Module handbook

for the Bachelor degree course

Biotechnology and Nanotechnology

at the South Westphalia University of Applied Sciences (SW UAS)

Iserlohn campus

01.11.2012

Compulsory modules

Elective modules

Compulsory modules

Introduction to chemistry					
Code P 1	Work load 210 hours	Credits 7	Semester 1st semester	Availability Every winter semester	Duration 1 semester

1	Activities a) 4 CH L b) 1 CH T c) 1 CH P	Contact time 67.5 hours	Private study 142.5 hours	Planned group size 10 students

2	Learning outcomes / competencies Acquisition of basic knowledge of chemistry as well as of simple preparative and analytical chemical methods with the aim of developing a basic understanding of chemicals, chemical properties and chemical conversion processes. The students possess the basic laboratory skills required for handling chemicals and can employ health and safety measures and accident prevention measures. They can perform certain simple chemical conversions independently following instructions, describe them qualitatively and quantitatively and understand the first fundamental correlations between the atomic structure and macroscopic properties of chemicals.
3	Contents Matter and its properties - Material structure of matter - Atomic structure of matter Elements and the periodic table - Atomic models, quantum numbers - Aufbau principle of the periodic table - Periodicity of chemical and physical properties Chemical compounds and chemical reactions - Chemical reaction equations - Stoichiometry The chemical bond - Basic types of chemical bond, transitional forms - Intermolecular attracting forces Chemical reactions and equilibria - Reversible reactions, law of mass action - Energy conversion in chemical reactions - Balance of acids, bases, pH value Solution properties - Real solutions, colloidal solutions - Electrolyte solutions - Solubility and solubility product - Colligative properties Redox reactions and electrochemistry - Oxidation, reduction - Redox system, electrochemical series

	Electrolysis, galvanic cells
4	Teaching methods Lecture, tutorial, practical
5	Prerequisites for participation: None
6	Examination forms Written exam
7	Requirements for awarding of credit points Successful participation in practical sessions, pass grade in module exam
8	Use of module
9	Weighting for final grade: 3.88%
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Peter Meisterjahn
11	Miscellaneous information

Physics I

Code	Work load	Credits	Semester	Availability	Duration
	9 hours	7	1st semester	Winter semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) Lecture 4 CH b) Tutorial 2 CH	6 CH	3 hours	Tutorials: 15

2	Learning outcomes / competencies Acquisition and application of basic physics knowledge
3	Contents - Introduction (physical values, dimensions) - Mechanics (one-dimensional and multidimensional motion, dynamics, gravitation, fields, work, energy, conservation laws, rotary motions, oscillations and waves) - Basics of electricity, electrostatics - Electrical and magnetic fields, induction, electromagnetic oscillations and waves - Passive electrical components and their properties, networks, basics of semiconduction and properties of semiconductor elements
4	Teaching methods Lecture, tutorial, practical
5	Prerequisites for participation Formal: No prerequisites Content-based: Geometry, algebra, basics of differential and integral calculus, trigonometric functions, logarithm function, exponential function
6	Examination forms

	Written exam, oral exam
7	Requirements for awarding of credit points Pass grade in module exams
8	Use of module (in other degree courses) No use
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. H. Sohlbach
11	Miscellaneous information

Mathematics I

Code	Work load	Credits	Semester	Availability	Duration
P3	210 hours	7	2nd semester	Every summer semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 4 CH L b) 2 CH T	67.5 hours	142.5 hours	60 students

2	**Learning outcomes / competencies** Acquisition of basic knowledge and skills for modelling and analysis of complex correlations using abstract mathematical structures from linear algebra and stochastics. The students are familiar with the basis mathematical structures required for exemplary description of qualitative and quantitative correlations in the field of application. They understand simple mathematic representations of these correlations and can formulate them. They can solve differential and integral calculus problems with and without the use of electronic aids and check their results for validity.
3	**Contents** Basics

	Quantities, relations, propositional logic, combinatorics Functions Representation, properties, limit values, consistency, simple functions: trigonometric, exponential and logarithm functions. Differential calculus Tangent line problems, derivations, derivation rules, curve sketching, series expansion of functions. Integral calculus Definite and indefinite integrals, fundamental theorem, integration rules and methods (partial integration, substitution, partial fraction decomposition). Complex numbers Basic arithmetic, exponential notation, raising numbers to a given power, square rooting, logarithms.
4	**Teaching methods** *Lecture, tutorial*
5	**Prerequisites for participation** *None*
6	**Examination forms** Written exam
7	**Requirements for awarding of credit points** *Pass grade in module exam and tutorial attendance certificate*
8	**Use of module** (in other degree courses) *None*
9	**Weighting for final grade** 3.88%
10	**Module advisor and principle lecturer** Prof. Dr. Krone
11	**Miscellaneous information**

Materials

Code	Work load	Credits	Semester	Availability	Duration
P4	150 hours	5	2^{nd} semester	Every winter semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 2 CH lecture b) 2 CH practical	45 hours	105 hours	10 students

2	**Learning outcomes / competencies** Acquisition of basic knowledge of materials. The students possess a principle understanding of materials and their properties. They are capable of applying testing and measuring methods systematically to determine material properties and evaluating them.
3	**Contents** Physical basics of materials - Structure of materials (crystalline, amorphous, partially crystalline) - Characterisation and determining of mechanical properties of materials - Construction of multiphase materials (phase diagrams, phase transformations, nucleation and crystal growth, formation of precipitates, metastable equilibria, diffusion processes) Concrete material systems – Ferrous materials (steel and cast iron) – Non-ferrous metals and their alloys (copper, nickel, chrome, aluminium, titanium, tin, zinc) – Polymer materials (structure, typical properties and their temperature dependency, selected plastics – Ceramic materials (structure, sintering processes, typical properties, selected oxide and non-oxide ceramics, resins)
4	**Teaching methods** Lecture, practical, seminar
5	**Prerequisites for participation** Practical: Participation in a safety briefing
6	**Examination forms** Written exam
7	**Requirements for awarding of credit points** Pass grade in module exam
8	**Use of module** (in other degree courses): No further use
9	**Weighting for final grade:** 2.78%
10	**Module advisor and principle lecturer** Prof. Dr. rer. nat. Nicole Rauch
11	**Miscellaneous information**

Physics II

Code	Work load	Credits	Semester	Availability	Duration
	X hours	X	X semester	Every summer and winter semester	X semester(s)

	Activities	Contact time	Private study	Planned group size
1	a) Lecture 3 CH b) Tutorial 1 CH c) Practical session on material from Physics I and II 1 CH	X CH / x hours	X hours	X students

2 Learning outcomes / competencies

The participants have a basic knowledge of geometric optics and physical optics up to the microscopic resolution limit of a microscope and can calculate simple optical superstructures. They can explain the structure of the atomic shell using the basic principles of quantum mechanics and draw the most important conclusions for spectroscopy. They know the structure of the atom nucleus and the effect of ionising radiation.

3 Contents

1 Optics

- Radiation laws, applications (pyrometry, medical diagnostics, Earth's radiation budget)
- Law of refraction, total reflection, optical fibres, optical lenses
- Geometric optics, imaging laws, imaging errors, magnifying glasses, achromatic lenses, camera lenses, biological applications
- Interference, diffraction, spectroscopes
- Microscope and microscopic resolution limit
- Scattering

2 Quantum mechanics

- Quantum nature of light, Planck's law, photoelectric effect
- Rutherford-Bohr atomic model
- Wave-particle duality, Compton scattering, matter waves
- Uncertainty principle, Schrödinger equation, potential well
- Quantum numbers
- Spectroscopy of the electron shell (selection rules, spin-orbit interaction, Zeeman effect)
- Molecules (covalent bonds, molecule oscillations, Franck-Condon principle)
- Spontaneous and induced emissions, lasers
- Fluorescence

3 Nuclear physics

- Interactions
- Systematic elementary particles
- Nuclear models
- Nuclear reactions (stability curve, β decay and K capture, α decay, decay

	laws, γ decay) ⅄ Induced nuclear reactions (nuclear weapons, nuclear fusion, fusion reactors, fission, fission reactors, Chernobyl and Fukushima) ⅄ Ionising radiation, interaction with matter, radiation protection (technical parameters, biological evaluation, limit values) (The content of this class is interlinked with the Biophysics class)
4	Teaching methods *Lecture, tutorial, practical*
5	Prerequisites for participation Formal: *Possible checks to see if participants are sufficiently prepared for practical session* Content-based: *Attendance of Physics I, A-level mathematics*
6	Examination forms Written exam (successful participation in the practical session is a prerequisite for sitting the exam)
7	Requirements for awarding of credit points *Pass grade in module exam*
8	Use of module (in other degree courses) *None*
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. rer. nat. D. Ihrig, Prof. Dr. rer. nat. H. Sohlbach
11	Miscellaneous information

Biology

Code	Work load	Credits	Semester	Availability	Duration
P 6	180 hours	6	1st semester	Lecture: WS Practical: SS	2 semesters

	Activities	Contact time	Private study	Planned group size
1	a) 3 CH L b) 1 CH P	45 hours	135 hours	15 students

2	Learning outcomes / competencies Introduction of students to principle of scientific working using biological problems. Acquisition of knowledge of general structural and functional principles of organisms and their development processes. The students have a basic knowledge of biological structural and functional principles and can

	solve biological problems with a systematic approach.
3	Contents Introduction Microorganisms — Plants — Animals; cell composition and function Cytology - Fine structure of prokaryotic and eukaryotic cells - Transport: diffusion, osmosis, endocytosis, exocytosis - Transport systems in eukaryotic cells - Cell-cell contacts; cell-substrate contacts; extracellular matrix Movement and excitability, molecular components of the cell, energy balance, protein synthesis Genetics: Reproduction, mitosis, meiosis, zygosis, anthropogenic interventions and mutations Evolution: Differentiation, development to multicellular organisms, multicellular organism organisation Blueprints and systematics: Plants and animals and their cellular structure using examples
4	Teaching methods *Lecture with practical*
5	Prerequisites for participation
6	Examination forms Combination exam of 2 written exams and paper
7	Requirements for awarding of credit points Pass grade in the examination element (written exam) offered at the end of the 1st semester and successful participation in the practical session, certified by a graded, written evaluation (protocol) over the course of the 2nd semester.
8	Use of module
9	Weighting for final grade: 3.33%
10	Module advisor and principle lecturer Prof. Dr. Eva Eisenbarth, Prof. Dr. Klaus Stadtlander
11	Miscellaneous information

Organic chemistry

Code	Work load	Credits	Semester	Availability	Duration
	X hours	5	2nd semester	Every summer semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 2 CH lecture b) 1 CH tutorial c) 1 CH practical	X CH / x hours	X hours	10 students

2 Learning outcomes / competencies

The students are in a position to evaluate whether and in which way organic compounds react with each other or with inorganic substances chemically. They are in a position to develop synthesis strategies for organic compounds. They can perform simple organic syntheses including the associated separation processes independently on a laboratory scale.

