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Module handbook

Industrial biotechnology

(Bachelor’s)

Version: 21.10.2021

Module handbook

Industrial Biotechnology bachelor's degree

Contents

Introduction to Biotechnology	
Code	(not yet provided)
Credits (ECTS)	6
Attendance	6 SWS
Teaching language	German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Grammel
Lecturer(s)	Prof. Dr. Grammel, Prof. Dr. Frühwirth, Prof. Hädicke
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 1
Prior knowledge	• Contents: none
Learning outcomes	Students who have successfully completed this module, • are familiar with the scientific and technological foundations as well as the social and economic framework conditions of biotechnology • are familiar with the diverse areas of application of biotechnology • are able to evaluate biotechnological processes in terms of their advantages and problems • have an insight into industrial biotechnology through visits to industrial biotechnology companies • have an overview of potential occupational fields and employers • know the essential basics of programming • know various applications of bioinformatics • can apply analyses of sequence analysis • have an understanding of the process engineering interrelationships for apparatus, plants and systems • are capable of recording processes and presenting them in accordance with standards • can interpret technical drawings
Contents	The following technical content is taught in this module: “Introduction to Industrial Biotechnology” lectures • Social, academic and industrial framework conditions • Characterisation and fields of application of white biotechnology • Raw materials and products • Ecological and economical aspects • Product range: Biofuels, vitamins, amino acids, fine and bulk chemicals, industrial enzymes, antibiotics, biopolymers • Fermentation processes • Current developments in industrial biotechnology “Introduction to Bioinformatics” lectures and tutorials • General programming basics • Data import and application deployment • Sequence analyses • Protein analyses

	• Analysis of RNA-Seq data • Phylogenetic tree analysis • Algorithms and applications for Next Generation Sequencing (NGS) "Introduction to Process Engineering" lectures • Classification of process engineering, sub-areas • Physical quantities and unit systems, common concentration measures in process engineering • Basic operations • Standard-compliant representation of processes: Block flow diagrams, process flow diagrams, piping and instrumentation flow diagrams • Application examples: procedural representation of processes from biotechnology
Literature	"Introduction to Industrial Biotechnology" lectures • 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 Lehrveranstaltung „Einführung in die Bioinformatik" • Bioinformatik – ein einführendes Lehrbuch, Thomas Dandekar, 2. Auflage, Springer Verlag, 2021 • Angewandte Bioinformatik, Paul M. Selzer, Richard J. Marhöfer, Oliver Koch, 2. Auflage, Springer Berlin, 2018
Teaching and learning forms	• Introduction to Industrial biotechnology (L), 2 SWS, 2LP • Introduction to Bioinformatics (L+T), 2 SWS, 2 LP • Introduction to Process Engineering (L+T), 2 SWS, 2 LP
Workload	**"Introduction to Industrial Biotechnology" lectures** Attendance: 30 h Independent study: 30 h **Introduction to Bioinformatics lectures + tutorials** Attendance: 30 h Independent study: 30 h **Introduction to Process Engineering lectures + tutorials** Attendance: 30 h Independent study: 30 h **total** Attendance: 90 h Independent study: 90 h

	Total: 180 h
Assessment Methods	The summative assessment is a written examination (60 minutes) about the entire module. Only students who have successfully passed the formative assessment for “Project Excursion I” (written paper) will be allowed to take the assessment.
Grading	The module grade corresponds to the result of the summative assessment.

Fundamentals of process engineering	
Credits (ECTS)	8
Attendance	8 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. techn. Frühwirth
Lecturer(s)	Prof. Dr. techn. Frühwirth, Prof. Dr. Mavoungou, Dr. Amann
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 2
Prior knowledge	• Contents: Recommendation:
Learning outcomes	Students who have successfully completed this module, • can describe basic concepts of fluid flow and apply them to technical problems, in frictionless and real considerations of flow through apparatus and plants • know technical applications such as tank flow, pumps and pipe flow • are familiar with systems with or without heat or material exchange • are able to apply the basic concepts of fluid mechanics and heat and mass transfer to technical problems • know the theoretical principles for a deeper understanding of biotechnological and process engineering processes • are familiar with the physical basics of mechanics, fluid mechanics and thermodynamics • can evaluate experimental data using thermodynamic and kinetic models in a solution-focused manner • are familiar with the basics of physico-chemical methods • have basic knowledge of technical thermodynamics • understand the concepts of technical thermodynamics and can apply them in a problem-focused manner • know the thermodynamics of combustion engines and refrigeration processes and can apply them to idealised design examples
Contents	The following technical content is taught in this module: “Transport Phenomena” lectures • Fluid mechanics: Application of Bernoulli's equation to ideal tanks and pipe systems • Description of laminar and turbulent flow • Real pipe and tank flow • Description and design of pumps and compressors • Material transfer: Mechanisms of material transfer, diffusion, convection • Model theories of material transfer • Transfer of gaseous components into liquids, kLa value methods • Heat transfer: Mechanisms of heat transfer, heat conduction, heat radiation “Thermodynamics” lectures

	• Chemical engineering thermodynamics: Thermodynamics of the phase boundary for droplets, bubbles, particles • Molecular and electrostatic interaction between phase boundaries • Influence of the phase boundary on technical processes • Ternary systems – mixing gaps • Technical thermodynamics: First and second law of thermodynamics • Application of the main theorems in technical questions • Thermodynamics of internal combustion engines, refrigeration processes, steam power plants and combustion "Physics" lectures + tutorials • Mechanics: Kinematics, Newtonian mechanics, conservation laws • Mechanics of liquids and gases: Density, pressure, fluid dynamics, viscosity, Hagen-Poiseuille law • Optics: Introduction to lens optics with in-depth examination of wave optics using diffraction phenomena, single slit and colour spectra, UV light, IR light. "Physical Chemistry" lectures + tutorials • Basic thermodynamic terms and definitions • Function of several variables, partial differential quotients, total differential, state and path functions • Intermolecular forces and aggregation • Chemical thermodynamics: Temperature and thermal motion of molecules (ideal gas law, kinetic gas theory, energy distribution as a function of temperature, real gases); characteristic functions, chemical potential, mixed phases, phase equilibria and phase diagrams, homogeneous and heterogeneous chemical equilibria; reaction kinetics • Gas solubilities: Henry's and Raoult's Laws • Dalton's law
Literature	"Transport Phenomena" lectures • Baer, Stefan, Wärme- und Stoffübertragung, Springer, 2013 • Vauck, Müller, Grundoperationen chemischer Verfahrenstechnik, Wiley "Thermodynamics" lectures • Günther Cerbe, Gernot Wilhelms: Technical thermodynamics: Theoretische Grundlagen und praktische Anwendungen, Hanser Verlag 2017 "Physics" lectures + tutorials • Halliday, Resnick, Walker; Halliday Physik - Bachelor Edition, Wiley-VCH, 2013 • Knight; Physics, Pearson Addison-Wesley, 2017 "Physical Chemistry" lectures + tutorials

	• 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, 2013 • Barrow, Physikalische Chemie, Bohmann Vieweg
Teaching and learning forms	• Transport Phenomena (L+T), 2 SWS, 2 LP • Thermodynamics (L+T), 2 SWS, 2 LP • Physics (L+T), 2 SWS, 2 LP • Physical Chemistry (L+T), 2 SWS, 2 LP
Workload	**Transport Phenomena lectures + tutorials** Attendance: 30 h Independent study: 30 h **Thermodynamics lectures + tutorials** Attendance: 30 h Independent study: 30 h **Physics lectures** Attendance: 30 h Independent study: 30 h **Physical Chemistry lectures** Attendance: 30 h Independent study: 30 h **total** Attendance: 120 h Independent study: 120 h Total: 240 h
Assessment Methods	The summative assessment is a written examination (120 minutes) about the entire module.
Grading	The module grade corresponds to the result of the summative assessment.

Mathematics and Biostatistics I	
Credits (ECTS)	6
Attendance	6 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Hädicke
Lecturer(s)	Hr. Rainer Dittmar, Hr. Christoph Dittmar
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 1
Prior knowledge	• Recommendation: Differential and integral calculus
Learning outcomes	Students who have successfully completed this module, • know the mathematical and statistical principles, ways of thinking and methods that are required in the course of the Industrial Biotechnology degree programme
Contents	The following technical content is taught in this module: "Mathematics and Biostatistics I" lectures • Basic concepts: Statements, quantities • Functions: Basic concepts, real-value functions – monotonicity, symmetry, periodicity, inverse function • Limit value of functions: Limits, continuity, poles, asymptotes, fractional rational functions • Differential calculus: Differentiability, differentiation rules, mean value theorem, curve discussion • Integral calculus: Primitive function, Riemann integral, indefinite, improper integrals, product, quotient rule, partial integration, fractional rational functions • Applications of integral calculus: Area, volume of solids of revolution, arc length of plane curves, surface area of solids of revolution • Power series: Development points, convergence behaviour, continuity, differentiability, integrability, identity theorem, Taylor series, Taylor's formula, MacLaurin series • Limit value determination with differentiation • Descriptive statistics: Characteristics, scales, data preparation, absolute and relative frequency, diagrams, histogram, empirical distribution function • Statistical measures, position measures, arithmetic, geometric, harmonic mean, quantiles, boxplot; measures of dispersion, variance, standard deviation, coefficient of variation • Covariance, correlation coefficient, regression analysis • Probability: Random experiment, sampling, probability space, geometric probabilities • Conditionality, independence: Bayes' theorem, decision trees • Random variables and their distributions: Distribution function, probability function, density function, expected values

	"Mathematics and Biostatistics I" tutorial • Exercises + solutions are provided as PDFs for each chapter of the lecture
Literature	"Mathematics and Biostatistics I" lectures • L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, 2014 • Schriever et al.: Wahrscheinlichkeitsrechnung 1+2, Beschreibende Statistik, Schließende Statistik "Mathematics and Biostatistics I" tutorial • Provided exercises + solutions • Schriever et al.: Wahrscheinlichkeitsrechnung 1+2, Beschreibende Statistik, Schließende Statistik
Teaching and learning forms	• Mathematics and Biostatistics I (L), 4 SWS, 4 LP • Mathematics and Biostatistics I (T), 2 SWS, 2 LP
Workload	**Mathematics and Biostatistics I lecture** Attendance: 60 h Independent study: 60 h **Mathematics and Biostatistics I tutorial** Attendance: 30 h Independent study: 30 h **total** Attendance: 90 h Independent study: 90 h Total: 180 h
Assessment Methods	The summative assessment is a written examination (60 minutes) about the entire module.
Grading	The module grade corresponds to the result of the summative assessment.

