JACOBS UNIVERSITY

Biotechnology

Bachelor‘s Degree Program (BSc)

Contents

1 Biotechnology at Jacobs University

1.1 Concept

1.1.1 Overview

Biotechnology is the translation of biological discoveries into sustainable technologies for human life. It comprises industrial, agricultural, medical and other technological applications. Biotechnology is an exciting and rapidly developing interdisciplinary science and there is an increasing demand for biotechnologists in many branches of industry such as pharmaceutical, chemical, health-care, and food industry. Its curriculum is meticulously designed based on the relevance of current life sciences research and demand of industries. The objective of the biotechnology undergraduate program is to provide students with the knowledge and skills required to pursue a professional career or to continue their studies towards an advanced degree. The program offers basic education in biotechnology and unique specialization courses in industrial biotechnology, high-throughput screening technology and biocatalyst engineering to match the increasing demand in biotechnological, chemical and pharmaceutical companies. Further specialization areas are offered in the fields of downstream processing and process simulation. The specialization in high-throughput screening technology addresses needs in companies for specialists capable of screening large collections of microorganisms or chemicals in order to identify novel biocatalysts or drugs. The specialization in biocatalyst engineering is offered in collaboration with Bioinformatics major. Specialization in industrial biotechnology shows the practice of using cells (especially microbial cells) or components of cells like enzymes to generate industrially useful products from renewable resources. A major focus of this lecture is metabolic engineering. Research groups in Biotechnology consist of talents with diverse educational background (bioprocess engineers, biochemists, biologists, chemical engineers, and chemists) from all over the world.

1.1.2 Practical training

In our training facility, future biotechnologists will gain profound hands-on experiences in fundamental experimental techniques and will be trained to handle state-of-the-art equipment. For effective practical training a PhD student is assigned to each small group of 4 to 5 students in addition to the supervising research instructor. In order to enhance interaction between undergraduate, grad-students, post-docs and faculty at all levels third year Biotechnology students have the opportunities to pursue a research project under the guidance of a world-class scientist. Having an extensive network with many large and reputable companies and start-up companies in the state of Bremen, we receive significant funding to undertake research projects in exciting fields such as biofuel cells, metabolic engineering, downstream processing, and nanocontainers for product recovery. To ensure the quality of our education students have to do a mandatory on-the-job training (2 months) in companies and we are delighted to obtain positive feedback from companies on the performance of our students.

1.2 Career Options

We believe that our students are well prepared to continue their education in many sciences and engineering programs and are as well-shaped scientists aware of their potential to do great

research at the interface between science and engineering. Many job opportunities are already available with a bachelor degree. Career opportunities include entry-level positions as biotechnologists, high-throughput screening specialists, bioprocess engineers, biochemical engineers, consultants, marketers and managers.

2 Modules: Biotechnology

For greater transparency of the logics and as guidance for the (prospective) student, we have structured the respective major programs in terms of modules. A module is defined as a combination of courses (lectures, lab units or other types of courses) interconnected by the same learning goals. Before listing the individual courses and describing their contents, these modules are presented and characterized by the skills and abilities that the student is expected to acquire. But irrespective of this overarching modular structure, the learning progress will be documented with credit points and grades attributed to the individual courses or lab units. This facilitates the control of the student's progress through the student as well as the university on a semester basis, while the modules may extend over a year or, in exceptional cases, even over longer periods. Only the core content of a major program is suited for modularization. The freely selectable Home School Electives and transdisciplinary courses fall outside this structure.

