SCIENCES, TECHNOLOGIES, HEALTH

BIOLOGICAL ENGINEERING

Niveau d'étude visé
BAC +5

Durée
2 année(s)

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Langue(s) d'enseignement
Français, Anglais

plugin.odf:Domaine régional
Génie biochimique, Bioingénierie - Biotechnologies, Biologie - Biochimie

Présentation

Objectifs

An engineer in biochemical engineering is able to master all the methodologies and processes associated with the conversion of biotic or non-biotic materials. In other words, he is able to design and optimize new processes, master the conception and realization of new bio-catalysts (micro-organisms, enzymes) and calculate biological reactors and unit operations of extraction-purification. The course combines a grounding in the field of life sciences (biology, biochemistry, microbiology, molecular biology, physiology, genetic engineering,?) and in engineering sciences (biochemical engineering, process engineering, extraction and separation techniques,?). The biotechnological engineer is thus capable of understanding the most modern concepts in molecular biology as well as mastering the concepts of thermodynamics and engineering based on a good understanding of physics and mathematics.

A large part of the course focuses on the acquisition of cross-disciplinary competences (languages, economics, project management, communication,?).

The biotechnological engineer will work in sectors ranging from health, agronomy, food science to the environment and will be equally competent in production units or bio-process development, R&D or fundamental research.

Et après

Conditions d'accès

Diplôme d'ingénieur habilité par la commission des titres d'ingénieur, 5 années d'études après la fin des études secondaires, confère le grade de Master.

Baccalauréat ou équivalent pour une admission en première année

Admission sur titre possible en année 2, 3 ou 4.

Admission

A tous les niveaux, l'admission aux INSA s'effectue par concours sur titres, dossier et éventuellement entretien ; le dossier rassemble des éléments d'évaluation obtenus par ailleurs par le candidat.

Plus de renseignement sur : http://www.insa-toulouse.fr/fr/admissions.html

Et après

Poursuite d'études

A ce titre, ils peuvent concevoir de nouveaux procédés et optimiser leur fonctionnement, maîtriser la conception et la réalisation de nouveaux biocatalyseurs (enzymes, micro organismes) répondant aux contraintes industrielles, et calculer des réacteurs biologiques et des opérations unitaires d'extraction-purification.

Le diplôme d'ingénieur confère le grade de Master et permet donc la poursuite d'étude en thèse.

Insertion professionnelle

Environ 35% des étudiants se dirigent vers le secteur de l'agro-alimentaire, 35% vers le secteur de l'industrie pharmaceutique et 15% vers le secteur de l'environnement.

En termes de métiers :

40% vont vers la recherche et le développement

20% vers la production

20% vers la qualité

10% vers le conseil ou le technico-commercial

Infos pratiques

Lieu(x)

Toulouse

Programme

FOURTH YEAR INSA TOULOUSE

Autumn semester

Cellular metabolism and regulation	5 crédits	65h
Genetic engineering	6 crédits	74h
Mass transfer	6 crédits	51h
Biochemical kinetics and bioreactor	6 crédits	69h
Improving autonomy and building a professional project	4 crédits	39h
Improve your management abilities	4 crédits	45h

Spring semester

Microbial and Mammalian cells culture	7 crédits	98h
Genetic and Enzymatic engineering	4 crédits	72h
Multi-disciplinary Projects	7 crédits	119h
Unit Operations	6 crédits	89h
Communicating within organizations	6 crédits	75h

FIFTH YEAR INSA TOULOUSE

Autumn semester

BIOSYNTHETIC BIOLOGY COURSES

Systems and Synthetic Biology for biotechnologies	12 crédits	109h
Design project	12 crédits	233h
Human Resources Management and Group Work	6 crédits	75h

MICROBIOLOGY AND BIOCATALYSIS COURSES

Microbiology and biocatalysis for industry	12 crédits	265h
Design project	12 crédits	233h
Human Resources Management and Group Work	6 crédits	75h

Spring semester

Training period (5th year)	21 crédits	2h
Training period (4th year)	9 crédits	1h

Cellular metabolism and regulation

ECTS
5 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
65h

En bref

Langue(s) d'enseignement: Français, Anglais

Présentation

Objectifs

Description of the main metabolic pathways. Thermodynamics and kinetics. Stoechiometric balances. Description of some pathway regulation. Interconnection between the different pathways within the carbon central metabolism.