Mathematics and Biostatistics II	
Credits (ECTS)	6
Attendance	6 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Hädicke
Lecturer(s)	Hr. Rainer Dittmar, Hr. Christoph Dittmar
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 2
Prior knowledge	• Recommendation: "Mathematics and Biostatistics I" lectures and tutorials
Learning outcomes	Students who have successfully completed this module, • know the advanced mathematical and statistical principles, ways of thinking and methods that are required in the course of the Industrial Biotechnology degree programme
Contents	The following technical content is taught in this module: "Mathematics and Biostatistics II" lecture • Complex numbers: Algebraic normal form, Gaussian number plane, trigonometric normal form, exponential form • Matrices: Transposed, square, diagonal, triangular, symmetric, skew symmetric matrices, inverse matrix, Gauss-Jordan method, rank of a matrix • Determinants: Basic definitions, Laplace's development theorem, rules for calculating determinants, eigenvalues, eigenvectors, characteristic polynomial • Real-value functions of several variables: Partial differentiation, tangential plane, gradient, Nabla operator, local extreme values, stationary points • Ordinary differential equations (DGLs): linear DGLs of first order, homogeneous, inhomogeneous, linear DGLs of nth order with constant coefficients • Special distributions: Binomial, hypergeometric, Poisson distribution; negative exponential distribution, normal distribution, chi square distribution, F-distribution, t-distribution • Estimation methods: Point estimators, properties of good estimators, expectation fidelity, consistency, minimum variance, construction methods for estimators, maximum likelihood, method of moments, least squares method • Estimation methods: Confidence ranges for probabilities, means and dispersions • Testing statistical hypotheses: Error types in testing, quality function, operational characteristics, special parametric test procedures, t-test, F-test, chi square test • Introduction to statistical experimental design and analysis of variance "Mathematics and Biostatistics II" tutorials

	• Exercises + solutions are provided as PDFs for each chapter of the lecture
Literature	"Mathematics and Biostatistics II" lecture • L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, 2014 • Schriever et al.: Wahrscheinlichkeitsrechnung 1+2, Beschreibende Statistik, Schließende Statistik "Mathematics and Biostatistics II" tutorials • Provided exercises + solutions • Schriever et al.: Wahrscheinlichkeitsrechnung 1+2, Beschreibende Statistik, Schließende Statistik
Teaching and learning forms	• Mathematics and Biostatistics II (L), 4 SWS, 4 LP • Mathematics and Biostatistics II (T), 2 SWS, 2 LP
Workload	**Mathematics and Biostatistics I lecture** Attendance: 60 h Independent study: 60 h **Mathematics and Biostatistics I tutorial** Attendance: 30 h Independent study: 30 h **total** Attendance: 90 h Independent study: 90 h Total: 180 h
Assessment Methods	The summative assessment is a written examination (60 minutes) about the entire module.
Grading	The module grade corresponds to the result of the summative assessment.

Basics of Chemistry	
Credits (ECTS)	7
Attendance	6 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Schips
Lecturer(s)	Prof. Dr. Schips, Prof. Dr. Traub
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 1
Prior knowledge	• Contents: Recommendation: School knowledge of Chemistry at Secondary Level II
Learning outcomes	Students who have successfully completed this module, • can practically apply the basics of laboratory practice in general, inorganic and analytical chemistry • are able to perform simple routine procedures in the chemical-analytical field, in the handling of volumetric instruments and precision balances and are able to record raw data from laboratory experiments in a laboratory notebook • can prepare simple test protocols according to the rules of GLP • have practical skills in preparing measured solutions, dilution series, titrations and water analysis • have basic knowledge of general and analytical chemistry • are familiar with occupational safety in the laboratory and can handle hazardous substances in the laboratory
Contents	The following technical content is taught in this module: "Introduction to Chemistry" lectures + tutorials • Introduction to human toxicology • Occupational safety and hazardous substances • Faculty of Biotechnology workplace guidelines • Quality assurance when working in laboratory practical work (keeping laboratory journals, general raw data acquisition, calibration, adjustment) • Definitions of analytical parameters (tasks of analytics; determination, detection, calibration of an analytical procedure) • Chemical calculation (e.g. preparation of measured solutions, calculation of mixtures, significance of measured quantities) • Overview of the periodic table of the elements • Practical introduction to routine laboratory techniques: Weighing, volume determinations (especially pipetting), filtration, melting point determination, recrystallisation, precipitation, detection methods "General Chemistry" lectures + tutorials • Chemical bonds • Intermolecular interactions

	• Quantities, content and concentration data (preparation of measured solutions and dilution series) • Chemical equilibrium and equilibrium constant • Acids and bases, pH value, pKs value, neutralisation reactions, acid-base buffer (buffer systems) • Energetics and kinetics of chemical reactions • Redox reactions / metal corrosion • Electrochemistry • Coordinative binding / chelate complexes • Precipitates and solubility product • Titrations (according to IUPAC) • Polarimetry • Refractometry "Chemistry" practical • Quantities, content and concentration data (preparation of measured solutions and dilution series) • Dimensional analysis/volumetric methods, acid-base titrations, redox titrations, complexometric titrations (water hardness determination), conductometry • Analytical methods (ion detection, coulometric titrations) • Acid-base buffer systems • Refractometry • Polarimetry • Electrochemistry
Literature	"Introduction to Chemistry" lectures + tutorials • Mortimer, Chemie, 13. Auflage, Thieme-Verlag, 2019 • Binnewies, Jäckel, Willner & Rayner-Canham, Allgemeine und Anorganische Chemie, 3. Auflage, Spektrum Akademischer Verlag, 2016 • Hübschmann, Links, Einführung in das chemische Rechnen, Handwerk und Technik • Eckardt, 1x1 Laborpraxis, Wiley-VCH, 2006 • Dane, Kleines chemisches Praktikum, Wiley-VCH, 2004 "General Chemistry" lectures + tutorials • Mortimer, Chemie, 13. Auflage, Thieme Verlag, 2019 • Atkins, Chemie - einfach alles, Wiley-VCH, 2006 • Otto, Analytische Chemie, 5. Auflage, Wiley-VCH, 2019 • Binnewies , Jäckel, Willner & Rayner-Canham. Allgemeine und anorganische Chemie, 3. Auflage, Spektrum akademischer Verlag, 2016 • IUPAC "Chemistry" practical • Mortimer, Chemie, 13.Auflage, Thieme Verlag, 2019 • Binnewies, Jäckel, Willner & Rayner-Canham, Allgemeine und Anorganische Chemie, 3. Auflage, Spektrum Akademischer Verlag, 2016 • Hübschmann, Links, Einführung in das chemische Rechnen, Handwerk und Technik

	• Eckardt, 1x1 Laborpraxis, Wiley-VCH, 2006 • Dane, Kleines chemisches Praktikum, Wiley-VCH, 2004 • Jander, Blasius, Lehrbuch der analytischen und präparativen anorganischen Chemie, 16. Auflage, 2006
Teaching and learning forms	• Introduction to Chemistry (L+T), 2 SWS, 2 LP • General Chemistry (L+T), 2 SWS, 2 LP • Chemistry practical (P), 2 SWS, 3 LP
Workload	**Introduction to Chemistry lectures + tutorials** Attendance: 30 h Independent study: 30 h **General Chemistry lectures + tutorials** Attendance: 30 h Independent study: 30 h **Chemistry practical** Attendance: 30 h Independent study: 60 h **total** Attendance: 90 h Independent study: 120 h Total: 210 h
Assessment Methods	The summative assessment is a written examination (90 minutes) about the entire module. Only students who have successfully passed the formative assessment for Chemistry practical" (written paper, log) will be allowed to take the assessment.
Grading	The module grade corresponds to the result of the summative assessment.

Analytical and Organic Chemistry I	
Credits (ECTS)	8
Attendance	6 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Schips
Lecturer(s)	Prof. Dr. Schips
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 2
Prior knowledge	• Contents: Semester 1: "Basics of Chemistry" lecture and "Chemistry practical"
Learning outcomes	Students who have successfully completed this module, • have a basic understanding of the structure and stereochemistry of organic compounds which forms the basis of following courses • are familiar with the structure and nomenclature of the most important organic compound classes • are familiar with the basic analytical methods for quantification, structure determination and separation of organic compounds • can apply the analytical methods in practice to characterise and quantify organic compounds
Contents	The following technical content is taught in this module: "Organic Chemistry I" lectures + tutorials • Structure and formula notation: Octet rule, Lewis formulas, VSEPR theory, mesomerism, substance classes and nomenclature, functional groups, overview of important natural substances • Chemical bonds: Types of chemical bond, hybridisation and MO model in organic chemistry • Isomerism: Constitution, configuration and conformation, stereochemistry, chirality, (R)/(S) nomenclature, Fischer projection, stereochemistry using exercise examples • Fundamentals of organic reactions: Kinetic and thermodynamically controlled reactions, catalysis, activation energy, reaction kinetics • Electrophiles and nucleophiles: Lewis Acid/Base theory, HSAB principle, organic acids and bases, oxidation and reduction in organic chemistry "Analytical Chemistry" lectures • 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

	Analytical Chemistry practical • Titrations and quantification of substances • Overview of chromatographic separation methods (DC, GC, gel chromatography, ion exchange chromatography), stationary and mobile phases, elutropic series, detection methods • Spectroscopic methods (UV-VIS, IR)
Literature	"Organic Chemistry I" lectures + tutorials • Grundlagen der Organischen Chemie, Joachim Buddrus, Walter de Gruyter GmbH (2015), ISBN 978-3-11-030559-3 • Basisbuch Organische Chemie, Carsten Schmuck, Pearson (2018); ISBN 978-3-8632-6821-3 "Analytical Chemistry" lectures • Bioanalytik, F. Lottspeich, Spektrum (2012), ISBN 978-3-8274-2942-1 • Instrumentelle Analytik, Dominik Steinhilber, Apotheker Verlag Stuttgart (2013), ISBN 978-3-8047-3074-8 • Spektroskopie, Joseph B. Lambert, Pearson (2012), ISBN 978-3-86894-146-3 Analytical Chemistry practical • Bioanalytik, F. Lottspeich, Spektrum (2012), ISBN: 978-3-8274-2942-1 • Instrumentelle Analytik, Dominik Steinhilber, Apothekerverlag Stuttgart (2013), ISBN 978-3-8047-3074-8 • Spektroskopie, Joseph B. Lambert, Pearson (2012), ISBN 978-3-86894-146-3
Teaching and learning forms	• Organic Chemistry I (L+T), 2 SWS, 2 LP • Analytical Chemistry (L), 2 SWS, 2 LP • Analytical Chemistry practical (P), 2 SWS, 4 LP
Workload	**"Organic Chemistry I" lectures + tutorials** Attendance: 30 h Independent study: 30 h **"Analytical Chemistry" lectures** Attendance: 30 h Independent study: 30 h **"Analytical Chemistry" practical** Attendance: 30 h Independent study: 90 h **total** Attendance: 90 h Independent study: 150 h Total: 240 h
Assessment Methods	The summative assessment is a written examination (90 minutes) about the entire module.

	Only students who have successfully passed the formative assessment “Analytical Chemistry practical” (P) (written paper, log) will be allowed to take the assessment.
Grading	The module grade corresponds to the result of the summative assessment.

