Module booklet

Course

Industrial biotechnology

Version: 23.06.2016

No liability is accepted for the correctness of the semester periods per week and LP listed in this module booklet. The course examination regulations are binding.

Table of contents of the modules

List of abbreviations

Exc.	Excursion
GLP	Good Laboratory Practice
GMP	Good Manufacturing Practice
h	Hours
K	Exam
LB	Lecturer
LP	Credit points
mP	Oral exam
N. N.	Nomen Nominandum (Assistant professor is not yet decided)
P	Practical course
PL	Performance test
PVL	Prerequisite
R	Presentation
S	Seminar
SA	Written composition
SWS	Semester periods per week
Ü	(practical) Exercise
V	Lecture

Introduction to biotechnology	
Code	(not yet made available)
Credits (as per ECTS)	6
Attendance time	6 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Grammel
Assistant professor(s)	Prof. Dr. Grammel, Prof. Dr. Schips, Prof. Dr. Frühwirth
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 1st Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have knowledge of the scientific, technological basics as well as of the social and economic frameworks of biotechnology, • recognise the multiple application domains for biotechnology, • are able to evaluate biotechnological processes with regards to their advantages and problems, • have insights into industrial biotechnology thanks to excursions in companies in the field of industrial biotechnology, • have an overview of potential employment fields and employers, • understand the process engineering interrelationships for devices, installations and systems, • are able to understand processes and represent them according to standards, • are able to interpret technical drawings
Content	The following technical contents are taught in this module: Lecture "Introduction to industrial biotechnology" • Social, scientific and industrial framework • Characterisation and application domains of white biotechnology • Raw materials and products • Ecological and economic aspects • Product spectrum: Biofuels, vitamins, amino acids, fine and bulk chemicals, industrial enzymes, antibiotics, biopolymers • Fermentation processes • Current trends: Biorefinery, system biology, synthetic biology Course "Project excursion I" • Fundamentals of biotechnology • Excursions to various companies in the field of industrial biotechnology • Business areas of the company to be visited

	Lecture + Exercise "Introduction to process engineering" • Classification of process engineering, sub-domains • Physical variables and unit systems, common concentration measurements in process engineering • Basic operations • Standardised representation of processes: block flowcharts, process flowcharts, piping and instrumentation flowcharts • Application examples: process engineering representation of processes from biotechnology
Literature	Lecture "Introduction to industrial biotechnology" • Molekulare Biotechnologie, Konzepte, Methoden und Anwendungen, 2. aktualisierte Auflage, Hrsg: M. Wink; Wiley-VCH • Biotechnologie für Einsteiger, 3. Auflage, Renneberg & Süßbier, Spektrum Verlag • Industrial Biotechnology – Sustainable Growth and Economic Success Ed.; W. Soetaert &E.J. Vandamme, Wiley-VCH, 2010 • Enzymes in Industry Production and Applications, Ed.: W. Aehle, Wiley-VCH, 2004 Course "Project excursion I" • Molekulare Biotechnologie, Konzepte, Methoden und Anwendungen, 2. aktualisierte Auflage, Hrsg: M. Wink; Wiley-VCH • Biotechnologie für Einsteiger, 3. Auflage, Renneberg & Süßbier, Spektrum Verlag • Industrial Biotechnology – Sustainable Growth and Economic Success Ed.: W. Soetaert & E.J. Vandamme, Wiley-VCH, 2010 • Enzymes in Industry Production and Applications, Ed.: W. Aehle, Wiley-VCH, 2004 • Company information material (internet) Lecture + Exercise "Introduction to process engineering" • Vauck, Müller, Grundoperationen chemischer Verfahrenstechnik, Wiley
Forms of teaching and learning	• Introduction to industrial biotechnology (V), 2 SWS, 2LP • Project excursion I (Exc.), 2 SWS, 2 LP • Introduction to process engineering (lecture + exercise), 2 SWS, 2 LP
Workload	**Lecture "Introduction to industrial biotechnology"** Attendance time: 30 h Individual study: 30 h **Excursion "Project excursion I"** Attendance time: 30 h Individual study: 30 h **Lecture + Exercise "Introduction to process engineering"** Attendance time: 30 h

	Individual study: 30 h **Total** Attendance time: 90 h Individual study: 90 h Total: 180 h
Evaluation method	The evaluation is a written exam (60 minutes) covering the entire module. Participation in this written examination requires students to have successfully completed the prerequisite of the "Project excursion I" excursion (written composition).
Grading	The module grade corresponds to the result of the examination.

Fundamentals of process engineering	
Code	(not yet made available)
Credits (as per ECTS)	8
Attendance time	8 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Frühwirth, Prof. Dr. Mavoungou, Prof. Dr. Burghardt
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 2nd Semester
Required knowledge	• Content: Recommendations:
Learning outcomes	Students that have successfully completed this module, • are able to describe basic concepts of fluid flow and apply them to technical problems, can analyse frictionless and adhering flows using devices and installations, • understand technical applications such as container flows, pumps and pipe flows, • understand systems with or without heat or matter exchanges, • are capable of applying basic concepts of fluid mechanics and are able to apply these to solve technical problems in heat and matter transfer, • understand the theoretical basics required for in-depth understanding of biotechnological and process engineering processes, • have good command of the physical basics of mechanics, fluid mechanics and thermodynamics, • are capable of evaluating experimental data using thermodynamic and kinetic models with focus on solutions, • have good command of the basics of physicochemical methods, • have basic knowledge in the domains of thermochemistry and of technical thermodynamics, • understand the concepts of technical thermodynamics and are capable of applying these to actual problems, • understand the thermodynamics of combustion engines, steam-driven installations, combustion and cooling processes and are capable of applying them to idealised design examples
Content	The following technical contents are taught in this module: Lecture + Exercise "Transport phenomena" • Fluid mechanics: Application of the Bernoulli equation to ideal containers and tube systems • Description of laminar and turbulent flows • Real tube and container flows • Description and design of pumps and compressors • Mass transfer: Mechanisms of material transmission, diffusion, convection

	• Model theories for material transmission • Transmission of gaseous components in liquids, kLa value methods • Heat transmission: Mechanisms of heat transmission, heat conduction, heat radiation Lecture + Exercise "Thermodynamics" • Chemical engineer thermodynamics: Thermodynamics of the phase limit for drops, bubbles, particles • Molecular and electrostatic interaction between phase limits • Influence of the phase limit on technical processes • Ternary systems - miscibility gaps • Technical thermodynamics: First and second law of thermodynamics • Application of the laws in technical problems • Thermodynamics of combustion engines, refrigeration processes, steam-powered machinery and combustion Lecture + Exercise "Physics" • Mechanics: Kinematics, Newtonian mechanics, laws of conservation • Mechanics of liquids and gases: Density, pressure, fluid dynamics, laminar flows, viscosity, Hagen-Poiseuille law • Heat transport: Heat conduction, heat radiation, black bodies Lecture + Exercise "Physical chemistry" • Basic terminology and definitions for thermodynamics • Functions of multiple variables, partial differential quotients, total differential, state and change functions • Forces and aggregation between molecules • Chemical thermodynamics: Temperature and thermal movement of molecules (ideal gas law, kinetic gas theory, energy distribution as a function of temperature, real gases); Characteristic functions, chemical potential, mixed phases, phase equilibriums and phase diagrams, homogeneous and heterogeneous chemical equilibriums; Reaction kinetics • Gaseous solubilities: Henry's and Raoult's laws • Dalton's law
Literature	Lecture + Exercise "Transport phenomena" • Baer, Stefan, Heat and material transmission, Springer • Vauck, Müller, Grundoperationen chemischer Verfahrenstechnik, Wiley Lecture + Exercise "Thermodynamics" • Günther Cerbe, Gernot Wilhelms: Technische Thermodynamik: Theoretische Grundlagen und praktische Anwendungen, Hanser Verlag 2013 Lecture + Exercise "Physics" • Halliday, Resnick, Walker; Halliday Physics - Bachelor Edition, Wiley-VCH, 2007

	• Knight; Physics, Pearson Addison-Wesley, 2008 Lecture + Exercise "Physical chemistry" • Gerd Wedler und Hans-Joachim Freund, Lehrbuch der physikalischen Chemie, 6. Auflage, Wiley VCH • Gerd Wedler und Hans-Joachim Freund, Arbeitsbuch der physikalischen Chemie, 6. Auflage, Wiley VCH • Peter W. Atkins, Physikalische Chemie, Wiley-VCH Barrow, Physikalische Chemie, Bohmann Vieweg
Forms of teaching and learning	• Transport phenomena (lecture + exercise), 2 SWS, 2 LP • Thermodynamics (lecture + exercise), 2SWS, 2 LP • Physics (lecture + exercise),2 SWS, 2 LP • Physical chemistry (lecture + exercise), 2 SWS, 2 LP
Workload	**Lecture + Exercise "Transport phenomena"** Attendance time: 30 h Individual study: 30 h **Lecture + Exercise "Thermodynamics"** Attendance time: 30 h Individual study: 30 h **Lecture + Exercise "Physics"** Attendance time: 30 h Individual study: 30 h **Lecture + Exercise "Physical chemistry"** Attendance time: 30 h Individual study: 30h **Total** Attendance time: 120h Individual study: 120 h Total: 240 h
Evaluation method	The examination is a written exam (120 minutes) covering the entire module.
Grading	The module grade corresponds to the result of the examination.

Mathematics and biostatistics I	
Code	(not yet made available)
Credits (as per ECTS)	6
Attendance time	6 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Ebert
Assistant professor(s)	Dr. Schriever, Mr. Dittmar
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 1st Semester
Required knowledge	• Content: Recommendation: Differential and integral calculus
Learning outcomes	Students that have successfully completed this module, • will understand mathematical and statistical fundamentals, mindsets and methods that will later be required in the industrial biotechnology course
Content	The following technical contents are taught in this module: Lecture "Mathematics and biostatistics I" • Basic terminology: assertions, quantities • Functions: Basic terminology, real-values functions - monotony, symmetry, periodicity, inverse functions • Limit values of functions: Limit values, continuity, poles, asymptotes, broken rational functions • Differential calculus: Differentiability, rules of differentiation, mean value theorem, curve sketching • Integral calculus: Root function, Riemann integral, indefinite, improper integrals, product, quotient rule, partial integration, broken rational functions • Applications of integral calculus: Surface areas, volumes of solids of revolution, arc lengths of flat curves, shell surfaces of solids of revolution • Power series: convergent points, convergence behaviour, continuity, differentiability, integrability, identity theorem, Taylor series, Taylor formula, MacLaurin series • Limit values calculation using differentiation • Descriptive statistics: features, scales, data cleaning, absolute and relative frequency, diagrams, histograms, empirical distribution function • Statistical measures, measures of location, arithmetic, geometric, harmonic mean, quantiles, box-plot; Measures of spread, variance, standard deviation, coefficient of variation • Covariance, coefficient of correlation, regression analysis • Probability calculation: Random experiment, random sampling, probability space, geometrical probabilities • Conditionality, independence: Bayes theorem, decision trees • Random variables and their distributions: Distribution

	function, probability function, density function, expected values Exercise "Mathematics and biostatistics I" • Exercises + solutions are made available in PDF format for each individual chapter in the course.
Literature	Lecture "Mathematics and biostatistics I" • L. Papula: Mathematik für Ingenieure und Naturwissenschaftler • Schriever et al.: Wahrscheinlichkeitsrechnung 1+2, Beschreibende Statistik, Schließende Statistik Exercise "Mathematics and biostatistics I" • provided exercises + solutions • Schriever et al.: Wahrscheinlichkeitsrechnung 1+2, Beschreibende Statistik, Schließende Statistik
Forms of teaching and learning	• Mathematics and biostatistics I (V), 4 SWS, 4 LP • Mathematics and biostatistics I (E), 2 SWS, 2 LP
Workload	**Lecture "Mathematics and biostatistics I"** Attendance time: 60 h Individual study: 60 h **Exercise "Mathematics and biostatistics I"** Attendance time: 30 h Individual study: 30 h **Total** Attendance time: 90 h Individual study: 90 h Total: 180 h
Evaluation method	The evaluation is a written exam (60 minutes) covering the entire module.
Grading	The module grade corresponds to the result of the examination.

