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"Gheorghe Asachi" Technical University of Iasi, Romania

Sub-session 1.2.
Microbial biodegradation assessment and improvement

Main lecture

ENGINEERING ENVIRONMENTAL CATALYSTS: FROM TRIAL-AND-ERROR TO SYNTHETIC BIOLOGY

Victor de Lorenzo

Systems Biology Program, Centro Nacional de Biotecnología CSIC, Madrid 28049, Spain

Abstract

One key objective of Environmental Biotechnology is the pursuit of biocatalysts for conversion of industrial waste into value and –if no other choice is available, mineralization, detoxification or immobilization of man-made pollutants. Traditional Genetic Engineering based on one-at-a-time modifications of the DNA complement of an existing organism (i.e., deletions, mutations, cloning and expression of one or few genes in a heterologous host) is quickly giving way to the systemic refactoring of entire functional blocks in heavily engineered bacteria. Still, our current capacity of DNA synthesis *á la carte* (> 1 Mb) is much more than our competence to engineer complex phenotypes, which hardly goes beyond handling 10-20 genes (~10-20 Kb). To mine desired activities out of the existing catalytic landscape of the metagenome we have developed a number of unidirectional transducers for coupling biotransformations to transcriptional activation of a selectable property. With these tools, desired reactions can be reclaimed directly from environmental DNA based on their biological activity instead of DNA sequence similarity. The next step to exploit biological properties for biotechnological applications is framed in what is growingly denominated *Synthetic Biology* (SB). This increasingly inclusive concept [i] encompasses new theoretical frameworks that address biological systems with the conceptual tools and the descriptive language of Engineering, [ii] addresses old questions and challenges with fresh approaches inspired in electric circuitry and mechanical manufacturing and [iii] pursues the creation of new materials with *á la carte* properties based on the rational combination of standardized biological parts decoupled from their natural context. In fact, standardization and detailed description of *minimal* biological parts and their interfaces, to the degree of reliability of the components of modern electronic circuits is one of the trademarks of the whole field. The basic notion behind SB is that any biological system can be seen as a complex combination of functional, stand-alone elements not unlike those found in man-made devices, and can thus be-deconstructed in a limited number of components and reconstructed in an entirely different configuration for the sake of modifying existing properties or creating altogether new ones. In this context, *Engineering* as a discipline transits from being an *analogy* of the rational combination of genes made possible by modern Molecular Biology and Biotechnology to being a veritable *methodology* to construct complex systems and novel properties based on formatted biological components. Some applications of these concepts in the design of superior whole-cell catalysts will be discussed.