Infos pratiques

Lieu(x)

Toulouse

Genetic engineering

ECTS
6 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
74h

En bref

Langue(s) d'enseignement: Français, Anglais

Présentation

Description

- mutations

- transformation

- conjugaison

- transduction

- transposons

Basic tools (enzymes, plasmids, oligonucleotides..)

- Gene cloning

- Expression of recombinant proteins

- Analysis of a gene and its functions (sequencing, gene expression analysis, mutagenesis, protein-protein interactions, ...)

Organisation:

At the beginning of the course, the student will receive a document containing the most important points of the course. Along the course, about two hours will be used to analyse scientific papers in the domain and to solve a general scientific question by proposing adapted molecular biology methods. Simple molecular biology experiments will be performed to allow the student to apply the different concepts seen during the course: microbiology, transduction, genetic engineering tools, use of antibiotics, microscopy, During labwork sessions the student will also manipulate a Molecular biology software. A Group work made on a scientific paper will be presented to the class.

Main difficulties for students:

* To integrate different techniques in a general scientific question

* To find the methods which will allow to solve a problem

Objectifs

At the end of this module, the student will have understood and be able to explain (main concepts):

- Basics of bacterial genetics.

- Basic tools used in genetic engineering (restriction enzymes, plasmids…)

- Basic methods like cloning, PCR, sequencing, direct mutagenesis, microarrays, libraries construction, gene expression analysis…

The student will be able to:

- to describe and summarize basic methods

- to insert these methods in a larger scientific and experimental context

- analyse and criticize a scientific paper in this domain

- perform a simple experiment of molecular biology

use an "in silico cloning" software

Pré-requis nécessaires

Microbiology / Basic molecular biology

Infos pratiques

Lieu(x)

› Toulouse

Mass transfer

ECTS
6 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
51h

En bref

Langue(s) d'enseignement: Français, Anglais

Présentation

Description

Fundamental laws of mass transfer phenomena : conduction, convection. Steady state and transient state. Mass balance. Transfer in several phases. Reaction and transfer. Application to biotechnologies (oxygen transfer). Heterogeneous catalysis. Optimal design methodology and experimental strategy. Experimental designs. Factorial designs. Response surface. Optimal responses determination. Study of mixtures.

Organisation:

Lectures, tutorials with exercises (application to bioprocess) and lab works

Objectifs

At the end of this module, the student will have understood and be able to explain (main concepts):

To understand mass transfer phenomena (diffusion, convection).

The student will be able to:

- read, interpret, propose an installation flowsheet
- to write global balances on a process in order to calculate matter and energy flows
- identify of information fluxes
- make an critical analysis of a process
- be able to design an optimal set of experiments

Pré-requis nécessaires

Thermodynamics of solutions / Differential and partial derivative operations

Infos pratiques

Lieu(x)

Toulouse

Biochemical kinetics and bioreactor

ECTS
6 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
69h

En bref

Langue(s) d'enseignement: Français, Anglais

Présentation

Description

Biochemical reactions, reactors and microbial engineering

Reactors instrumentations

Microbial kinetics

Material Balances, stoichiometric and yield relationships

Thermodynamic Balances

Idealized reactors (Batch, Continuous Stirred Tank Reactor, Tubular Reactor), combinations of ideal reactors, recycling reactors and real reactors

Distribution of residence times

Modeling real reactors with combination of ideal reactors

Organisation:

Lectures, Tutorials.

Practical courses,

1) Saccharomyces cerevisiae culture. Kinetic and mathematical analysis

2) Enzyme reactor design

Objectifs

Understanding and implementing the biological reactions

Elements in biochemical engineering. Description of the bioreactor and its instrumentation. Mass, elementary and energetic balances. Application to ethanolic fermentation. Numerical experimental data treatment

Pré-requis nécessaires

Chemical and enzymatic kinetics / Differential and matrix calculations

Infos pratiques

Lieu(x)

- Toulouse

Improving autonomy and building a professional project

ECTS
4 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
39h

Présentation

Objectifs

Construire une équipe projet, Approfondir ses connaissances,

Investir le métier, les domaines d'activité, les fonctions.

L'étudiant devra être capable de :

- d'analyser avec les autres un problème posé (Identifier le problème, définir les axes d'approche dans un bilan interactif : organisation, physique, technique, stratégique, motivation, confiance...

- de décider ensemble (permettre à tout le monde d'exprimer son avis, ajuster et réguler sa conduite en fonction de l'analyse collective),

- d'identifier les ressources du groupe (sens critique, repérage des points forts et faibles de chacun).