Mathematics and biostatistics II	
Code	(not yet made available)
Credits (as per ECTS)	6
Attendance time	6 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Ebert
Assistant professor(s)	Dr. Schriever, Mr. Dittmar
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 2nd Semester
Required knowledge	• Content: Recommendation: Lecture + Exercises "Mathematics and biostatistics I"
Learning outcomes	Students that have successfully completed this module, • have in-depth knowledge of mathematical and statistical fundamentals, mindsets and methods, that will later be required in the industrial biotechnology course
Content	The following technical contents are taught in this module: Vorlesung "Mathematik und Biostatistik II" • Complex numbers: Algebraic normal form, Gauss number plane, trigonometric normal form, exponential form • Matrices: Transposed, quadratic, diagonal, triangular, symmetric, skew symmetric matrices, inverse matrix, Gauß-Jordan method, rank of a matrix • Determinants: Basic definitions, Laplace expansion theorem, calculation rules for determinants, eigenvalues, eigenvectors, characteristic polynomial • Real-valued functions of multiple variables: Partial differentiation, tangential plane, gradient, Nabla operator, local extreme values, stationary points • Common differential equations (DEq): linear 1st order DEq, homogeneous, inhomogeneous, linear n-th order DEqs with constant coefficients • Special distributions: Binomial, hyper-geometrical, Poisson distribution; Negative exponential distribution, normal distribution, Chi-square distribution, F-distribution, t-distribution • Estimation methods: Point estimates, properties of good estimators, expectation fidelity, consistency, minimal variance, construction methods for estimator functions, maximum likelihood, moments, least-squares methods • Estimation methods: Confidence intervals for probabilities, means and spreads • Testing statistical hypotheses: Types of errors when testing, objective function, operation characteristic, special parametric tests, t-Test, F-test, Chi-square test • Introduction to statistical experiment design and analysis of variance

	Exercises "Mathematics and biostatistics II" • Exercises + solutions are made available in PDF format for each individual chapter in the course.
Literature	Vorlesung "Mathematik und Biostatistik II" • L. Papula: Mathematik für Ingenieure und Naturwissenschaftler • Schriever et al.: Wahrscheinlichkeitsrechnung 1+2, Beschreibende Statistik, Schließende Statistik Exercises "Mathematics and biostatistics II" • provided exercises + solutions • Schriever et al.: Wahrscheinlichkeitsrechnung 1+2, Beschreibende Statistik, Schließende Statistik
Forms of teaching and learning	• Mathematics and biostatistics II (V), 4 SWS, 4 LP • Mathematics and biostatistics II (Ü), 2 SWS, 2 LP
Workload	**Vorlesung "Mathematik und Biostatistik II"** Attendance time: 60 h Individual study: 60 h **Exercises "Mathematics and biostatistics II"** Attendance time: 30 h Individual study: 30 h **Total** Attendance time: 90 h Individual study: 90 h Total: 180 h
Evaluation method	The evaluation is a written exam (60 minutes) covering the entire module.
Grading	The module grade corresponds to the result of the examination.

Fundamentals of chemistry	
Code	(not yet made available)
Credits (as per ECTS)	7
Attendance time	6 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Schips
Assistant professor(s)	Prof. Dr. Schips
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 1st Semester
Required knowledge	• Content: Recommendation: school knowledge of chemistry, secondary level II
Learning outcomes	Students that have successfully completed this module, • are capable of practically applying the basics of laboratory practice in general, inorganic and analytical chemistry • have good command of simple routine work processes in the chemical-analytical domain, when using volume measurement devices and fine scales and are capable of recording raw experimental data in a laboratory journal, • are capable of creating simple experimental protocols following GLP rules, • have practical knowledge regarding the manufacturing of titrants, dilution series, titrations and water analysis, • have basic knowledge of general and analytical chemistry, • understand laboratory work safety and are capable of manipulating hazardous materials in laboratory settings
Content	The following technical contents are taught in this module: Lecture + Exercise "Introduction to chemistry" • Introduction to human toxicology • Work safety and hazardous substances • Faculty of Biotechnology Operating Instructions • Quality assurance when working in laboratory practical work (Keeping laboratory journals, general raw data acquisition, calibration, adjustment) • Definition of terms of analytical characteristic variables (Task domain of analysis; Determination, proof, detection, calibration of an analytic process • Chemical calculation (inter alia, manufacturing of titrants, mixture calculation, significance of measured variables) • Periodic system of the elements • Practical introduction to routine laboratory techniques: Weighing, volume measurement (in particular pipetting), filtration, determination of fusion points, recrystallization, reprecipitation, detection methods Lecture + Exercise "General chemistry" • Chemical compounds • Interactions between molecules

	• Quantity, content and concentration specifications (manufacturing of titrants and dilution series) • Chemical equilibrium and equilibrium constant • Acids/bases, pH value, pKs value, neutralisation reactions, acid-base buffer (buffer systems) • Energy and kinetics of chemical reactions • Redox reactions / metal corrosion • Electrochemistry • Dative bond / chelate complexes • Precipitations and solubility product • Titration (as per IUPAC) • Polarimetry • Refractometry Practical course "Practical course in chemistry" • Quantity, content and concentration specifications (manufacturing of titrants and dilution series) • Volumetric analysis/volumetric methods, acid-base-titration, Redox-titration, complexometric titration (determination of water hardness), conductometry • Analysis procedures (ion detection, coulometric titrations) • Acid-base buffer systems • Refractometry • Polarimetry • Electrochemistry
Literature	Lecture + Exercise "Introduction to chemistry" • Mortimer, Chemie, 10. Auflage, ThiemeVerlag • Binnewies, Jäckel, Willner & Rayner-Canham, Allgemeine und Anorganische Chemie, 2. Auflage, Spektrum Akademischer Verlag • Hübschmann, links, Einführung in das chemische Rechnen, Handwerk und Technik • Eckardt, 1x1 Laborpraxis, Wiley-VCH • Dane, Kleines chemisches Praktikum, Wiley-VCH Lecture + Exercise "General chemistry" • Mortimer, Chemie, 10. Auflage, Thieme Verlag • Atkins, Chemie einfach Alles, Wiley-VCH • Otto. Analytische Chemie, 4. Auflage, Wiley-VCH • Binnewies, Jäckel, Willner & Rayner-Canham. Allgemeine4 und anorganische Chemie, 2. Auflage, Spektrum akademischer Verlag • IUPAC Practical course "Practical course in chemistry" • Mortimer. Chemie, 10.Auflage, Thieme Verlag • Binnewies, Jäckel, Willner & Rayner-Canham, Allgemeine und Anorganische Chemie, 2. Auflage, Spektrum Akademischer Verlag • Hübschmann, links, Einführung in das chemische Rechnen, Handwerk und Technik

	• Eckardt. 1x1 Laboratory practice. Wiley-VCH • Dane. Kleines chemisches Praktikum. Wiley-VCH • Jander, Blasius. Lehrbuch der analytischen und präparativen anorganischen Chemie, 16. Auflage
Forms of teaching and learning	• Introduction to chemistry (lecture + exercise), 2 SWS, 2 LP • General chemistry (lecture + exercise), 2 SWS, 2 LP • Chemistry practical course (P), 2 SWS, 3 LP
Workload	**Lecture + Exercise "Introduction to chemistry"** Attendance time: 30 h Individual study: 30 h **Lecture + Exercise "General chemistry"** Attendance time: 30 h Individual study: 30 h **Practical course "Practical course in chemistry"** Attendance time: 30 h Individual study: 60 h **Total** Attendance time: 90 h Individual study: 120 h Total: 210 h
Evaluation method	The examination is a written exam (90 minutes) covering the entire module. Participation in this written examination requires students to have successfully completed the prerequisite practical course "Chemistry practical course" (written composition, protocols).
Grading	The module grade corresponds to the result of the examination.

Analytic and organic chemistry I	
Code	(not yet made available)
Credits (as per ECTS)	8
Attendance time	6 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Schips
Assistant professor(s)	Prof. Dr. Schips
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 2nd Semester
Required knowledge	• Content: Recommendation: 1st semester: Lecture "Fundamentals of chemistry" and "Chemistry practical course"
Learning outcomes	Students that have successfully completed this module, • have a basic understanding of the structure and stereochemistry of organic compounds as a basis for the following course units, • understand the structure and nomenclature of the most important organic compound classes, • are familiar with the basic analytical methods for quantifying, determining the structure and separating organic compounds, • are capable of applying analytical methods in practice for characterisation and quantification of organic compounds,
Content	The following technical contents are taught in this module: Lecture + Exercise "Organic chemistry I" • Structure and formula notation: Octet rule, Lewis formulae, VSEPR theory, mesomerism, substance classes and nomenclature, functional groups, important natural materials in the overview • Chemical bond: Types of chemical bonds, hybridisation and MO model in organic chemistry • Isomerism: Constitution, configuration and conformation, stereochemistry, chilarity, (R)/(S) nomenclature, Fischer projection, stereochemistry with training exercises • Fundamentals of organic reactions: Kinetic and thermodynamic controlled reactions, catalysis, activation energy, reaction kinetics • Electrophilicity and nucleophilicity: Lewis acid/base theory, HSAB principle, organic acids and bases, oxidation and reduction in organic chemistry Lecture "Analytical chemistry" • Chromatographic separation methods (DC, GC, HPLC, gel chromatography, ion exchange chromatography), stationary and mobile phases, elutropic series, detection methods • Spectroscopic methods (UV-VIS, IR, MS, NMR)

	• Polarimetry, characterisation of chiral compounds, refractometry Practical course "Analytical chemistry practical course" • Titration and quantification of materials • Chromatographic separation methods (DC, GC, gel chromatography, ion exchange chromatography), stationary and mobile phases, elutrope series, detection methods • Spectroscopic methods (UV-VIS, IR)
Literature	Lecture + Exercise "Organic chemistry I" • Grundlagen der Organischen Chemie, Joachim Budrus, Walter de Gruyter GmbH (2010), ISBN 978-11-024894-4 • Basisbuch Organische Chemie, Carsten Schmuck, Pearson (2013); ISBN 978-3-86894-061-9 Lecture "Analytical chemistry" • Bioanalytik, F. Lottspeich, Spektrum (2012), ISBN 978-3-8274-2942-1 • Instrumentelle Analytik, Dominik Steinhilber, Apotheker Verlag Stuttgart (2002), ISBN 3-7692-2994-0 • Spektroskopie, Joseph B. Lambert, Pearson (2012), ISBN 978-3-86894-146-3 Practical course "Analytical chemistry practical course" • Bioanalytik, F. Lottspeich, Spektrum (2012), ISBN: 978-3-8274-2942-1 • Instrumentelle Analytik, Dominik Steinhilber, Apothekerverlag Stuttgart (2002), ISBN 3-7692-2994-0 • Spektroskopie, Joseph B. Lambert, Pearson (2012), ISBN 978-3-86894-146-3
Forms of teaching and learning	• Organic chemistry I (lecture + exercise), 2 SWS, 2 LP • Analytic chemistry (V), 2 SWS, 2 LP • Practical course Analytical chemistry (P), 2 SWS, 4 LP
Workload	**Lecture + Exercise "Organic chemistry I"** Attendance time: 30 h Individual study: 30 h **Lecture "Analytical chemistry"** Attendance time: 30 h Individual study: 30 h **Practical course "Analytical chemistry practical course"** Attendance time: 30 h Individual study: 90 h **Total** Attendance time: 90 h Individual study: 150 h Total: 240 h
Evaluation method	The examination is a written exam (90 minutes) covering the

	entire module. Participation in this written examination requires students to have successfully completed the prerequisite "Analytical chemistry practical course (P)" (written composition, protocols).
Grading	The module grade corresponds to the result of the examination.

