Laboratory of BioProcess Systems Engineering

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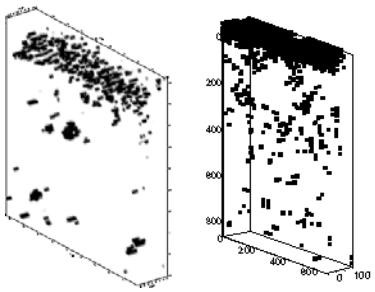
Our missions are (1) to bring a good fortune in human life through the elucidation and utilization of "bio-potential" by understanding sequential biological events (BioProcess) in the reaction field (Systems), and (2) to develop human resources of biochemical engineers. Our targets are the analysis, simulation, forecasting and control of various bioprocesses related to microorganisms as well as mammalian cells, and establishing methodologies for the utilization and application of the principles of such processes. We are also concerned with medical contribution, such as regenerative medicine including the production of cultured tissues.

Our main topics, which are targeted for the biological elements (such as enzyme) governing the reactions as well as the regions (such as cells and tissues) providing the reaction field, are "The bioprocess design in tissue engineering by understanding the reconstruction of human tissues" and "The construction of bioproduction process for microorganisms by understanding biological community in co-cultures". BioProcess Systems Engineering (BPSE) is conceived as an interdisciplinary technology supported by the above academic fields. BPSE can contribute to many bioproduction systems through mixed cultures, such as fermented foods as well as cultured tissues.

The bioprocess design in tissue engineering by understanding the reconstruction of human tissues

Tissue engineered systems will play a key role in moving away from conventional surgeries by providing a new solution to tissue loss. Unlike traditional approaches for treatment of lost tissue or damaged organ function, tissue engineering enables to replace damaged tissue with regenerated tissue that is designed and constructed to meet the needs of each individual patient. The manufacturing processes for cultured tissue have to be constructed on the basis of a novel strategy when compared with conventional process including petrochemicals and pharmaceuticals. The raw materials and products for the manufacturing are cells themselves obtained from the patients (or the donors) and cultured tissues, respectively. In addition, the raw materials have heterogeneity depending on the state of patients and location of cell harvest, and the products are varied in size for individual patients. These features request the unique strategy in manufacturing process with minimum of raw materials and maximum of products. For the stability in manufacturing process of cultured human tissues and its quality control for clinical application, our interests include the design of culture operation (manufacturing process) and vessels (bioreactor) as well as the standardization of quality control for cell and tissues.

Intelligent bioreactor system for culture passage

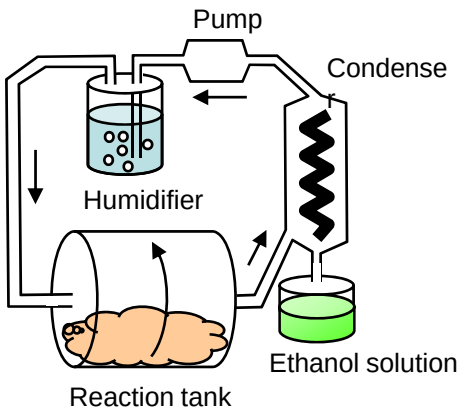


Spatial cell distribution in cultured tissues (left; observation, right; simulation)

The construction of bioproduction process for microorganisms by understanding biological community in co-cultures

To produce bioethanol from lignocellulose, we are developing a bacterial delignification system and a consolidated continuous solid state fermentation (CCSSF) system. These systems make it possible to produce bioethanol by geographically-distributed facilities at a reasonable cost and with a minimum energy-input.

Since LAB and yeasts live symbiotically in many fermented foods, it is important to understand interactions between them. We found that LAB display some cytosolic proteins on the surface the cells and these proteins have affinity to yeast mannan at acidic pHs. These results allow us to make a working hypothesis that when LAB are subjected to stresses such as lactic acid and hydrogen peroxide, they ask yeast to help remove these metabolites by displaying these proteins on their cell surface.



The CCSSF system
(Delignified materials, saccharifying enzymes and yeast are placed in the reaction tank)