3 Contents

Basics of organic chemistry

- Formular representations organic compounds
- Systematics of organic chemistry — properties of homologous series
- Isomerism and molecular geometry, orbitals
- Chirality, enantiomers, optical activity
- Compounds with more than one chiral centre
- Cahn-Ingold-Prelog priority rules

Families

- Alkanes, alkenes, alkynes, cyclic hydrocarbons
- Alcohols, amines, aromatic compounds
- Aldehydes and ketones
- Carboxylic acids and derivatives (esters, amides, halogenides, anhydrides, nitriles)
- Isocyanates and derivatives (carbamides, urethanes)
- Ethers and epoxides

Reaction types

- Radical halogenation – stability of radicals
- Electrophilic addition to C-C double bonds – Markovnikov's rule
- Nucleophilic substitution – S_N1 and S_N2 – Stability of carbenium ions
- Elimination – E1 and E2 – Hofmann and Zaitsev product
- Electrophilic substitution on aromatic compounds – Mesomeric and inductive effect
- Chemical reactions from carboxylic acids and their derivatives
- Chemical reactions of aldehydes and ketones

4 Teaching methods

Lecture, tutorial, practical

5 Prerequisites for participation

Formal: –

Content-based: –

6	Examination forms Written exam
7	Requirements for awarding of credit points Successful participation in practical sessions, pass grade in module exam
8	Use of module –
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Helmut Fobbe
11	Miscellaneous information –

Physical chemistry 1

Code	Work load	Credits	Semester	Availability	Duration
P 8	150 hours	5	2nd sem.	Every summer semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 3 CH L b) 1 CH P	45 hours	105 hours	10 students

2	Learning outcomes / competencies The students know basic terms, phenomena and methods of physical chemistry. They understand the behaviour of gases and can describe them physicochemically. They know the basic laws of chemical reaction kinetics and can verify them using simple examples. They understand the behaviour of electrolytic systems and can describe and implement them electrochemically. In addition, the students have knowledge of the experimental identification of physicochemical dimensions.
3	Contents Gases and gas laws - Ideal gases - Applications of the ideal gas law - Real gases - Gas mixtures - Basics of kinetic gas theory Chemical reaction kinetics - Reaction speed - Concentration dependency of the reaction speed - Time dependency of the reaction speed

	- Single-step reactions - Reaction mechanisms - Temperature dependency of the reaction speed - Catalysis Conductivity and interactions in ionic systems - Ions, electrolytes - Specific conductivity - Molar and equivalent conductivity - Experiential conductivity laws - Ion movement and migration - Mean ion activity and activity coefficients - Ionic strength - Applications of conductivity measurements
4	Teaching methods Lecture, practical
5	Prerequisites for participation
6	Examination forms Written exam
7	Requirements for awarding of credit points Successful participation in practical sessions, pass grade in module exam
8	Use of module
9	Weighting for final grade: 2.78%
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Peter Meisterjahn
11	Miscellaneous information

Mathematics II

Code	Work load	Credits	Semester	Availability	Duration
	180 hours	6	2nd semester	Every summer semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 4 CH L b) 2 CH T	67.5 hours	112.5 hours	60 students

2	**Learning outcomes / competencies** Acquisition of basic knowledge and skills for modelling and analysis of complex correlations using abstract mathematical structures from linear algebra and

	stochastics. The students can analyse geometric data with the aid of vector analysis and describe and solve sets of linear equations with the aid of matrices. They have a command of the basic terms of stochastics. They are in a position to compile and analyse simple, stochastic models and to determine the probabilities of events. In addition, they are in a position to apply procedures from linear algebra and stochastics to application problems.
3	**Contents** Vector analysis and analytical geometry Representation of vectors, vector spaces, vector operations. Points, straight lines, planes. Calculation of distances, angles, intersections Linear algebra Matrices as linear functions, sets of linear equations, Gauss–Jordan elimination, solvability and number of solutions, inverse matrix, determinants Combinatorics Permutations, combinations with and without repetition Calculating probability Random experiments, frequency, probability, conditional probability, random variables, distribution functions Basics of statistics Attributes and frequencies, parameters, statistics methods
4	**Teaching methods** *Lecture, tutorial*
5	**Prerequisites for participation** *None*
6	**Examination forms** Written exam
7	**Requirements for awarding of credit points** *Pass grade in module exam and tutorial attendance certificate*
8	**Use of module** (in other degree courses) *None*
9	**Weighting for final grade** 3.33%
10	**Module advisor and principle lecturer**

	Prof. Dr. Krone
11	**Miscellaneous information**

Electronics, sensors and controllers

Code	Work load	Credits	Semester	Availability	Duration
	6 hours	5	2^{nd} sem.	Summer semester	1 semester

1	Activities a) Lecture 2 CH b) Tutorial 1 CH c) Practical 1 CH	Contact time 4 CH / 4 hours	Private study 2 hours	Planned group size Tutorial: 15 students Practical 10 students

2	Learning outcomes / competencies The students learn the functionality and properties of sensors, switches for sensor signal processing and electronic controls as well as how to handle electronic measuring equipment.
3	Contents • Properties and applications of semiconductor components (diodes, FETs), operational amplifiers and analogue-digital as well as digital-analogue converters; • Sensors and sensor signal processing for measuring temperature, pressure and substance concentration values; • Structure and properties of simple control circuits with P, PI and PID controllers
4	Teaching methods Lecture, tutorial, practical
5	Prerequisites for participation Formal: None Content-based: Contents of Physics I
6	Examination forms Written exam, oral exam
7	Requirements for awarding of credit points Pass grade in module exams
8	Use of module (in other degree courses) None
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. H. Sohlbach

11	Miscellaneous information

Principles of data processing

Code	Work load	Credits	Semester	Availability	Duration
P 11	210 hours	7	2nd – 3rd semester	Every summer semester	2 semesters

1	Activities	Contact time	Private study	Planned group size
	a) 1 CH L (SS) b) 1CH T (SS) c) 1 CH S (WS) d) 2 CH P (WS)	67.5 hours	142.5 hours	24 students (tutorial), 15 students (practical)

2	**Learning outcomes / competencies** The “Principles of data processing” module communicates a basic understanding of the visualization and processing of data on the one hand and an introduction to algorithmic thinking and system analysis on the other. This provides the students with the prerequisites for systematic software development and the application of structured dataflow programming. As such, the students are in a position to realise small and medium-sized software projects independently.
3	**Contents** - Introduction to the topic What is “Computer science”? - Number systems and the representation of numbers - Data types (numerical, Boolean, symbols) - Data structures (data fields, data networks, strings) - Simple methods for designing algorithms (pseudocode, structograms) and introduction to structured programming - Structure dataflow programming - Structured analysis (SA: dataflow diagrams, data catalogue, mini specs) - Realisation of a software architecture based on finite state automata - (Finite state diagram, state event matrix) - Introduction to program development environment LabVIEW (as an example for structured dataflow programming - Realisation of software projects with the aid of program development environment LabVIEW
4	**Teaching methods** Seminar teaching with group work, learn team coaching, peer instruction
5	**Prerequisites for participation** Formal: Pass grade in the exam in the Mathematics 1 module
6	**Examination forms** Portfolio, ongoing exams through the semester, process-oriented examination performance

7	Requirements for awarding of credit points Pass grade in module exam
8	Use of module (in other degree courses): No further use
9	Weighting for final grade: 3.88%
10	Module advisor and principle lecturer Prof. Dr.-Ing. Bernward Mütterlein
11	Miscellaneous information Literature: H.-P. Gumm, M.Sommer. Einführung in die Informatik. Oldenbourg, 2006 H. Ernst. Grundkurs Informatik. Vieweg, 2008 B. Mütterlein. Handbuch für die Programmierung mit LabVIEW. Spektrum Akademischer Verlag, 2009 J. Travis, J. Kring. LabVIEW for Everyone. Prentice Hall, 2007

Computer science

Code	Work load	Credits	Semester	Availability	Duration
	120 hours	4	2	Every summer semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) Lecture 2 CH b) Tutorial 2 CH	4 CH / 60 hours	60 hours	24 students (tutorial)

2	Learning outcomes / competencies *The students* • *have a basic understanding of the visualization and processing (e.g., rounding errors) of information on the machine.* • *know methods for the designing of algorithms and can apply these as problem-solving techniques, e.g., in the designing of experiments or as a prerequisite for the programming in the Laboratory automation module.* • *have the ability to perform rough calculations for plausibility checks.* • *can create professional diagrams.* • *can compile technical documents (test protocols, laboratory journal) which are correct in form and content.* • *have a good command of literature research in the SW UAS library catalogue.*
3	Contents