Microbiology	
Credits (ECTS)	10
Attendance	7 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Grammel
Lecturer(s)	Prof. Dr. Grammel
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 1
Prior knowledge	• Contents: Recommendation: Practical skills in handling simple laboratory equipment (pipettes, balances, etc.), school level English, basic knowledge of organic chemistry
Learning outcomes	Students who have successfully completed this module, • have basic theoretical and practical knowledge of the structure, function and application of microbial cells • understand basic principles of bacterial metabolism and its significance for ecology and biotechnology • can apply sterile working methods and basic microbiological working techniques • can work in a group • can create scientific protocols • can consider scientific standards in the preparation of texts • know the various forms and properties of prokaryotes • are familiar with the structure and function of bacterial cells and their significance for ecology, industrial biotechnology and as pathogens • understand bacterial energy metabolism and its importance for the environment and industrial applications • can apply microbiological working techniques, cultivation procedures, sterile technology, microscopy, etc. • can describe the metabolic performance of microorganisms • can identify microorganisms using physiological and molecular tests
Contents	The following technical content is taught in this module: “Microbiology” lecture • Diversity of microorganisms • Morphological, microscopic and physiological properties • Metabolic capacities and size ratios • Taxonomy, phylogenetic tree • Structure of prokaryotic cells: Cell shell, cell wall, cell membrane, cytoplasm, inclusion body • Functions of cell membrane: Transport, signal processing, motility • Signal transduction and gene regulation • Important microorganism groups: Endospores, enterobacteria, actinomycetes, etc. • Fundamentals of energy metabolism • Respiration processes, aerobic-anaerobic

	• Fermentation metabolism • Photosynthesis • Ecological aspects • Material cycles “Microbiology” practical • Biological safety (GenTG, GenTSV, BioStoffV) • Production of culture media • Autoclave sterilisation • Disinfection processes • Characterisation of biotechnologically relevant microorganisms • Microscopic techniques (staining, fluorescence) • Identification with rRNA sequence analysis • Microbial breakdown of polymers • Growth kinetics
Literature	“Microbiology” lecture • Lecture notes • G. Fuchs und H.Schlegel, Allgemeine Mikrobiologie, ISBN 978-3-13-241885-1, 10. Aufl., 2017 • Brock Biology of Microorganisms ISBN-13:978-0-13-196893-6 “Microbiology” practical • Practical notes • G.Fuchs und H.Schlegel: Allgemeine Mikrobiologie, ISBN 978-3-13-241885-1, 10. Aufl., 2017 • Brock Biology of Microorgnisms, iSBN-13: 978-0-13-196893-6 • Steinbüchel-Oppermann-Sanio: Mikrobiologisches Praktikum (Springer Lehrbuch), ISBN:978-3642177026
Teaching and learning forms	• Microbiology lectures, 2 SWS, 2 LP • Microbiology practical, 5 SWS, 8 LP
Workload	**“Microbiology” lectures** Attendance: 30 h Independent study: 30 h **Praktikum** Attendance: 75 h Independent study: 165 h **total** Attendance: 105 h Independent study: 195 h Total: 300 h
Assessment Methods	The summative assessment is a written examination (60 minutes) about the entire module. Only students who have successfully passed the formative assessment “Microbiology practical” (P) (written paper, log) will be allowed to take the assessment.

Grading	The module grade corresponds to the result of the summative assessment.

Molecular Biology	
Credits (ECTS)	8
Attendance	6 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Grammel
Lecturer(s)	Dr. Manuela Kast, Prof. Dr. Grammel
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 2
Prior knowledge	• Contents: Recommendation: Basic knowledge of the genetic processes taking place in the cell • Practical: Recommendation: Knowledge of the cultivation of microorganisms, sterile working methods
Learning outcomes	Students who have successfully completed this module, • know the genetic processes in a cell • can apply the basic methods for the production and handling of genetically modified microorganisms (GMOs) in practice • are familiar with the legal regulations for the proper handling of GMOs • are familiar with the genetic processes in the cell (replication, transcription, translation), mutations and repair of DNA, organisation and regulation • are proficient in the methodical handling of nucleic acids (methods of genetic engineering) • are aware of possible applications of molecular biology in industrial biotechnology (selected examples) • know basic molecular biological techniques for generating genetically modified microorganisms and for the heterologous expression of recombinant proteins • know strategies for cloning experiments • can work together in groups • can write experimental protocols and scientific documents using a laboratory journal
Contents	The following technical content is taught in this module: “Molecular Biology” lectures • Molecular Biology: Definitions, milestones, current status • Structure of nucleic acids: Nucleotides, double helix, DNA rings; cell nucleus, chromatin, nucleosome, chromosomes • Chromatin and chromosomes: Folding structures, mitosis, cell cycle • Replication: Replication fork processes in prokaryotes and eukaryotes • Transcription: Gene structure, promoter structure, transcription factors, elongation, termination • Processing the mRNA: Splicing, editing, capping, poly-adenylation • Translation: Process and elements of translation, ribosomes, palindromes

	• Genetic code, recombination, mutation, repair, polymorphisms, dominant and recessive hereditary traits • Genetic engineering methods, restriction enzymes, vectors, molecular cloning, DNA sequencing, PCR and qRT-PCR • Cell systems for industrial biotechnology: Prokaryotes, yeasts, diatoms, maritime systems • Introduction to stem cell genetics, "Lab-On-A-Chip" "Molecular Biology" practical • Strategies for cloning a gene in *E.coli* • Restriction digestion • Plasmid preparation • PCR and gel electrophoresis • Preparative gel electrophoresis • Transformation and selection • Heterologous protein expression in *E.coli*
Literature	"Molecular Biology" lectures • Molekulare Genetik, Rolf Knippers, Thieme Verlag, Stuttgart, 11. Auflage, Februar 2018 • Molecular Biology of the Gene, Watson, Baker, Bell, Gann, Levine, Losick, Addison Wesley Verlag, 5. Auflage, 2006 • Molecular Biology of the Gene, Watson, Andrew P. Read Wiley-Liss Verlag Molecular Biology practical • Practical notes • Mulhardt, Der Experimentator: Molekularbiologie/Genomics, Spektrum Akademischer Verlag, ISBN-13:978-3827420367
Teaching and learning forms	• Molecular Biology (L), 2 SWS, 2 LP • Molecular Biology practical (P), 4 SWS, 6 LP
Workload	**"Molecular Biology" lectures** Attendance: 30 h Independent study: 30 h **"Molecular Biology" practical** Attendance: 60 h Independent study: 120 h **total** Attendance: 90 h Independent study: 150 h Total: 240 h
Assessment Methods	The summative assessment is a written examination (60 minutes) about the entire module. Only students who have successfully passed the formative assessment for "Molecular Biology practical" (written paper, log) will be allowed to take the assessment.
Grading	The module grade corresponds to the result of the summative assessment.

Biochemistry	
Credits (ECTS)	7
Attendance	6 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Ebert
Lecturer(s)	Prof. Dr. Ebert
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 3
Prior knowledge	• Contents: Recommendation: Basics of chemistry and microbiology
Learning outcomes	Students who have successfully completed this module, • know the action of biomolecules, especially enzymes, and their function in metabolism • are familiar with the pathways of basic metabolism • understand the basic principles of the regulation of metabolism • can practically investigate, analyse and theoretically evaluate protein samples • know the function of biomolecules and metabolism • can handle proteins practically • can investigate enzyme kinetics • can distinguish between the most important types of inhibitors
Contents	The following technical content is taught in this module: "Biochemistry" lectures and tutorials • Enzymes and their function • Bioenergetics, redox reactions in biology • Glycolysis and regulation of carbohydrate metabolism • Biosynthesis of carbohydrates (gluconeognesis), amino acids, lipids and nucleotides • Citrates cycle and its regulation • Electron transport and ATP synthesis Biochemistry practical • Basic mechanical disruption of cells • Enzyme enrichment by ammonium sulphate precipitation • SDS-PAGE • Measurement of enzyme activities and inhibition experiments • Determination of Michaelis-Menten parameters • Photometric enzyme tests for the determination of sugars and other metabolites • HPLC methods in bioanalysis
Literature	"Biochemistry" lectures and tutorials • Lecture notes • Michael Cox, David Nelson; Lehninger Biochemie, 4. Auflage, Springer-Verlag, 2009

	• Stryer Biochemie, Lubert Stryer, Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto, 8. Auflage, 2017, Springer-Verlag • Biochemie, H. Robert Horton und Laurence A. Moran, 4. Auflage, Pearson Studium – Biologie Biochemistry practical • Practical notes • Michael Cox, David Nelson; Lehninger Biochemie, 4. Auflage, Springer-Verlag • Stryer Biochemie, Lubert Stryer, Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto, 8. Auflage, 2017, Springer-Verlag • Biochemie, H. Robert Horton und Laurence A. Moran, 4. Auflage, Pearson Studium – Biologie
Teaching and learning forms	• Biochemistry (L+T), 2 SWS, 2 LP • Biochemistry practical (P), 4 SWS, 5 LP
Workload	**"Biochemistry" lectures and tutorials** Attendance: 30 h Independent study: 30 h **"Biochemistry" practical** Attendance: 60 h Independent study: 90 h **total** Attendance: 90 h Independent study: 120 h Total: 210 h
Assessment Methods	The summative assessment is a written examination (60 minutes) about the entire module. Only students who have successfully passed the formative assessment for "Biochemistry practical" (written paper, log) will be allowed to take the assessment.
Grading	The module grade corresponds to the result of the summative assessment.

Interdisciplinary Competences	
Credits (ECTS)	6
Attendance	6 SWS
Teaching language	Teaching: German (in Semester 3), English (in Semester 4) Assessments: German or English for international students
Duration	2 semesters
Frequency	Yearly
Module coordinator	Prof. Dr. Grammel
Lecturer(s)	Edgar Schiebel, Linda Fish, Prof. Dr. Grammel
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 3+4
Prior knowledge	• Contents: Recommendation: Basic knowledge of MS (Office Word/Powerpoint) and Internet research, use of PC and Internet; school level English
Learning outcomes	Students who have successfully completed this module, • have developed competences that are necessary for highly qualified activities in a wide range of areas in a modern information society • are proficient in the use of various information sources, mainly internet-based databases • can critically evaluate different sources of information • are familiar with presentation techniques and public relations • are familiar with academic work and presentation techniques • can apply presentation techniques in tutorials and their own presentations • are aware of appropriate information resources in the field of industrial biotechnology and are able to apply them • have language skills to understand and express themselves professionally in English in the specialist subject areas
Contents	The following technical content is taught in this module: "Technical English" lectures + tutorials • Writing and understanding scientific texts and documents • Presentation of information (graphics, diagrams, etc.) • General communication situations in everyday working life "Academic Presentation Techniques" lectures and tutorials • Methods of presentation: Planning, personal preparation, media selection and use, body language • Presentation techniques: Presentation structure, visualisation of content, argumentation techniques, dealing with objections (repartee techniques), best practice examples • Academic work: academic quality criteria, source research, source evaluation and selection, citing sources, reading strategies • Academic papers: Forms of academic work, copyright and usage rights, formal structure

	• Short presentation: Introductory presentations • Press releases: Analysis of a press release and presentation of the results by students using a flipchart (group exercise) • Student presentations: Creation of own presentations (10 min) and the accompanying handouts "Information Procurement/Management" lectures + tutorials • Search engines, catalogues, online databases • Original academic literature • Academic publishing practice • Patent research • Molecular biology databases and bioinformatics
Literature	"Technical English" lectures + tutorials • Bauer, Jürgen; English for Technical Purposes • Additional literature references will be provided by the lecturer "Academic Presentation Techniques" lectures and tutorials • 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 "Information Procurement/Management" lectures + tutorials • Topics are updated every semester. Literature references will be provided by the lecturer.
Teaching and learning forms	• Technical English (L+T), 2 SWS, 2 LP • Academic Presentation Techniques (L+T), 2 SWS, 2 LP • Information Procurement/Management (L+T), 2 SWS, 2 LP
Workload	**"Technical English" lectures + tutorials** Attendance: 30 h Independent study: 30 h **"Academic Presentation Techniques" lectures and tutorials** Attendance: 30 h Independent study: 30 h **"Information Procurement/Management" lectures + tutorials** Attendance: 30 h Independent study: 30 h **total** Attendance: 90 h Independent study: 90 h Total: 180 h
Assessment Methods	The summative assessment is a written examination (60 minutes) about the entire module. Only students who have successfully passed the formative assessments for "Academic Presentation Techniques" and "Information

	Procurement/Management" (written papers) will be allowed to take the written assessment.
Grading	The module grade corresponds to the result of the summative assessment.

