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Complex systems in BioEngineering: integrative approaches for Biotechnology

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Bioengineering has high potential for complex systems (CS) in modelling and simulation. Biological systems are composed of functional elements, with high variety of chemical and physical properties, presenting large diversity of structures at any scale. Composites and control structures that build-up from the different levels, form self-organised and regulated mechanisms, that provide adaptation and redundancy of systems supporting life. Therefore, CS modelling of cells, colonies and tissues is an important challenge in the post-genome era of Biotechnology. The authors' first CS technology was applied to macroscale simulations. The "legacy technology" provides bioengineering the fundamentals for scenario technologies to develop mesoscale to macroscale systems. Therefore, one of the main challenges for theoretical research in Biotechnology is to develop strategies that enable the description of systems at multi-scale levels, for biological, biochemical and physical components. Simulation tools are now being developed for process prototyping. These include both physics and cell dynamics (cycle and metabolism), cell to cell communications and colony dynamics (quorum sensing) inside bioreactors. Currently as a "work in progress", the authors present some of their strategies, as well as, theoretical and experimental CS challenges of modelling and simulating the flocculating yeast growth during fed-batch fermentations.