

## Editorial: Nanobio versus Bionano – what’s in a name?

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Like the six blind men of the fable attempting to conjure the shape of an elephant by touching one its trunk and the other its leg, nanotechnology means many different things to many different people. The widely accepted U.S. National Nanotechnology Initiative definition, “the understanding and control of matter at the nanoscale, at dimensions between approximately 1 and 100 nm, where unique phenomena enable novel applications”, aims at distinguishing nanotechnology from miniaturization and at emphasizing the unusual physico-chemical properties that materials exhibit at the nanoscale. Yet, the development of visualization tools to study nanoscale objects and that of innovative methods to fabricate nano/micromechanical systems and fluidic devices have been powerful forces in the birth and continued growth of nanotechnology. The addition of the qualifier “bio” – in itself an enormously vast area with its own clades and clans – could only complicate the picture. Indeed, self-defined bionanotechnologists and nanobiotechnologists soon appeared, perhaps attempting to capture in a name their grounding in a given discipline, or define the nature of the path that led them to nanotechnology.

In this Special Issue of *Biotechnology Journal*, we have assembled 11 manuscripts to compare and contrast the “nanobio” and “bionano” fields and highlight where and how these two areas dovetail within a continuum of length scales, technical approaches and scientific goals. The first five “nanobio” articles emphasize the development of miniaturized tools and devices for stem cell research, regenerative medicine, developmental biology, neurosensing, and protein drug delivery;

the following six “bionano” articles focus on self-assembly and the use of biological materials and systems to develop novel nano-enabled products.

Advances in nanobiotechnology are highly dependent on newly established quantitative experimental methods that enable high-throughput screening and high information content analysis of biological samples. Importantly, due to scaling effects at the micro- and nanoscales, the minimum sample volumes up to several hundred picoliters to microliters are often required to achieve sufficient detection limits in low abundance analytes. Many of these technologies allow for the integration of multiple functional characteristics onto miniaturized assay platforms, with parallel multiplexed microfluidic functionalities. In addition, new biomimetic three-dimensional cell culture environments can provide unique experimental platforms for cell-based assays.

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In the following pages, Cooper-White et al. [1] present a comprehensive review of micro- and nanofabricated arrays providing cellular environments for stem cell handling and regenerative medicine. Takayama and coworkers [2] describe the use of microfluidics to culture stem cells and study the effect of stimuli on the culture and differentiation of pluripotent stem cells. Lu and co-authors [3] highlight various microfluidic tools that have been developed to manipulate small organisms for developmental biology studies and drug dis-

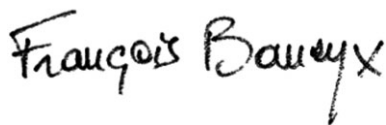
covery. Nam et al. [4] demonstrate a single-cell-sized neural microelectrode with gold grain-shaped nanostructures, improving neuroelectronic interfaces for neural recording and stimulation using rat hippocampal neuronal cultures. Finally, in an article that forms the bridge to the bionano section of the issue, Lee and coworkers [5] describe a novel technique for controlled delivery of thrombin that relies on DNA nanostructures and thrombin-binding aptamers.

Bionanotechnology borrows inspiration from nature and aims at improving upon its already remarkable performance by allowing for the synthesis, physico-chemical modification, and assembly of novel materials, structures and systems with exquisite control over composition, geometry and function. Here, self-assembly schemes driven by designed and designer biomacromolecules play an essential role, hierarchy is important, and the formidable inventory of tools and techniques developed by molecular, synthetic and computational biologists can be fully exploited. Because it relies on biological processes that operate best under mild conditions or temperature and pressure, bionanotechnology also has the ambition of becoming the “green” arm of nanotechnology.