Organic Chemistry II and Natural Products	
Credits (ECTS)	9
Attendance	8 SWS
Teaching language	Teaching: German (in Semester 3), English (in Semester 4) Assessments: German or English for international students
Duration	2 semesters
Frequency	Yearly
Module coordinator	Prof. Dr. Schips
Lecturer(s)	Prof. Dr. Schips, Prof. Dr. Hädicke
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 3+4
Prior knowledge	• Contents: Recommendation: Analytical and Organic Chemistry I module
Learning outcomes	Students who have successfully completed this module, • are familiar with the most important methods of organic-preparative chemistry in connection with the synthesis of natural substances • can apply basic preparatory operations of organic chemistry in the laboratory • know the most important reaction mechanisms of organic chemistry • are able to process and chemically modify natural substances • know current trends in the biotechnology industry • can explain the concept of biorefineries • can read and interpret current reports from industrial biotechnology
Contents	The following technical content is taught in this module: "Organic Chemistry II and Natural Products" lectures and tutorials • Basic concepts of organic reactions: Reactivity of functional groups according to substance classes, reactions of alkanes, nucleophilic substitution, elimination, addition, electrophilic aromatic substitution, reactions of carbonyl compounds, enolates and enols, selected natural substance classes (carbohydrates, fats and oils, terpenes, alkaloids) "Organic Chemistry II and Natural Products" practical • Classical separation methods in the laboratory (recrystallisation, extraction, suction, distillation) • Characterisation of organic compounds using melting point, refractive index, IR spectra, HPLC and GC separation • Preparative synthetic methods, basic reaction types: substitution, addition, elimination, CH-acid reactions on selected compound classes, creation of a literature study • Organic reactions with renewable raw materials (vegetable oils, cellulose digestion) "Biotechnology Product" lecture

	• Typical biotechnological bulk and fine chemicals • Current reports from industrial biotechnology • Microbial electrochemical systems • Concepts of biorefineries • Material utilisation of CO_2
Literature	"Organic Chemistry II and Natural Products" lectures and tutorials • „Grundlagen der Organischen Chemie" Joachim Buddrus, Walter de Gruyter GmbH (2015), ISBN 978-3-11-030559-3. • „Basisbuch Organische Chemie" Carsten Schmuck, Pearson Verlag (2018), ISBN 978-3-8632-6821-3. • „Organische Reaktionen" Ulrich Lünig, Spektrum (2010), ISBN: 978-8274-2478-5 • „Naturstoffchemie" Peter Nuhn, Hirlitz (2006), ISBN: 978-37-7761363-5 "Organic Chemistry II and Natural Products" practical • „Organikum" 24. Auflage (2015), WILEY-VCH Verlag, ISBN: 978-3-527-33968-6 • „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 (2009), ISBN: 978-3-8274-1981-1. "Biotechnology Product" lecture • Subject-relevant current publications
Teaching and learning forms	• Organic Chemistry II and Natural Products (L), 2 SWS, 2 LP, Semester 4 • Organic Chemistry II and Natural Products practical (P), 4 SWS, 5 LP, Semester 4 • Biotechnological Products (L), 2 SWS, 2 LP, Semester 3
Workload	**"Organic Chemistry and Natural Products" lectures** Attendance: 30 h Independent study: 30 h **"Organic Chemistry and Natural Products" practical** Attendance: 60 h Independent study: 90 h **"Biotechnology Products" lectures** Attendance: 30 h Independent study: 30 h **total** Attendance: 120 h Independent study: 150 h Total: 270 h
Assessment Methods	The summative assessment is a written examination (90 minutes) about the entire module. Only students who have successfully passed the formative assessment for "Organic

	Chemistry and Natural Products practical" (written paper, log) will be allowed to take the assessment.
Grading	The module grade corresponds to the result of the summative assessment.

Technical Microbiology	
Credits (ECTS)	7
Attendance	6 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Grammel
Lecturer(s)	Prof. Dr. Grammel
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 3
Prior knowledge	• Contents: Recommendation: Knowledge of metabolic physiology of prokaryotes and yeasts, Microbiology lecture (Semester 1), Molecular Biology lecture (Semester 2) • Practical: Recommendation: Microbiological and laboratory chemistry techniques
Learning outcomes	Students who have successfully completed this module, • have theoretical and practical knowledge of the technical and biological principles of biotechnological production processes • are familiar with methods of industrial biotechnology based on fermentation processes • are aware of the possible applications of microorganisms for the production of chemical products and energy sources • know the metabolic performance of industrially relevant microorganisms • are aware of the most important expression systems and their areas of application • have theoretical and practical knowledge of the equipment design and operation of bioreactors • can assess the application potential of different microorganisms in biotechnology • have skills in planning, implementing, analysing and evaluating fermentation processes • have practical skills in bioreactor measurement techniques, sampling techniques, process control systems and biochemical analysis methods • can determine relevant process parameters • are able to process, interpret and graphically represent fermentation results
Contents	The following technical content is taught in this module: “Technical Microbiology” lectures • Structure and function of different types of bioreactors • Measurement technology at the bioreactor • Bioprocess engineering basics • Biotechnological conversion of renewable raw materials into chemical products and energy by microorganisms • Production organisms and expression systems • Methods of metabolic engineering, synthetic biology • Application potentials of bacteria • Metabolism of production organisms

	• Optimisation of biotechnological processes “Technical Microbiology” practical • Structure and operation of bioreactors • Aerobic fermentation for the production of proteins • Anaerobic fermentation for the production of biofuels • Sampling techniques • Process control systems • Analysis of substrates and products from fermenter samples • Evaluation and balancing of fermentation processes
Literature	Vorlesung „Technische Mikrobiologie • Antranikian, Garabed (Hrsg.), Angewandte Mikrobiologie, Springer Verlag, 2006 • Sahm, H., Antranikian, G., Stahmann, K.-P., Takors, R. (Hrsg.), Industrielle Mikrobiologie, Springer Spektrum, 2013 “Technical Microbiology” practical • will be provided (practical notes, fermenter manuals)
Teaching and learning forms	• Technical Microbiology (L), 2 SWS, 2 LP • Technical Microbiology practical (P), 4 SWS, 5 LP
Workload	**“Technical Microbiology” lectures** Attendance: 30 h Independent study: 30 h **“Technical Microbiology” practical** Attendance: 60 h Independent study: 90 h **total** Attendance: 90 h Independent study: 120 h Total: 210 h
Assessment Methods	The summative assessment is a written examination (60 minutes) about the entire module. Only students who have successfully passed the formative assessment for “Technical Microbiology practical” (written paper, logs) will be allowed to take the assessment.
Grading	The module grade corresponds to the result of the summative assessment.

Process Engineering	
Credits (ECTS)	11
Attendance	10 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr.techn. Frühwirth
Lecturer(s)	Prof. Dr.techn. Frühwirth, Dr.-Ing. Britta Schwartze
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 3
Prior knowledge	• Contents: Recommendation: Chemical thermodynamics, mass and heat transfer, general chemistry, fundamentals of process engineering
Learning outcomes	Students who have successfully completed this module, • master basic operations on the interface of biotechnology and process engineering, specifically material separation processes with and without chemical reaction • know the basic thermal operations of distillation, adsorption and absorption, extraction and drying • can apply calculation procedures and design methods for the separation operations absorption, distillation, extraction and drying and evaluate equipment designs • are able to apply methods for the quantitative description of the basic operations in the generation, separation, segregation, mixing and handling of dispersed substances • know and can mathematically describe technical applications such as mixing and stirring • can independently work on reaction engineering tasks and correctly interpret kinetics data • can compile reports on reactive systems
Contents	The following technical content is taught in this module: “Process Engineering” lectures and tutorials • Rectification of binary mixtures: continuous and discontinuous rectification, separation stage concept, stage design in the McCabeThiele diagram, limiting conditions of the design, thermal state of the feed flow, apparatus design: Soil columns / packed columns • Absorption: continuous and discontinuous, separation stage concept, sorption mechanisms - physisorption and chemisorption, solvent selection, absorption/desorption, graphical representation - stage design, apparatus design, selection of apparatus according to phase contact, adsorption mechanisms • Extraction: Principle of liquid/liquid extraction, solvent selection, representation of extraction processes in a triangular diagram, 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 high-pressure extraction

	• Drying: Types of drying, properties of humid air: State variables, representation of state changes in the Mollier diagram, dryer design "Mechanical Process Engineering" lectures + tutorials • Particle technology: Representation of quantity distributions: Sum frequency, frequency density, position parameter, separation function, degree of separation, agglomeration • Filtration: Methods, mathematical description of cake filtration, non-idealities in cake filtration, filtration equipment, membrane processes • Deposits: Storage – bunkers, heaps, flow through heaps – fluidised bed, design of fluidised beds • Sedimentation: Forces on individual particles, settling velocity, design of sedimentation apparatus, design of sedimentation equipment • Centrifugation: Settling speed in the centrifugal field, centrifuge design, centrifuge equipment, centrifuge selection • Mixing and stirring, agitator power input, agitator design, mixing time characteristics "Reaction Technology" lectures and tutorials • Reaction kinetics: Reaction rate, reaction order, rate laws – integral method time laws, mechanisms, temperature dependence, pressure dependence • Ideal reactors: isothermal with mass balance, heat balance, DRC, CRC, RR, comparison • Non-isothermal reaction control Adiabatic reaction control Polytropic reaction control • Real reactors (residence time behaviour, dispersion model, cascade model) "Process Engineering" practical • Discontinuous rectification, separation of a binary system • Solid extraction: Extraction of a non-polar component from a renewable raw material using Soxhlet and supercritical CO_2 extraction • Description and technical design of fermenter systems, power input of agitators • Centrifuge design • Reaction technology: Production of a biofuel from residues, pre-treatment of the residue, implementation of the synthesis with recording of the kinetics data, reaction-technical description and evaluation of the process
Literature	"Process Engineering" lectures and tutorials • Thermische Verfahrenstechnik: Grundlagen und Methoden, Mersmann, Kind, Stichlmair, Springer, 2005 "Mechanical Process Engineering" lectures + tutorials

	• Verfahrenstechnik, Hemming, Wagner, Vogel, 2011 "Reaction Technology" lectures and tutorials • Chemische Verfahrenstechnik: Berechnung, Auslegung und Betrieb chemischer Reaktoren, Hertwig, Martens, De Gruyter, 2012 "Process Engineering" practical • Verfahrenstechnik, Hemming, Wagner, Vogel, 2011
Teaching and learning forms	• Thermal Process Engineering (L+T), 2 SWS, 2 LP • Mechanical Process Engineering (L+T), 2 SWS, 2 LP • Reaction Technology (L+T), 2 SWS, 2 LP • Process Engineering Practical (P), 4 SWS, 5 LP
Workload	**"Thermal Process Engineering" lectures and tutorials** Attendance: 30 h Independent study: 30 h **"Mechanical Process Engineering" lectures + tutorials** Attendance: 30 h Independent study: 30 h **"Reaction Technology" lectures + tutorials** Attendance: 30 h Independent study: 30 h **"Process Engineering" practical** Attendance: 60 h Independent study: 90 h **total** Attendance: 150 h Independent study: 180 h Total: 330 h
Assessment Methods	The summative assessment is a written examination (90 minutes) about the entire module. Only students who have successfully passed the formative assessment for "Process Engineering practical" (written paper, log) will be allowed to take the assessment.
Grading	The module grade corresponds to the result of the summative assessment.

