ChE-311

Biochemical engineering

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

Language of teaching	English
Credits	3
Session	Summer
Semester	Spring
Exam	Written
Workload	90h
Weeks	14
Hours	**3 weekly**
Courses	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)

- DSP context and relevance
- Selection of a purification strategy
- Liquid/solid separations and cell lysis
- Precipitation and crystallization
- Adsorption and chromatography
- Membrane techniques

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; precipitation; heat; pH; electrolytes; solvents;

polymers; Cohn equation; crystallization; supersaturation; crystal growth kinetics; adsorbent and adsorbate; active charcoal; adsorption isotherm; Langmuir; Freundlich; adsorption kinetics; fixed-bed adsorption; static and dynamic capacity; ion exchange; hydrophobic interaction; affinity chromatography; van Deemter equation; cross-flow; membrane structure; transmembrane pressure; osmotic pressure; retention factor; molecular weight cut-off; concentration; fractionation; diafiltration;

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

CH 210 - Biochimie
ChE 201 - Introduction to chemical engineering
ChE 204 - Introduciton to transport phenomena
ChE 310 - Fundamentals of separaiton processes
ChE 320 - Bioreactor modeling and simulation

Important concepts to start the course

Reaction kinetics, modeling
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 teaching assistant(s))

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.

Supervision

Office hours	No
Assistant.e.s	Yes
Forum	No
Others	There are no specific office hours. The teaching assistant(s) and the professors (who are not on the campus) can be reached anytime during the semester vie E-mail, phone or video conference.

Resources

Bibliography

Bioprocess Engineering Principles. Pauline M. Doran, Ross P. Carlson & Kate Morrissey, 3rd ed., Academic Press, 2024
Bioprozesstechnik. Horst Chmiel, Ralf Takors & Dirk Weuster-Botz, 4. Auflage, Springer, 2018
Bioprocess engineering - basic concepts. Michael L. Shuler, Fikret Kargi & Matthew DeLisa, 3rd ed., Prentice Hall, 2017

Ressources en bibliothèque

- Find the references at the Library

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