Microbiology	
Code	(not yet made available)
Credits (as per ECTS)	10
Attendance time	7 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Grammel
Assistant professor(s)	Prof. Dr. Grammel
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 1st Semester
Required knowledge	• Content: Recommendations: Practical knowledge in the use of simple laboratory devices (pipettes, scales, etc.), school-level English, basic knowledge of organic chemistry
Learning outcomes	Students that have successfully completed this module, • have basic theoretical and practical knowledge of the structure, function and application of microbial cells, • understand the basic principles of bacterial metabolism and its significance for ecology and biotechnology, • are capable of applying sterile work methods and basic microbiological work techniques, • are able to work in groups, • are capable of creating scientific protocols, • take scientific standards into account when creating texts, • understand the various forms and properties of procaryotes, • have knowledge of the structure and function of bacterial cells and their significance for ecology, industrial biotechnology and as pathogens, • understand the bacterial metabolism and its significance for the environment and industrial applications, • are capable of applying microbiological work methods, cultivation procedures, sterile techniques, microscopy, • can characterise metabolic activities of micro-organisms, • can identify micro-organisms through physiological and molecular tests,
Content	The following technical contents are taught in this module: Lecture "Microbiology" • Diversity of micro-organisms • Morphological, microscopic and physiological properties, • metabolic activities and size ratios, • taxonomy, phylogenetic tree • Structure of procaryotic cells: Cellular envelope, cell wall, cellular membrane, cytoplasm, inclusion bodies • Functions of the cellular membrane: Transport, signal processing, motility • Signal transduction and genetic regulation • Important micro-organism groups: Endospore formers,

	enterobacteria, actinomycetes, among others. • Fundamentals of metabolism • Breathing processes, aerobic - anaerobic • Fermentation metabolism • Photosynthesis • Ecological aspects • Biogeochemical cycles Practical course "Microbiological practical course" • Biological safety (GenTG, GenTSV, BioStoffV) • Manufacturing of culture media • Sterilisation in the autoclave • Disinfection procedures • Characterisation of biotechnologically relevant micro-organisms • Microscopy techniques (colouring, fluorescence) • Identification through rRNA sequence analysis • Microbial degradation of polymers • Growth kinetics
Literature	Lecture "Microbiology" • Lecture notes • G. Fuchs und H. Schlegel, Allgemeine Mikrobiologie, ISBN 3-13-444608-1 (ISBN 978-3-13-444608-1) • Brock Biology of Microorganisms ISBN-13:978-0-13-196893-6 Practical course "Microbiological practical course" • Lecture notes on the practical course • G. Fuchs und H. Schlegel: Allgemeine Mikrobiologie, ISBN 3-13-444608-1 (ISBN 978-3-13-444608-1) • Brock Biology of Microorganisms, ISBN-13: 978-0-13-196893-6 • Steinbüchel-Oppermann-Sanio: Mikrobiologisches Praktikum (Springer Lehrbuch), ISBN:978-3642177026
Forms of teaching and learning	• Microbiology (V), 2 SWS, 2 LP • Microbiological practical course (P), 5 SWS, 8 LP
Workload	**Lecture "Microbiology"** Attendance time: 30 h Individual study: 30 h **Practical course "Microbiological practical course"** Attendance time: 75 h Individual study: 165 h **Total** Attendance time: 105 h Individual study: 195 h Total: 300 h

Evaluation method	The evaluation is a written exam (60 minutes) covering the entire module. Participation in this written examination requires students to have successfully completed the prerequisite "Microbiology practical course (P)" (written composition, protocols)
Grading	The module grade corresponds to the result of the examination.

Molecular biology	
Code	(not yet made available)
Credits (as per ECTS)	8
Attendance time	6 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Grammel
Assistant professor(s)	Dr. Weith, Prof. Dr. Grammel
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 2nd Semester
Required knowledge	• Content: Recommendation: Basic knowledge of the genetic processes within the cell • Practical: Recommendation: Knowledge of the cultivation of micro-organisms, sterile work procedures
Learning outcomes	Students that have successfully completed this module, • understand the genetic processes within a cell, • can apply the basic methods for generating and manipulating genetically modified micro-organisms (GMO) in practice, • understand the legal regulations concerning appropriate manipulation of GMOs, • understand the genetic processes within the cell (replication, transcription, translation), mutations and repair of DNA, organisation and regulation, • have good command of the basics of methodic manipulation of nucleic acids (genetic engineering methods), • understand the use possibilities for molecular biology in industrial biotechnology (selected examples), • understand the basic molecular biology work techniques for generating genetically modified micro-organisms and for heterologous expression of recombinant proteins, • understand strategies for cloning experiments, • are able to work in teams, • are capable of authoring experiment protocols and scientific documents based on the laboratory journal
Content	The following technical contents are taught in this module: Lecture "Molecular biology" • Molecular biology: Definition of terminology, milestones, current state • Structure of nucleic acids: Nucleotides, double-helix, DNA rings; cell core, chromatin, nucleosome, chromosomes • Chromatin and chromosomes: Folding structures, mitosis, cell cycle • Replication: Processes at the replication fork in pro- and eucaryotes • Transcription: Gene structure, promotor structure, transcription factors, elongation, termination

	• Processing the mRNA: Splicing, editing, capping, polyadenylation • Translation: Sequence and elements of translation, ribosomes, palindromes • Genetic code, recombination, mutation, repair, polymorphism, dominant and recessive heredities • Genetic engineering methods, restriction enzymes, vectors, molecular cloning, DNA sequencing, PCR and qRT-PCR • Cell systems for industrial biotechnology: Procaryotes, yeasts, diatoms, marine systems • Introduction to stem cell genetics "Lab-On-A-Chip" Practical course "Molecular biology practical course" • Strategies for cloning a gene in *E.coli* • Restriction digest • Plasmid preparation • PCR and gel electrophoresis • Preparative gel electrophoresis • Transformation and selection • Heterologous protein expression in *E.coli*
Literature	Lecture "Molecular biology" • Molekulare Genetik, Rolf Knippers, Thieme Verlag, Stuttgart, 9. Auflage, Februar 2006 • Molecular Biology of the Gene, Watson, Baker, Bell, Gann, Levine, Losick, Addison Wesley Verlag, 5. Auflage, 2006 • Human Molecular Genetics, Tom Strachan, Andrew P. Read Wiley-Liss Verlag Practical course "Molecular biology practical course" • Lecture notes on the practical course • Mulhardt, Der Experimentator: Molekularbiologie/Genomics, Spektrum Akademischer Verlag, ISBN-13:978-3827420367
Forms of teaching and learning	• Molecular biology (V), 2 SWS, 2 LP • Molecular biology practical course (P), 4 SWS, 6 LP
Workload	**Lecture "Molecular biology"** Attendance time: 30 h Individual study: 30 h **Practical course "Molecular biology practical course"** Attendance time: 60 h Individual study: 120 h **Total** Attendance time: 90 h Individual study: 150 h Total: 240 h
Evaluation method	The evaluation is a written exam (60 minutes) covering the entire module. Participation in this written examination requires students to have successfully completed the prerequisite practical course

	"Molecular biology practical course" (written composition, protocols).
Grading	The module grade corresponds to the result of the examination.

Biochemistry	
Code	(not yet made available)
Credits (as per ECTS)	7
Attendance time	6 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Ebert
Assistant professor(s)	Prof. Dr. Ebert
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 3rd Semester
Required knowledge	• Content: Recommendation: Fundamentals of chemistry and microbiology
Learning outcomes	Students that have successfully completed this module, • understand the actions of bio-molecules, in particular enzymes and their functions in metabolism, • are capable of performing practical laboratory work using proteins, • can examine and analyse protein samples in practice and theoretically evaluate them • understand the functions of bio-molecules and metabolism, • can manipulate proteins in practice, • understand the analysis of enzyme kinetics, • are capable of analysing protein samples,
Content	The following technical contents are taught in this module: Lecture and exercise "Biochemistry" • Enzymes and their function • Bioenergetics, Redox reactions in biology • Glycolysis and regulation of carbohydrate metabolism • Biosynthesis of carbohydrates (gluconeogenesis), amino acids, lipids and nucleotides • Citrate cycle and its regulation • Electron transport and ATP synthesis • Photosynthesis Praktikum „Praktikum Biochemie“ • Fundamentals of mechanical isolation/disintegration of cells • Enrichment of enzymes through ammonium sulphate precipitation • SDS-PAGE • Measurement of enzyme activities • Determination of Michaelis-Menten parameters • Photometric enzyme tests for determination of sugars and other metabolites • HPLC methods in bioanalytics
Literature	Lecture and exercise "Biochemistry" • Lecture notes • Michael Cox, David Nelson; Lehninger Biochemie, 4. Auflage,

	Springer-Verlag • Stryer Biochemie, Lubert Stryer, John L. Tymoczko, Jeremy, 7. Auflage, Springer-Verlag • Biochemie, H. Robert Horton und Laurence A. Moran, 4. Auflage, Pearson Studium – Biologie Praktikum „Praktikum Biochemie“ • Lecture notes on the practical course • Michael Cox, David Nelson; Lehninger Biochemie, 4. Auflage, Springer-Verlag • Stryer Biochemie, Lubert Stryer, John L. Tymoczko, Jeremy, 7. Auflage, Springer-Verlag • Biochemie, H. Robert Horton und Laurence A. Moran, 4. Auflage, Pearson Studium – Biologie
Forms of teaching and learning	• Biochemistry (lecture + exercise), 2 SWS, 2 LP • Biochemistry practical course (P), 4 SWS, 5 LP
Workload	**Lecture and exercise "Biochemistry"** Attendance time: 30 h Individual study: 30 h **Praktikum „Praktikum Biochemie“** Attendance time: 60 h Individual study: 90 h **Total** Attendance time: 90 h Individual study: 120 h Total: 210 h
Evaluation method	The evaluation is a written exam (60 minutes) covering the entire module. Participation in this written examination requires students to have successfully completed the prerequisite practical course "Biochemistry practical course" (written composition, protocols).
Grading	The module grade corresponds to the result of the examination.

Interdisciplinary competences	
Code	(not yet made available)
Credits (as per ECTS)	6
Attendance time	6 SWS
Course language	German (3rd Semester), English (4th Semester)
Duration	2 Semester
Rota	annually
Module coordinator	Prof. Dr. Grammel
Assistant professor(s)	Dr. Kipper-Albertini, Prof. Dr. Grammel; NN
Incorporation in the degree programs	Industrial Biotechnology BSc, mandatory module, 3rd + 4th Semester
Required knowledge	• Content: Recommendation: Basic knowledge of MS (Office Word/PowerPoint) and internet searches, use of a PC and the internet; school-level English
Learning outcomes	Students that have successfully completed this module, • have acquired competences required for highly qualified activities in various areas of a modern information technology society, • have mastered the use of various information sources, mainly internet-based databases, • can critically evaluate various information sources, • understand presentation techniques and public relations work • understand scientific work and presentation techniques, • can apply presentation techniques in exercises and presentations • know the relevant information sources in the domain of industrial biotechnology and are able to apply them, • command sufficient language expertise in English to understand the said domains in English and be capable of correctly expressing themselves in professional English
Content	The following technical contents are taught in this module: Lecture + Exercise "Technical English" • Authoring and understanding scientific texts and documents • Representation of information (schematics, diagrams, etc.) • General communication situations in everyday professional activity Lecture + Exercise "Scientific presentation technique" • Methods of presentation: Planning, personal preparation, media selection and use, body language • Presentation techniques: Presentation structure, visualisation of contents, argumentation techniques, handling of objections (repartee techniques), best practice examples • Scientific work: Scientific quality criteria, source research, source evaluation and selection, citing sources, reading strategies

	• Scientific work: Types of scientific work, copyright and exploitation rights, formal structure • Short presentation: Round of introductions • Press release: Analysis of a press release and presentation of the results by students using a flip chart (group exercise) • Presentations by students: Creating own presentations (10 min) and the associated handouts Lecture + Exercise "Information collection/management" • Search engines, catalogues, databases in internet • Scientific original literature • Scientific publication practice • Patent search • Molecular biological databases and bioinformatics
Literature	Lecture+ Exercise "Technical English" • Bauer, Jürgen; English for Technical Purposes • further literature indications are provided by the assistant professor Lecture + Exercise "Scientific presentation technique" • Lecture notes • H. Balzert, M. Schröder, C. Schäfer: Wissenschaftliches Arbeiten: Ethik, Inhalt & Form wiss. Arbeiten, Handwerkszeug, Quellen, Projektmanagement, Präsentation, 2. Auflage, W3L-Verlag, Herdecke/Witten 2011 Lecture +Exercise "Information collection/management" • Topics are updated every semester. Literature details are provided by the assistant professor.
Forms of teaching and learning	• Technical English (lecture + exercise), 2 SWS, 2 LP, 3rd Semester • Scientific presentation technique (lecture + exercise), 2 SWS, 2 LP, 3rd Semester • Information collection/management (L+Ex), 2SWS, 2 LP, 4th Semester
Workload	**Lecture + Exercise "Technical English"** Attendance time: 30 h Individual study: 30 h **Lecture + Exercise "Scientific presentation technique"** Attendance time: 30 h Individual study: 30 h **Lecture + Exercise "Information collection/management"** Attendance time: 30 h Individual study: 30 h

	Total Attendance time: 90 h Individual study: 90 h Total: 180 h
Evaluation method	The evaluation is a written exam (60 minutes) covering the entire module. Participation in this written examination requires students to have successfully completed the prerequisite of the course "Scientific presentation technique" and of the course "Information collection/management'" (respectively one written composition).
Grading	The module grade corresponds to the result of the examination.