Lieu(x)

Toulouse

Infos pratiques

Improve your management abilities

ECTS
4 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
45h

Présentation

Objectifs

At the end of this module, the student will have understood and be able to explain :

* The basic rules of business law

* The objectives, principles and means of marketing

* The principles and procedures of financial diagnosis and / or investment

The student will be able to :

Apply principles and rules of management and law in simple situations. Take into account the parameters of the management (customer needs, cost effectiveness and legal compliance).

Infos pratiques

Contacts

Education manager
LUCIE LECLERT
+33.(0)562266003
leclert@insa-toulouse.fr

Lieu(x)

Toulouse

Microbial and Mammalian cells culture

ECTS
7 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
98h

En bref

Langue(s) d'enseignement: Français, Anglais

Présentation

Description

Basic concept of cellular biology, establishment of a cell line, normal and transformed cells, culture media and culture systems, contaminations, transfection, different uses of mammalian cells

Kinetic models of growth and metabolites production , effects of the variables and environmental parameters, interaction between the biological dynamics and the mass transfers, equations of the bio-reactors: batch, chémostat, plug flow reactors, fed-batch, reactor with cellular recycling, application to the metabolites productions, numerical processing of the experimental data.

Organisation:

At the beginning of the course the students will receive a document containing the major informations given in the course and a document with the informations "step by step" to manipulate themselves two cell lines.

The " uses of mammalian cells" will be treated by the students themselves, groups of 3 students will work on different examples and will present the results of their work.

Main difficulties for students:

-practice of mammalian cell cultures

-mathematical approach of the various concepts of biochemical engineering

Objectifs

At the end of this module, the student will have understood and be able to explain (main concepts):

- How to establish a cell line in culture
- Mammalian cell culture specificities in terms of conditions and media
- Major uses of mammalian cells
- - Various kinetic behaviours of microbial growth and production
- Several strategies from implementation of the microbial cultures in the bio-reactor

The student will be able to:

- use a vocabulary specific to cell culture
- name major characteristics of a mammalian cell
- manipulate a cell line
- analyse, comment and criticize a scientific paper in the domain
- to calculate the various kinetic and stoechiometric parameters of microbial cultures

to calculate the potentialities of productions for the various bio-reactors

Pré-requis nécessaires

Basic knowledge of cellular biology

Basic concepts of molecular biology

Courses on kinetics, microbiology, metabolism, reactor engineering

Infos pratiques

Contacts

Education manager
STEPHANE GUILLOUET
guilloue@insa-toulouse.fr

Lieu(x)

Toulouse

Genetic and Enzymatic engineering

ECTS
4 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
72h

En bref

Langue(s) d'enseignement: Français, Anglais

Présentation

Description

Enzymatic engineering

Overview of protein structures, Computational tools and softwares for DNA and protein sequence analyses sequence analyses / Iinitiation to molecular graphism and molecular modelling / analyses and comparisons of 3D structures/ Case study: a-amylase family.

Genetic engineering

Genetic engineering will be taught through the preparation of literature review reports related to genetic engineering and synthetic biology (genome editing, metabolic engineering, control of gene expression, etc..). This will be completed by the oral presentation and critical analysis of a scientific article in front of the student class.

Organisation:

Lectures, practical courses, literature review, oral presentation.

Objectifs

At the end of this module, the student will have understood and be able to explain (main concepts):

Enzyme engineering

Understand the bioinformatics methods and computational tools used for i) genome assembly and annotation, ii) genome and protein sequence and structure analysis iii) comprehension of enzyme mechanism and engineering.

Genetic engineering

Understand the main approaches used for genetic engineering and synthetic biology. Understand the methodology used for scientific article search in data bases, for writing a scientific literature review and presenting a critical analysis of scientific articles.

The student will be able to:

Enzymatic engineering

Describe the methods used for bioinformatics analysis of genome and protein structures (sequence alignment and molecular modelling and graphism tools). Apply computational

methods to structure-activity relationship studies and enzyme engineering.

Genetic engineering

Use of bibliographic database for scientific article search.

Construct and write a scientific literature review

Know and describe various approaches and methods entering in the field of genetic engineering.

Pré-requis nécessaires

Structural biochemistry and molecular biology

Infos pratiques

Lieu(x)

› Toulouse

Multi-disciplinary Projects

ECTS
7 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
119h

En bref

Langue(s) d'enseignement: Français, Anglais

Présentation

Description

The program includes 4 parts:

- Methodology for project management

- Principles of the " quality, safety and environment respect" approach

- Multidisciplinary project that mobilizes knowledge in biochemical engineering, transfer phenomena, bioreactors engineering, balance sheet and unit operations

- The practice of individual and collective sports activities

Organisation:

The application of the learnings is made in group activities

The QSE approach is applied on practical class.