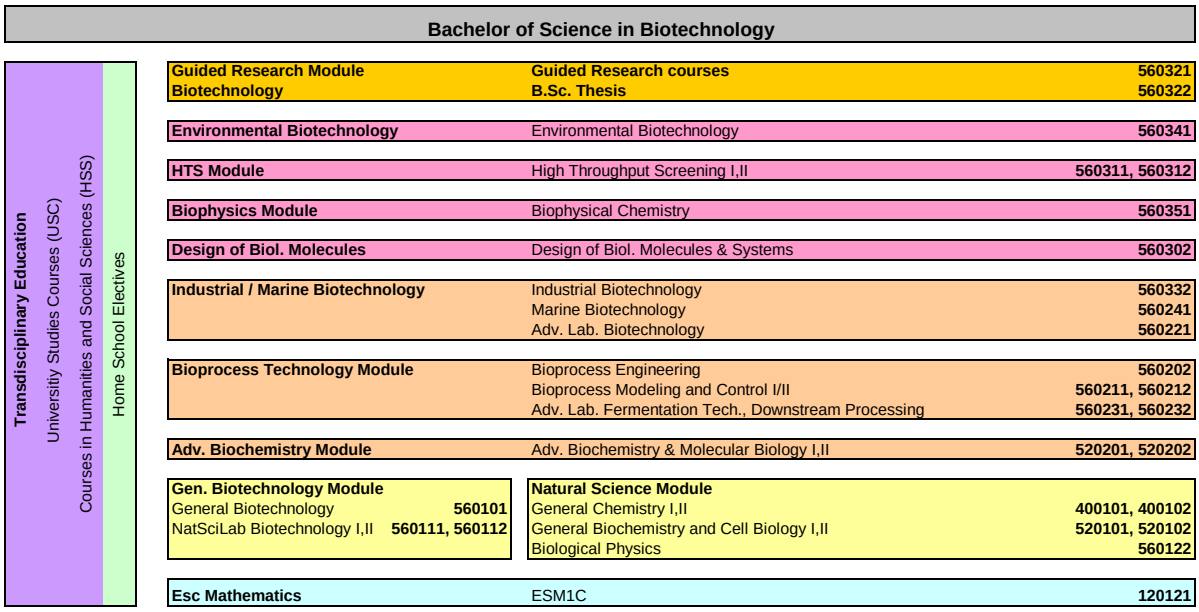

Figure 1: Biotechnology Module Structure

Subsequently the individual modules are being defined with respect to learning goals and acquired competencies. The listed course numbers constitute a reference to the individual courses and the descriptions of their contents.

2.1 General Science

Home School Electives and transdisciplinary courses are not listed as modules.

120110 – Mathematics Module

Short Name: ESM for LifeChem
Semester: 1
Credit Points: 5 ECTS

General Information Students of Biotechnology are required to take one Engineering and Science Mathematics course: See Engineering and Science Mathematics handbook.

Courses
120121 Engineering and Science Mathematics IC

xxx – Natural Science Modules

Short Name: ModGenSES
Semester: 1 – 2
Credit Points: 30 ECTS

General Information This includes the additional first year general science modules that consist of the general lectures and associated lab units which are required from all students majoring in the School of Engineering and Science.

Learning goals
- This should offer the student an introduction into other sciences offered within the School of Engineering and Science (SES).

Courses
4 General Engineering and Science lectures (5 ECTS credits each)

4 Natural Science Lab Units associated with the above lectures (2.5 ECTS credits each)

2.2 Biotechnology Major

560100 – General Biotechnology

Short Name: ModGenBioTech
Semester: 1 – 2
Credit Points: 10 ECTS

General Information In this module, the General Biotechnology lecture introduces the subject and is substantiated by the Biotechnology lab course over a period of two semesters.

Learning goals

- This module introduces students to the scope and language of biotechnology as a modern discipline combining life sciences and bioprocess engineering. Basic knowledge is provided in microbiology, biochemistry, molecular biology and genetics as well as bioprocesses. The development of first practical lab skills is a central goal of the practical training.
- Students learn how to design a scientific experiment, how to use the basic analytical instruments, how to perform a scientific analysis of experimental data and how to deliver these results in a scientific sound manner.
- The content of practical and theoretical lectures is combined to transfer theoretical knowledge to the lab experiments.
- As a crucial step towards safe laboratory work, the students also learn where and how to access information about hazardous chemicals as they have to prepare Material Safety Data. Students also get familiar with working in a certified Gen Labor S1.
- Students are exposed to scientific literature.

Courses

560101 General Biotechnology
560111 Natural Science Lab Unit Biotechnology I
560112 Natural Science Lab Unit Biotechnology II

560200 – Industrial/Marine Biotechnology Module

Short Name: ModIndBioTech
Semester: 3 – 6
Credit Points: 17.5 ECTS

General Information This module provides the foundation of current methods and processes in Industrial and Marine Biotechnology. The module starts with a lecture in the second year which will give an overview of the state of the art of Marine Biotechnology with a focus on applications using bacteria, micro- and makroalgae, as well as on aspects of modern aquacultures. The module continues with a lab course which gives a comprehensive overview about a typical process in Research and Development in the field of Industrial Biotechnology. The third part of the module is an advanced lecture providing knowledge concerning basic concepts, methods and products in the field of Industrial Biotechnology.