Organic chemistry II and natural materials	
Code	(not yet made available)
Credits (as per ECTS)	9
Attendance time	8 SWS
Course language	German (3rd Semester), English (4th Semester)
Duration	2 Semester
Rota	annually
Module coordinator	Prof. Dr. Schips
Assistant professor(s)	Prof. Dr. Schips, Prof. Dr. Ebert
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 3rd+ 4th Semester
Required knowledge	• Content: Recommendation: Analytical and organic chemistry module I
Learning outcomes	Students that have successfully completed this module, • have knowledge of the most important methods of organic preparative chemistry in connection with natural materials • are capable of applying basic operations of organic chemistry in the laboratory • understand the most important reaction mechanisms of organic chemistry • are capable of reconditioning and chemically modifying natural materials
Content	The following technical contents are taught in this module: Lecture + Exercise "Organic chemistry II and natural materials" • Basic terminology of organic reactions: Reactivity of functional groups as per materials classes, alkane reactions, nucleophile substitution, elimination, addition, electrophile aromate substitution, reaction of carbonyl compounds, enolates and enoles, selected natural materials classes (carbohydrates, fats and oils, terpenes) Practical course "Organic chemistry II and natural materials practical course" • Teaching of classic separation methods in the laboratory (recrystallization, extraction, suction, distillation) • Characterisation of organic compounds via melting point, refraction index, IR spectra, HPLC and GC separation • Preparative synthetic methods, base reaction types: Substitution, addition, elimination, CH acid reactions on selected compound classes, creation of a preparation from literature • Organic reactions with renewable materials (plant oils, cellulose isolation) Lecture "Biotechnological products" • Use of fossil and renewable raw materials: Raw materials transition, added-value chains, platform chemicals, biorefinery concept • Technical biopolymers: Explanation of terminology,

	structure and formation, manufacturing processes, application possibilities, PLA, strength, PHA, monomer components from renewable materials • Important intermediary products: Vitamins, plant protection products, pharmaceuticals, cosmetics, microbiologically created alcohol, organic acids and vitamins • Evaluation of the environmental accounting of products, e-factor, sustainability and bioeconomy, market trends.
Literature	Lecture + Exercise "Organic chemistry II and natural materials" • „Grundlagen der Organischen Chemie“ Joachim Buddrus, Walter de Gruyter GmbH (2010), ISBN: 978-11-024894-4. • „Basisbuch Organische Chemie“ Carsten Schmuck, Person Verlag (2013), ISBN: 978-3-86894-061-9. • „Organische Reaktionen“ Ulrich Lünig, Spektrum (2010), ISBN: 978-8274-2478-5 • „Naturstoffchemie" Peter Nuhn, Hirlitz (2006), ISBN: 978-37-7761363-5 Practical course "Organic chemistry II and natural materials practical course" • „Organikum“ 23. Auflage (2009), WILEY-VCH Verlag, ISBN: 978-3-527-32451-1 • „Integriertes Organisch-Chemisches Praktikum (I.O.C.-Praktikum)“ Siegfried Hünig, Lehmanns (2012), ISBN: 978-3-86541-149-5 • „Praktikum Präparative Organische Chemie“ R. Brückner, Spektrum (2008), ISBN: 978-3-8274-1505-9. Lecture "Biotechnological products" • „Einführung in die Technische Chemie“, Arno Behr, Spektrum Akademischer Verlag (2010), ISBN: 978-3-8274-2073-2 • „Industrielle Mikrobiologie“ Garabed Antranikian, Springer Spektrum Verlag (2012), ISBN: 978-3-8274-3039-7 • "Biorefineries – Industrial Processes and Products" Birgit Kamm, WILEY-VCH (2010), ISBN: 978-3-527-32953-3 • "Catalysis for Renewables" Gabriele Centi, WILEY-VCH Publishing (2007), ISBN: 978-3-527-31788-2.
Forms of teaching and learning	• Organic chemistry II and natural materials (V), 2 SWS, 2 LP, 4th Semester • Organic chemistry II and natural materials practical course (P), 4 SWS, 5 LP, 4th Semester • Biotechnological products (V), 2 SWS, 2 LP, 3rd Semester
Workload	**Lecture "Organic chemistry II and natural materials"** Attendance time: 30 h Individual study: 30 h **Practical course "Organic chemistry II and natural materials practical course"** Attendance time: 60 h Individual study: 90 h

	Lecture "Biotechnological products" Attendance time: 30 h Individual study: 30 h **Total** Attendance time: 120 h Individual study: 150 h Total: 270 h
Evaluation method	The examination is a written exam (90 minutes) covering the entire module. Participation in this written exam requires students to have successfully completed the prerequisite of the practical course "Organic chemistry II and natural materials practical course" (written composition, protocols).
Grading	The module grade corresponds to the result of the examination.

Technical microbiology	
Code	(not yet made available)
Credits (as per ECTS)	7
Attendance time	6 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Grammel
Assistant professor(s)	Prof. Dr. Grammel
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 3rd Semester
Required knowledge	• Content: Recommendation: Knowledge of metabolism physiology of procaryots and yeasts, microbiology lecture (1st Semester), Molecular biology lecture (2nd Semester) • Practical: Recommendation: Microbiological and laboratory-chemical work techniques
Learning outcomes	Students that have successfully completed this module, • have theoretical and practical knowledge of the technical and biological basics of biotechnological production methods • understand methods of industrial biotechnology based on fermentation processes • understand the application possibilities of microorganisms in the manufacture of chemical products and energy sources • understand the metabolic activities of industrially relevant microorganisms • understand the most important expression systems and their application domains • have theoretical and practical knowledge of mechanical structure and mode of operation of bioreactors • can evaluate the application potentials of various micro-organisms in biotechnology • command expertise in planning, execution, analysis and evaluation of fermentation processes • have practical knowledge of measurement technology for the bioreactor, sample retrieval techniques, process control systems and biochemical analysis methods • can determine relevant process parameters • can process, interpret and graphically represent fermentation results
Content	The following technical contents are taught in this module: Lecture "Technical microbiology" • Structure and function of various bioreactor types • Measurement technology for the bioreactor • Bioprocess technology basics • Biotechnological transformation of renewable raw materials into chemical products and energy through microorganisms • Production organisms and expression systems

	• Methods of metabolic engineering, synthetic biology • Application potentials of bacteria • Metabolism of production organisms • Optimisation of biotechnological processes Practical course "Technical microbiology practical course" • Structure and operation of bioreactors • Aerobic fermentation for production of proteins • Anaerobic fermentation for production of biofuels • Sample retrieval techniques • Process control systems • Analysis of substrates and products from fermenter samples • Evaluation and balancing of fermentation processes
Literature	Lecture "Technical microbiology" • Antranikian, Garabed (Hrsg.), Angewandte Mikrobiologie, Springer Verlag • Sahm, H., Antranikian, G., Stahmann, K.-P., Takors, R. (Hrsg.), Industrielle Mikrobiologie, Springer Spektrum Practical course "Technical microbiology practical course" • is provided (Practical course notes, fermenter manuals)
Forms of teaching and learning	• Technical microbiology (V), 2 SWS, 2 LP • Technical microbiology practical course (P), 4 SWS, 5 LP
Workload	**Lecture "Technical microbiology"** Attendance time: 30 h Individual study: 30 h **Practical course "Technical microbiology practical course"** Attendance time: 60 h Individual study: 90 h **Total** Attendance time: 90 h Individual study: 120 h Total: 210 h
Evaluation method	The evaluation is a written exam (60 minutes) covering the entire module. Participation in this written examination requires students to have successfully completed the prerequisite practical course "Technical microbiology practical course" (written composition, protocols).
Grading	The module grade corresponds to the result of the examination.

Process engineering	
Code	(not yet made available)
Credits (as per ECTS)	11
Attendance time	10 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Frühwirth
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 3rd Semester
Required knowledge	• Content: Recommendation: Chemical thermodynamics, heat and matter transfer, general chemistry, basics of process engineering
Learning outcomes	Students that have successfully completed this module, • master basic operations at the interface of biotechnology and process engineering, in particular matter separation methods with and without chemical reactions • understand the basic thermal operations of distillation, ad- and absorption, extraction and drying • can apply calculation methods and design methods for the separation operations of absorption, distillation, extraction and drying and evaluate mechanical models • can apply methods for quantitative description of basic operations when generating, separating, precipitating, mixing and handling dispersive materials • can describe technical applications such as mixing and stirring and mathematically describe these • can autonomously process problems of reaction technology and correctly interpret kinetics data • can create balances via reactive and non-reactive systems
Content	The following technical contents are taught in this module: Lecture + Exercise "Thermal process engineering" • Rectification of binary solutions: continuous and discontinuous rectification, separation steps concept, step construction in the McCabeThiele diagram, limit conditions of the design, feed flow thermal state, mechanical design: Plate columns/packed columns • Absorption: continuous and discontinuous, separation steps concept, physisorption and chemisorption sorption mechanisms, solvent selection, absorption/desorption, graphical representation - step construction, mechanical design, selection of equipment depending on phase contact, adsorption mechanisms • Extraction: Principle of liquid/liquid extraction, solvent selection, representation of extraction processes in triangle diagrams, design of liquid/liquid extraction processes (cross-flow/counter-flow), principle of solid/liquid extraction, principle of high pressure extraction, separation of the

	extract in HD extraction • Drying: Types of drying, properties of humid air: State variables, representation of state changes in Mollier diagrams, dryer design Lecture + Exercise "Mechanical process engineering" • Particle technology: Representation of distributions of quantities: Total frequency, frequency density, location parameters, separating function, degree of separation, agglomeration • Filtration: Methods, mathematical description of cake filtration, non-ideality of cake filtration, filtration mechanical design, membrane method • Aggregate materials: Storage - bunkers, stockpiles, aggregate materials through-flow - turbulent layer, design of turbulent layers • Sedimentation: Forces on individual particles, deposition speed, design of sedimentation equipment, mechanical execution of sedimentation • Centrifugation: Deposition speed in the centrifugal field, design of centrifuges, centrifuge mechanical designs, selection of centrifuges • Cyclone principle • Mixing and agitation, power input of agitators, agitator design Lecture + Exercise "Reaction technology" • Reaction kinetics: Reaction speed, reaction order, speed laws - integral method • Processes: Creation of block flowcharts for process engineering processes, recording of appropriate balance limits, balancing of stationary systems with and without chemical reactions, balancing of transient systems without chemical reaction, balancing of composite systems - interconnection of several basic operations with and without recycle and bypass flows, creation of material flow tables Practical course "Process engineering practical course" • Discontinuous rectification, separation of a binary system • Solids extraction: Extraction of a nonpolar component from renewable raw material using Soxleth and overcritical CO_2 extraction • Description and technical design of fermenter systems, power input of agitators and determination of k_La-values • Reaction technology: Creation of a biofuel from residual materials, pre-treatment of the residual material, execution of the synthesis with recording of the kinetics data, description in terms of reaction and evaluation of the process
Literature	Lecture + Exercise "Thermal process engineering" • Thermische Verfahrenstechnik: Grundlagen und Methoden, Mersmann, Kind, Stichlmair, Springer, 2005

	Lecture + Exercise "Mechanical process engineering" • Verfahrenstechnik, Hemming, Wagner, Vogel, 2011 Lecture + Exercise "Reaction technology" • Chemische Verfahrenstechnik: Berechnung, Auslegung und Betrieb chemischer Reaktoren, Hertwig, Martens, Oldenbourg, 2007 Practical course "Process engineering practical course" • Verfahrenstechnik, Hemming, Wagner, Vogel, 2011
Forms of teaching and learning	• Thermal process engineering (lecture + exercise), 2 SWS, 2 LP • Mechanical process engineering(lecture + exercise), 2 SWS, 2 LP • Reaction technology (lecture + exercise), 2 SWS, 2 LP • Process engineering practical course (P), 4 SWS, 5 LP
Workload	**Lecture + Exercise "Thermal process engineering"** Attendance time: 30 h Individual study: 30 h **Lecture + Exercise "Mechanical process engineering"** Attendance time: 30 h Individual study: 30 h **Lecture + Exercise "Reaction technology"** Attendance time: 30 h Individual study: 30 h **Practical course "Process engineering practical course"** Attendance time: 60 h Individual study: 90 h **Total** Attendance time: 150 h Individual study: 180 h Total: 330 h
Evaluation method	The examination is a written exam (90 minutes) covering the entire module. Participation in this written examination requires students to have successfully completed the prerequisite practical course "Process engineering practical course" (written composition, protocols).
Grading	The module grade corresponds to the result of the examination.