Biotechnological Plants	
Credits (ECTS)	10
Attendance	9 SWS
Teaching language	Teaching: English Assessments: German or English for international students
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr.techn. Frühwirth
Lecturer(s)	Prof. Dr.techn. Frühwirth, Dipl. Ing. Grubmüller, Klaus Mensch
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 4
Prior knowledge	• Contents: Recommendation: Process Engineering, Technical Microbiology, Mathematics and Statistics, Process Engineering Practical, Technical Microbiology Practical
Learning outcomes	Students who have successfully completed this module, • can design apparatus in compliance with the AD 2000 calculation regulations • are proficient in the technical and organisational features of plant construction • can use experimental investigations sensibly and incorporate the results into a plant design • are familiar with the basics of electrical engineering such as voltage and current and components such as resistors, capacitors and inductors • can calculate simple circuits with resistors • have basic knowledge of measurement technology for measuring various mechanical variables • are proficient in the fundamentals of control technology • can use theoretically acquired knowledge for selected basic operations • are able to use measurement data obtained in the laboratory to mathematically describe basic operations • are able to experimentally investigate complex biotechnological issues in project-based small groups and incorporate the findings into a plant scale-up
Contents	The following technical content is taught in this module: “Apparatus and Plant Engineering” lectures and tutorials • Phase model for the implementation of processing plants • Contractual aspects of plant engineering • Project documentation • Plant commissioning • Processes: Creation of block flow diagrams for process engineering processes • Balancing: Identification of suitable balance limits, balancing of stationary systems and transient systems with and without chemical reaction • Basics of apparatus engineering: Machine elements, mechanical strength, production engineering • Materials in plant engineering: Classification, properties, mechanical and thermal behaviour of materials

	• Mechanical strength: Tension concept, components under tensile load • Dimensioning of pressure tanks under internal and external overpressure • Dimensioning of tank connections – domed bases under internal overpressure • Drawing simple installation sketches of tank connections and flanges • Fittings, safety devices in apparatus • Seals “Electrical, Measuring, Control and Regulating Technology” lectures and tutorials • Electrical Engineering fundamentals: Ohm's law, circuit laws, node rule, calculation of voltage dividers and simple ohmic networks, electrotechnical components such as resistors, capacitors, inductors, diodes, transistors, operational amplifiers and filters • Digital technology: Difference between analogue and digital signal, logic function, data interpretation, binary arithmetic, sampling theorem, AD/DA converter. • Measurement technology: Basic concepts, measuring electrical variables such as current, voltage, power, frequency and resistance. Measuring non-electrical variables such as temperature, pressure, viscosity, flow, 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 fundamentals of controllers “Process Development/Scale Up” practical • Process development: Independent monitoring of a task from the determination of the topic to the rough design of an industrial plant • Experimental development of biotechnological processes: Project plan, laboratory protocol, results • Preparation of project documentation Block flow diagram, material flow table • Technology mapping • Prospects for industrial implementation
Literature	“Apparatus and Plant Engineering” lectures and tutorials • AD 2000 Regelwerk TÜV “Electrical, Measuring, Control and Regulating Technology” lectures and tutorials • Taschenbuch der Messtechnik Hoffmann Carl Hanser Verlag, 2015 “Process Development/Scale Up” practical

	• Erikson, Johansson, Design of Experiments, Umetrics 2008. Schwister, Lewen, Verfahrenstechnik für Ingenieure, Hanser, 2019
Teaching and learning forms	• Apparatus and Plant Engineering (L+T), 3 SWS, 3 LP • Electrical, Measuring, Control and Regulating Technology (L+T), 2 SWS, 2 LP • Process Development/Scale Up (P), 4 SWS, 5 LP
Workload	**"Apparatus and Plant Engineering" lectures and tutorials** Attendance: 45 h Independent study: 45 h **"Electrical, Measuring, Control and Regulating Technology" lectures and tutorials** Attendance: 30 h Independent study: 30 h **"Process Development/Scale Up" practical** Attendance: 60 h Independent study: 90 h **total** Attendance: 135 h Independent study: 165 h Total: 300 h
Assessment Methods	The summative assessment is a written examination (90 minutes) about the entire module. Only students who have successfully passed the formative assessment for "Process Development/Scale Up practical" (written paper, presentation) will be allowed to take the assessment.
Grading	The module grade corresponds to the result of the summative assessment.

Bioprocess Technology	
Credits (ECTS)	7
Attendance	7 SWS
Teaching language	Teaching: English Assessments: German or English for international students
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Ebert
Lecturer(s)	Prof. Dr. Ebert
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 4
Prior knowledge	• Contents: Recommendation: Technical Microbiology, Biochemistry
Learning outcomes	Students who have successfully completed this module, • are familiar with biological processes for substance production with microorganisms in bioreactors • are able to perform a fed-batch fermentation on a 20 L scale, as well as the product processing and analysis, and to evaluate and assess the process • are proficient in basic aspects of statistical experimental design
Contents	The following technical content is taught in this module: “Bioprocess Technology” lectures • Economic efficiency of bioprocesses considering different aspects of production • Media components and media composition, media development • Growth kinetics and growth models (Monod model and logistic growth) • Balancing bioprocesses • Derivation of bioprocess models (batch, fed-batch, continuous processes with and without cell retention) • Cleaning and sterilisation processes • Transport processes in bio-suspensions • Introduction to statistical experimental design (full factorial and partial factorial experimental designs, data evaluation, introduction to MODDE software) “Bioprocess Technology” practical • Reactor preparation, sterilisation, production of media and buffers • Process control and balancing of an *E. coli* process on a 30 L scale • Process control in fed-batch mode for cultivation of *Cupriavidus necator* and production of polyhydroxybutyric acid • Process monitoring and analytics online and offline (substrates and metabolites) • Optimisation of the processing of biopolymers (here: polyhydroxybutyric acid) using statistical experimental design and aspects of scale-up to production scale.

	• Gas chromatographic analysis of the product including derivatisation • Evaluation of the specific process parameters in the bioreactor • Determination of the yields of the overall process
Literature	"Bioprocess Technology" lectures • Lecture notes • Chmiel, Horst; Bioprozesstechnik, Spektrum-Verlag, 3. Auflage • Storhas, Winfried; Bioverfahrensentwicklung; Wiley-VCH, 2. Auflage • Villadsen, John; Fundamental Bioengineering; Wiley-VCH, 1. Auflage • Hu, Wei-Shou; Engineering Principles in Biotechnology; Wiley, 1. Auflage "Bioprocess Technology" practical • Practical notes • Chmiel, Horst; Bioprozesstechnik, Spektrum-Verlag, 3. Auflage • Steinbüchel, Oppermann-Sanio, Ewering, Pötter; Mikrobiologisches Praktikum, Springer Spektrum-Verlag, 2. Auflage
Teaching and learning forms	• Bioprocess Technology (L), 2 SWS, 2 LP • Bioprocess Technology practical (P), 5 SWS, 5 LP
Workload	**"Bioprocess Technology" lectures** Attendance: 30 h Independent study: 30 h **"Bioprocess Technology" practical** Attendance: 75 h Independent study: 75 h **total** Attendance: 105 h Independent study: 105 h Total: 210 h
Assessment Methods	The summative assessment is a written examination (60 minutes) about the entire module. Only students who have successfully passed the formative assessment for "Bioprocess Technology practical" (P) (written paper, presentation) will be allowed to take the assessment.
Grading	The module grade corresponds to the result of the summative assessment.

New Technologies	
Credits (ECTS)	10
Attendance	7 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Ebert
Lecturer(s)	Prof. Dr. Ebert, Prof. Dr. Frühwirth, Prof. Dr. Grammel, Prof. Dr. Schips, Prof. Dr. Hädicke
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 5
Prior knowledge	• Contents: Recommendation: Selected articles on relevant topics of current industrial production; Bioprocess Technology; Biotechnological Plants; Technical Microbiology; Project Excursions I
Learning outcomes	Students who have successfully completed this module, • are familiar with current processes and research areas in biotechnology • are able to work on current topics scientifically • are familiar with current topics in biotechnology • are able to work with scientific literature (review and primary articles) • Written and oral presentation techniques • are proficient in practical work on current topics in biotechnological research and development • have an advanced insight into industrial biotechnology through visits to industrial biotechnology companies • have knowledge of industrial biotechnology processes
Contents	The following technical content is taught in this module: “New Technology in Bioprocesses” seminar • Selected topics on new techniques in bioprocesses • Topical primary articles are researched (state of the art) • This literature is summarised, elaborated and explained in an oral and written presentation • Handouts are prepared for the presentation. “New Bioprocesses” practical • Communicating academic work • Planning experiments and smaller projects • Independent academic work • Practical use of laboratory equipment depending on the field of application • Recording of experimental data and presentation to a scientific audience “Project Excursions II” excursion • Deeper insight into current biotechnological processes • Excursions to various companies in industrial biotechnology • Work areas of the companies to be visited
Literature	“New Technology in Bioprocesses” seminar

	• Selected articles on relevant topics of industrial biotechnological processes and practical skills "New Bioprocesses" practical • Current publications on relevant topics • Textbooks for the relevant courses "Project Excursions II" excursion • 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 • Online information about companies
Teaching and learning forms	• New Technology in Bioprocesses (S), 2 SWS, 2 LP • New Bioprocesses practical (P), 3 SWS, 6 LP • Project Excursions II (Ex.), 2 SWS, 2 LP
Workload	**"New Technology in Bioprocesses" seminar** Attendance: 30 h Independent study: 30 h **"New Bioprocesses" practical** Attendance: 45 h Independent study: 135 h **Excursion "Project Excursions II"** Attendance: 30 h Independent study: 30 h **total** Attendance: 105 h Independent study: 195 h Total: 300 h
Assessment Methods	The summative assessment is a combination of the practical laboratory grade (single grade) and the presentation and written paper for the seminar (double grade). There is a written task and poster presentation of the theoretically and practically researched topic as a formative assessment. The module is only graded after the formative assessment has been passed.
Grading	The module grade corresponds to the result of the summative assessment.

