Bioreaction Engineering: Evolution and Future Needs

Michael L. Shuler, Chemical Engineering and Biomedical Engineering, Cornell University, 270 Olin Hall, Ithaca, NY 14853

While bioreaction engineering extends into prehistory (e.g. alcoholic beverages) this talk will begin with the era when people sought to educate themselves as biochemical engineers by seeking cross-disciplinary training in chemical engineering and biology. The emphasis of this talk will be on bioprocesses with occasional mention of biophysical or biomedical applications. This initial era corresponds to the development of bioprocesses for production of antibiotics and extended into small molecule production. Simple kinetic expressions were coupled to transport issues. In the 1960's the development of immobilized enzymes inspired a new wave of analysis. Also, there began to emerge concepts of modeling cells as chemical reactors with internal structure. The 1980's saw chemical engineers embracing problems in production of biologics using recombinant DNA technology. The 1970's and 1980's saw the emergence of truly modern biochemical engineering with a much higher level of integration of molecular biology with chemical engineering principles. The advancement of mechanistic biological insight allowed the application of sophisticated engineering analysis to cellular metabolism. The field of metabolic engineering is largely dominated by biochemical engineers. Additionally the emphasis on production of therapeutic proteins resulted in development of bioprocesses based on animal cells instead of bacteria and yeast. In the last decade the development of techniques to rapidly determine the genomic content of a whole organism is changing the nature of biological discovery. The primary issue in life sciences is how to relate genomic structure to the physiology of an organism and its response to environmental changes. Another technological driver is the integration of microfluidics with cell culture. Microbioreactors have the potential to improve process optimization significantly. A key factor is whether large-scale reactor performance can be predicted with such microbioreactors. Technologies based on both genomics and microfabrication will remain significant opportunities for bioreaction engineering in the next two decades. The demarcation between bioprocess technology and biomedical applications, especially in terms of diagnostics and regenerative medicine, will become very fuzzy as cross-over applications of the same technology platforms and ideas will become increasingly common.