Biotechnological installations	
Code	(not yet made available)
Credits (as per ECTS)	10
Attendance time	9 SWS
Course language	English
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Frühwirth, Dipl. Ing. Grubmüller
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 4th Semester
Required knowledge	• Content: Recommendation: Process engineering, technical microbiology, mathematics and statistics, process engineering practical course, technical microbiology practical course
Learning outcomes	Students that have successfully completed this module, • can design devices under observation of the AD 2000 calculation directives • master the technical and organisational basics of plant construction • can sensibly make use of experimental analyses and incorporate the results into a plant design • understand the electrotechnical basics such as voltage and current or building elements such as resistors, capacitors and inductances • can calculate simple circuits with resistors • have basic knowledge of measurement techniques for various mechanical variables • master the basics of control technology • can apply the theoretically acquired knowledge for selected basic operations • are capable of applying acquired measurement data from the laboratory for mathematical description of the processed basic operations • have the ability to experimentally examine complex biotechnological problems in small project-oriented groups and to implement the obtained knowledge in an installation scale up
Content	The following technical contents are taught in this module: Lecture + Exercise "Equipment and plant construction" • Contractual aspects of plant construction • Project documentation • Commissioning plants • Fundamentals of equipment design: Machine elements, materials resistance, manufacturing technology • Materials in installation construction: Classification, properties, mechanical and thermal behaviour of materials • Strength of materials: The term "stress", structural elements under tensile load

	• Dimensioning of pressurised containers with inner and outer positive pressure • Dimensioning of container closures - convex floors under inner positive pressure • Creation of simple installation schematics of container closures and flanges • Armatures, safety installations in equipment • Seals Lecture + Exercise "Electrical, measurement, control and regulation technology" • Electro-technical basics: Ohm's law, mesh rule, node rule, calculation of potential dividers and simple ohmic circuits, electro-technical components such as resistors, capacitors, inductances, diodes, transistors, operational amplifiers and filters • Digital technology: Difference between analogue and digital signal, logic function, data interpretation, binary calculation, sampling theorem, AD/DA converter. • Measurement technology: Basic terminology, measurement of electrical variables such as current, voltage, power, frequency and resistance. Measurement of non-electrical variables such as temperature, pressure, viscosity, flow rate, density, concentrations, oxygen measurement, measurement errors and error calculation • Control and regulation technology: Control loop, controller types, controller design, stability of a controller, behaviour of the controlled system and basics of controllers Practical course "Process development/scale up" • Autonomous pursuit of an assignment from the definition of the subject up to the calculation of an industrial installation • Experimental development of biotechnological processes: Project plan, laboratory protocol, results • Creation of project documentation block flowchart, materials flow table • Technology attribution • Perspectives for industrial implementation
Literature	Lecture + Exercise "Equipment and plant construction" • AD 2000 Regelwerk TÜV Lecture + Exercise "Electrical, measurement, control and regulation technology" • Taschenbuch der Messtechnik Hoffmann Carl Hanser Verlag, 2007 Practical course "Process development/scale up" • Erikson, Johansson, Design of Experiments, Umetrics 2008, Schwister, Lewen, Verfahrenstechnik für Ingenieure, Hanser, 2012

Forms of teaching and learning	• Equipment and plant construction (lecture + exercise), 3 SWS, 3 LP • Electrical, measurement, control and regulation technology (lecture + exercise), 2 SWS, 2 LP • Process development/Scale up (P), 4 SWS, 5 LP
Workload	**Lecture + Exercise "Equipment and plant construction"** Attendance time: 45 h Individual study: 45 h **Lecture + Exercise "Electrical, measurement, control and regulation technology"** Attendance time: 30 h Individual study: 30 h **Practical course "Process development/scale up"** Attendance time: 60 h Individual study: 90 h **Total** Attendance time: 135 h Individual study: 165 h Total: 300 h
Evaluation method	The examination is a written exam (90 minutes) covering the entire module. Participation in this written examination requires students to have successfully completed the prerequisite practical course "Process development/Scale up" (written composition, presentation).
Grading	The module grade corresponds to the result of the examination.

Bioprocess engineering	
Code	(not yet made available)
Credits (as per ECTS)	7
Attendance time	7 SWS
Course language	English
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Ebert
Assistant professor(s)	Prof. Dr. Ebert
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 4th Semester
Required knowledge	• Content: Recommendation: Technical microbiology, biochemistry
Learning outcomes	Students that have successfully completed this module, • understand biological methods for materials production using microorganisms in bioreactors • are capable of conducting a fed-batch fermentation at a scale of 20 litres with preparation and analysis of the product, as well as of evaluating and balancing the process • master basic aspects of statistical experiment planning • understand biological methods for materials production using microorganisms in bioreactors
Content	The following technical contents are taught in this module: Lecture "Bioprocess engineering" • Profitability of bioprocesses under consideration of various aspects of a production • Media components and media composition, development of media • Growth kinetics and growth models (Monod model and logistic growth) • Balancing of bioprocesses • Derivation of bioprocess models (batch, fed-batch, continuous process with and without cell retention • Cleaning and sterilisation processes • Transport processes in biosuspensions • Introduction to design of experiments (DOE) (full-factorial and fractional factorial experiment designs, data evaluation, introduction to the "MODDE" software Practical course "Bioprocess engineering practical course" • Reactor preparation, sterilisation, manufacture of media and buffers • Process control in the fed-batch mode for cultivation of *Cupriavidus necator* and the manufacture of Polyhydroxybutyrate • Process monitoring and online and offline analysis (substrate and metabolic products) • Optimisation of the reconditioning process of biopolymers (here: polyhydroxybutyrate) using DOE as well as aspects of the scale-up to the production scale.

	• Gas-chromatography analysis of products including derivatisation • Evaluation with regards to the specific process parameters in the bioreactor • Determination of the yields of the complete process
Literature	Lecture "Bioprocess engineering" • Lecture notes • Chmiel, Horst; Bioprozesstechnik, Spektrum-Verlag, 3. Auflage • Storhas, Winfried; Bioverfahrensentwicklung; Wiley-VCH, 2. Auflage Practical course "Bioprocess engineering practical course" • Practical course handout • Chmiel, Horst; Bioprozesstechnik, Spektrum-Verlag, 3. Auflage • Steinbüchel, Oppermann-Sanio, Ewering, Pötter; Mikrobiologisches Praktikum, Springer Spektrum-Verlag, 2. Auflage
Forms of teaching and learning	• Bioprocess engineering (V), 2 SWS, 2 LP • Bioprocess engineering practical course (P), 5 SWS, 5 LP
Workload	**Lecture "Bioprocess engineering"** Attendance time: 30 h Individual study: 30 h **Practical course "Bioprocess engineering practical course"** Attendance time: 75 h Individual study: 75 h **Total** Attendance time: 105 h Individual study: 105 h Total: 210 h
Evaluation method	The evaluation is a written exam (60 minutes) covering the entire module. Participation in this written examination requires students to have successfully completed the prerequisite "Bioprocess technology practical course (P)" (written composition, presentation).
Grading	The module grade corresponds to the result of the examination.

New technologies	
Code	(not yet available)
Credits (as per ECTS)	10
Attendance time	7 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Ebert
Assistant professor(s)	Prof. Dr. Ebert, Prof. Dr. Frühwirth, Prof. Dr. Grammel
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 5th Semester
Required knowledge	• Content: Recommendation: Selected articles on relevant themes of the current industrial production: Bioprocess technology; Biotechnological plants; Technical microbiology; Project excursions I
Learning outcomes	Students that have successfully completed this module, • understand current methods and research domains of biotechnology • are capable of scientifically analysing current thematics • are familiar with current thematics of biotechnology • can work with scientific literature (overview and primary articles) • written and oral presentation techniques • master practical work on current subjects of biotechnological research and development • have an extended insight into industrial biotechnology through excursions to companies in the domain of industrial biotechnology • have knowledge of industrial processes in biotechnology
Content	The following technical contents are taught in this module: Seminar "New techniques in bioprocesses" • Selected thematics on new techniques in bioprocesses • Research will be conducted on primary articles fitting the thematic • This literature will be summed up, analysed and explained in a written and oral presentation • A handout will be created with the presentation. Practical course "New bioprocesses practical course" • Communication of scientific works • Experiment planning and smaller projects • Practical use of laboratory equipment depending on the application domain • Recording experimental data and presentation to a scientific audience Excursion "Project excursions II" • In-depth insight into current biotechnological processes

	• Excursions to various companies in the field of industrial biotechnology • Business areas of the company to be visited
Literature	Seminar "New techniques in bioprocesses" • Selected articles on relevant themes around biotechnological processes and practical course Practical course "New bioprocesses practical course" • current publications on the respectively attributed thematics • Textbooks of the respectively relevant courses Excursion "Project excursions II" • Molekulare Biotechnologie, Konzepte, Methoden und Anwendungen, 2. aktualisierte Auflage, Hrsg.: M. Wink;Wiley-VCH • Bioverfahrensentwicklung, Winfried Storhas, 2. Auflage, Wiley-VCH-Verlag GmbH • Industrial Biotechnology -Sustainable Growth and Economic Success Ed.; W. Soetaert & E. J. Vandamme, Wiley-VCH, 2010 • Enzymes in Industry Production and Applications, Ed.; W.Aehle, Wiley-VCH, 2004 • Company information material (internet)
Forms of teaching and learning	• New technologies in bioprocesses (S), 2 SWS, 2 LP • New bioprocesses practical course (P), 3 SWS, 6 LP • Project excursions II (Exc.), 2 SWS, 2 LP
Workload	**Seminar "New techniques in bioprocesses"** Attendance time: 30 h Individual study: 30 h **Practical course "New bioprocesses practical course"** Attendance time: 45 h Individual study: 135 h **Excursion "Project excursions II"** Attendance time: 30 h Individual study: 30 h **Total** Attendance time: 105 h Individual study: 195 h Total: 300 h
Evaluation method	The examination is a written composition covering the entire module. Handing in this written composition requires students to have successfully completed the prerequisite "New technologies in bioprocesses (S)" (written composition).
Grading	The module grade corresponds to the result of the examination.