Learning goals

- The goal of this module is to provide students with the fundamentals and practical applications of Biotechnology in the field of Industrial and Marine Biotechnology.
- The laboratory course provides students with hand on experience in developing a whole bioprocess, from gene to product.
- In addition to technical skills, market driven situations are considered in the frame of real cases analysis.
- Concepts and examples of pathway engineering and microbial strain improvement are included in the lectures. Students will study current scientific publications and learn to present recent achievements in the field.

Courses
560221 Advanced Lab Course Biotechnology
560241 Marine Biotechnology
560332 Industrial Biotechnology

560210 – BIOPROCESS TECHNOLOGY MODULE

Short Name: ModBioProcTec
Semester: 3 – 4
Credit Points: 22.5 ECTS

General Information This second year module provides the basis for bioprocess technology and engineering, bioreactor and plant design and is supported by practical courses.

Learning goals

- This module teaches students on the principles and practice of bioprocess technology, Fundamentals of industrial microbiology are also provided.
- One lab course is devoted mainly to fermentation technology, bioreactor engineering and enzyme reactor design and scale-up. Students learn how to choose, configure, design and develop industrial fermentations.
- A second lab course is mainly devoted to cell culture technology and downstream processing. Students learn how to handle more delicate processes and how to design for a successful recovery and purification train, suitable for large-scale applications.
- Students are familiarized with engineering calculations, mass transfer phenomena, thermodynamics and kinetics, material and energy balances, (bio-)chemical reactor design and scale up of bioreactors.
- Students will be trained in the mathematical modeling and simulation of important unit operations commonly used in the bioprocess industry. They will learn how to describe the dynamics of such systems and to develop appropriate control strategies.
- Students learn how to tackle real life industrial challenges using bioprocess engineering approaches.
- Students explore the new directions in the field by analyzing scientific literature.

Courses
560202 Bioprocess Engineering
560211 Bioprocess Modeling and Control I
560212 Bioprocess Modeling and Control II
560231 Advanced Lab Course Fermentation Technology
560232 Advanced Lab Course Downstream BioProcessing

520210 – Biochemistry Module

Short Name: ModBC
Semester: 3–4
Credit Points: 10.0 ECTS

General Information This module consists of four lectures. However, only two courses of this module are required for Biotechnology students.

Learning goals

- The students should obtain a detailed knowledge of basic and advanced theoretical concepts of biochemistry that can serve as a solid and reliable basis for future work and education.
- In addition, they should become familiar with basic and advanced biochemical experimental methods that provide an entry point into independent experimental work.
- They learn to apply knowledge to novel problems and to find, understand, and interpret additional specific information from the literature and WEB resources.
- Students learn to interpret experimental results with respect to accuracy and reliability
- Besides this, their quantitative analytical skills are trained. They are taught in design of simple experiments, and learn about the meaning and importance of positive and negative controls.
- Furthermore, the students communicate experimental results to others in verbal and written form.

Courses
520201 Adv. Biochemistry and Molecular Biology I
520202 Adv. Biochemistry and Molecular Biology II
520251 Microbiology
520252 Plant Biochemistry and Biotechnology

560300 – Design of Biomolecules and Systems

Short Name: ModDesBioMolSys
Semester: 6
Credit Points: 5 ECTS

General Information In this module, students will be introduced to rational design approaches in protein bioengineering.

Learning goals

- Transdisciplinary approach, including molecular biology, protein chemistry, bioinformatics, computational biophysics, and biochemical engineering.
- Molecular modeling methods applied to the rational design of biological molecules.
- Application of these technologies to biocatalysts, drug design, and material science among others.

Courses
560302 Design of Biological Molecules and Systems

560310 – High-Throughput Screening Module

Short Name: ModHigh-throughScreen
Semester: 5 – 6
Credit Points: 10 ECTS

General Information In this module, students will be introduced to current methods and strategies in industry.