	Component 1: Computer science (approx. 2 CH) • *Number systems and the representation of numbers* • *Data types (numerical, Boolean, symbols)* • *Boolean algebra, combinatorial circuits* • *Data structures (data fields, data networks, strings)* • *Methods for designing algorithms (pseudocode, structograms)* Component 2: Basics of academic working (Approx. 2 CH, continuation of the Human biology module) • *Logarithms and exponents, estimates (Fermi problems), course of the functions* • *Compilation of technical documents (test protocols, reports) with an introduction to word processing (Open Office, LaTeX, etc.)* • *Visualization and evaluation of test results with an introduction to data analysis (Origin, DIAdem, etc.)* • *Literature research, bibliographical references and citation systems with an introduction to literature research with the SW UAS catalogue*
4	Teaching methods *Lecture, compulsory tutorial*
5	Prerequisites for participation Formal: *None* Content-based: *None*
6	Examination form *Written exam lasting 84 minutes* *Permitted aids in exam: One self-compiled DIN A4 page (handwritten)*
7	Requirements for awarding of credit points *Pass grade in module exam*
8	Use of module (in other degree courses) –
9	Weighting for final grade *4/180*
10	Module advisor and principle lecturer *Prof. Dr.-Ing. Bernward Mütterlein*
11	Miscellaneous information *Literature:* *H.-P. Gumm, M.Sommer. Einführung in die Informatik. Oldenbourg, 2006* *H. Ernst. Grundkurs Informatik. Vieweg, 2008*

	B. Mütterlein. Handbuch für die Programmierung mit LabVIEW. Spektrum Akademischer Verlag, 2009 *P. Rechenberg. Technisches Schreiben. Hanser 2006* *K. Eden, H. Gebhard. Dokumentation in der Mess- und Prüftechnik. Vieweg+Teubner 2011*

Macromolecular chemistry

Code	Work load	Credits	Semester	Availability	Duration
	X hours	4	3rd sem.	Every winter semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 3 CH lecture c) 1 CH practical	X CH / x hours	X hours	10 students

2	Learning outcomes / competencies The students are in a position to correlate chemical and/or nanoscale structure and macroscopic features of macromolecular chemicals together (knowledge of structure-property relationships). They are also in a position to vary the properties of macromolecules systematically using this knowledge. They can also perform simple macromolecular syntheses independently on a laboratory scale.
3	Contents Basics of macromolecular chemistry - Structure and properties of thermoplastics, thermosetting resins and elastomers - Chain-growth polymerisation reactions, polymerisation procedures, copolymerisation - Step-growth polymerisation reactions: condensation polymerisation and polyaddition - Technical production of macromolecular chemicals Production, properties and use of technical plastics - Polyolefins, especially PE and PP - Halogenated polyolefins, especially PVC, PTFE - Styrene polymers, especially PS, ABS, and SAN - Additional thermoplastics from chain-growth polymerisation reactions, e.g., PMMA and POM - Plastics from condensation polymerisation: PA, PET, PF, UF, MF; PC - Plastics from polyaddition: Epoxy resins, polyurethanes - Deterioration and recycling of plastics - Modification of polymer materials with additives incl. nanoparticles Production, properties and use of resinous polymers - Natural resins, modified natural products - Polyester, acrylic resins, - Plastic dispersions

	- Phenolic resins and melamine resins - Epoxy resins and polyurethanes
4	Teaching methods Lecture, practical
5	Prerequisites for participation Formal: -. Content-based: -
6	Examination forms Written exam
7	Requirements for awarding of credit points Successful participation in practical sessions, pass grade in module exam
8	Use of module –
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Helmut Fobbe
11	Miscellaneous information –

Physical chemistry II

Code	Work load	Credits	Semester	Availability	Duration
P 13	150 hours	5	3rd semester	Winter semester	1 semester

1	Activities a) 3 CH L b) 1 CH P	Contact time 45 hours	Private study 105 hours	Planned group size 10 students
2	Learning outcomes / competencies The students know the basic terms, phenomena and methods of physical chemistry. They have a good command of the basics of thermochemistry, have a fundamental understanding of chemical equations and can describe these qualitatively and quantitatively. They can apply the laws of thermodynamics to chemical reactions and understand the relationship between thermodynamic and electrochemical values. In addition, they also have a basic knowledge of electrode kinetics.			
3	Contents Thermochemistry			

	- Energy, forms of energy, types of energy - Thermal capacity, specific thermal capacity - Reaction energy, reaction enthalpy - Thermochemical equations - Hess' law - Change in enthalpy in physical processes - Enthalpy of formation, standard enthalpy of formation - Binding energy, average binding energy Chemical equilibrium - Reactions in equilibrium - The equilibrium constants K_c , K_p and K_a - Heterogeneous equilibria - Le Chatelier's principle - Equilibria in solutions - Acid-base equilibria - Complex equilibria - Basics of chemical thermodynamics - The principles of thermodynamics - Enthalpy - Free enthalpy, free standard enthalpy - Entropy, absolute entropy - Chemical potential - Equilibrium and free enthalpy of reaction - Temperature dependency of the equilibrium constants Electrochemistry and thermodynamics - Equilibrium on phase limits, electrochemical potential - Electrode potential and application of potential measurements - Free enthalpy of reaction and electromotive force Electrode kinetics

4	Teaching methods Lecture, practical
5	Prerequisites for participation
6	Examination forms Written exam
7	Requirements for awarding of credit points Successful participation in practical session, pass grade in module exam
8	Use of module
9	Weighting for final grade: 2.78%
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Peter Meisterjahn
11	Miscellaneous information

Biochemistry

Code	Work load	Credits	Semester	Availability	Duration
	X hours	4	3rd sem.	Every summer and winter semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) Lecture b) Tutorial	3 CH / 2.25 hours 1 CH / 0.75 hours	X hours	X students

2	Learning outcomes / competencies *The students know the different metabolic pathways and their basic structures. They recognise the functional necessity of the biological structures for functional integrity. They understand the necessity of compartmentalisation in the cell and the significance of the environmental factors on the metabolism of the cells.*
3	Contents *Introduction: The cell and its functions/cycles* *Components of life and their structures:* *- Carbohydrates, lipids/fats, amino acids and nucleic acids* *Macromolecules:* *Carbohydrates, e.g., starches, cellulose, chitin, murein, nucleic acids, DNA and RNA, 3D forms, proteins and their 3D structural forms* *Enzymes and their functions:*

	Enzyme kinetics: Michaelis-Menten, Lineweaver-Burk, Km and Vmax as reference values, specific activity, IU and katal units, substrate and effect specificity, calculations *Glycolysis* *- FBP, KDPG and pentose phosphate pathway – Reference to biotechnological production of EtOH, lactic acid and its current scientific use* *Citric acid cycle* *- Regulation points, feedback, multi-enzyme complexes pyruvate dehydrogenase and succinate dehydrogenase; glyoxylate cycle = fatty acid degradation. Short discussion of current biotechnological production processes* *End oxidation* *- Respiratory chain, reduction potential gradient, provision of ATP with ATP synthase, membrane function, chemiosmotic theory. Reference to bionanotechnological uses in the form of nanomotors* *Photosynthesis* *- Electron transport chain, energy consumption and conversion. C3, C4 and CAM plants; photorespiration / use/damage to plants as amino acid suppliers; adaption to light and temperature conditions, scientific possibilities for use; oxygenic and anoxygenic photosynthesis; alternatives to CO_2 fixation; purple bacteria, cyanobacteria and comparison with each other.* *Additional CO_2 fixation pathways* *- Reductive Acetyl-coA pathway, reductive tricarboxylic acid cycle, 3-hydroxypropionate pathway* *Nitrogen catabolism: Urea cycle, ammonia, uric acid, urea, purine acids*
4	Teaching methods *Traditional lecture, put into practice in a practical session or solving mathematical problems*
5	Prerequisites for participation Formal: *None* Content-based: *Biology lecture should have been attended*
6	Examination forms Written exam
7	Requirements for awarding of credit points *4 credits are awarded for successful completion of the module.* *Prerequisite for the earning of the credits is successful passing of the module with a pass grade in the test component (written exam).*
8	Use of module (in other degree courses) None
9	Weighting for final grade
10	Module advisor and principle lecturer Prof.Dr. Klaus Stadtlander
11	Miscellaneous information Literature: All biochemistry reference works

Microbiology					
Code P 15	Work load 150 hours	Credits 5	Semester 2nd semester	Availability Summer semester	Duration 1 semester

1	Activities a) Lecture b) Practical	Contact time 45 hours	Private study 105 hours	Planned group size Subgroups of 15 students

2	Learning outcomes / competencies The students know the basic of microbiology and have a solid understanding of prokaryotic topics. They can represent the significance of microorganisms for humans and nature. They are in a position to put microbial process into context with nanotechnological applications.
3	Contents Introduction to microbiology Evolution of kingdoms, general characteristics, cycle of matter in nature, symbionts, microorganisms serving humans, pathogens Bacteria and fungi Genome, nanostructure of the cells, taxonomy and classification, particularities of prokaryotic cells, life forms of fungi, biotechnological application Viruses and nanobiology Bacterial nano dirt and health, existence and development of viruses, viruses as nanotools, detection of viruses with nanowires, nanomarkers of bacterial systems, nanomagnets Growth and feeding of microorganisms Composition and feeding types, life strategies, substrates and adaptation, cultivation, growth and cell division, sterilisation, diagnostics Nanobiotechnology Basic mechanisms of biotechnology, antibacterial nanolayers, ion channels as nanosensors, genetic modification of DNA on a nanoscopic scale, flagella and biomolecular motors
4	Teaching methods Lecture with seminar elements, practical
5	Prerequisites for participation Formal: None Content-based: None
6	Examination forms Written exam, practical session report
7	Requirements for awarding of credit points Pass grade in written exam / successful participation in practical session
8	Use of module (in other degree courses) None
9	Weighting for final grade