Enzymes and proteins	
Code	(not yet made available)
Credits (as per ECTS)	6
Attendance time	6 SWS
Course language	German (5th Semester), English (4th Semester)
Duration	2 Semester
Rota	annually
Module coordinator	Prof. Dr. Ebert
Assistant professor(s)	Prof. Dr. Ebert
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 4th and 5th semester
Required knowledge	• Content: Recommendations: Biochemistry
Learning outcomes	Students that have successfully completed this module, • understand the development, characterisation and application possibilities of technical enzymes • master the basics of enzyme kinetics and regulation • can characterise biomolecules via the measurement of enzyme activities
Content	The following technical contents are taught in this module: Lecture "Protein chemistry" • Introduction to protein chemistry • Structure and composition of proteins: Stereochemistry of the main chain, structure and mobility of the side chain, acid-base behaviour of the side chain, polarity of the side chain, chemical differentiation • Structure systems in proteins (helix, folding pattern, reverse turn, domains), X-ray diffraction analysis, interaction between protein side chains • Non-protein structure components (glycosylation, phosphate groups, N-terminal acyl residues) • Enzyme screening and protein engineering (rational design, directed evolution, saturated mutagenesis (CAST, B-Fit)) • Coenzymes and reaction mechanisms Lecture "Enzyme kinetics" • Fundamentals of chemical kinetics • Enzyme-substrate complex and Michaelis-Menten equation • Enzyme assays • Reversible inhibition and activation, competing substrates • Irreversible inhibitors • Reactions with several substrates • Temperature and pH effects Regulation of enzyme activities Seminar "Proteins used in the industry" • Hand out of selected subjects on proteins used in the industry • Primary articles appropriate to the subjects are to be

	researched • This literature will be summed up, analysed and explained in a written and oral presentation • A handout is created for the presentation
Literature	Lecture "Protein chemistry" • Alfred Schellenberger (Hrsg.) Enzymkatalyse: Einführung in die Chemie, Biochemie und Technologie der Enzyme, Springer-Verlag, ISBN: 978-3642734366 • Buchholz, Klaus, Kasche, Volker, Bornscheuer, Uwe Theo. Biocatalysts and Enzyme Technology, Wiley VCH-Verlag GmbH, ISBN: 9783527329892 • Aehle, W. Enzymes in Industry, Production and Application, Wiley VCH Verlag GmbH, ISBN 9783527316892 Lecture "Enzyme kinetics" • Athel Cornish-Bowden "Fundamentals of Enzyme Kinetics" Wiley-Blackwell Seminar "Proteins used in the industry" • Selected articles on relevant subjects concerning enzymes and proteins in the industry
Forms of teaching and learning	• Protein chemistry (V), 2 SWS, 2 LP, 4th Semester • Enzyme kinetics (V, 2 SWS, 2 LP), 5th Semester • Proteins used in the industry (S), 2 SWS, 2 LP, 4th Semester
Workload	**Lecture "Protein chemistry"** Attendance time: 30 h Individual study: 30 h **Lecture "Enzyme kinetics"** Attendance time: 30 h Individual study: 30 h **Seminar "Proteins used in the industry"** Attendance time: 30 h Individual study: 30 h **Total** Attendance time: 90 h Individual study: 90 h Total: 180 h
Evaluation method	The evaluation is a written exam (60 minutes) covering the entire module. Participation in this written examination requires students to have successfully completed the prerequisite seminar "Proteins used in the industry (S)" (written composition).
Grading	The module grade corresponds to the result of the examination.

Product isolation	
Code	(not yet made available)
Credits (as per ECTS)	8
Attendance time	6 SWS
Course language	German (5th Semester), English (4th Semester)
Duration	2 Semester
Rota	annually
Module coordinator	Prof. Dr. Ebert
Assistant professor(s)	Prof. Dr. Ebert
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 4th and 5th semester
Required knowledge	• Content: Recommendations: Biochemistry
Learning outcomes	Students that have successfully completed this module, • are capable of analysing and characterising biomolecules • can practically implement precipitation methods, protein crystallisation, ion-exchange chromatography and tangential flow filtrations • can characterise biomolecules via the measurement of enzyme activities • can determine the purity of protein solutions • can biologically process biomolecules
Content	The following technical contents are taught in this module: Lecture "Product isolation" • Introduction to the preparation of biomolecules • Methods of cell isolation • Fundamentals of chromatography • Chromatographic separation processes for separation of biomolecules • Radial and continuous chromatography • Precipitation and crystallisation • Filtering methods • Two-phase systems for separation of biomolecules Practical course "Product isolation practical course" • Cell isolation via ultrasound probe and high pressure homogeniser • Determination of binding conditions of a protein using DOE on various ion exchange resins under various conditions in 96-well scale ("resin-screening") • Chromatography for enzyme enrichment using the laboratory standard affinity (His-tag) and ion exchange chromatography • Determination of enzyme activities, protein analysis using SDS-PAGE, total protein content determination • Crystallisation of a protein • Tangential flow filtration
Literature	Lecture "Product isolation"

	• Lecture notes Practical course "Product isolation practical course" • Lecture notes
Forms of teaching and learning	• Product isolation (V), 2 SWS, 2 LP, 4th Semester • Product isolation practical course (P), 4 SWS, 6 LP, 5th Semester,
Workload	**Lecture "Product isolation"** Attendance time: 30 h Individual study: 30 h **Practical course "Product isolation practical course"** Attendance time: 60 h Individual study: 120 h **Total** Attendance time: 90 h Individual study: 150 h Total: 240 h
Evaluation method	The evaluation is a written exam (60 minutes) covering the entire module. Participation in this written examination requires students to have successfully completed the prerequisite "Product isolation practical course (P)" (written composition, protocols).
Grading	The module grade corresponds to the result of the examination.

Biocatalysis	
Code	(not yet made available)
Credits (as per ECTS)	10
Attendance time	8 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Schips
Assistant professor(s)	Prof. Dr. Schips
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 5th Semester
Required knowledge	• Content: Recommendation: Organic chemistry, biochemistry, molecular biology, microbiology, technical microbiology • Practical: Recommendation: Organic chemistry practical course, biochemical practical course
Learning outcomes	Students that have successfully completed this module, • understand the practical applications of enzymes and whole cells as biocatalysts • can perform asymmetric syntheses using natural materials in various reaction media • understand the advantages of immobilisation for a technical application • have an overview of biocatalysts currently used in the industry • receive an overview of important bio-organic reactions • understand functions and principles of enzymes as biocatalysts for organic reactions and their advantages and disadvantages in technical applications • have an overview of the important enzyme classes (hydrolases, oxidoreductases, transferases, isomerases) in bio-organic synthesis • are familiar with the prerequisites for kinetic chiral resolution and desymmetrisation reactions • are shown what significance chiral syntons have in the pharmaceutical and agro-industrial sectors using examples • learn basic methods of immobilisation • can perform practical work with enzymes and whole cells as biocatalysts for chemical reactions • can work with various reaction conditions such as aqueous or organic fluids • understand the phase transfer of substrates, immobilisation techniques, manufacture of asymmetrical products using chiral resolution and desymmetrisation (meso-trick), stereospecific syntheses using natural materials without protective groups, polymerisation • understand the most important fine and bulk chemicals that are manufactured using biotechnological methods • understand the use of renewable raw materials for sustainable production of recyclable materials and energy

	and the relationship to current products • understand the advantages and disadvantages as well as environmental accounting of products through discussion of examples • understand the use, manufacture and analysis of industrial enzymes • can work with scientific literature (overview and primary articles) • master written and oral presentation skills
Content	The following technical contents are taught in this module: Lecture "Biocatalysis" • Structure and function of biocatalysts, basic terminology of biocatalysis, application of whole cells or enzymes, reaction of enzyme classes with catalytic mechanisms (hydrolases, oxidoreductases, transferases, lyases, ligases, isomerases), chiral resolution, meso-trick, active substance intermediary products, Kazlauskas principle, prelog principle, solubilisation of substrates, application of selected enzymes (lipases, esterases, nitrilhydrases, dehalogenases, chlorperoxidases), whole cell biotransformations using yeast cell • Application example (ChiPros, HFC syrup, propranolol beta-blocker) from the industry • technical application of enzymes through immobilisation of the enzymes. • all common methods of immobilisation Practical course "Biocatalysis practical course" • Working with esterases, lipases, isomerases, oxidoreductases and cofactor regeneration, asymmetric synthesis (chiral resolution, meso-trick), immobilisation methods with whole cells and enzymes, reactions on natural materials without protective groups, polymerisation reactions • Reaction monitoring via pH-value and DC, determination of ee-values using chiral GC separation • Purity determination via polarimetry, characterisation using ATR-IR
Literature	Lecture "Biocatalysis" • “Bioorganikum - Praktikum der Biokatalyse" Günter E. Jeromin, M. Bertau; Wiley VCH Verlag (2005) • "Biotransformations in organic chemistry" Kurt Farber; Springer-Verlag (2011). Practical course "Biocatalysis practical course" • "Bioorganikum" Günter E. Jeromin, WILEY-VCH Verlag (2006), ISBN: 978-3-527-31245-0.
Forms of teaching and learning	• Biocatalysis (V), 2 SWS, 2 LP • Biocatalysis practical course (P), 6 SWS, 8 LP

Workload	**Lecture "Biocatalysis"** Attendance time: 30 h Individual study: 30 h **Practical course "Biocatalysis"** Attendance time: 90 h Individual study: 150 h **Total** Attendance time: 120 h Individual study: 180 h Total: 300 h
Evaluation method	The examination is a written exam (90 minutes) covering the entire module. Participation in this written examination requires students to have successfully completed the prerequisite "Biocatalysis practical course (P)" (written composition, protocols).
Grading	The module grade corresponds to the result of the examination.

Practical study semester	
Code	(not yet made available)
Credits (as per ECTS)	30
Attendance time	Industry internship with at least 95 attendance days + 4 SWS accompanying seminar
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Schips
Assistant professor(s)	Various experts
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 6th Semester
Required knowledge	• Content: Recommendation: Modules from up to and including the 5th Semester
Learning outcomes	Students that have successfully completed this module, • have practical experience in an industrial company or a research facility in the domain of biotechnology • can practically apply obtained knowledge • have obtained insights into the operational work method and social structure • have communicative and social key qualifications from their encounters with superiors and team members • can evaluate and summarise methodical procedures in scientific protocols and reports • are ready for professional activity early • understand the framework of the internship semester from information events • are prepared for the incorporation into an industrial company or a research facility with a focus on biotechnology • can summarise, analyse and present experiences and results of practical activities to an expert audience Seminar "Accompanying course" • have practical experience in an industrial company or a research facility in the domain of biotechnology • have insights into the operational work method and social structure • understand research or development methods • are familiar with process and operational tasks as well as with industrial production installations • have communicative and social key qualifications from their encounters with superiors and team members
Content	The following technical contents are taught in this module: Practical course "Industrial internship (min. 95 attendance days)" • Introduction into the framework and the execution of the practical semester • Evaluation and presentation of the learned methods, work methods, work conditions, operational tasks

	• Research or development tasks in industrial production installations Seminar "Accompanying course for the practical semester" • Professional activities within a biotechnology industrial company, whereby some specialised scientific subjects are dealt with under supervision • Practical experience in the industry in production companies and research facilities
Literature	• depending on the subject
Forms of teaching and learning	• Industrial internship (P), min. 95 attendance days, 26 LP • Accompanying course for the practical semester (S), 4 SWS, 4 LP
Workload	**Practical course "Industrial internship (min. 95 attendance days)"** Min. 95 attendance days Attendance time: 760 h Individual study: 20 h **Seminar "Accompanying course for the practical semester"** Attendance time: 60 h Individual study: 60 h **Total** Attendance time: 840 h Individual study: 60 h Total: 900 h
Evaluation method	The examination is a written composition (report on the industrial internship)
Grading	The module grade corresponds to the grade of the written composition (report on the industrial internship)

Business economics and management	
Code	(not yet made available)
Credits (as per ECTS)	6
Attendance time	4 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Schips
Assistant professor(s)	Mr Lozanowski, Mr Hülk
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: Recommendation: Secondary level II school knowledge
Learning outcomes	Students that have successfully completed this module, • master the basics of selected sub-domains of business economics • understand the necessity, prerequisites and instruments that are indispensable for company management oriented towards maximisation of economic benefits and profits • obtain overviews of an ecological approach in product development and master methods of environmental accounting and life cycle analysis • can evaluate the sustainability of a product and are thereby capable of operating bio-economically • can design the life-cycle phases that a technical product (from the product idea and development, through production, the actual use, to recycling/disposal) goes through as per the model of sustainable development with a focus on the current economic and ecological challenges • can understand basic economic relationships • are familiar with certain fundamental indicators for corporate management. These are followed by further question complexes such as constitutional and institutional frameworks of a company, i.e. the students know what needs to be taken into account when creating a business with regards to legal form, organisation and location selection • understand according to which criteria an investment decision should be made • understand which possibilities exist for capital acquisition
Content	The following technical contents are taught in this module: Lecture and exercise "Environmental accounting" • Communication of the basics of environmental accounting (methods and practice) • Environmental effects in the product life-cycle, ecological hotspots and optimisation potentials • Problem Shifting • Steps of environmental accounting as per ISO 14040/44 • Learn how to perform environmental accounting

	• Learn to critically evaluate environmental accounting studies by others • Use of diverse application examples, inter alia from the automotive industry, in particular for electric vehicles • Introduction into the subjects of environmental product declarations (EPD), product environmental footprint category rules (PEFCRs) and organisation environmental footprint sector rules (OEFSRs) • The exercise is composed of software training (Umberto Nxt LCA) and a team project task. Lecture and exercise "Fundamentals of business management" • Business management studies in scientific systems, definition of terminology (economy, economies, economic systems), legal forms (individual enterprise, business partnerships, incorporated companies) • Location factors • Structure organisation: Single- and multi-line systems. Functional organisation, divisional organisation, matrix organisation • Domains and tasks of acquisitions, optimal order quantities • Problems and tasks of production economics, models of production management • The term "investment", investments as a decision problem, target setting and possible actions for an investor, • Methods of investment calculation (static methods and dynamic methods) • The term "financing", types of financing (categorisation as per source of the capital and position of the capital providers), foreign financing through credit financing
Literature	Lecture and exercise "Environmental accounting" • Walter Klopffer, Birgit: Life Cycle Assessment (LCA), 1.Auflage, 2014, ISBN: 978-3-527-32986-1. • Löpffer, W.; Grahl, B.: Ökobilanz (LCA): Ein Leitfaden für Ausbildung und Beruf. Wiley-VCH 2009, ISBN 978-3-527-32043-1. • Hallay, H.; Pfriem, R.: Öko-Controlling: Umweltschutz in mittelständischen Unternehmen. Campus-Verlag 1992, ISBN 978-3-5933-4738-7. • Förtsch, G.; Meinholz, H.: Handbuch Betriebliches Umweltmanagement. Springer Verlag 2011, ISBN 978-3-8348-1756-3 Lecture and exercise "Fundamentals of business management" • Olfert, K. und Rahn, H.: Einführung in die Betriebswirtschaftslehre, 6. Auflage, 2001. • Schierenbeck, H.: Grundzüge der Betriebswirtschaftslehre, 15. Auflage, 2000. • Wöhe, G. und Bilstein, J.: Grundzüge der Unternehmensfinanzierung, 9. Auflage, 2002. • Hentze, J.: Personalwirtschaftslehre Bd. 1 und Bd. 2, 6.