Objectifs

At the end of this module, the student will have understood and be able to explain (main concepts):

- The methods for project rational management

- The main concepts and the tools for quality

- The specific requirements for safety and environment in project management.

The student will be able to:

- Implement only and/or in a team the projects of actions,

- Manage in specialist the implementation and the follow-up of a project

- Plan actions and anticipate those of the others,

- Regulate the activity during project implementation,

- Make choices adapted to the interactions between the actors in order to be efficient,

- Communicate to obtain the wish action,

- Allocate roles between the partners by taking into account the individual skills,

- Act according to the constraints and to the adversity.

Pré-requis nécessaires

I1CCGE40 / I2CCGE10 / I3CCGE10 / I3BEMT10 / Biochemical engineering/ Transfer phenomena

Infos pratiques

Lieu(x)

Toulouse

Unit Operations

ECTS
6 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
89h

En bref

Langue(s) d'enseignement: Français, Anglais

Présentation

Description

Fundamental laws of heat transfer phenomena : conduction, convection and radiation. Thermal resistance. Conduction in solids : steady state and transient state. Natural and forced convection. Heat and mass exchanger: theory, calculations, technology.

Organisation:

Lectures, tutorials with exercises (application to bioprocess) and lab works

Objectifs

At the end of this module, the student will have understood and be able to explain (main concepts):

heat transfer phenomena: conduction, convection and radiation.

Mass transfer : principles of distillation and absorption

The student will be able to:

Size heat and mass exchangers

Infos pratiques

Lieu(x)

Toulouse

Communicating within organizations

ECTS
6 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
75h

Présentation

Objectifs

The classes given in French will focus on :

- How to react to society's demand for technical and scientific information

- How to foster critical thinking in order to give appropriate answers when questioned about such issues

- How to communicate effectively in the workplace

The classes given in English will focus on the specific linguistic characteristics of English used in such contexts in order for the students to understand and master them.

The students will also be made aware of the specificity of professional communication within the English-speaking world

Module L2

The objectives, defined in reference to the CEFRL for the 5 language activities, depend on the language studied - Chinese, German, Spanish - and the level of the student.

They can be consulted on :

https://moodle.insa-toulouse.fr/course/view.php?id=44

In certain cases, students may be authorised to follow an English module instead of another language.

Pré-requis nécessaires

For classes in English : mastery of general English.

Infos pratiques

Lieu(x)

Toulouse

Systems and Synthetic Biology for biotechnologies

ECTS
12 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
109h

En bref

Langue(s) d'enseignement: Français, Anglais

Présentation

Description

Programme (detailed contents) (62h) :

1) *Generalities concerning Systems Biology* (23h) :

. Why ? => Complexity of the cell (especially in terms of regulation) and of higher organisms, importance of network biology

. How ? => Approaches and methods, genetic tools, modelling tools and statistics, -omics technologies, informatics tools.

2) *Systems Biology for health* (12h) :

. Relevance for studying complex diseases

. Focus on cancer which is archetypal (complexity of intra-cellular factors (genetic and epigenetic complexity...) and extra-cellular factors (influence of other cell types, angiogenesis...)) illustrated by examples.

3) *Generalities, principles and field of application of synthetic biology* (15h)

- definition(s) and advantages of synthetic biology

- methods of synthetic biology

- identification and engineering of enzymes and metabolic pathways adapted to the final goal

- description of specific genetic tools developed for synthetic biology, presentation of host organisms to use, description of tools for optimization of metabolic fluxes to achieve high product titers

4) *Synthetic biology for industrial biotechnologies* (12h)

Interest for the biological production of existing bulk chemicals. Presentation of the challenges, the complexity but also the industrial success stories of this approach through several industrial examples.

Organisation:

The theoretical courses will be distributed the first semester (the corresponding lab work is performed at the end of the semester).

