ChE-311

Biochemical engineering

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Cursus	Sem.	Type
Biotechnology minor	E	Opt.
Chemical Engineering	BA6	Obl.
HES - CGC	E	Obl.

Contact language	English
Credits	3
Session	Summer
Semester	Spring
Exam	Written
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

This course introduces the basic principles of bioprocess engineering and highlights the similarities and differences with chemical engineering. Without going into the fundamentals, it proposes an overview of the techniques for fermentation as well as product purification (DownStream Processing).

Content

Biochemical engineering

- The cell as a biocatalyst, its needs and performance
- Bioreactor systems
- Bioprocess analytics and control
- Bioprocess design
- Batch, fed-batch, and continuous culture

Downstream Processing (DSP)

- Selection of a purification strategy
- Liquid/solid separations and cell lysis
- Liquid/liquid extraction and precipitation
- Adsorption and chromatography
- Membrane techniques
- Trends and trend-setters in DSP

Keywords

Bioprocess engineering: Structure of prokaryotic and eukaryotic cells, cell components, elemental composition of cells, metabolic pathways (repetition), uptake system, membranepotential, basic functions of a bioreactor, types of bioreactors, agitation and oxygen transfer, upstream processing, sterilization techniques, bioprocess automation, PAT, Liebig's law, mass and energy balances, oxygen requirements, yield coefficients, requirements for a successful batch, growth kinetics, Monod kinetics, stoichiometric model, integral medium design, microbial growth on defined and complex media, substrate inhibition, cell physiology of nutrient limited batch cultures, batch growth extended, direct and indirect estimation of biomass, feed strategies, product formation, high cell-density fed-batches, chemostat, nutrient limitation, wash-out, optimal productivity, growth physiology, two-stage chemostat.
Downstream processing: significance of DSP; chemical and biotechnological DSP; biomolecules; purity; yield; (bio)activity retention; physical and thermal separations; thermodynamics; equilibrium; kinetics, sedimentation; terminal settling velocity; centrifugation; filtration; filtration cake; compressibility; cake and filter resistance; cell lysis; cell wall structure and composition; high pressure homogenizator; bead mill;raffinate; extract; partition coefficient; equilibrium line;

operating line; graphical solution; extraction yield; ATPS; precipitation; heat; pH; electrolytes; solvents; polymers; Cohn equation; adsorbent and adsorbate; active charcoal; adsorption isotherm; Langmuir; Freundlich; adsorption kinetics; fixed-bed adsorption; expanded bed adsorption; breakthrough curve; ion exchange; hydrophobic interaction; affinity chromatography; van Deemter equation; particles and solutes; suspensions and solutions; cross-flow; membrane structure; transmembrane pressure; osmotic pressure; retention factor; molecular weight cut-off; concentration; fractionation; diafiltration; downstream bottleneck; convection vs diffusion; monolith and membrane chromatography; single-use equipment; ABC approach

Learning Prerequisites

Required courses

No mandatory prerequisite course. Basic knowledge in microbiology, biochemistry and process engineering are however a plus, and would help understand and master the different concepts presented in the course.

Recommended courses

"Phénomènes de transfert", "Introduction au génie chimique I & II"

Important concepts to start the course

Reaction kinetics
Mass balances (stationary and transient)
Heat, momentum and mass transfer

Learning Outcomes

By the end of the course, the student must be able to:

- Distinguish the different types of bioreactors
- Dimension bioreactors and separation equipments
- Compare the various modes of fermentation
- Carry out calculations of yields in biomass or product
- Select appropriately a bioprocess configuration
- Interpret results based on taught concepts
- Propose adequate strategies for the development of bioprocesses or purification protocols
- Differentiate between chemical engineering and bioprocess engineering

Transversal skills

- Use a work methodology appropriate to the task.
- Use both general and domain specific IT resources and tools
- Access and evaluate appropriate sources of information.

Teaching methods

The module is taught in weekly 3 hours blocks comprising 2 hours lecturing and 1 hour exercises (with assistants)

Expected student activities

A regular attending of the course is the best way to achieve the learning goals with a minimal amount of personal work at home. The proposed exercises illustrate and complete the theoretical aspects presented during the course. An active participation to the exercise sessions is then highly recommended.

Assessment methods

A written exam will be held at the end of the semester.

Resources

Bibliography

"Biochemical Engineering", Harvey W. Blanch and Douglas S. Clark,2nd ed., Taylor & Francis, 1997
"Bioprocess Engineering Principles", Pauline M. Doran, 2nd ed., Academic Press, 2013

Ressources en bibliothèque

- Biochemical Engineering / Blanch
- Bioprocess Engineering Principles / Doran

Notes/Handbook

There is no manuscript for the course. However, all the material that is presented (copies of transparencies, additonal material, exercises and correction thereof) is available and can be downloaded from the Moodle platform.

Moodle Link

- https://go.epfl.ch/ChE-311