	Auflage
Forms of teaching and learning	• Environmental accounting (lecture + exercise), 2 SWS, 3 LP • Fundamentals of business management (lecture + exercise), 2 SWS, 3 LP
Workload	**Lecture and exercise "Environmental accounting"** Attendance time: 30 h Individual study: 60 h **Lecture and exercise "Fundamentals of business management"** Attendance time: 30 h Individual study: 60 h **Total** Attendance time: 60 h Individual study: 120 h Total: 180 h
Evaluation method	The evaluation is a written exam (60 minutes) covering the entire module.
Grading	The module grade corresponds to the result of the examination.

Bachelor thesis	
Code	(not yet made available)
Credits as per ECTS	16
Attendance time	Bachelor thesis (Internship) +2 SWS
Course language	German, English
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Grammel
Assistant professor(s)	Prof. Dr. Ebert, Prof. Dr. Frühwirth, Prof. Dr. Schips, Prof. Dr. Grammel, NN
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: Recommendation: Modules from the 1st and 2nd study stages
Learning outcomes	Students that have successfully completed this module, • have the demonstrable capability of extensively autonomously conducting a scientific study in an academic or industrial environment with a relationship to industrial biotechnology • can analyse the obtained results professionally and present them in a colloquium • are capable of creating a written report complying with scientific standards • can demonstrate their learned capability to extensively autonomously work on a scientific problem • are capable of planning and conducting experiments and analysing the results • can analyse the obtained results in an attractive presentation form • can categorise and evaluate the obtained results and work in a scientific context or in the context of the company • can factually defend the work in a discussion
Content	• Work on projects in an industrial company or research facility • Creation of a written report complying with scientific standards • Public presentation of the bachelor thesis and discussion of the results
Literature	• depending on the subject of the bachelor thesis
Forms of teaching and learning	• Bachelor thesis, x SWS, 12 LP • Colloquium on the bachelor thesis (S), 2 SWS, 4 LP
Workload	**Practical course "Bachelor thesis"** Attendance time: 360 h **Seminar "Colloquium on the bachelor thesis"** Attendance time: 30 h Individual study: 90h

	Total Attendance time: 390 h Individual study: 90 h Total: 480 h
Evaluation method	**Two examinations** take place in this module. The "bachelor thesis" requires a written composition, as well as the "colloquium on the bachelor thesis" as an oral examination. The written composition must be handed in to the secretary's office for the course of studies at the latest three months after registration for the bachelor thesis and must contain a summary of the results in German and English.
Grading	The module grade is calculated from the grades for the colloquium on the bachelor thesis and the grade of the bachelor thesis. The grade of the bachelor thesis represents 75% of the total grade and that of the colloquium 25%.

Elective subject Biofuels	
Code	(not yet made available)
Credits (as per ECTS)	3
Attendance time	2 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Frühwirth
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have specific additional knowledge in various domains, • can autonomously work with current scientific literature, • have in-depth knowledge of presentation techniques, Seminar "Biofuels" • can ecologically and economically evaluate first and second generation biofuels • are capable of technically classifying methods for the manufacture of biofuels
Content	The following technical contents are communicated in this elective subject: Seminar "Biofuels" • Renewable energies • Biomass potential, raw material base • Framework for the use of biofuels • Current: Bioethanol, biodiesel, biogas, biogenic hydrogen • Innovative biofuels: Butanol, DME, cellulose ethanol
Literature	• Bühler, Biokraftstoffe, Reihe Nachhaltigkeit, Auswahl an wissenschaftlichen Publikationen
Forms of teaching and learning	• Biofuels (S), 2 SWS, 3 LP
Workload	**Seminar "Biofuels"** Attendance time: 30 h Individual study: 60 h **Total** Attendance time: 60 h Individual study: 120 h Total: 180 h
Evaluation method	The examination is a written composition.
Grading	The module grade corresponds to the result of the examination. To obtain the required 6 CP, two of the offered **courses** (i.e. a total of 4 SWS) must be selected. The number and title of the offered courses can vary from one semester to another

Elective subject Phototrophic biotechnology	
Code	(not yet made available)
Credits (as per ECTS)	3
Attendance time	2 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Grammel
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have specific additional knowledge in various domains, • can autonomously work with current scientific literature, • have in-depth knowledge of presentation techniques, Seminar "Phototrophic biotechnology" • dispose of knowledge on the various metabolic processes of photosynthetic bacteria and micro-algae, • are familiar with cultivation procedures in photobioreactors. • understand the application possibilities for biotechnology, • are capable of evaluating the application potentials of phototropic micro-organisms with regards to energetic, economic and ecological aspects • are familiar with the national and international company environment.
Content	The following technical contents are communicated in this elective subject: • Physiological and ecological fundamentals • Model organisms for the development of biotechnological processes • Cultivation processes, photobioreactors, process control • Application examples of photosynthetic bacteria and micro-algae for production processes in industrial and pharmaceutical biotechnology as well as for environmental biotechnology • Economic and scientific environment • Companies with activities in the domain of photobiotechnology
Literature	• Literature details will be provided by the assistant professor
Forms of teaching and learning	• Phototropic biotechnology (S), 2 SWS, 3 LP
Workload	**Seminar "Phototrophic biotechnology"** Attendance time: 30 h Individual study: 60 h

	Total Attendance time: 60 h Individual study: 120 h Total: 180 h
Evaluation method	The examination is a written composition.
Grading	The module grade corresponds to the result of the examination. To obtain the required 6 CP, two of the offered **courses** (i.e. a total of 4 SWS) must be selected. The number and title of the offered courses can vary from one semester to another

Elective subject Use of algal biomass	
Code	(not yet made available)
Credits (as per ECTS)	3
Attendance time	2 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Frühwirth
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have specific additional knowledge in various domains, • can autonomously work with current scientific literature, • have in-depth knowledge of presentation techniques, Seminar "Use of algal biomass" • understand the basic types of photobioreactors as application examples for reactor technology and its important design criteria, • are familiar with the most current examples of production installations, • can evaluate algae production processes as complete processes energetically, ecologically and economically
Content	The following technical contents are communicated in this elective subject: Seminar "Use of algal biomass" • Cultivation of phototropic bacteria: Open and closed installations • Algal reactors in the form of agitated vessels, bubble columns, airlift reactors, plate reactors: Fluid mechanics, influence on mass transfer • Technical concepts for light influx in photobioreactors • Automation of cultivation installations • Reconditioning of algal biomass • Utilisations of algal biomass
Literature	• Topics are updated every semester. Literature indications are provided by the assistant professor. Seminar "Pharmaceutical biotechnology"
Forms of teaching and learning	• Use of algal biomass (S), 2 SWS, 3 LP
Workload	**Seminar "Use of algal biomass"** Attendance time: 30 h Individual study: 60 h **Total** Attendance time: 60 h Individual study: 120 h Total: 180 h

Evaluation method	The examination is a written composition for each.
Grading	The module grade corresponds to the result of the examination. To obtain the required 6 CP, two of the offered **courses** (i.e. a total of 4 SWS) must be selected. The number and title of the offered courses can vary from one semester to another

Elective subject Synthetic biology	
Code	(not yet made available)
Credits (as per ECTS)	3
Attendance time	2 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Grammel
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have specific additional knowledge in various domains, • can autonomously work with current scientific literature, • have in-depth knowledge of presentation techniques, Seminar "Synthetic biology" • are capable of estimating the significance of synthetic biology for future development of biotechnology, • are familiar with the methods and processes of synthetic biology, • can evaluate the potential of synthetic biotechnology for industrial biotechnology, pharmaceuticals, medicine and the environment, • can assess the potential risks and ethical aspects
Content	The following technical contents are communicated in this elective subject: Seminar "Synthetic biology" • Definition of terms, delimitation from metabolic engineering, systems biology • Methods (modelling, genetic engineering) and concepts • Implementation in the industry, involved companies and research institutes • Legal and ethical aspects • iGEM contest • Model organisms. Cell as a "chassis" • Synthetic biology as a future technology in industrial biotechnology • Applications in industrial biotechnology • Applications in pharmaceutical biotechnology and medicine • Applications in environmental biotechnology
Literature	• Alfred Puehler und Bernd Müller-Röber. Synthetische Biologie: Die Geburt einer neuen Technikwissenschaft (acatech DISKUTIERT). 2011. Springer • Arno Schrauwers und Bert Poolman. Synthetische Biologie - Der Mensch als Schöpfer? 2013. Springer Spektrum • Markus W. Covert. Fundamentals of Systems Biology: From

	Synthetic Circuits to Whole-cell Models. 2014, CRC Press • Markus Schmidt Synthetic Biology: Industrial and Environmental Applications. 2012, Wiley-Blackwell • Specialist articles are handed out at the seminar
Forms of teaching and learning	• Synthetic biology (S), 2 SWS, 3 LP
Workload	**Seminar "Synthetic biology"** Attendance time: 30 h Individual study: 60 h **Total** Attendance time: 60 h Individual study: 120 h Total: 180 h
Evaluation method	The examination is a written composition.
Grading	The module grade corresponds to the result of the examination. To obtain the required 6 CP, two of the offered **courses** (i.e. a total of 4 SWS) must be selected. The number and title of the offered courses can vary from one semester to another

Elective subject Biomaterials	
Code	(not yet made available)
Credits (as per ECTS)	6
Attendance time	4 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Schips
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have specific additional knowledge in various domains, • can autonomously work with current scientific literature, • have in-depth knowledge of presentation techniques, Seminar "Biomaterials" • understand the properties and application domains of biomaterials in medical technology, in particular for biopolymers • learn biotechnological processes for manufacturing and modifying biomaterials • receive an overview of the application of biomaterials in medical technology
Content	The following technical contents are communicated in this elective subject: • Renewable energies • Biomass potential, raw material base • Framework for the use of biofuels • Current biofuels: Bioethanol, biodiesel, biogas, biogenic hydrogen • Innovative biofuels: Butanol, DME, cellulose ethanol
Literature	• Joon Park; Biomaterials: An Introduction; Springer Publishing, ISBN 978-1-4419-2281-6 • J.S. Temenoff, A.G. Mikos; Biomaterials; Person Publishing, ISBN 978-0-13-009710-1 • Erich Wintermantel, Suk-Woo Ha; Medizintechnik: Life Science Engineering; Springer Verlag, ISBN 978-3-540-93935-1 • Klaus Buchholz, Volker Kasche, Uwe Theo Bornscheuer; Biocatalysts and Enzyme Technology; WILEY-VCH Publishing GmbH & Co. KGaA, ISBN 3-527-30497-5
Forms of teaching and learning	• Biomaterials (S), 2 SWS, 3 LP
Workload	**Seminar "Biomaterials"** Attendance time: 30 h Individual study: 60 h **Total**