10	Module advisor and principle lecturer Prof. Dr. rer. nat. Kilian Hennes
11	Miscellaneous information None

Instrumental analytics					
Code	Work load	Credits	Semester	Availability	Duration
	X hours	X	3rd semester	Every winter semester	1 semester

1	Activities	Contact time	Private study	Planned group size
	a) Lecture (3 CH) b) Practical (2 CH)	X CH / x hours	X hours	10 students

2	Learning outcomes / competencies *After attending the lecture and participating in the practical session, the students can apply the most important chemical analysis methods and evaluate/analyse measurements.*
3	Contents - Good laboratory practice, calibration methods (serial dilution, standard addition procedures, etc.), validation of measured values (verification of validity, statistical tests, control cards), error calculation (frequency distribution of measured values, standard deviation and confidence interval, error propagation) - Basics of spectrometry (laws of absorption, structure of spectra), quantitative spectroscopy - UV/Vis spectrometry (structure of spectrometers, prisms and grating spectrometers, sources of radiation and detectors) and their applications (FES, AAS, ICP, fluorescence spectrometry), applications - IR spectrometry: FTIR principle, structure of IR spectra, sources of radiation and detectors, sample preparation, NDIR, applications - Nuclear magnetic resonance (NMR) - Mass spectrometry: ionisation methods (electron collision and chemical ionisation, etc.), mass spectrometers (magnetic, sector mass, quadrupole, etc.), detectors, applications - Gas chromatography (GC): chromatography principles, structure of a GC, the phase system, detectors, feeding systems, sample preparation, qualitative and quantitative TLC, applications - High-performance liquid chromatography (HPLC): comparison with GC, structure of an HPLC, detectors, special types of the HPLC (adsorption chromatography, reversed phase, ion chromatography), applications
4	Teaching methods *Lecture and practical session*
5	Prerequisites for participation

	Formal: *Safety briefing for participation in practical session* *Possible checks to see if participants are sufficiently prepared* Content-based: *Participation in Physics II module (optics, atoms and nuclei)*
6	Examination forms Written exam (successful completion of the practical session is a prerequisite for sitting the written exam)
7	Requirements for awarding of credit points *Pass grade in module exam*
8	Use of module (in other degree courses) *None*
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. rer. nat. D. Ihrig, Prof. Dr. rer. nat. H.M. Heise
11	Miscellaneous information

Process engineering

Code	Work load	Credits	Semester	Availability	Duration
	120 hours	4	4th semester	Every summer semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 2 CH lecture b) 1 CH tutorial c) 1 CH practical	4 CH / 60 hours	60 hours	10 students

2	Learning outcomes / competencies The students have the basic ability to participate in the industrial realisation of a chemical or biochemical procedure. They are in a position to identify problems occurring during scaling up and define practical solution possibilities. This applies to both chemical and biochemical syntheses and the associated preparation, separation and cleaning steps in biotechnology and technical chemistry.
3	Contents 1. Introduction to technical chemistry: - General introduction: Essence of technical chemistry, composites in the chemical industry, co-products, joint products and by-products, basics of scaling up - Basics of physical chemistry: Thermodynamics, state functions, chemical potential, chemical equilibrium, phase equilibria, reaction kinetics, reaction order, heat and mass

	transport - Ideal and real reactors: Reactors, reactor chain, plug-flow reactors - Thermal separating processes: Distillation, rectification, absorption, extraction - Mechanical separating processes: Overview, pumps, compressors, cyclone separators - Flow charts: Types, standard symbols 2. Reprocessing methods in bioprocess engineering: - Reprocessing and cleaning of products, process-indicated diagram - Filtration, filtration methods and procedures - Sedimentation, centrifugation, methods and apparatus, calculations - Cell disruption, apparatus and methods - Separation of soluble products, precipitation, dialysis, chromatography and electrophoresis, - Crystallisation procedures, drying and microencapsulation procedures - Immobilisation methods
4	Teaching methods Lecture, tutorial, practical
5	Prerequisites for participation Formal: -. Content-based: -
6	Examination forms Written exam
7	Requirements for awarding of credit points Successful participation in practical sessions, pass grade in module exam
8	Use of module –
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Helmut Fobbe, Prof. Dr. rer. nat. Klaus Stadtlander
11	Miscellaneous information –

Biophysics / bioprocess technology					
Code	Work load X hours	Credits 7	Semester 3rd+4th semester	Availability Every semester, summer semester, ...	Duration 2 semesters

1	Activities	Contact time	Private study	Planned group size
	a) 5 L b) 1 T	CH / hours CH / hours	hours	X students

2 **Learning outcomes / competencies**

Part 1: The participants can apply basic principles and knowledge of physics (especially thermodynamics) and physical chemistry to biological systems. They have basic knowledge of biophysics and medical physics, about energetics in biological reactions and of cells; they can apply this knowledge to basic medical problems.

Part 2: The participants have a basic knowledge of processes in biotechnology. They can basically plan biotechnological procedures and perform them. They can estimate which conditions need to be fulfilled and how.

3 Contents

Part 1:

I. Ionising radiation

Natural and civilisational radiation exposure, radiation exposure from medical diagnostics and therapeutics, effect of ionising radiation on humans, Hiroshima and Nagasaki, deterministic and stochastic radiation damage

II. Thermodynamics and implications for evolution

III. Kinetics

Basic principles of kinetics, population dynamics, enzyme kinetics (Michaelis-Menten, Lineweaver-Burk and Eadie-Hofstee), dynamics of biomass growth (Monod), pharmokinetics

IV. Membranes

Structure (membrane components, functions)

Transport phenomena: Basics (osmosis, diffusion); permeability coefficient; transport of lipid-soluble substances (diffusive transport, flux coupling, Staverman equations); carrier transport and channels; active transport

Saltatory conduction: Membrane resting potential, dynamics of salutatory conduction, neuronal control of muscles, muscle contraction, structure of musculature, electrical accidents

Neurons

	V. Medical physics *Breathing, kidneys, hormone regulation cycles (osmolarity, Na+/Ka+ concentration, blood sugar, menstrual cycle and lactation, thyroid) liver, heart, hearing and balance organs, structure of the eye, immune and lymphatic systems* *VI. The most important procedures in oncological diagnostics and treatment* *X-rays, computer-assisted tomography (CAT), magnet resonance imaging (MRI), positron emission tomography (PET), heavy ion therapy, cervical cancer,* optical coherence tomography (OCT), *ultrasonic methods* *Part 2:* *I. Bioreactors* *Models and versions of bioreactors, classification of fermentation processes, preparation, operation and harvesting of a bioreactor, flow charts* *II. Sterilisation technology* *Sterilisation methods, sterilisation criteria; sterilisation procedures for reactors and media* *III. Process analytics* *Process parameters pH, PO_2, temperature; biomass, activity; substrate/product concentration* *Measuring and control engineering = measurement and control.* *IV. Fermentation technology: Microbial growth* *Vaccination production, substrate requirements, selection of media, bioprocess models: balances and kinetics, possibility of controlling biochemical activities, feeding strategies, fed-batch, continuous) and procedures; immobilised cell systems (active & inactive); mixed populations; special bioreactor types* *V. Rheology and ventilation* *Reactor technology, flow behaviour of fermentation broths, fumigation, oxygen requirement and transfer* *VI. Scaling up* *VII. Simulation and modelling of biotechnological processes*
4	Teaching methods *Traditional lecture, tutorial in form of practical experiments*
5	Prerequisites for participation Formal: *None* Content-based: *The General chemistry, Biology and Physics lectures should have been attended*
6	Examination forms Written exam
7	Requirements for awarding of credit points *7 credits are awarded for successful completion of the module.* *Prerequisite for the earning of the credits is successful passing of the module with a pass grade*

	in the test component (written exam).
8	Use of module (in other degree courses) None
9	Weighting for final grade
10	Module advisor and principle lecturer Prof.Dr. Dieter Ihrig, Prof.Dr. Klaus Stadtlander
11	Miscellaneous information Literature: All biochemistry, biophysics and bioprocess engineering reference works

Microanalytics and nanoanalytics I

Code	Work load	Credits	Semester	Availability	Duration
P 19	150 hours	5	4th semester	Summer semester	1 semester

1	Activities a) 2 CH L b) 2 CH P	Contact time 45 hours	Private study 105 hours	Planned group size 10 students

2	Learning outcomes / competencies The students acquire theoretical and practical knowledge about the performance and the application limits of microstructural characterisation processes. The acquired knowledge will be applied to different situations and improved in the practical session. The students are in a position to select suitable microanalytical and nanoanalytical processes based on the problem and to interpret and evaluate the gathered information.
3	Contents Building on the basics of optics: Resolving capacity of microscopic procedures Light microscopic procedures (conventional microscopy, phase contrast microscopy, fluorescence microscopy, polarisation microscopy, confocal microscopy) Scanning electron microscopy (SEM), Rotational rheology
4	Teaching methods Lecture, practical
5	Prerequisites for participation Successful participation in “Physics” module For the practical session: Participation in a safety briefing
6	Examination forms Written exam
7	Requirements for awarding of credit points Pass grade in module exam
8	Use of module (in other degree courses): No further use

9	Weighting for final grade: 2.78%
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Nicole Rauch
11	Miscellaneous information

Nanomaterials

Code	Work load	Credits	Semester	Availability	Duration
	X hours	X	4th semester	Every summer semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 4 CH L b) 2 CH P	X CH / x hours	X hours	10 students

2 Learning outcomes / competencies

The students understand nanomaterials as a central element of nanotechnology and know different application possibilities and fields of application in industry and technology. They know different types of nanomaterials (nanoparticles, nanolayers, nanocomposites and nanowhisker structures) and are able to produce these, process them and adapt them to a particular function.