Enzymes and Proteins	
Credits (ECTS)	6
Attendance	6 SWS
Teaching language	Teaching: English (in Semester 4), German (in Semester 5) Assessments: German or English for international students
Duration	2 semesters
Frequency	Yearly
Module coordinator	Prof. Dr. Ebert
Lecturer(s)	Prof. Dr. Ebert, Dr. Manuela Kast
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 4 and 5
Prior knowledge	• Biochemistry
Learning outcomes	Students who have successfully completed this module, • know the structure of proteins and the influence of certain amino acids on the secondary structure • know methods for engineering enzymes (e.g. directed evolution, CASTing) • understand the most important cofactors and reaction types and mechanisms in which they are involved • are proficient in the evaluation of enzyme kinetics using various methods • know the different types of inhibitors and can describe them mathematically • are familiar with cooperativity and allostery in enzyme-catalysed reactions • have mastered the Hill equation
Contents	The following technical content is taught in this module: "Protein Chemistry" lecture • 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 chains, polarity of the side chains, chemical differentiation • Structural systems in proteins (helix, leaflet, inflection kink, domains), X-ray structure analysis, interaction between protein side chains • Non-protein structural components (glycosylation, phosphate groups, N-terminal acyl residues) • Enzyme screening and protein engineering (rational design, directed evolution, saturation mutagenesis (CAST, B-Fit) • Co-enzymes and reaction mechanisms "Enzyme Kinetics" lecture • Fundamentals of chemical kinetics • Enzyme-substrate complex and Michaelis-Menten equation (partially reversible, irreversible, reversible) as well as different plots for evaluation • Reversible inhibition and activation, competing substrates • Irreversible inhibitors

	• Reactions with multiple substrates • Temperature and pH effects • Regulation of enzyme activities • Allostery and cooperativity • Hill equation “Industrial Enzymes” seminar • Current topics in industrial biotechnology around enzymes
Literature	“Protein Chemistry” lecture • 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 Vorlesung “Enzymkinetik” • Athel Cornish-Bowden "Fundamentals of Enzyme Kinetics" Wiley-Blackwell
Teaching and learning forms	• Protein Chemistry (L), Semester 4, 2 SWS, 2 LP • Enzyme Kinetics (L), Semester 5, 2 SWS, 2 LP • Industrial Enzymes (S), Semester 4, 2 SWS, 2 LP
Workload	**“Protein Chemistry” lecture** Attendance: 30 h Independent study: 30 h **“Enzyme Kinetics” lecture** Attendance: 30 h Independent study: 30 h **“Industrial Enzymes” seminar** Attendance: 30 h Independent study: 30 h **total** Attendance: 90 h Independent study: 90 h Total: 180 h
Assessment Methods	The summative assessment is a written examination (60 minutes) about the entire module. Only students who have successfully passed the formative assessment for “Industrial Enzymes” (S) (written paper, presentation) will be allowed to take the assessment.
Grading	The module grade corresponds to the result of the summative assessment.

Product Isolation	
Credits (ECTS)	8
Attendance	6 SWS
Teaching language	Teaching: English (in Semester 4), German (in Semester 5) Assessments: German or English for international students
Duration	2 semesters
Frequency	Yearly
Module coordinator	Prof. Dr. Ebert
Lecturer(s)	Prof. Dr. Ebert
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 4 and 5
Prior knowledge	• Biochemistry
Learning outcomes	Students who have successfully completed this module, • understand the important principles and methods of protein purification on a laboratory and process scale • are able to practically prepare and characterise biomolecules • can carry out precipitation processes, protein crystallisation, chromatography and tangential flow filtration in practice • can characterise biomolecules by measuring enzyme activities • can determine the purity of protein solutions
Contents	The following technical content is taught in this module: “Product Isolation” lecture • Introduction to the preparation of biomolecules • Methods of cell disruption • Fundamentals of chromatography • Chromatographic separation methods for separating biomolecules (ion exchanger, hydrophobic interaction, mixed mode, affinity, reversed phase and size exclusion) • Process design for production scale • Radial and continuous chromatography • Precipitation and crystallisation • Filtration process • Two-phase systems for separating biomolecules “Product Isolation” practical • Cell disruption with ultrasound probe and high-pressure homogeniser • Determination of binding conditions of a protein using statistical design of experiments (DOE) on different ion exchange resins under various conditions on a 96-well scale (“resin screening”) • Chromatography for enzyme enrichment on a laboratory scale Affinity and ion exchange chromatography • Determination of enzyme activities, protein analysis using SDS-PAGE, Western Plot, total protein content determination

	• Crystallisation of a protein • Tangential flow filtration
Literature	"Protein Processing" lectures • Lecture notes "Enzyme Technology" practical • Lecture notes
Teaching and learning forms	• Product Isolation (L), Semester 4, 2 SWS, 2 LP • Product Isolation Practical (P), Semester 5, 4 SWS, 6 LP
Workload	**"Protein Processing" lecture** Attendance: 30 h Independent study: 30 h **"Enzyme Technology" practical** Attendance: 60 h Independent study: 120 h **total** Attendance: 90 h Independent study: 150 h Total: 240 h
Assessment Methods	The summative assessment is a written examination (60 minutes) about the entire module. Only students who have successfully passed the formative assessment "Product Isolation practical" (P) (written paper, log) will be allowed to take the assessment.
Grading	The module grade corresponds to the result of the summative assessment.

Biocatalysis	
Credits (ECTS)	10
Attendance	8 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Schips
Lecturer(s)	Prof. Dr. Schips
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 5
Prior knowledge	• Contents: Organic chemistry, biochemistry, molecular biology, microbiology, technical microbiology • Practical: Organic-chemical practical, biochemical practical
Learning outcomes	Students who have successfully completed this module, • know the application of enzymes and whole cells as biocatalysts in practice • can carry out asymmetric syntheses with natural substances in different reaction media • know the advantages of immobilisation for technical application • have an overview of biocatalysts currently used in industry • acquire an overview of important bioorganic reactions • know the function and principles of enzymes as biocatalysts for organic reactions and the advantages and disadvantages of their technical application • acquire an overview of the most important enzyme classes (hydrolases, oxidoreductases, transferases, isomerases) in bioorganic synthesis • learn the requirements for kinetic racemate cleavages and de-symmetrisation reactions • learn by example about the importance of chiral synthons in the pharmaceutical and agrochemical industries • learn basic methods of immobilisation • can work practically with enzymes and whole cells as biocatalysts for chemical reactions • can work with different reaction conditions, such as in aqueous or organic media • know the phase mediation of substrates, immobilisation techniques, production of asymmetric products using racemate cleavage and de-symmetrisation (meso-trick), stereospecific syntheses with natural products without protective groups, polymerisation • know the most important fine and bulk chemicals produced using biotechnological processes • are familiar with the use of renewable raw materials for the sustainable production of recyclable materials and energy and the relation to current products • are aware of the advantages and disadvantages as well as the life cycle assessment of products, from examples • are familiar with the use, production and analysis of industrial enzymes

	• can work with scientific literature (review and primary articles) • demonstrate proficiency in written and oral presentation techniques
Contents	The following technical content is taught in this module: "Biocatlysis" lecture • Structure and function of biocatalysts, basic concepts of biocatalysis, application of whole cells or enzymes, reactions of enzyme classes with catalytic mechanisms (hydrolases, oxidoreductases, transferases, lyases, ligases, isomerases), racemate cleavage, meso-trick, drug precursors, Kazlauskas rule, Prelog rule, solubilisation of substrates, application of selected enzymes (lipases, esterases, nitrile hydratases, dehalogenases, chlorine peroxidase), whole-cell biotransformations with yeast cells • Application examples (chipros, HFC syrup, beta blocker propranolol) from industry • Technical application of enzymes through immobilisation of the enzymes. • All common methods of immobilisation • Use of fossil and renewable raw materials: Raw material transformation, value chains, platform chemicals, biorefinery concept • Technical biopolymers: Explanation of terms, structure and composition, manufacturing process, possible applications, PLA, strength, PHA, monomer building blocks from renewable raw materials • Important intermediate products: Vitamins, phytopharmaceuticals, pharmaceuticals, cosmetics, microbiologically produced alcohols, organic acids and vitamins • Life cycle assessment of products, e-factor, sustainability and bioeconomy, market trends. "Biocatalysis" practical • Working with esterases, lipases, isomerases, oxidoreductases and cofactor regeneration, asymmetric synthesis (racemate cleavage, meso-trick), immobilisation methods with whole cells and enzymes, reactions involving natural substances without protective groups, polymerisation reactions • Reaction tracking using pH and DC, determination of ee-values with chiral GC separation • Purity determination using polarimetry, characterisation with ATR-IR
Literature	"Biocatlysis" lecture • Bioorganikum - Praktikum der Biokatalyse" Günter E. Jeromin, M. Bertau; Wiley VCH Verlag (2005)

	• Biotransformations in Organic Chemistry" Kurt Farber; Springer-Verlag (2011). • Einführung in die Technische Chemie“ Arno Behr, Spektrum Akademischer Verlag (2016), ISBN: 978-3-662-52855-6. • „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 Verlag (2007), ISBN: 978-3-527-31788-2. “Biocatalysis” practical • Bioorganikum“ Günter E. Jeromin, WILEY-VCH Verlag (2005), ISBN: 978-3-527-31245-0.
Teaching and learning forms	• Biocatalysis (L), Semester 4, 2 SWS, 2 LP • Biocatalysis Practical (P), Semester 5, 6 SWS, 8 LP
Workload	**Biocatalysis lecture** Attendance: 30 h Independent study: 30 h **Biocatalysis practical** Attendance: 90 h Independent study: 150 h **total** Attendance: 120 h Independent study: 180 h Total: 300 h
Assessment Methods	The summative assessment is a written examination (90 minutes) about the entire module. Only students who have successfully passed the formative assessment “Biocatalysis practical” (P) will be allowed to take the assessment.
Grading	The module grade corresponds to the result of the summative assessment.

Studium Generale	
Credits (ECTS)	2
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	over 5 semesters
Frequency	Yearly
Module coordinator	Prof. Dr. Frühwirth
Lecturer(s)	Various
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 1 - 5
Prior knowledge	• Compare the subject-specific examination regulations for the corresponding degree programme in the current or selected version at the time of starting the degree programme.
Learning outcomes	Students who have successfully completed this module have acquired knowledge from a wide range of fields and have had the opportunity to explore topics that are not directly related to their chosen degree programme. Within Studium Generale, students have the opportunity to further their studies through various foreign language courses, lecture series or workshops on areas including culture, communication and economics.
Contents	The following technical content is taught in this module: Various courses
Literature	none
Teaching and learning forms	• Studium Generale (S), 2 SWS, 2 LP
Workload	**Studium Generale** Attendance: 30 h Independent study: 30 h **total** Attendance: 30 h Independent study: 30 h Total: 60 h
Assessment Methods	The summative assessment is a written paper or an oral examination. All students are required to acquire 2 LP by taking part in the interdisciplinary programme offered by Biberach University of Applied Sciences (Studium Generale) and must do so by the fifth semester of study.
Grading	The module grade corresponds to the result of the summative assessment.