Objectifs

At the end of this module, the student will have understood and be able to explain (main concepts):

- how Systems Biology is changing the way biological systems are studied by allowing us to examine the cell

and organism as a whole, especially Systems Biotechnology that allows optimal design and development of upstream to downstream bioprocesses by taking a systems-approach (with *Escherichia coli* as the main bacterial producer studied), and Systems Medicine that considers diseases as 'perturbations of networks', and transforms the way drugs are developed by targeting multiple components of networks and pathways perturbed in diseases ;

- why Synthetic Biology an emerging field is located at the intersection of life science and engineering and is the application of the principles of engineering to the construction of life with desired properties in a rational and systematic way ; - what are the wide objectives of synthetic biology and their application for biomedicine, the cheaper synthesis of biopharmaceuticals, sustainable chemical synthesis by efficient biotransformation, environment and energy

The student will be able to:

- consider a biological question by applying a systems biology approach and study the mechanisms underlying complex biological processes as integrated systems of many interacting components. Systems biology involves (1) collection of large sets of experimental data, (2) proposal of mathematical models that might account for at least some significant aspects of this data set, (3) accurate computer solution of the mathematical equations to obtain numerical predictions, and (4) assessment of the quality of the model by comparing numerical simulations with the experimental data. Thus the student will acquire skills in network biology and genetic engineering, but also in mathematics (statistics, modelling), computer sciences and 'omics' technologies allowing acquisition of large-scale biological data.

- conceive of and purpose a synthetic biology approach to introduce novel functionality into engineered organisms for production purposes or for building new materials. The student should be able to develop the most appropriate strategy and choose the adapted technical methods to reach the goal of engineered biological systems with optimized biosynthetic pathways and develop efficient routes for producing pharmacologically active compounds, industrially important bulk chemicals, and liquid fuels for transportation

Infos pratiques

Lieu(x)

Toulouse

Design project

ECTS
12 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
233h

En bref

Langue(s) d'enseignement: Français, Anglais

Présentation

Description

With the help of a tutor, students carry out part of an industrial process design/ This work involves a literature survey, getting technical data and design of the process using acquired knowledge on coupled heat and mass transfer, unit operations and associated processes.

Objectifs

At the end of this module, the student will have understood and be able to explain (main concepts):

To allow students to apply their knowledge to the design of a practical project in biochemical engineering.

The student will be able to:

- propose an installation flowsheet
- to write global balances on a process in order to calculate matter and energy flows
- make an critical analysis of a process

Pré-requis nécessaires

Bioreactor ; Unit operations

Infos pratiques

Lieu(x)

Toulouse

Human Resources Management and Group Work

ECTS
6 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
75h

Présentation

Objectifs

At the end of this module, the student will have understood and be able to explain (main concepts) :

Human Resource Management

Aims and organisation of a Human Resources position, job analysis and forecasting, recruiting, work motivation, skills, salary, training, career management, conflict mitigation, work contract

Social Psychology

Groups, what they are, their influences and dynamics

The student will be able to analyse a group situation

Pré-requis nécessaires

None

Lieu(x)

Toulouse

Infos pratiques

Microbiology and biocatalysis for industry

ECTS
12 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
265h

En bref

Langue(s) d'enseignement: Français, Anglais

Présentation

Description

Program (detailed contents):

Microbial physiology

- Physiological behavior for industrial production (starter, proteins, polysaccharides, amino acids, antibiotics,...)

- Cell energetics and constraints for industrial implementation

Modelling

- Modelling strategy for the microbial reaction

- Phenomenological models

- Metabolic flux models

- Structured models

Behavior of high cell density bioreactor

- continuous culture reactors, recycled cell reactors

- Fed-batch reactors

Bioreactor control

- Fed-batch control for limiting conditions

- Optimization strategy for no limiting conditions

Distillation - heat exchange - chemical and biological reactors

Biocatalysis

New ways of modifying properties of biocatalysts

Use of enzymes in industry

Bioseparation techniques for proteins

Organisation:

- lectures

- projects

- Lab work

Objectifs

At the end of this module, the student will have understood and be able to explain (main concepts) :

- High cell density microbial cultures for industrial production, integrating the physiological constraints

- Modelling the biological reaction

- Controlling the fermentation process

- The design of an industrial process

- Applied enzyme catalysis

The student will be able to:

- design and simulate models describing the microbial productions

- design and implement microbial cultures for high performance reactors

- apply enzyme engineering techniques

Pré-requis nécessaires

Structural and metabolic biochemistry - Microbiology - Microbiological engineering -Bioreactor engineering

Infos pratiques

Lieu(x)

> Toulouse

Training period (5th year)

ECTS
21 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
2h

En bref

Langue(s) d'enseignement: Français, Anglais

Infos pratiques

Lieu(x)

Toulouse

Training period (4th year)

ECTS
9 crédits

Composante
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Volume horaire
1h

En bref

Langue(s) d'enseignement: Français, Anglais

Infos pratiques

Lieu(x)

Toulouse