3 Contents

Basics

Clarification of the term “nanotechnology”

Historical development of nanotechnology

Production of nanomaterials

Bottom-up and top-down approach

Physical procedures (PVD technology, laser ablation, lithography, high energy milling, extreme plastic deformation, separation of glasses, thermoplastic fibre technology, electrical arcs, delamination of tones und layered silicates, spray drying, electrospinning processes…)

Chemical procedures (CVD technology, sol-gel technology, precipitation, oxidation/reduction, controlled detonation, pyrolysis, hydrolysis, electrochemical separation/electroplating, microemulsion procedure, hydrothermal procedures, gas phase synthesis…)

Characterisation of nanomaterials

Features of microscopic procedures (REM,TEM, RTM, AFM)

Features of spectroscopic procedures (light diffusion, ESCA, XPS, AES, WAXS, NMR, SIMS…)

Wetting and contact angle measurement (Young’s equation; measuring procedure for determining surface tensions)

Types of nanomaterials

Nanoparticles (morphologies)

Inorganic nanomaterials: metallic, oxidic and chalcogenidic nanomaterials, carbon nanomaterials (soot, carbon nanotubes, fullerenes, graphene, nanodiamond)

Organic nanomaterials: Dendrimers, hyperbranched polymers, functionalised carbon nanomaterials

Application and use of nanomaterials

	Features of risk assessment and toxicology of nanomaterials Self-cleaning surfaces (Lotus effect, photocatalysis) Transparent, conductive layers (ITO, SnO_2) Solar applications Sunscreens Sensors Scratch-resistant coatings Functional and decorative glass and ceramic glass layers Anti-corrosion and anti-scaling layers
4	Teaching methods *Lecture, practical*
5	Prerequisites for participation Formal: - Content-based: -
6	Examination forms Written exam
7	Requirements for awarding of credit points Successful participation in practical sessions, pass grade in module exam
8	Use of module (in other degree courses) —
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. Fobbe, Prof. Dr. Meisterjahn, Prof. Dr. Rikowski
11	Miscellaneous information

Biomaterials

Code	Work load	Credits	Semester	Availability	Duration
P 21	150 hours	5	4th Sem.	Every summer semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 2 CH L b) 2 CH S	45 hours	105 hours	15 students

2	Learning outcomes / competencies The students have a basic knowledge of the structure of material systems and techniques for influencing biologically

	medically relevant material parameters. They know the material parameters which influence the biological and medical interaction with the implant in the long and short terms. The students know the features of the approval process for medical devices and have studied the corresponding regulations.
3	Contents Structure of tissues in contact with implants • Biomechanics: Mechanical properties of supporting tissues, anisotropy, viscoelasticity; distribution of tension during different movements, biomechanics of supporting tissue, lubrication of joints, requirement profiles of biomaterials: Mechanical properties: • Material failures in implants: Stress shielding, corrosion behaviour; abrasion and wear, fatigue, forced and fatigue fractures • Metallic biomaterials: Titanium and titanium alloys; cobalt-chrome base alloys, steels; shape memory alloys • Ceramics and glasses Aluminium oxide; zirconium oxides; bioactive materials • Polymers; Hydrogels; scaffold materials, degradable and biologically stable polymer materials • Features of regenerative medicine Tissue engineering and the framework materials employed • Indications for the use of different implants Conditions which can be alleviated or cured using implants. Operative techniques for the use of enossal implants and dental implants Long-term problems after implants:
4	Teaching methods Lecture and seminar in English
5	Prerequisites for participation Formal: Pass grade in the Materials module exam. Content-based: The module builds on the contents of the Materials module
6	Examination forms Combination exam with mid-term exam (33%), final exam (33%), seminar and

	paper (33%) Percentages in (): Share of the complete points for determining the final grade
7	Requirements for awarding of credit points *Pass grade in the examination element (written exam) and successful presentation in English including a paper in German on the presentation topic.*
8	Use of module (in other degree courses) ./.
9	Weighting for final grade: 2.78%
10	Module advisor and principle lecturer Eva Eisenbarth
11	Miscellaneous information

Metallic materials and corrosion

Code	Work load	Credits	Semester	Availability	Duration
P 22	180 hours	6	5th sem.	Winter semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 2 CH L b) 2 CH P	45 hours	75 hours	15 students

2	Learning outcomes / competencies Acquisition of basic knowledge of the properties of metals, corrosion and corrosion protection. The students know the alloys employed in practice and their properties. They know how these properties can be influenced with a heat treatment, for example. They know the basics of corrosion and the different types of corrosion as well as the corrosion protection possibilities.
3	Contents Structure of metals and their structure - Flaws in metals - Heat treatment, hardening mechanisms - Phase diagrams - Properties of technical alloys Basics of corrosion - Corrosion mechanisms; - Types of corrosion Basics of corrosion protection - - Electrochemical and phase limit corrosion protection measures

4	Teaching methods Lecture and practical session
5	Prerequisites for participation Formal: Practical: Participation in a safety briefing
6	Examination forms Written exam
7	Requirements for awarding of credit points Pass grade in the test component (written exam).
8	Use of module (in other degree courses): No further use
9	Weighting for final grade: 3.33%
10	Module advisor and principle lecturer Prof. Dr.-Ing. Ralf Feser
11	Miscellaneous information

Work experience

Code	Work load	Credpape	Semester	Availability	Duration
	900 hours	30	6th semester	Every semester, as required	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) Work experience	As required	–	–

2	Learning outcomes / competencies Introducing the students to the professional activities of a Bachelor of Science via assignment of concrete tasks and practical, suitable cooperation in companies or other institutions for relevant professional experience.
3	Contents Preferably application-oriented and thus industry-related issues from the entire range of knowledge fields communicated in the programme — where possible, in cooperation with industrial companies, research institutes or authorities.
4	Teaching methods Meeting with the work experience semester advisor/mentor.
5	Prerequisites for participation

	Student are permitted to apply for the work experience semester if they have gained 84 credits in the first, second and third semesters and 48 credits from the fourth and fifth semesters in accordance with Appendix 1 BPO (Bachelor examination ordinance). As a general rule, the work experience semester advisor makes the decision about approval for the work experience semester. In the case of doubt, the examination board shall decide.
6	Examination forms —
7	Requirements for awarding of credit points The work experience semester will be recognised if a) the instructing institution has provided a positive reference about the cooperation, b) the student has provided information about the status of the work in the scope of the work experience semester at the lecturer's request c) the student has submitted a final report to the lecturer complying with his specifications d) the student's internship tasks corresponded to the purpose of the work experience semester and the student performed the tasks assigned to him satisfactorily; the reference from the instructing institution and the final report should be taken into account here.
8	Use of module (in other degree courses) —
9	Weighting for final grade —
10	Module advisor and principle lecturer Responsible professor at SW UAS
11	Miscellaneous information

Project work

Code	Work load	Credits	Semester	*Availability*	Duration
P 24	300 hours	10	6th semester	Annually in the first half of the 6th semester	Max. 12 weeks

	Activities	Contact time	Private study	Planned group size
1	–	–	–	–

2	Learning outcomes / competencies Development of the ability to process a practice-relevant, scientific-technical question independently and successfully. Methodical preparation of the final report and its contents and thus development of the ability to complete this successfully. Instruction and training of interdisciplinary skills, key competences and method competences.
3	Contents Independent literature studies, own experimental work and examinations,

	personal advice from assigned professor
4	Teaching methods Project work.
5	Prerequisites for participation: 120 ECTS
6	Examination forms Paper with presentation
7	Requirements for awarding of credit points Successful performance of project work
8	Use of module (in other degree courses)
9	Weighting for final grade: 5.56%
10	Module advisor and principle lecturer Responsible professor at the South Westphalia University of Applied Sciences
11	Miscellaneous information

Bachelor thesis

Code	Work load	Credits	Semester	Availability	Duration
P 25	480 hours	16	6th semester	Every year in the second half of the 6th semester, in courses with a work experience element in the second half of the 7th semester.	8 weeks

	Activities	Contact time	Private study	Planned group size
1	-	–	–	

2	Learning outcomes / competencies Proof that the student has the ability to process a practice-relevant, scientific-technical question independently and successfully within a set period of time. Proof that the student possesses interdisciplinary skills, key competences and method competences.
3	Contents In principle, the Bachelor thesis can be on a topic from any part of the entire range of knowledge fields communicated in the course. Paper represents an independent examination of corresponding scientific and technical matters.
4	Teaching methods Independent literature studies, own experimental work and examinations, personal advice from assigned professor
5	Prerequisites for participation

	A student may only submit a Bachelor thesis if: a) he is matriculated at the South Westphalia University of Applied Sciences or admitted as a cross-registered student in accordance with § 52 Para. 2 German Higher Education Act (HG); b) he has earned 90 ECTS in the compulsory modules of the first, second and third semesters; c) has earned 48 ECTS in the compulsory and elective modules of the fourth, fifth and sixth semesters; d) he can provide evidence of 30 credits for the work experience in courses with a work experience element.
6	Examination forms
7	Requirements for awarding of credit points Pass grade for Bachelor thesis
8	Use of module (in other degree courses)
9	Weighting for final grade: 8.89%
10	Module advisor and principle lecturer A responsible professor at the South Westphalia University of Applied Sciences
11	Miscellaneous information

Thesis seminar

Code	Work load	Credits	Semester	Availability	Duration
P 26	120 hours	4	6th semester	Following and as the final step of the Bachelor thesis	30 to 45 mins

	Activities	Contact time	Private study	Planned group size
1	Oral exam	–	-	

2	Learning outcomes / competencies The thesis seminar is used to determine that the students are capable of explaining the results of their Bachelor thesis, the academic foundations, their interdisciplinary context and their relevance to other fields orally and justify them independently as well as estimating their significance for industry. The means in which the topic of the Bachelor thesis was approached should also be considered.
3	The thesis seminar covers the subject of the Bachelor thesis and any possible cross references to the knowledge fields communicated in the course.
4	Teaching methods
5	Prerequisites for participation a) Matriculation as student or admission as cross-registered student in accordance with § 52 Para. 2 German Higher Education Act (HG);

	b) Earning 160 ECTS in the compulsory and elective modules; c) Earning 30 ECTS for the work experience in courses with a work experience element; d) Earning 16 ECTS for the Bachelor thesis.
6	Examination forms Oral exam
7	Requirements for awarding of credit points Pass grade for thesis seminar
8	Use of module (in other degree courses)
9	Weighting for final grade: 2.22%
10	Module advisor and principle lecturer The professor assigned for the Bachelor thesis and the second examiner.
11	Miscellaneous information

Part II

Elective modules

Note on the elective modules

The following criteria must be taken into account with respect to the availability of the elective modules:

They are only offered if:

1.) The minimum number of participants as prescribed by the dean in consultation with the faculty board is attained;

2.) The current and personal workload of the professor in question has been taken into account.