Practical semester of study	
Credits (ECTS)	30
Attendance	Industrial placement with at least 95 attendance days + 4 SWS for accompanying seminar
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Schips
Lecturer(s)	Various experts
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 6
Prior knowledge	• Contents: Modules up to and including Semester 5 (recommendation)
Learning outcomes	Students who have successfully completed this module, • have practical experience in an industrial company or a research institution in the field of biotechnology • can apply acquired knowledge in practical use cases • have insights into the company's working methods and social structure • have key communicative and social skills from working with superiors and team members • can evaluate and summarise methodological processes in scientific logs and reports • are prepared for professional life • know the general conditions of the practical semester from briefing sessions • are prepared for induction in an industrial company or a research institution with a biotechnological focus • can summarise and evaluate their experiences and results of practical activities and present them in front of a professional audience "Accompanying Course" seminar • have practical experience in an industrial company or a research institution in the field of biotechnology • have insights into the company's working methods and social structure • are familiar with research and development methods • are experienced in process and operational tasks as well as industrial production equipment • have key communicative and social skills from working with superiors and team members
Contents	The following technical content is taught in this module: Industry placement (min. 95 attendance days) • Introduction to the framework conditions and the organisation of the practical semester • Evaluation and presentation of the methods learned, working practices, working conditions, operational tasks • Research or development tasks in industrial production facilities

	Course accompanying the practical semester • Job-related activities in a biotechnological industrial company, working on subject-related, sometimes scientific, topics under supervision • Practical industrial experience in manufacturing companies and research institutions • Students are required to fill out a progress sheet demonstrating that they have attended.
Literature	• Subject-dependent
Teaching and learning forms	• Industry placement (P), min. 95 attendance days, 25 LP • Practical Viva, 1 SWS, 1 LP • Course Accompanying the Practical Semester (S), 4 SWS, 4 LP
Workload	**Industry Placement** Min. 95 attendance days Attendance: 740 h Independent study: 10 h **Viva for practical** Attendance: 15 h Independent study: 15 h **Course accompanying the practical semester** Attendance: 60 h Independent study: 60 h **total** Attendance: 815 h Independent study: 85 h Total: 900 h
Assessment Methods	The summative assessment is a written paper with viva (report on industry placement).
Grading	The module grade corresponds to the result of the written paper (report on industry placement).

Business Administration and Management	
Credits (ECTS)	6
Attendance	4 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Hädicke
Lecturer(s)	Herr Lozanovski, Herr Roth
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: School knowledge at Secondary Level II
Learning outcomes	Students who have successfully completed this module, • have a good command of the basics of selected sub-areas of business administration • are familiar with the necessity, prerequisites and instruments that are essential for economic corporate management aimed at maximising benefits/profits • obtain insight into an ecological approach to product development and are proficient in methods of life cycle assessment and analysis • can assess the sustainability of a product in order to be able to practice bioeconomics • can structure the life cycle phases through which a technical product passes (from the product idea and development to production, actual use and recycling) in accordance with the guiding principle of sustainable development in light of the current economic and ecological challenges • can understand basic economic relationships • are familiar with some fundamental figures of corporate management. This is followed by additional questions on the constitutional and institutional framework conditions of a business, i.e. the students know what needs to be considered when founding a business in terms of legal structure, organisation and choice of location • know the criteria according to which an investment decision should be made • know what options there are for raising capital
Contents	The following technical content is taught in this module: “Life Cycle Assessment” lectures + tutorials • Basics of life cycle assessment (methodology and practice) • Environmental impacts in the product life cycle, ecological hotspots and optimisation potentials • Problem shifting • Steps of a life cycle assessment according to ISO 14040/44 • Learning to carry out a life cycle assessment • Learning to critically evaluate other life cycle assessment studies • Use of diverse examples, including from the automotive sector, especially for electromobility

	• Introduction to the topics of Environmental Product Declarations (EPDs), Product Environmental Footprint Category Rules (PEFCRs) and Organisation Environmental Footprint Sector Rules (OEFSRs) • The tutorial includes software training (software and database system GaBi) and implementation of a life cycle assessment. "Fundamentals of Business Administration" lectures and tutorials • Business administration in a scientific system, explanation of terms (economy, business, economic systems), legal forms (sole proprietorships, partnerships, corporations) • Location factors • Organisational structure: Single and multi-line systems. Functional organisation, divisional organisation, matrix organisation • Areas and functions of procurement, optimal order quantity • Problems and tasks of production management, models of production management • Investment concepts, investment as a decision-making problem, objectives and possible investor actions • Investment appraisal methods (static and dynamic methods) • Financing concept, types of financing (classification according to the origin of capital and the position of the capital providers), debt financing through credit financing
Literature	"Life Cycle Assessment" lectures + tutorials • Klöpffer, Walter; Grahl, 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. • European Commission - Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. First edition March 2010. EUR 24708 EN. Luxembourg. Publications Office of the European Union; 2010, ISBN 978-92-79-19092-6 "Fundamentals of Business Administration" lectures and tutorials • 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

Teaching and learning forms	• Life Cycle Assessment (L+T), 2 SWS, 3 LP • Fundamentals of Business Administration (L+T), 2 SWS, 3 LP
Workload	**Life Cycle Assessment lectures + tutorials** Attendance: 30 h Independent study: 60 h **Fundamentals of Business Administration lectures and tutorials** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written examination (60 minutes) about the entire module.
Grading	The module grade corresponds to the result of the summative assessment.

Biofuels elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr.techn. Frühwirth
Lecturer(s)	Prof. Dr.techn. Frühwirth
Introduction to the programme	Industrial Biotechnology BSc, elective module, Semester 7
Prior knowledge	• Contents: Process engineering, plant and apparatus engineering
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "Biofuels" seminar • can assess first and second generation biofuels ecologically and economically • are able to technically classify processes for the production of biofuels
Contents	The following technical content is taught in this elective: "Biofuels" seminar • Renewable energies • Biomass potential, raw material base • Framework conditions for the use of biofuels • Currently used biofuels: Bioethanol, biodiesel, biogas, biogenic hydrogen • Innovative biofuels: Butanol, DME, cellulose ethanol
Literature	• Bühler, Biokraftstoffe, Reihe Nachhaltigkeit, selection of scientific publications
Teaching and learning forms	• Biofuels (S), 2 SWS, 3 LP
Workload	**Biofuels seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written paper.
Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the available courses** (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester

Phototrophic Biotechnology elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Frühwirth
Lecturer(s)	Prof. Dr. Grammel
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: none
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "Phototrophic Biotechnology" seminar • are familiar with the diverse metabolic processes of photosynthetic bacteria and microalgae • are familiar with cultivation procedures in photobioreactors. • know the possible applications in biotechnology • are able to evaluate the application potentials of phototrophic microorganisms in terms of energetic, economic and ecological aspects • know the corporate environment nationally and internationally
Contents	The following technical content is taught in this elective: • Physiological and ecological basics • Model organisms for the development of biotechnological processes • Cultivation methods, photobioreactors, process control • Examples of applications of photosynthetic bacteria and microalgae for production processes in industrial and pharmaceutical biotechnology as well as in environmental biotechnology • Economic and scientific environment • Companies with activities in the field of photo-biotechnology
Literature	• Literature references will be handed out by the lecturer
Teaching and learning forms	• Phototrophic Biotechnology (S), 2 SWS, 3 LP
Workload	**"Phototrophic Biotechnology" seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written paper.

Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the available courses** (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester

Advanced Process Engineering elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. techn. Heike Frühwirth
Lecturer(s)	Prof. Dr. techn. Heike Frühwirth
Introduction to the programme	Industrial Biotechnology BSc, elective module, Semester 7
Prior knowledge	• Contents: Fundamentals of process engineering
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "Advanced Process Engineering" seminar • are familiar with the most important theories, principles and methods of process development • are proficient in the basic principles of plant design through to sensitivity studies and process tracking of existing plants • are able to assess the limitations of different methods and models
Contents	The following technical content is taught in this elective: "Advanced Process Engineering" seminar • Calculation methods for selected basic process engineering operations • Hybrid processes • Methods of process development • Comparison and technological assessment of industrial processes
Teaching and learning forms	• Advanced Process Engineering (S), 2 SWS, 3 LP
Workload	**"Advanced Process Engineering" seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written paper.
Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the available courses** (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester

Synthetic Biology elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Frühwirth
Lecturer(s)	Prof. Dr. Grammel
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: none
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "Synthetic Biology" seminar • can assess the significance of synthetic biology for the future development of biotechnology • are familiar with the methods and procedures of synthetic biology • are able to assess the potential of synthetic biotechnology for industrial biotechnology, pharmaceuticals, medicine and the environment • can critically evaluate the possible risks and ethical aspects
Contents	The following technical content is taught in this elective: "Synthetic Biology" seminar • Definitions of terms, differentiation from metabolic engineering, systems biology • Methods (modelling, genetic engineering) and concepts • Implementation in industry, involved companies and research institutions • Legal and ethical aspects • iGEM competition • Model organisms. Cells as a "chassis" • Synthetic biology as a future technology in industrial biotechnology • Application in industrial biotechnology • Application in pharmaceutical biotechnology and medicine • Application 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. Will be issued in the seminar
Teaching and learning forms	• Synthetic Biology (S), 2 SWS, 3 LP
Workload	**Synthetic Biology seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written paper.
Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the available courses** (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester

Biomaterials elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Frühwirth
Lecturer(s)	Prof. Dr. Schips
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: none
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "Biomaterials" seminar • know the properties and fields of application of biomaterials in medical technology, especially biopolymers • learn about biotechnological processes to produce and modify biomaterials • learn an overview of the application of biomaterials in medical technology
Contents	The following technical content is taught in this elective: • Application of materials in medical technology • Immune response to foreign bodies (foreign body reaction) and biocompatibility • Interaction of cells with materials • Biomaterials, implant materials and their application
Literature	• Joon Park; Biomaterials: An Introduction; Springer Verlag, ISBN 978-1-4419-2281-6 • J.S. Temenoff, A.G. Mikos; Biomaterials; Person Verlag, 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 Verlag GmbH & Co. KGaA, ISBN 3-527-30497-5
Teaching and learning forms	• Biomaterials (S), 2 SWS, 3 LP
Workload	**"Biomaterials" seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment in each case is a written paper.

Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the available courses** (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester.