Learning goals
- Fundamental biophysics of recent high-throughput technologies
- Principles and practice of analytical biochemical methods and cell culture as applied to high throughput formats
- Scientific tools to follow the rapid development in this field
- Students are expected to learn how to define a system so as to screen for certain target active molecule and how to implement these measurement strategies in large-scale formats.

Courses
560311 High-throughput Screening Technology I
560312 High-throughput Screening Technology II

560340 – Environmental Biotechnology

Short Name: ModEnvBioTech
Semester: 5
Credit Points: 5 ECTS

General Information In this module, students will be introduced to the fundamental principles and applications of Environmental Biotechnology.

Learning goals
- This course focuses mainly on removal of organic waste from polluted water.
- It examines the operation and maintenance of biological processes in wastewater treatment plants.
- Mechanisms of aerobic and anaerobic treatment of waste water will be discussed.
- All the different aerobic and anaerobic biological processes that are involved in the elimination of organic pollution from waste water will be discussed in the course.
- Anaerobic fermentation to produce energy from renewable sources.
- Techniques to remove pollution from contaminated soil.

Courses
560341 Environmental Biotechnology

560350 – Biophysics Module

Short Name: ModBioPhys
Semester: 5
Credit Points: 5 ECTS

General Information In this module one lecture is offered.

Learning goals

- The focus of the lecture is to understand the thermodynamics and kinetics of structure formation and association of biomolecules as well as basic properties of biological membranes.
- The lecture will also provide a comprehensive overview about all modern aspects of research methods and tools to gain insight into this area of science which is the basis for understanding the most fundamental principles of interaction of molecules in biological systems.

Courses
560351 Biophysical Chemistry

560320 – Guided Research Biotechnology/B.Sc. Thesis

Short Name: ModGRBScThBioTech
Semester: 5 – 6
Credit Points: 15 ECTS

General Information Lab rotations. Within these courses the students start to work in the research laboratories. Two to four different research labs may be visited during the two semesters.

Learning goals

- During each guided research rotation, they learn to work independently on one project related to the research groups' topic.
- They get an overview of the state-of-the-art techniques used and learn how to approach experimental problems beyond the limitations of the previous lab course settings.
- They learn to take over responsibility for themselves as well as for group-tasks and to organize their time in an efficient way.
- At the end of each lab rotation, the students have to write a report that trains them for writing their B.Sc. thesis which contains experimental results from all 4 guided research rotations.

Courses
560321 Guided Research Biotechnology
560322 B.Sc. Thesis

3 Requirements for a B.Sc. in Biotechnology

3.1 General Requirements

To obtain a B.Sc. degree at Jacobs University a minimum of 180 ECTS credit points must be earned over a period of 6 semesters.

- A minimum of 140 ECTS credits must be earned in the School of Engineering and Science.
- 30 ECTS credits must be earned through transdisciplinary courses, comprised of courses in the School of Humanities and Social Sciences (**HSS**) and University Studies Courses (**USC**). Students can choose how many USCs or HSS courses they take.
- 10 ECTS credits (4 courses) are accredited either for language courses or additional Home School electives. Students can decide whether they take language courses or not.

3.2 Mandatory Courses for the Major

Requirements of the Major

Students choose 140 ECTS credits out of the following courses:

- **Year 1 level courses:**
  - General Biotechnology (560101, 5 ECTS credits)
  - Natural Science Lab Units (NatSciLabs) Biotechnology I/II (560111, 560112, 5 ECTS credits)
  - Engineering and Science Mathematics IC (120121, 5 ECTS credits)
  - Biological Physics (560122, 5 ECTS credits)
  - General Chemistry I/II (400101, 400102, 10 ECTS credits)
  - General Biochemistry and Cell Biology I/II (520101, 520102, 10 ECTS credits)

- **Year 2 level courses**:
  - Bioprocess Engineering (560202, 5 ECTS credits)
  - Bioprocess Modeling and Control I/II (560211, 560212, 10 ECTS credits)
  - Marine Biotechnology (560241, 5 ECTS credits)
  - Advanced Lab Courses in Biotechnology (560221), Fermentation Technology (560231), and Downstream Processing (560232), 15 ECTS credits
  - Advanced Biochemistry and Molecular Biology I/II (520201, 520202) or Microbiology and Plant Biochemistry and Biotechnology (520251, 520252) or Advanced Physical Chemistry I/II (400211, 400212), 10 ECTS credits

