society and the environment. We have tried to encapsulate some representative key areas in this volume to illustrate the breadth of organisms, models and applications that fall under the nanobiotechnology theme. We have considered contributions under four headings: technical developments for the study of macromolecular devices, DNA nanodevices, protein nanodevices, and applications, the latter including aspects of bioremediation, biosensors and bioengineering.

Several contributions use emerging or consolidated nanotechnologies for the analysis and characterization of nanodevices, which are mainly based on DNA or proteins. Perhaps somehow artificially, we selected two papers as falling mainly under the “technical developments” section. First, [Allemand](#) and colleagues study molecular motors for DNA translocation, taking advantage of the use of magnetic tweezers, a potent tool for single molecule analysis. Acting forces on single DNA or protein molecules can be estimated and thus the strength and speed of different nanomotors can be compared. In turn, [Fotiadis](#) reviews the use of atomic force microscopy (AFM) for the study of membrane proteins. AFM is ideal for the study of membrane proteins since it can be used on proteins embedded in lipid bilayers, something most alternative techniques cannot do.

[Simmel](#) discusses a beautiful example of a DNA nanodevice. Rigid DNA scaffolds of any desired length and shape can be constructed with the template of a viral single-stranded DNA and a few dozen staples. This is called Origami DNA. Excitingly, proteins can now be placed on these Origami structures with better than nanometric precision, to build up chemical nanofactories. If these nanostructures fulfil their expectations, they could be the foundation of a whole new field of chemical science. Of course, DNA is not the only nanodevice on which proteins can be displayed. Inspired by the compartmentalization inherent to the organization of biological systems, [Retterer and Simpson](#) carried out a provoking and thorough review on how to construct and use different types of micro- and nanoscale compartments, both inorganic and bio-based, and of their potential use in next-generation biotechnology and synthetic biology.

[Cabezon, Carrascosa and Stock](#) use different (but related) protein nanodevices for their critical analyses. [Cuervo and Carrascosa](#) review the existing work on viral connectors, protein nanomachines responsible for viral DNA packaging and release. Due to their biological functions, viral connectors constitute functional DNA nanopores with interesting nanotech applications that are discussed in the paper. [Cabezon](#) and colleagues use also crystal structures as driving technologies. Their work focuses on the structural comparisons between different rotary motors. Interestingly, they find that similar atomic structures explain the function of rotary motors involved in widely different biological processes, such as bacterial cell division, bacterial conjugation (the exchange of DNA between bacteria) and protein secretion.

The ATP synthase seems to be a well analyzed prototype on which an ample variety of motors can be modelled. The paper by [Stock](#) and colleagues focuses on the latest molecular models of the reversible bacterial flagellar motor (BFM) and the strategies used to derive them. The BFM is a self-assembling rotary nano-machine, converting a flux of cations into the mechanical rotation of the flagellum that propels the bacterium through liquid. As a well-characterized large biomolecular complex, it provides convergence between nanotechnology and biology, requiring atomic level understanding of structure and function. The paper clearly describes the current models for the BFM and several molecular explanations of experimental data from detailed biochemical, electron microscopic and structural studies.

Microorganisms are of great importance in nanobiotechnology, and there is growing interest in microbial production of nanoparticles for a range of purposes. [Hennebel](#) and colleagues provide a state-of-the art overview of the microbial production of palladium (Pd) nanoparticles and their applications in environmental biotechnology, here exemplified with the treatment of halogenated organic compounds. Precious metals such as Pd can be recovered from waste streams by precipitation as nanoparticles on bacteria. These biogenic nanoparticles (bio-Pd) are very active in dehalogenation, reduction, hydrogenation and C–C bonding reactions, and examples of their applications for the treatment of contaminated soils and sediments are also described in this article. [McMaster](#) elegantly describes the use and application of atomic force microscopy to study the fungal–mineral interface. Fungi are extremely important organisms in many biotechnological processes but less appreciated is their important roles as geoactive agents, where their importance in solubilizing soil minerals and releasing nutrients such as phosphate can determine plant productivity. In this paper, AFM has been used to monitor colonization of phyllosilicate minerals in microcosms containing only plants, mineral and mycorrhizal fungi. Other experiments are also described where it has been possible to monitor dissolution at the unit cell level and to extract activation energies for specific dissolution processes mediated by oxalic acid on biotite. Such observations provide new insights for fungal weathering at the nanoscale. In their article, [Wang](#) and colleagues discuss biomedical applications of biogenic silica and polyphosphate. Silica is the main mineral component of sponge skeletal elements (siliceous spicules) while polyphosphate is an important multifunctional polymer found in many living organisms, including microorganisms and animals, where it acts in a structural context and also as a reserve of P. These substances can be prepared enzymically (bio-silica and (bio-polyP) or chemically (bio-polyP) and have intriguing applications in the treatment of human bone diseases and dysfunctions, such as osteoporosis. Silicate-based sponge skeletons can serve as a template for the development of calcium-based skeletons, while bio-polyP is increasingly appreciated in the context of bone formation. [Keatch](#) and colleagues describe several applications of biomaterials in regenerative medicine, especially in the context of the extracellular matrix (ECM), a multi-component network of biological macromolecules such as collagen and glycoproteins, within or on which human cells are adherent.

The ECM has recently been found to have an influence on gene expression, cell migration and functional homeostasis, and this paper highlights selected examples that have relevance to regenerative medicine, particularly development of the next generation of advanced wound care devices for the clinical treatment of chronic wounds.

We hope that this special issue of *Current Opinion in Biotechnology* will stimulate further ideas and research in this important area of current science, and be of interest to a wide range of readers in the multiplicity of fields that contribute to biotechnological advances. We also thank the authors who accepted our invitations to contribute to this volume, and for their timely production of carefully written and up-to-date manuscripts.

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