Inorganic layers					
Code W 1	Work load 180 hours	Credits 6	Semester 4th semester	Availability Summer semester	Duration 1 semester

1	Activities a) 2 CH L b) 2 CH T	Contact time 45 hours	Private study 135 hours	Planned group size 10 students

2	Learning outcomes / competencies The students know the different types of inorganic layers and their technical application possibilities. They have theoretical knowledge and practical abilities in the chemical, electrochemical and physical production of inorganic layers with functions. They know the different possibilities for verifying the function and can apply these in experiments. The students are thus capable of performing coating tasks for and functional checks on inorganic layers purposefully.
3	Contents Introduction - Types of inorganic layers and substrate classes - Bonding strength and adhesion of layers - Types of transition zones between layers and substrates - Pretreatment methods Methods of blooming and surface finishing - Physical technologies (PVD procedure) - (Evaporating technology; sputter technique; ion plating and reactive versions; ion implants) - Chemical technologies (Pyrolysis and chemosynthesis (CVD procedure); Chemically reductive separation; electrodeposition and electroplating; anodisation and anodising technology; sol-gel chemistry and dip coating - Other coating processes (Thermal spraying; surface-layer welding; plating processes, hot dip metal coating) Surface and layer verification - Spectroscopic, mechanical, electrical and electrochemical methods)
4	Teaching methods Lecture, practical
5	Prerequisites for participation Formal: 60 ECTS

6	Examination forms Written exam
7	Requirements for awarding of credit points Successful participation in practical sessions, pass grade in module exam
8	Use of module: No further use
9	Weighting for final grade: 3.33%
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Peter Meisterjahn
11	Miscellaneous information

Applications of low temperature plasma technology

Code	Work load	Credits	Semester	Availability	Duration
	180 hours	6	4th or 5th semester	Every semester (depending on demand)	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) Lecture b) Practical	45 hours	135 hours	X students

2	Learning outcomes / competencies Graduates have extensive knowledge of the application of low temperature plasmas and barrier discharges. They understand the processes and can apply them purposefully in practice.
3	Contents ⅄ Economic significance of plasma technology ⅄ Plasma theory Physics of plasmas Chemical processes in plasmas Plasma diagnosis Plasma excitation ⅄ Vacuum technology Structure and description of systems employing vacuum technology Vacuum pumps Vacuum components

	⅄ Fields of application Plasma polymerisation Cleaning and activation of surfaces Functionalisation Biocompatible surfaces Medical applications Plasma nitriding and plasma carburising ⅄ Barrier discharges Medical technology Plasma sterilisation and treatment of hard-to-heal wounds
4	Teaching methods Lecture and practical session
5	Prerequisites for participation Formal: Safety briefing for participation in practical session Content-based: Participation in the Physics II, Biophysics and Instrumental analytics modules
6	Examination forms Paper with presentation or written exam
7	Requirements for awarding of credit points Pass grade in exam
8	Use of module (in other degree courses) None
9	Weighting for final grade 3.33%
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Ihrig
11	Miscellaneous information

Occupational health and safety

Code	Work load	Credits	Semester	Availability	Duration
	120 hours	4	4th or 5th semester	Every semester (depending on demand)	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) Lecture (2 CH) b) Seminar and practical (2 CH)	45 hours	75 hours	20 students

2	**Learning outcomes / competencies** The participants will acquire extensive knowledge of the basics of occupational health and safety including legal requirements and of applying safety measures in the workplace and of the analysis methods applied in the medical sector. The aim is to be able to apply the analytical methods and measuring systems tailored to the problem, whereby sampling and evaluation methods form important aspects. The participants can evaluate the toxic potential of the most important exposures and perform risk assessments.
3	**Contents** • Basics of occupational health and safety (occupational health and safety legislation, risk assessment, limit value concept, toxicology, medical health and safety, plant safety, legal regulations such as the German Ordinance on Hazardous Substances (GefStoffV), German Law on Chemical Substances (ChemG), etc. • Hazardous substances — definition and overview • Analytical methods and analysis systems, safety engineering Measurement planning and sampling (location-based and personal), instrumental analysis systems, electrochemical sensor technology, photometric analysis, determination of exposures, new machine developments • Special, environmental medical measuring systems for monitoring workplaces and biomonitoring • Applications for different example hazardous substance groups Anthropogenic, biogenic and geogenic hazardous substances Dust and soot analysis, nanomaterials, bioaerosols Heavy metal analysis Hydrocarbons (solvents, PAK, aldehydes, etc.) Halogenised hydrocarbons (PHDD/F, PCB, etc.) Chemical indoor pollution
4	**Teaching methods** Lecture with integrated seminar and practical session
5	**Prerequisites for participation** Formal: None Content-based: None
6	**Examination forms**

	Paper with presentation
7	Requirements for awarding of credit points Pass grade in exam
8	Use of module (in other degree courses) None
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. rer. nat. D. Ihrig, Prof. Dr. rer. nat. H.M. Heise
11	Miscellaneous information

Business studies

Code	Work load	Credits	Semester	Availability	Duration
W 4	180 hours	6	4th/5th semester	Winter semester	1 semester

1	Activities Lecture: 2 CH / 22.5 hours Tutorial: 2 CH / 22.5 hours	Contact time 45 hours	Private study 135 hours	Planned group size Lecture: All
2	Learning outcomes / competencies The students should be able to define basic terms (turnover, profit, ROIs, productivity, etc.) and apply them to corporate situations. In addition, the students should acquire knowledge of the organisational structure of companies (line organisation, line and staff organisation and divisional organisation) and their legal forms (OHG, KG, AG, GmbH). Moreover, the students should also become familiar with instruments and measures from the companies' functional areas such as ABC analysis, calculating order quantities, marketing measures for improving the selling situation (advertising, pricing, etc.). The students are taught how to understand economic circumstances in the company better and assess them. More detailed teaching objectives will be provided in the course.			

3	Contents 1. Basics • Basic terms • Corporate objectives 2. Companies • Organisation • Legal forms • Social partners 3. Procurement • Procurement planning • Investment appraisal 4. Marketing • Market • Pricing
4	Teaching methods Lecture (50%), tutorial (50%)
5	Prerequisites for participation Formal: 60 ECTS
6	Examination forms Written exam
7	Requirements for awarding of credit points Pass grade in module exam
8	Use of module (in other degree courses) In “Applied Computer Science” (BPO 2009)
9	Weighting for final grade 3.33%
10	Module advisor and principle lecturer Prof. Dr. rer. pol. Jürgen Gerhardt
11	Miscellaneous information Literature: • Jung, H.: Allgemeine Betriebswirtschaftslehre, 12. Aufl., München/Wien 2010 • Schierenbeck, H.: Grundzüge der Betriebswirtschaftslehre, 17. Aufl.,

	München/Wien 2008 • Thommen, J.-P./Achleitner, A.-K.: Allgemeine Betriebswirtschaftslehre. Umfassende Einführung aus managementorientierter Sicht, 6. Aufl., Wiesbaden 2009 • Wöhe, G.: Einführung in die Allgemeine Betriebswirtschaftslehre, 24. Aufl., München 2010

Biocompatibility testing

Code	Work load	Credits	Semester	Availability	Duration
W 6	180 hours	6	4th and 5th semester	Lecture in summer semester Practical in winter semester	2 semesters

	Activities	Contact time	Private study	Planned group size
1	a) 2 CH L b) 2 CH P	45 hours	135 hours	10 students

2	Learning outcomes / competencies Teaching objectives: Acquisition of knowledge of biologically and medically relevant procedures for testing materials, knowledge of in vitro test methods for biocompatibility tests; working with scientific texts. Competencies: The student will become familiar with different requirements profiles for materials in biological systems and learn to check the suitability of materials for a certain application systematically. In this context, the student will become familiar with existing testing standards for materials in biological systems. The student is given an insight into current research activities in the field of biomaterials and has a good command of analytical evaluation of scientific texts.