- **Year 3 level courses:**
  - Industrial Biotechnology (560332, 5 ECTs credits)
  - Design of Biological Molecules & Systems (560302, 5 ECTS credits)
  - High Throughput Screening Technology (560311, 560312, 10 ECTS credits)
  - Environmental Biotechnology (560341, 5 ECTS credits)
  - Guided Research Biotechnology (560321, 7.5 ECTS credits)
  - B.Sc. Thesis (560322, 7.5 ECTS credits)

3.2.1 School Recommendation

In order to have a real option to decide for a major at the end of the first year students should take three general lectures plus per semester three matching laboratory courses including those prescribed by the major.

4 Recommended Course Plan

Year 1 Courses	**Fall**	**C**	**T**	**Spring**	**C**	**T**
ESc Mathematics IC	120121	*5*	m			
General Biotechnology	560101	*5*	m			
Biotechnology Natural Science Lab Modules I/II	560111	*2.5*	m	560112	*2.5*	m
Biological Physics				560122	*5*	m
General Chemistry I/II	400101	*5*	m	400102	*5*	m
Chemistry Natural Science Lab Modules	400111	*2.5*	e	400112	*2.5*	e
General Biochemistry and Cell Biology I/II	520101	*5*	m	520102	*5*	m
BCCB Natural Science Lab Modules I/II	520111	*2.5*	e	520112	*2.5*	e
Transdisciplinary Courses		*5*	u		*5*	u
Running Total / *Semester Total*	32.5	*32.5*		60	*27.5*	

Year 2 Courses	**Fall**	**C**	**T**	**Spring**	**C**	**T**
Bioprocess Engineering				560202	*5*	m
Marine Biotechnology	560241	*5*	m			
Bioprocess Modeling and Control I/II	560211	*5*	m	560212	*5*	m
Advanced Biochemistry I/II	520201			520202		
or						
Microbiology / Plant Biochemistry & Biotechnol.	520251			520252		
or						
Advanced Physical Chemistry I/II	400211	*5*	m	400212	*5*	m
Advanced Lab Courses Biotechnology	560221	*7.5*	m			
Advanced Lab Course Fermentation Technology	560231	*3.75*	m			
Advanced Lab Course Downstream BioProcessing				560232	*3.75*	m
Transdisciplinary Courses		*5*	u		*5*	u
Language Courses or Home School Electives		*2.5*	e		*2.5*	e
Running Total / *Semester Total*	93.75	*33.75*		120	*26.25*	

Year 3 Courses	**Fall**	**C**	**T**	**Spring**	**C**	**T**
Industrial Biotechnology				560332	*5*	m
Design of Biol. Mol. & Systems				560302	*5*	m
High Throughput Screening Tech. I/II	560311	*5*	m	560312	*5*	m
Environmental Biotechnology	560341	*5*	m			
Biophysical Chemistry	560351	*5*	e			
Guided Research	560321	*7.5*	m			
Guided Research and B.Sc. Thesis Biotechnology				560322	*7.5*	m
Transdisciplinary Courses		*5*	u		*5*	u
Language Courses or Home School Electives		*2.5*	e		*2.5*	e
Running Total / *Semester Total*	150	*30*		180	*30*	

C = ECTS credit points, T=type (m=mandatory, e=elective, u=university), Transdisciplinary Courses are School of Humanities and Social Sciences and University Studies Courses

4.1 Recommendation Professional Skills

The SES highly recommends attending the Professional Skills seminars offered by the Career Services Center. Those seminars include soft skills development seminars and application training which will help you cope with your studies and master your internship and job search.

All undergraduate students are required to complete an internship, normally to be accomplished between the second and third year of study. Information about the internship will be listed on the transcript.
The internship must last at least two consecutive months. No credits are connected to the internship requirement.
For more information on internships see http://www.jacobs-university.de/career-services/internship.