	Attendance time: 60 h Individual study: 120 h Total: 180 h
Evaluation method	The examination is a written composition for each.
Grading	The module grade corresponds to the result of the examination. To obtain the required 6 CP, two of the offered **courses** (i.e. a total of 4 SWS) must be selected. The number and title of the offered courses can vary from one semester to another

Elective subject Environmental biotechnology	
Code	(not yet made available)
Credits (as per ECTS)	3
Attendance time	2 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Grammel
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have specific additional knowledge in various domains, • can autonomously work with current scientific literature, • have in-depth knowledge of presentation techniques, Seminar "Environmental biotechnology" • are capable of applying biological decomposition and restructuring processes in technical processes for removal of pollutants • have strategies for complete and environmentally-friendly pollutant removal • can practically apply such methods in environmental biotechnology application domains ranging from groundwater and soil decontamination to exhaust air cleaning, metal recycling and decontamination of ecosystems
Content	The following technical contents are communicated in this elective subject: Seminar "Environmental biotechnology" • Mechanisms of biodegradation of pollutants • Soil decontamination • Biological wastewater treatment • Aerobic membrane processes • Organic residues: Composting, fermentation • Exhaust gases: Biofilters, bio-scrubbers • Bio-hydrometallurgy • Rehabilitation of ecosystems
Literature	• Grundlagen, Anwendungen und Perspektiven, Thomas Raphael, Springer Verlag
Forms of teaching and learning	• Environmental biotechnology (S), 2 SWS, 3 LP
Workload	**Seminar "Environmental biotechnology"** Attendance time: 30 h Individual study: 60 h

	Total Attendance time: 60 h Individual study: 120 h Total: 180 h
Evaluation method	The examination is a written composition.
Grading	The module grade corresponds to the result of the examination. To obtain the required 6 CP, two of the offered **courses** (i.e. a total of 4 SWS) must be selected. The number and title of the offered courses can vary from one semester to another

Elective subject GMP, GLP	
Code	(not yet made available)
Credits (as per ECTS)	3
Attendance time	2 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Ebert
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have specific additional knowledge in various domains, • can autonomously work with current scientific literature, • have in-depth knowledge of presentation techniques, Seminar "GMP (Good Manufacturing Practice), GLP (Good Laboratory Practice)" • are familiar with the contents of quality assurance from "GMP (Good Manufacturing Practice)" and "GLP (Good Laboratory Practice)", • can furthermore use the basic terms such as qualification, validation, risk assessment, etc. from quality assurance
Content	The following technical contents are communicated in this elective subject: Seminar "GMP, GLP" • What is quality? • Consequences of severe quality defects • Quality management and quality assurance • Steps for qualification with examples • Sequence of a validation based on the example of analysis methods • Work instructions and manufacturing instructions • Delimitation GMP/GLP • Monitoring agencies, Country / Federation • EC guideline of Good Manufacturing Practice • Clean room zones with division into airlocks, quality control, production, storage and examples of clean room installations • Classification and objectives of clean room zones • Seminar work on articles from specialist journals and from individual specialist literature such as the EC guideline for Good Manufacturing Practice, etc.
Literature	• Lecture documents • ICH guidelines • EU GMP guideline
Forms of teaching and learning	• GMP, GLP (S), 2 SWS, 3 LP

Workload	**Seminar "GMP, GLP"** Attendance time: 30 h Individual study: 60 h **Total** Attendance time: 60 h Individual study: 120 h Total: 180 h
Evaluation method	The examination is a written composition.
Grading	The module grade corresponds to the result of the examination. To obtain the required 6 CP, two of the offered **courses** (i.e. a total of 4 SWS) must be selected. The number and title of the offered courses can vary from one semester to another

Elective subject Industrial waste materials	
Code	(not yet made available)
Credits (as per ECTS)	3
Attendance time	2 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Traub-Eberhard
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have specific additional knowledge in various domains, • can autonomously work with current scientific literature, • have in-depth knowledge of presentation techniques, Seminar "Industrial waste materials" • have an overview of the effect and residues of important pollutant classes in industrial waste • are capable of evaluating the corresponding hazard potentials and can develop targeted strategies for elimination of these pollutants
Content	The following technical contents are communicated in this elective subject: Seminar "Industrial waste materials" • Overview of important pollutant classes in industrial waste • Effects of pollutants (ecotoxicology, human toxicology) • Behaviour of pollutants in water, soil, air
Literature	Seminar "Industrial waste materials" • Friedhelm Korte (Hrsg.): Lehrbuch der ökologischen Chemie: Grundlagen und Konzepte für die ökologische Beurteilung von Chemikalien Stuttgart, New York : Thieme, (zuletzt) 2001
Forms of teaching and learning	• Industrial waste (S), 2 SWS, 3 LP
Workload	**Seminar "Industrial waste materials"** Attendance time: 30 h Individual study: 60 h **Total** Attendance time: 60 h Individual study: 120 h Total: 180 h
Evaluation method	The examination is a written composition.
Grading	The module grade corresponds to the result of the examination. To obtain the required 6 CP, two of the offered **courses** (i.e. a total of 4 SWS) must be selected. The number and title of the offered courses can vary from one semester to another

Elective subject Biocatalysis (consolidation)	
Code	(not yet made available)
Credits (as per ECTS)	3
Attendance time	2 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Schips
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have specific additional knowledge in various domains, • can autonomously work with current scientific literature, • have in-depth knowledge of presentation techniques, Seminar "Biocatalysis (consolidation)" • are capable of evaluating technical biocatalytic processes and of placing them in relation to other processes • are familiar with current developments and research themes in the area of biocatalysis • have an in-depth understanding of the application of isolated enzymes and whole cell systems in technical systems
Content	The following technical contents are communicated in this elective subject: Seminar "Biocatalysis (consolidation)" • Extraction and production of enzymes according to a technical standard • Reactors for biocatalysis & bio-transformations • Industrial applications of various enzyme classes • Current trends and research projects in the domain of biocatalysis
Literature	• Klaus Buchholz, Volker Kasche, Uwe Theo Bornscheuer; Biocatalysts and Enzyme Technology; WILEY-VCH Verlag GmbH & Co. KGaA, ISBN 3-527-30497-5 • Andreas S. Bommarius, Bettina R. Riebel; Biocatalysis, Fundamentals and Applications; WILEY-VCH Verlag GmbH & Co. KGaA, ISBN 3-527-30344-8
Forms of teaching and learning	• Biocatalysis (consolidation) (S), 2 SWS, 3 LP
Workload	**Seminar "Biocatalysis (consolidation)"** Attendance time: 30 h Individual study: 60 h **Total**

	Attendance time: 60 h Individual study: 120 h Total: 180 h
Evaluation method	The examination is a written composition.
Grading	The module grade corresponds to the result of the examination. To obtain the required 6 CP, two of the offered **courses** (i.e. a total of 4 SWS) must be selected. The number and title of the offered courses can vary from one semester to another

Elective subject Pharmaceutical biotechnology	
Code	(not yet made available)
Credits (as per ECTS)	3
Attendance time	2 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Ebert
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have specific additional knowledge in various domains, • can autonomously work with current scientific literature, • have in-depth knowledge of presentation techniques, Seminar "Pharmaceutical biotechnology" • know important bio-pharmaceutical active substances • understand the basics of a pharmaceutical manufacturing process • master important aspects of GMP/GLP
Content	The following technical contents are communicated in this elective subject: Seminar "Pharmaceutical biotechnology" • Bio-pharmaceutical active substances • Cell line development • Cellular culture processes (upstream processing) • Protein purification (downstream processing) • Manufacturing a monoclonal antibody • Clinical phases and market approval
Literature	• Lecture notes, current publications, • Uwe Gottschalk (Hrsg.) Process Scale Purification of Antibodies, Wiley-Verlag
Forms of teaching and learning	• Pharmaceutical biotechnology (S), 2 SWS, 3 LP
Workload	**Seminar "Pharmaceutical biotechnology"** Attendance time: 30 h Individual study: 60 h **Total** Attendance time: 60 h Individual study: 120 h Total: 180 h
Evaluation method	The examination is a written composition.
Grading	The module grade corresponds to the result of the examination. To obtain the required 6 CP, two of the offered **courses** (i.e. a total of 4 SWS) must be selected. The number and title of the offered courses can vary from one semester to another

Elective subject International excursion	
Code	(not yet made available)
Credits (as per ECTS)	3
Attendance time	2 SWS
Course language	German, English
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Ebert
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have specific additional knowledge in various domains, • can autonomously work with current scientific literature, • have in-depth knowledge of presentation techniques, Excursion "International excursion" • know companies abroad, • have knowledge of the various business cultures in other countries, • know about products and production processes in the visited companies
Content	The following technical contents are communicated in this elective subject: Excursion "International excursion" • Visit to various biotechnological companies abroad • Tour the companies • Elaboration of the background knowledge on the companies and their products
Literature	• Information on the visited companies
Forms of teaching and learning	• International excursion (Exc.), 2 SWS, 3 LP
Workload	**Excursion "International excursion"** Attendance time: 30 h Individual study: 60 h **Total** Attendance time: 60 h Individual study: 120 h Total: 180 h
Evaluation method	The examination is a written composition.
Grading	The module grade corresponds to the result of the examination. To obtain the required 6 CP, two of the offered **courses** (i.e. a total of 4 SWS) must be selected. The number and title of the offered courses can vary from one semester to another

Elective subject Ethics in biotechnology	
Code	(not yet made available)
Credits (as per ECTS)	3
Attendance time	2 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	NN
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have specific additional knowledge in various domains, • can autonomously work with current scientific literature, • have in-depth knowledge of presentation techniques, Seminar "Ethics in biotechnology" • understand problem areas in natural sciences, • are particularly capable of assessing biotechnological processes with consequences for man and the environment, • understand important bioethics approaches, • develop a sense of responsibility when dealing with the risks and possibilities of technical developments
Content	The following technical contents are taught in this module: Seminar "Ethics in biotechnology" • Possibilities and limits of natural sciences, • Environment and health: New foods (genetically modified; functional) • Responsible use of resources • Weighing of risks and uses of biotechnology
Literature	• Topics are updated annually, literature details will be provided by the assistant professor
Forms of teaching and learning	• Ethik in der Biotechnologie (S), 2 SWS, 3 LP
Workload	**Seminar "Ethics in biotechnology"** Attendance time: 30 h Individual study: 60 h **Total** Attendance time: 60 h Individual study: 120 h Total: 180 h
Evaluation method	The examination is a written composition.
Grading	The module grade corresponds to the result of the examination. To obtain the required 6 CP, two of the offered **courses** (i.e. a total of 4 SWS) must be selected. The number and title of the offered courses can vary from one semester to another

Elective subject Biorefineries	
Code	(not yet made available)
Credits (as per ECTS)	3
Attendance time	2 SWS
Course language	German
Duration	1 semester
Rota	annually
Module coordinator	Prof. Dr. Frühwirth
Assistant professor(s)	Prof. Dr. Frühwirth
Incorporation in the degree programs	Industrial biotechnology BSc, mandatory module, 7th Semester
Required knowledge	• Content: none
Learning outcomes	Students that have successfully completed this module, • have specific additional knowledge in various domains, • can autonomously work with current scientific literature, • have in-depth knowledge of presentation techniques, Seminar "Biorefineries" • understand the latest biorefinery concepts, • can ecologically and economically evaluate biorefineries using examples
Content	The following technical contents are communicated in this elective subject: Seminar "Biorefineries" • Raw materials base: Wood, whole plants, grass • Processes: chemical, thermo-chemical, biotechnological • Products: Fuels, foods and feedstuffs, bulk and fine chemicals • Current application examples
Literature	• Stoffliche Nutzung nachwachsender Rohstoffe, Oliver Türk, Springer, 2013
Forms of teaching and learning	• Biorefineries(S), 2 SWS, 3 LP
Workload	**Seminar "Biorefineries"** Attendance time: 30 h Individual study: 60 h **Total** Attendance time: 60 h Individual study: 120 h Total: 180 h
Evaluation method	The examination is a written composition.
Grading	The module grade corresponds to the result of the examination. To obtain the required 6 CP, two of the offered **courses** (i.e. a total of 4 SWS) must be selected. The number and title of the offered courses can vary from one semester to another