3	Contents Materials in contact with biological systems, interaction between biological systems and materials, blood and tissue, adhesion processes Requirements on materials in biological systems, medical technology Basics of material testing: Mechanical properties, material fatigue, corrosion, degradation, wear Surface analytics and cytotoxicity and haemocompatibility; cell function testing, material selection, optimisation of materials for biological applications, surface modifications Corrosion processes in a biological environment, standards for testing biocompatibility, directives for approvals of medical devices in accordance with the German Medical Devices Act (MPG).
4	Teaching methods Lecture with practical
5	Prerequisites for participation Formal: 60 ECTS
6	Examination forms Written exam and tutorial attendance certificate
7	Requirements for awarding of credit points Pass grade in module exams
8	Use of module: No further use
9	Weighting for final grade: 3.33%
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Eva Eisenbarth
11	Miscellaneous information

Bionanotechnology

Code	Work load	Credits	Semester	Availability	Duration
	120 hours	X	5th semester	Every winter semester	1 semester

1	Activities a) 3 CH lecture c) 1 CH practical	Contact time 4 CH / 60 hours	Private study 60 hours	Planned group size 15 students
2	Learning outcomes / competencies The students have a basic knowledge of nanotechnologies. They know the methods and			

	procedures for production and characterising synthetic nanostructures and know natural nanostructural systems from biology. The can apply nanotechnological methods to biological systems and understand their significance for medical and biological procedures and therapies.
3	Contents 1. Structures, surfaces, particles, devices Nanotechnological tools, nanoanalytical methods and procedures Chemical procedures, physical procedures Surface modification 2. Toxicological aspects and occupational health and safety 3. Protein-based and DNA-based nanostructures Self-aggregation; molecular motors 4. Electrochemical characterisation of metallic materials for biomedical applications 5. Tissue engineering Overview of regenerative procedures, principles of tissue engineering Cell differentiation using nanoscale structures, nanostructured tissue substitute materials, cell encapsulation 6. Medical application of nanotechnology Nanotechnologically modified biomaterials via - surface modifications - optimisation of mechanical properties - Surface-specific materials Drug delivery systems - Overview of employed systems - Setting degradability - Release kinetics Nanosystems and microsystems - Pacemakers - Pump systems for drug delivery - Nanorobots 7. Nanobiomechanics Modern theory of nerve impulses (soliton theory) Mechanics of DNA Cell adhesion 8. Dynamics of horizontal gene transfer

	9. Nanobiophotonics - Confocal, 4π, STED, widefield and optical near field microscopy - Optical tweezers - Flow cytometry 10. Nanotechnology in molecular biology - Ferromagnetic nanoparticles - Emulsion PCR - Nanopore system for sequencing 11. Diagnostics - Rapid test formats - Arrays - Lab-on-a-chip technologies
4	Teaching methods Lecture, tutorial, practical
5	Prerequisites for participation Formal: -. Content-based: -
6	Examination forms Written exam
7	Requirements for awarding of credit points Successful participation in practical sessions, pass grade in module exam
8	Use of module –
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. E.Eisenbarth, Prof. Dr. K.Hennes, Prof. Dr. D.Ihrig, Prof. Dr. P.Meisterjahn, Prof. Dr. E.Rikowski, Prof. Dr. K.Stadtlander
11	Miscellaneous information - Feedback from Mj, Ihrig, Hennes, Sta,

Bioprocess engineering					
Code	Work load XX hours	Credits 6	Semester 5^{th} sem.	Availability Every winter semester	Duration 1 semester

1	Activities a) Lecture 1.5 CH b) Practical 2 CH c) Excursion 0.5 CH	Contact time 4 CH / 60 hours	Private study X hours	Planned group size 15 students

2	Learning outcomes / competencies *Acquisition of detailed knowledge of bioprocess engineering with the aim of applying this in practice tailored to the problem. The students can work basically with bioreactors. They understand the relationships between culturing cells, the massive employment of the cells in fermentation, the subsequent processing and the cost pressure when procuring the raw materials. They understand the differences between the individual processes and can estimate and decide which process would be best suited to which step in intended production.*
3	Contents *Overview of microorganisms and cells: bacteria, fungi and yeasts, algae, viruses, plant and animal cells* ***Procedural basics** of fermentation: rheology of biosuspensions, mixing and gassing, mixing times, power number (Np), power uptake of gassed and ungassed bioreactors, mass transfer, oxygen transport* ***Classification of bioreactors**, reactor types, characterisation of STR, CSTR, plug-flow reactors, loop reactor, reactor comparison, reactor construction and peripheral equipment (vessels, materials, drive, stirrers, controls and instruments, foam destroyers, pumps, incoming and outgoing air filters, sterile constructions), measuring and control engineering in the bioreactor* ***Operational modes** of reactors in general; surface and submerged fermentation; batch, fed-batch and continuous procedures* ***Bioprocess development** (phases of process development, process flow charts, necessary infrastructure, safety and environmental aspects, economic aspects) immobilisation of biocatalysts (immobilisation methods, reactors for immobilised catalysts), dismantling bioreactors, cleaning, cleaning agents* ***Scaling methods**, upscaling of laboratory processes in biotechnology* ***Course of technical fermentations**: Isolation and culturing of vaccine cultures, substrate preparation, sterilisation, fermentation, processing* *Traditional and modern **fermentation procedures** and products in pharmacology, chemistry, environmental and agricultural economics* *− Harvesting of cell substance; baker’s yeast; nutritional and feed yeasts;* *− Single-cell proteins, fermentation processes and incomplete oxidations;* *− Primary biosynthesis products, bulk chemicals; fine chemicals*

	− *Technical enzymes = biocatalysts; antibiotics, other secondary metabolites* − *Microbial substance transformation (biotransformations)*
4	Teaching methods *Traditional lecture with seminar contributions from the students. The practical session should be performed independently using original literature.*
5	Prerequisites for participation Formal: *6 ECTS* Content-based: *Successful completion of the "Biology", "Microbiology" and Biophysics/bioprocess technology" modules.*
6	Examination forms Paper, presentation and practical session report in portfolio process (30%, 30%, 40%)
7	Requirements for awarding of credit points *Pass grade in module exam*
8	Use of module (in other degree courses)
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. Klaus Stadtlander
11	Miscellaneous information Literature: 1) *H.Chmiel: Bioprozesstechnik, Elsevier (2006)* 2) *W.Storhas: Bioverfahrensentwicklung, Wiley-VCH (2003)* 3) *K.Schügerl: Bioreaktionstechnik, Birkhäuser (1997)* 4) *A.T.Jackson: Verfahrenstechnik in der Biotechnologie, Springer Verlag (1993)*

Genetic engineering

Code	Work load	Credits	Semester	Availability	Duration
WP 9	180 hours	6	5th semester	Winter semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 3 CH lecture c) 1 CH practical	45 hours	135 hours	Subgroups of 10 students
2	Learning outcomes / competencies The students know the basics of genetic engineering and as such know the significance of nanotechnology for modern genetic engineering. They can assess its applicability in technical			

	and medical procedures and can participate competently in bioethical discussions.
3	Contents Introduction to genetic engineering History of genetic engineering, cloning and PCR, plasmids, nanobiology DNA preparation and DNA manipulation Cleaning, restriction enzymes, ligation, cell integration, E. coli vectors, vectors for eukaryotic cells, biolistics with nanoparticles, selection and gene libraries, identification of clones, PCR in nanospheres Application of genetic engineering in research Basics of structural analysis, gene expression and gene function, nano-display libraries, nanopore sequencing Application of genetic engineering in biotechnology Protein production in E. coli, nanoscale inclusion bodies, protein production in eukaryotic cells, nanoparticles in cancer treatment, identification of genes causing conditions, gene therapy, applications in agriculture, genetic engineering in forensics Bioethics Innovation and ethics, biotechnological production, human cloning, medical diagnostics, foetal protection rights, cloning technology on animals, plant cultivation
4	Teaching methods Lecture with seminar elements, practical
5	Prerequisites for participation Formal: 60 ECTS. Student must have achieved a pass grade in the Molecular biology exam. Content-based: The student must have completed the Molecular biology module.
6	Examination forms Lecture with seminar elements, practical
7	Requirements for awarding of credit points Pass grade in written exam / successful participation in practical session
8	Use of module (in other degree courses) None
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Kilian Hennes
11	Miscellaneous information None

Global climate problems

Code	Work load	Credits	Semester	Availability	Duration
	180 hours	6	4th or 5th semester	Every semester (depending on demand)	1 semester

1	Activities	Contact time	Private study	Planned group size
	a) Lecture (2 CH) b) Seminar (2 CH)	45 hours	135 hours	X students

2 Learning outcomes / competencies

The participants acquire in-depth knowledge of the structure of the climate system with the aim of being able to understand the effects of human actions on climate protection and evaluating technical climate protection possibilities.

3 Contents

- Radiation budget and structure of the atmosphere

  Solar irradiation, tier structure of atmosphere, global current system, history of the atmosphere, socioeconomic influences

- Oceanology

  Measuring methods, waves and tides, dynamics (ocean currents, coupling of surface zones with deep sea, energy transport)

- Basics of meteorology

  Navier-Stokes equation, geostrophic wind, development and stabilisation of high and low pressure zones, atmospheric water balance, El Niño, collection of climatological data

- Anthropogenic changes to the Earth's climate

  Climate history, CO_2 and other trace gases, climate models, consequences of climate shifts

- Climate policies

  Energy and economic policies, CO_2 sequestration, energy policies in Germany

- Efficient energy use

  Condensing technology, thermal insulation, combined heat and power generation, combined cycle power plants, GDI/TDI engines

- Regenerative energy sources

  Thermal solar energy, photovoltaics, hydropower, wind power, short rotation forestry

4 Teaching methods

Lecture with integrated seminar

5 Prerequisites for participation

Formal: None

Content-based: None

6 Examination forms

	Paper with presentation
7	Requirements for awarding of credit points Pass grade in exam
8	Use of module (in other degree courses) None
9	Weighting for final grade 3.33%
10	Module advisor and principle lecturer Prof. Dr. rer. nat. D. Ihrig
11	Miscellaneous information

Human biology

Code	Work load	Credits	Semester	Availability	Duration
	120 hours	4	1st semester 2nd semester	Lecture: WS Practical: SS	2 semester

1	**Activities** a) Lecture b) Practical	**Contact time** 4 CH / 3 hours	**Private study** 4 hours/week	**Planned group size** 20 students

2	**Learning outcomes / competencies** • The s tudent develops a basic understanding of the structure and function of the five basic of tissue and the organs composed of them • He can describe biological processes with physical parameters and analyse them with scientific systematics.
3	**Contents** **Component I: Structure and function of human tissue and organs** • Cytology ◦ Membrane and substance transport ◦- Transport systems in eukaryotic cells ◦ Cell-cell contacts; cell-substrate contacts ◦ Protein synthesis