5 Courses: Biotechnology

5.1 First Year of Study

560111 – Natural Science Lab Unit Biotechnology I

Short Name: NatSciLabBioTech I
Type: Lab
Semester: 1
Credit Points: 2.5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents Experiments in the Biotechnology lab unit will introduce students in basic techniques of biotechnology and train basic laboratory skills. Course days include e.g. the handling of pipettes, balances, pH meters, centrifuges and spectrophotometers. Experiments include yoghurt fermentation, titration, gel electrophoresis, protein determination, transformation of bacteria with plasmid DNA, determination of enzyme activities, and thin layer chromatography of synthetic food colorants.

560101 – General Biotechnology

Short Name: GenBioTech
Type: Lecture
Semester: 1
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents The course is an introduction for students into the broad area of biotechnology. Biotechnology is a highly interdisciplinary field combining general biology, molecular genetics, microbiology, biochemistry, enzyme technology, bioprocess engineering, molecular medicine and others in order develop a product or process for human utilization. The course gives an overview about the different kinds of traditional and modern biotechnological products and processes and communicates the essential basic knowledge.

560112 – Natural Science Lab Unit Biotechnology II

Short Name: NatSciLabBioTech II
Type: Lab
Semester: 2
Credit Points: 2.5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents Experiments in the second Biotechnology lab unit will introduce students in basic techniques of cell cultivation and downstream processing. Solid state fermentation will be used to produce an enzyme (proteinase) by a filamentous fungus. The evolution of the culture (enzyme activity, pH, carbohydrate and protein concentration) will be determined. In the second part of the course, students will use ion exchange chromatography to purify the enzyme lysozyme from eggs. The purification process will be characterized using three techniques: determining the protein concentration using the Bradford assay, determining the level of enzyme activity using an assay based on hydrolysis of bacterial cell walls, and determining the purity using SDS-Polyacrylamide gel electrophoresis.

560122 – Biological Physics

Short Name: BioPhys
Type: Lecture
Semester: 2
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents To understand and design biotechnological processes quantification is necessary. This course introduces general physical principles needed to quantify biological phenomena. To facilitate the understanding we provide also some basic mathematical procedures. We introduce the concept of forces, potentials, electric fields but also fluidic dynamics, heat, flow. The relevance is demonstrated using the example of the bacterium Escherichia coli for which we characterize the underlying principle of motion, diffusion, elasticity and energetics.

5.2 Second Year of Study

560202 – Bioprocess Engineering

Short Name: BioProcEng
Type: Lecture
Semester: 4
Credit Points: 5 ECTS
Prerequisites: 560101, 560112
Corequisites: None
Tutorial: None

Course contents Biotechnology heavily depends on process engineering in order to deliver real products (or services) to the market and in order to generate a positive impact on modern societies. A biotechnologist has to master current industrial bioprocessing practice, from the microbial or cell producer (bio-reaction) to the highly purified, formulated product. He/she must be able to design and optimize new processes, calculate for biological reactors, and develop efficient recovery and purification procedures (downstream processing). In this course students will learn how to design a bioprocessing ”train”. Important aspects are: Operating

considerations for microbial fermentations, cell bioreactors for suspension and immobilized cultures, Selection, scale-up, and operation, of bioreactors and enzyme reactors, Primary recovery and purification of products, Bioprocess considerations in using animal cell cultures, plant cell cultures, and genetically engineered organisms, among others. Practical demonstrations may take place during the Course. Students will utilize a software package for process design and cost evaluation. New trends in bioprocess technology will be analyzed by focusing on innovative case studies.

560211, 560112 – Bioprocess Modeling and Control I, II

Short Name: BioProcMC I, II
Type: Lecture
Semester: 3 – 4
Credit Points: 5 ECTS
Prerequisites: 560101, 560112
Corequisites: None
Tutorial: None

Course contents The first part of a two semester course in Bioprocess Modeling and Control is designed to provide students with a fundamental understanding of bioprocess concepts and applications. The course will focus on the modeling of stationary bioprocesses, it includes the formulation of material and energy balances as well as balances on reactive and non-reactive processes and complex plants. The course will also cover the modeling of heat transfer phenomena in heat exchangers and bioreactors. The second course in Bioprocess Modeling and Control provides students with an in depth understanding of the modeling of biochemical engineering dynamics and the control of bioreactors. Beyond the basic concepts of modeling, process dynamic fundamentals, bioprocess kinetics and the modeling of stagewise processes will be covered. An introduction to modern simulation techniques and software will be given. Students will be enabled to formulate mathematical models and to implement them into simulation software packages. Some attention will be paid to reactor design for bioprocesses. A particular focus of the course will lie on the design and analysis of modern industrial control strategies for biotechnological processes.