In the “bionano” part of the Special Issue, LaBean and coworkers [6] describe how the self-assembly of a novel DNA dendritic nanostructure can be used for the detection of arbitrary DNA sequences. Clark et al. [7] re-engineer the filamentous  $\gamma$ -pre-foldin of the hyperthermophile *Methanocaldococcus jannaschii* to template the formation of platinum nanowires (also see the commentary by Dordick [8]). Yi et al. [9] use to-

baculo mosaic virus mRNA of different lengths to produce viral building blocks of well-controlled dimensions with an eye towards nanoelectronics and nanocatalysis applications. Gruber and coworkers [10] show that it is possible to develop an economically viable process for the production of a new bifunctional peptide that bind both to hair and pigment nanoparticles for hair coloring. Finally, Chen et al. [11] investigate how nanoparticle size affects the enzymatic activity of immobilized enzymes while Tamerler and coworkers [12] use a gold-binding peptide to control the orientation of immobilized enzymes at gold surfaces.

We hope that the papers featured in this Special Issue will help illustrate the essence of nanobio and bionano. More importantly, just like top-down and bottom-up approaches will need to merge to fully realize the promise of nanotechnology; nanobio and bionano are bound to converge in a not-too-distant future. What the name of the field will be finally, remains to be seen.



Prof. **François Baneyx**

Department of Chemical Engineering, University of Washington, USA  
E-mail: baneyx@u.washington.edu

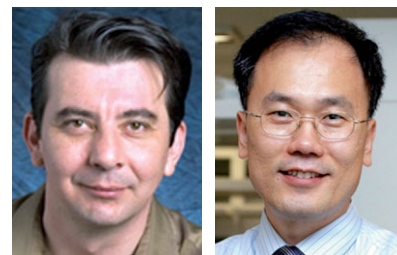


Prof. **Je-Kyun Park**

Department of Bio and Brain Engineering, Korea Advanced Institute of Science and Technology, Korea  
E-mail: jekyun@kaist.ac.kr

## References

- [1] Titmarsh, D. M., Chen, H., Wolvetang, E. J., Cooper-White, J. J., Arrayed cellular environments for stem cells and regenerative medicine. *Biotechnol. J.* 2013, 8, 167–179.
- [2] Llesher-Perez, S. C., Frampton, J. P., Takayama, S., Microfluidic systems: A new toolbox for pluripotent stem cells. *Biotechnol. J.* 2013, 8, 180–191.
- [3] Hwang, H., Lu, H., Microfluidic tools for developmental studies of small model organisms –nematodes, fruit flies, and zebrafish. *Biotechnol. J.* 2013, 8, 192–205.
- [4] Kim, R., Hong, N., Nam, Y., Gold nanograin microelectrodes for neuroelectronic interfaces. *Biotechnol. J.* 2013, 8, 206–214.
- [5] Sung, J. H., Han, D., Lee, J. B., Self-assembled DNA-based giant thrombin nanoparticles for controlled release. *Biotechnol. J.* 2013, 8, 215–220.
- [6] Chandran, H., Rangnekar, A., Shetty, G., Schultes, E. A. et al., An autonomously self-assembling dendritic DNA nanostructure for target DNA detection. *Biotechnol. J.* 2013, 8, 221–227.
- [7] Glover, D. J., Giger, L., Kim, J. R., Clark, D. S., Engineering protein filaments with enhanced thermostability for nanomaterials. *Biotechnol. J.* 2013, 8, 228–236.
- [8] Dordick, J. S., Functional nanoscale biomolecular materials. *Biotechnol. J.* 2013, 8, 165–166.
- [9] Rego, J. M., Lee, J. H., Lee, D. H., Yi, H., Biologically inspired strategy for programmed assembly of viral building blocks with controlled dimensions. *Biotechnol. J.* 2013, 8, 237–246.
- [10] Rouvière, P. E., Li, J., Brill, D. J., Reiss, L. D., Bionanotechnology application of polypeptides in a hair color product: Self-assembly enables expression, processing, and functionality. *Biotechnol. J.* 2013, 8, 247–256.
- [11] Tsai, S. L., Park, M., Chen, W., Size-modulated synergy of cellulase clustering for enhanced cellulose hydrolysis. *Biotechnol. J.* 2013, 8, 257–261.
- [12] Cetinel, S., Caliskan, H. B., Yucesoy, D. T., Senem, A. et al., Addressable self immobilization of lactate dehydrogenase across multiple length scales. *Biotechnol. J.* 2013, 8, 262–272.



François Baneyx and Je-Kyun Park