Environmental Biotechnology elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Frühwirth
Lecturer(s)	Prof. Dr. Grammel
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: none
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "Environmental Biotechnology" seminar • are able to apply biological degradation and conversion processes in technical processes for the removal of pollutants • have strategies for the complete and environmentally friendly removal of pollutants • can apply these processes in practice in environmental biotechnological applications ranging from groundwater and soil decontamination to exhaust air purification, metal recycling and ecosystem rehabilitation
Contents	The following technical content is taught in this elective: "Environmental Biotechnology" seminar • Mechanisms of the biodegradation of pollutants • Soil decontamination • Biological waste water treatment • Aerobic membrane processes • Organic residues: Composting, fermentation • Exhaust gases: Biofilter, bioscrubber • Biohydrometallurgy • Rehabilitationof ecosystems
Literature	• Grundlagen, Anwendungen und Perspektiven, Thomas Raphael, Springer Verlag
Teaching and learning forms	• Environmental Biotechnology (S), 2 SWS, 3 LP
Workload	**Environmental Biotechnology seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written paper.
Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the**

	available courses (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester

GMP, GLP elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Schips
Lecturer(s)	Prof. Dr. Ebert
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: none
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "GMP (Good Manufacturing Practice), GLP (Good Laboratory Practice)" seminar • are familiar with the contents of "Good Laboratory Practice (GLP)" and "Good Manufacturing Practice (GMP)" quality assurance systems • can also understand basic quality assurance terms such as qualification, validation, risk assessment, etc.
Contents	The following technical content is taught in this elective: "GMP, GLP" seminar • What does quality mean? • Consequences of poor quality • Quality management and quality assurance • Levels of qualification with examples • Process of a validation using the example of analytical methods • Operating instructions and manufacturing instructions • Limitations of GMP/GLP • Monitoring authorities, state / federal government • EC Guide to Good Manufacturing Practice • Cleanroom zones with separation of airlocks, quality control, production, storage and examples of cleanroom installations • Classification and objectives of cleanroom zones • Seminar work on articles from journals and specialist books such as EC Guide to Good Manufacturing Practice, etc.
Literature	• Lecture notes • ICH guidelines • EU GMP guidelines
Teaching and learning forms	• GMP, GLP (S), 2 SWS, 3 LP
Workload	**"GMP, GLP" seminar** Attendance: 30 h Independent study: 60 h

	total Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written paper.
Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the available courses** (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester.

Industrial Waste elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Frühwirth
Lecturer(s)	Prof. Dr. Traub-Eberhard
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: none
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "Industrial Waste" seminar • have an overview of the effect and distribution of the most important classes of pollutants in industrial waste • are able to assess corresponding hazard potentials and develop targeted strategies to eliminate pollutants
Contents	The following technical content is taught in this elective: "Industrial Waste" seminar • Overview of important pollutant classes in industrial waste • Impact of pollutants (ecotoxicology, human toxicology) • Behaviourof pollutants in water, soil, air
Literature	"Industrial Waste" seminar • Friedhelm Korte (Hrsg.): Lehrbuch der ökologischen Chemie: Grundlagen und Konzepte für die ökologische Beurteilung von Chemikalien; Stuttgart, New York: Thieme, (zuletzt) 2001
Teaching and learning forms	• Industrial Waste (S), 2 SWS, 3 LP
Workload	**"Industrial Waste" seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written paper.
Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the available courses** (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester.

Advanced Biocatalysis elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Frühwirth
Lecturer(s)	Prof. Dr. Schips
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: none
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "Advanced Biocatalysis" seminar • are able to assess technical biocatalysis processes and relate them to other processes • know current developments and research topics in the field of biocatalysis • have an advanced understanding of the application of isolated enzymes and whole-cell systems in technical systems
Contents	The following technical content is taught in this elective: "Advanced Biocatalysis" seminar • Extraction and production of enzymes on a technical scale • Reactors for biocatalysis & biotransformations • Industrial applications of different enzyme classes • Current trends and research projects in the field 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 • Research current primary literature from journals
Teaching and learning forms	• Advanced Biocatalysis (S), 2 SWS, 3 LP
Workload	**Advanced Biocatalysis seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written paper.
Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the**

	available courses (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester.

Pharmaceutical Biotechnology elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Schips
Lecturer(s)	Prof. Dr. Ebert
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: none
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "Pharmaceutical Biotechnology" seminar • know important biopharmaceutical active substances • know the fundamentals of a pharmaceutical manufacturing process • are familiar with the most important aspects of GMP/GLP
Contents	The following technical content is taught in this elective: "Pharmaceutical Biotechnology" seminar • Biopharmaceutical active substances • Cell line development • Cell culture processes (upstream processing) • Protein purification (downstream processing) • Production of a biopharmaceutical active substance (e.g. monoclonal antibody) • Clinical phases and market approval
Literature	• Lecture notes, current publications., • Uwe Gottschalk (Hrsg.), Process Scale Purification of Antibodies, Wiley-Verlag
Teaching and learning forms	• Pharmaceutical Biotechnology (S), 2 SWS, 3 LP
Workload	**Pharmaceutical Biotechnology seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written paper.
Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the available courses** (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester.

International Excursion elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Schips
Lecturer(s)	Prof. Dr. Hädicke
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: none
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "International Excursion" seminar • are familiar with companies abroad • have knowledge about different corporate cultures in other countries • know about products and production processes of the visited companies
Contents	The following technical content is taught in this elective: "International Excursion" seminar • Visit various biotechnology companies abroad • Tour the companies • Acquire background knowledge about the companies and their products
Literature	• Information about the companies visited
Teaching and learning forms	• International Excursions (Ex.), 2 SWS, 3 LP
Workload	**International Excursions seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written paper.
Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the available courses** (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester.

New Developments in Biotechnology elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Frühwirth
Lecturer(s)	N.N.
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: none
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "New Developments in Biotechnology" seminar • are able to understand and interpret the latest biotechnological processes • have an overview of current developments in industrial biotechnology • can implement current research concepts in practice
Contents	The following technical content is taught in this elective: "New Developments in Biotechnology" seminar • Automated development of new production organisms • Miniaturisation of biochemical analytics, especially in systems biology "omics" methods • Microcultivation systems with laboratory robotics • Modularisation of biological systems
Literature	• Current specialist publications
Teaching and learning forms	• New Developments in Biotechnology (S), 2 SWS, 3 LP
Workload	**New Developments in Biotechnology seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written paper.
Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the available courses** (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester

Business Start-up elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Every semester
Module coordinator	Prof. Dr. Frühwirth
Lecturer(s)	Prof. Dr. Cornelia Gretz
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: none
Learning outcomes	Students who have completed this elective: • Obtained insights into entrepreneurial thinking and action • Developed ideas and translated them into a business concept • Learned about and applied different design thinking methods to drive the generation of ideas • Developed a prototype • Verified and validated their business concept with customers • Presented their developed concept with a pitch and a business plan
Contents	The following technical content is taught in this elective: • develop an idea outline, • turn this abstract idea into a business model • pitch this business model • work interdisciplinarily in a team, in a self-organised and creative way • apply basic economic knowledge • evaluate the opportunities and challenges of setting up a business
Literature	• Lecture notes, current publications • Blank/Dorf: „Das Handbuch für Start-Ups“ • Osterwalder: „Business Model Generation“ • Fitzpatrick: „Mom-Test“
Teaching and learning forms	Attendance, independent group work, creative working, 2 SWS, 3 LP
Workload	**Business Start-up seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h
Assessment Methods	Performance is assessed through a team presentation and a written paper.
Grading	The final grade is calculated from the presentation grade (40%) and the written paper (60%). In order to achieve the required 6 CP, **two of the available courses** (i.e. a total of 4 SWS) must be selected in this module.

	The number and titles of the courses offered may vary from semester to semester

Ethics in Biotechnology elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Frühwirth
Lecturer(s)	N.N.
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: none
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "Ethics in Biotechnology" seminar • know problem areas in the natural sciences • can assess biotechnological processes in particular and their consequences for humans and the environment • are familiar with important bioethical approaches • develop a sense of responsibility in dealing with risks and potentials of technical developments
Contents	The following technical content is taught in this module: "Ethics in Biotechnology" seminar • Possibilities and limits of natural science • Environment and health: Novel foods (genetically modified; functional) • Responsible use of resources • Consideration of the risks and benefits of biotechnology
Literature	• Topics are updated annually, references are provided by the lecturer
Teaching and learning forms	• Ethics in Biotechnology (S), 2 SWS, 3 LP
Workload	**Ethics in Biotechnology seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written paper.
Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the available courses** (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester.

Biorefineries elective	
Credits (ECTS)	3
Attendance	2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr.techn. Frühwirth
Lecturer(s)	Prof. Dr.techn. Frühwirth
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: none
Learning outcomes	Students who have successfully completed this module, • have specialised additional knowledge in different areas • can work independently on current scientific texts • have in-depth knowledge of presentation techniques "Biorefineries" seminar • know the latest biorefinery concepts • can evaluate biorefineries ecologically and economically using examples
Contents	The following technical content is taught in this elective: "Biorefineries" seminar • Raw material: wood, whole plants, grass • Processes: chemical, thermochemical, biotechnological • Products: fuels, food and feed, bulk and fine chemicals • Current application examples
Literature	• Stoffliche Nutzung nachwachsender Rohstoffe, Oliver Türk, Springer, 2014
Teaching and learning forms	• Biorefineries (S), 2 SWS, 3 LP
Workload	**Biorefineries seminar** Attendance: 30 h Independent study: 60 h **total** Attendance: 60 h Independent study: 120 h Total: 180 h
Assessment Methods	The summative assessment is a written paper.
Grading	The module grade corresponds to the result of the summative assessment. In order to achieve the required 6 CP, **two of the available courses** (i.e. a total of 4 SWS) must be selected in this module. The number and titles of the courses offered may vary from semester to semester

Bachelor's thesis	
Credits (ECTS)	16
Attendance	Bachelor's thesis (work placement) +2 SWS
Teaching language	Teaching and assessment: German
Duration	1 semester
Frequency	Yearly
Module coordinator	Prof. Dr. Hädicke
Lecturer(s)	Prof. Dr. Ebert, Prof. Dr. Frühwirth, Prof. Dr. Schips, Prof. Dr. Grammel, Prof. Dr. Hädicke
Introduction to the programme	Industrial Biotechnology BSc, compulsory module, Semester 7
Prior knowledge	• Contents: First and second stage modules
Learning outcomes	Students who have successfully completed this module, • have demonstrated the ability to work mostly independently on a scientific problem in an academic or industrial environment on a topic related to industrial biotechnology • can professionally analyse the results achieved and present them in a final viva • are able to produce a written paper in accordance with academic standards • can demonstrate their acquired ability to work on scientific issues largely independently • are able to plan and conduct experiments and evaluate the results • can present the results achieved in an interesting manner • can classify and evaluate the results achieved and the work in an academic context or in the context of the company • can defend the work objectively in discussion
Contents	• Work on projects in an industrial company or a research institution • Produce a written paper in accordance with academic standards • Public presentation of the Bachelor's thesis and discussion of the results
Literature	• Depends on the topic of the thesis
Teaching and learning forms	• Bachelor's thesis, 16 SWS, 12 LP • Bachelor's thesis viva (S), 2 SWS, 4 LP
Workload	**"Bachelor's thesis" work placement** Attendance: 360 h **"Bachelor's thesis viva" seminar** Attendance: 30 h Independent study: 90 h **total** Attendance: 390 h Independent study: 90 h Total: 480 h

Assessment Methods	There are **two assessments** in this module. The “Bachelor’s Thesis” involves a written paper and the “Presentation for the Bachelor’s Thesis”, an oral assessment. The written paper must be submitted to the programme secretary’s office no later than three months after registration for the Bachelor’s thesis and must contain a summary of the results in German and English.
Grading	The module grade is calculated from the grades for the viva for the Bachelor’s thesis and the grade of the Bachelor's thesis itself. The grade for the Bachelor's thesis accounts for 75% of the final grade and the viva for 25% of the final grade.