560241 – Marine Biotechnology

Short Name: MarBioTech
Type: Lecture
Semester: 3
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents Marine biotechnologies can be understood as being the various techniques of managing marine living systems for the pro?t of mankind. The domain covered by marine biotechnologies is vast and ranges over various overlapping disciplines, from environmental

biology to the chemistry of natural substances and bioprocess engineering. The course will give an overview over the current state of the art of marine biotechnology with a focus on 'real world' applications. Attention will be paid to special adaptations of marine organisms useful for biotechnology. Applications using bacteria, micro- and makroalgae, as well as aspects of modern aquaculture will be discussed in detail. During the course, two excursions are planed (Biotechnica exibition, and visiting companies near Bremen).

560221 – Advanced Lab Course Biotechnology

Short Name: AdvBioTechLab
Type: Lab
Semester: 3
Credit Points: 7.5 ECTS
Prerequisites: 560101, 560112
Corequisites: None
Tutorial: None

Course contents Future biotechnologists gain hands-on experience in fundamental techniques of molecular biology and are trained to handle state-of-the-art equipment for bio-process engineering and downstream processing. Starting with an in depth understanding of genetic engineering and laboratory evolution methods, the students follow the path of the gene from cultivation through product formation to product recovery. This first part of the practical lab course includes genetic engineering of microbial DNA (directed evolution) and subsequently introducing the mutated genes into microorganisms via transformation.
The second part of the practical course involves cultivation of microorganisms in laboratory scale as well as in production scale (fermentation). Our students will learn methods of concentrating the cell mass and applying different methods to recover a product suitable for subsequent processing (e.g. high pressure homogenizer).
The third part of the practical course includes the purification of proteins by chromatography.

560231 – Advanced Lab Course Fermentation Technology

Short Name: AdvFermTechLab
Type: Lab
Semester: 3
Credit Points: 3.75 ECTS
Prerequisites: 560102,560112
Corequisites: 560201
Tutorial: None

Course contents This laboratory course will give students hands on experience with working with biochemical reactors and simulations. Students will gain experience in using modern equipment and instrumentation. The statistical optimisation of process variables will be introduced to the students and subsequently applied to a defined experimental situation. Fermentation processes, involving microbial cells or filamentous fungi, will be optimised at the bench scale in order to produce a valuable product, like enzymes, proteins, or secondary metabolites.

Scale-up of the process will follow either in the submerged or the solid substrate fermentation mode. Productivity and yields will be calculated and compare to known industrial processes

560232 – Advanced Lab Course Downstream BioProcessing

Short Name: AdvDownEngLab
Type: Lab
Semester: 4
Credit Points: 3.75 ECTS
Prerequisites: 560101, 560112
Corequisites: 560201
Tutorial: None

Course contents The area of downstream processing comprises the development of product isolation processes for large scale biotechnological production. This laboratory course will give students hands on experiences in the key steps of downstream processing (primary recovery, intermediate and high resolution purification, polishing) which account in pharmaceutical industries for up to 80 % all production costs.

5.3 Third Year of Study

560332 – Industrial Biotechnology

Short Name: IndBioTech
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 560101
Corequisites: None
Tutorial: None

Course contents This advanced course in Biotechnology is based on the first year course of General Biotechnology and educates the students particularly in the field of Industrial Biotechnology. Industrial Biotechnology (also known in Europe as White Biotechnology) is the application of Biotechnology for industrial purposes, including manufacturing, alternative energy (or ”bioenergy”), and biomaterials. It includes the practice of using cells (especially microbial cells) or components of cells like enzymes to generate industrially useful products from renewable resources. The lecture will provide knowledge about the diversity of microbial metabolism and how it is used to convert renewable substrate into industrially relevant products. Concepts and examples of pathway engineering and microbial strain improvement are included. Students will study current scientific publications and present recent achievements in the field.

560302 – Design of Biological Molecules and Systems

Short Name: DesBioMolSys
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents The course is intended to give an overview on theoretical/ computational aspects of biological molecule and system design. The course provides an introduction to different bioinformatics and molecular modeling methods to study and/or to predict effect(s) of mutations on bio-molecular structure and function, ligand-receptor binding, dynamics of bio-molecular system in solution and at interfaces, drug design and virtual screening methods.

560311, 560312 – High-throughput Screening Technology I, II

Short Name: HighScreenTech I, II
Type: Lecture
Semester: 5 – 6
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents High throughput screening (HTS) has evolved to a status of a separate science wherein the diverse disciplines of biology, chemistry, genetic engineering, robotics, computer science, and data management have merged to create a functional conglomerate with a single goal: discovery. HTS is a central function in the modern drug discovery process. Methods of HTS are basically methods of analytical biochemistry (photometry, purification, electrophoresis, kinetic assay, immunoassay, etc.). Profound knowledge of these methods is crucially important for assay design, its validation, data analysis and decision making. The linchpin of HTS is assay design, where detection techniques are one of the essential parts. During the course we will learn principles of the various detection techniques (light absorption, fluorescence, radioisotope techniques). Also we will learn physical principles of many analytical biochemical instruments used for multi-sample analysis (microplate readers, scintillation counters) as well as consumables for HTS. In this course we will cover state of the art HTS technologies including automated liquid handling machines (robots). A focus will be on genetic engineering techniques and screening systems involved. Additionally required automation and engineering approaches will be covered in detail. The goal is to provide students with a background that enables them to successfully implement HTS strategies in real world applications of high-tech industry by mining the created diversity and finding the needle in haystack.

560341 – Environmental Biotechnology

Short Name: EnvBioTech
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents Environmental Biotechnology is also known as Grey Biotechnology. It is the fundamental basis of applied biotechnology when it is applied to and used to study processes in the natural environment. Environmental Biotechnology could also imply that one try to harness biological process for commercial uses and exploitation. The growing concern over the quality of our environment demands prevention of polluting releases in the ecosystem and treatment of pollutants already there. The lecture course will deal with aerobic and anaerobic treatment of waste water. The most important part of a waste-water cleaning plant is the biological part. During several hours of stay a considerable part of the pollution is removed by bacteria and the BOD5 (biological oxygen demand) is reduced by 85 to 95% during the waste-water treatment. Modern waste-water treatment plants do a good job for the removal of the organic matter. The problem nowadays is the removal of nitrogen (ammonia and nitrate) and phosphate from waste-water. The essential processes are nitrification (i.e. oxidation of ammonia to nitrate) and denitrification (i.e. the reduction of nitrate to nitrogen). These processes cannot proceed at the same time or in the same place because nitrification needs high oxygen concentration (oxygen concentration above 2 mg/l) whereas denitrification needs anaerobic condition (oxygen concentration lower than 0.1 mg/l). All the different aerobic and anaerobic biological processes that are involved in the elimination of organic pollution from waste water and soil will be discussed in the course.

560351 – Biophysical Chemistry

Short Name: Biophys
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents Interactions between molecules, such as antibody-antigen, enzyme-substrates, receptor-membrane are the base of biological processes. This course introduces current theoretical and experimental tools to quantify such interaction between biomolecules. We begin with a molecular view to introduce the relevant forces and interaction necessary to understand and perform molecular modeling. In a second part we follow a more macroscopic thermodynamic view: substrate binding or partitioning, cooperative effects, transport across membranes to name a few keywords. The third part is devoted to kinetic phenomena and the necessary experimental techniques as relaxation theory, correlation spectroscopy, stopped flow.

560321, 560322 – Guided Research in Biochemical Engineering/B.Sc. Thesis

Short Name: GRBSCTh BioTech
Type: Research
Semester: 5 – 6
Credit Points: 7.5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: None

Course contents This lab course intends to intensely train students in laboratory practice on a given research project of the Instructors group. It is an integrated part of the lab rotations each student has to attend during the 3rd year education. Two lab rotations per each semester of the 3rd year will give the students the opportunity to visit two to four different research laboratories of the various life sciences disciplines participating in this course structure. All individual lab rotations will finally be written up in a thesis to prove the students ability of performing independent research. Scheduling has to be decided between the students and the individual instructors of the particular lab rotations.