	• Genetics
	  ◦ Mitosis, meiosis
	  ◦ Orthogenesis
	  ◦ Mendelian genetics, Morganian genetics and eugenics
	• Histology
	  ◦ Biomedical and anatomical characteristics of tissues and organs
	• Physiology
	  ◦ Functioning of muscles, nervous system, internal organs, cardiovascular system
	  ◦ Sensory physiology
	• Biomechanics
	  ◦ Structure and function of bones and joints at rest and in motion
	
	Component II. Basics of scientific working in biology
	• Physical basics of biomechanics
	  ◦ SI units
	  ◦ Equations and dimension analysis
	• Logarithms and exponents in sensory physiology
	• Basic techniques for biological practical sessions
	  ◦ Composition of technical documents
	  ◦ Visualization and evaluation of test results

	Component III. Practical: • Histology and microscopy of tissue sections (of five basic tissue types)
4	**Teaching methods** *Lecture with practical*
5	**Prerequisites for participation** **Formal:** A pass grade in the written exams (total sum of points from both exams) in the winter semester is a prerequisite for participation in the practical session in the summer semester. **Content-based:** None
6	**Examination forms** Combination exam of 2 written exams and a paper. Each exam is worth 45% percent of the final grade; the paper for the practical session is worth 10%.
7	**Requirements for awarding of credit points** **Work load** The module covers 150 hours. Of these, 45 hours are taken up with participation in the lecture and practical session and 50 hours are taken up with preparing and tidying up after the events. 40 hours are taken up in preparation for and sitting the examinations during the course. 15 hours are assigned for free reading. Awarding of **credits** A total of 5 credits are awarded for successful completion of the module. The first

	prerequisite for the awarding of 4 credits is a pass grade in the examination element (written exam) offered at the end of the 1st semester. The prerequisite for the awarding of the additional credit (1) is successful participation in the practical session, proven by a written evaluation (protocol) over the course of the 2nd semester.
8	**Use of module** (in other degree courses) *Integrated course x, integrated course y, combination courses* *Second subject z*
9	**Weighting for final grade:**
10	**Module advisor and principle lecturer** Prof. Dr. Eva Eisenbarth, Prof. Dr. Bernward Mütterlein
11	**Miscellaneous information** Physiology: Lehrbuch by Rainer Klinke, Hans-Christian Pape, Armin Kurtz a nd Stefan Silbernagl, Thieme, Stuttgart 2009 Sobotta Lehrbuch Histologie: Urban & Fischer Verlag, Elsevier GmbH (2010) P. Rechenberg: Technisches Schreiben, Hanser 2006 K. Eden, H. Gebhard: Dokumentation in der Mess- und Prüftechnik, Vieweg+Teubner Verlag; 2012

Immunology

Code	Work load	Credits	Semester	Availability	Duration
WP 12	180 hours	6	5th sem.	Winter semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 3 CH lecture c) 1 CH practical	45 hours	135 hours	Subgroups of 10 students

2	Learning outcomes / competencies The students know the basics of immunology and can assess its applicability in technical and medical procedures. They are in a position to apply the basic immunological principles in the modification of diagnostic procedures and design assay formats of nanoscale immunosensors.
3	Contents Basics of immunology and nanobiosensors Antigen-antibody interaction, production and cleaning of antibodies, coupling of antibodies to nanoparticles, microseparation and nanoseparation, fluorescence-activated cell sorting, immobilisation, quantitative immunoassays, nanogold in immunoassays, western blot, in-situ immunolocalisation, immunoprecipitation, special immunoassays

	The adaptive immune system Antigen-antibody interaction, cellular principles, B cells and antibodies, antibody diversity, T cells and MHC proteins, activation of helper T cells and lymphocytes, Infection and diagnostics Nano dirt and innate immunity, introduction to pathogens, cell biology of infections, lateral flow assays for identifying pathogens, BioMEMS, nanoarrays
4	Teaching methods Lecture with seminar elements, practical
5	Prerequisites for participation Formal: 60 ECTS and the student must have achieved a pass grade in the Molecular biology or Cell biology exam. Content-based: The student must have completed the Molecular biology or Cell biology module.
6	Examination forms Written exam, practical session report
7	Requirements for awarding of credit points Pass grade in written exam / successful participation in practical session
8	Use of module (in other degree courses) None
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Kilian Hennes
11	Miscellaneous information

Linear optimisation

Code	Work load	Credits	Semester	Availability	Duration
W 13	180 hours	6	4th/5th semester	Annually	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 2 CH L b) 2 CH T/P	45 hours	135 hours	20 - 30
2	Learning outcomes / competencies			

	The students become familiar with the fundamental mathematical model types and the corresponding solution procedures from the field of linear optimisation. After attending the course, the students are in a position to compile a corresponding mathematical model for a definitive problem (e.g., cutting problem, mixing problem, the production planning, investment planning, etc.) and to solve paper by hand or with the help of the Excel Solver using a suitable method (e.g., the simplex method).
3	Contents The important mathematical model types and solution methods in linear optimisation are explained. Using a range of concrete examples, some of which are also solved with the help of the Excel Solver, the matter is explored in more detail, allowing students to solve optimisation problems occurring in practice. Some of the required basics from the field of mathematics (especially how to solve sets of linear equations) are revised at the beginning of the course. Contents: 1. Mathematical basics 2. Creation of optimisation models 3. Linear optimisation problems • The linear model • Graphic solution and geometric interpretation • The standard form of a linear optimisation problem • The primal simplex method • The dual simplex method • The two-phase simplex method 4. Solving linear programs with the Excel Solver
4	Teaching methods Lectures, seminars, tutorials and practical sessions
5	Prerequisites for participation Formal: 60 ECTS Content-based: Basics module in mathematics
6	Examination forms Written exam
7	Requirements for awarding of credit points Pass grade in module exam
8	Use of module (in other degree courses): No further use
9	Weighting for final grade: 3.33%
10	Module advisor and principle lecturer Prof. Dr. Hardy Moock
11	Miscellaneous information: Up-to-date literature details will be provided at the start of the course

Laboratory automation

Code	Work load	Credits	Semester	Availability	Duration
	120 hours	4	3rd semester	Every winter semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	b) Seminar 2 CH b) Tutorial 2 CH	4 CH / 60 hours	60 hours	24 students (seminar), 15 students (practical)

2 Learning outcomes / competencies

The students

- *have an overview of the problems in laboratory automation.*
- *are able to apply software engineering methods to analyse and structure smaller and medium-sized (software) projects.*
- *are in a position to realise smaller and medium-sized software projects independently with the help of the LabVIEW development environment in terms of the programming.*
- *possess the knowledge required to pass the certificate to become a CLAD (Certified LabVIEW Associate Developer) offered by National Instruments.*

3 Contents

Component 1: Seminar

- *Structured analysis (SA: dataflow diagrams, data catalogue, mini specs)*
- *Realisation of a software architecture based on finite state automata (finite state diagram, state event matrix)*
- *Introduction to the program development environment LabVIEW (as an example of structured dataflow programming)*

Component 2: Practical

- *Processing of software projects with LabVIEW (the practical tasks should vary slightly from semester to semester)*
  - *Introduction to the program development environment LabVIEW*
  - *Simulation of a simple bioreactor*
  - *Commissioning a simple bioreactor*
  - *Pattern recognition: identification of microorganisms, blister inspection, analysis of cell images (simulation)*
  - *Determination of copper sulphate concentration ($CuSO_4$) via photometer*
  - *Simple databases (cell images, histological sections)*
  - *Determination of titanium oxide thickness via potentiostat*
  - *Representation of fractals*
  - *Integration of representation of fractals in the model for a final automaton*

Component 3: Basics of academic working

- *Presentation techniques: compilation of presentations*

	(more in-depth work in subsequent modules)
4	Teaching methods *Seminar teaching with group work, learn team coaching, practical*
5	Prerequisites for participation Formal: *Pass grade in the exam in the Computer science module*
6	Examination forms *Portfolio (the elements will be notified at the beginning of the course)*
7	Requirements for awarding of credit points *Pass grade in module exam*
8	Use of module (in other degree courses) *-*
9	Weighting for final grade *4/180*
10	Module advisor and principle lecturer *Prof. Dr.-Ing. Bernward Mütterlein*
11	Miscellaneous information *Literature:* *B. Mütterlein. Handbuch für die Programmierung mit LabVIEW. Spektrum Akademischer Verlag, 2009* *J. Travis, J. Kring. LabVIEW for Everyone. Prentice Hall, 2007* *G. Reynolds. ZEN oder die Kunst der Präsentation. Addison-Wesley 2008*

Membrane technology

Code	Work load	Credits	Semester	Availability	Duration
W 16	180	6	4^{th} or 5^{th}	As required	1 semester

1	Activities a) 2 CH L + 1 CH S b) 1 CH P	Contact time 45 hours	Private study 135 hours	Planned group size 12 students
2	Learning outcomes / competencies			

	The students have a detailed knowledge of the production, characterisation and application of membranes in different technological fields (biotechnology and medical technology, foodstuffs industry, chemical industry, environmental technology, power engineering).
3	Contents Materials for the production of membranes and their characteristics Manufacturing processes for synthetic membranes Characterisation of membranes - Characterisation of porous membranes - Characterisation of ionic membranes - Characterisation of non-porous membranes Transport processes in membranes Membrane processes Osmosis, microfiltration, ultrafiltration, reverse osmosis, nanofiltration, piezodialysis Gas separation with porous and non-porous membranes, pervaporation, carrier membranes, dialysis Membrane distillation Membrane contactors Electrodialysis, membrane electrolysis, fuel cells Membrane reactors Polarisation phenomena and fouling of membranes Membrane modules and process design
4	Teaching methods Lecture, practical, seminar
5	Prerequisites for participation Formal: 60 ECTS
6	Examination forms Written exam
7	Requirements for awarding of credit points Pass grade in module exam
8	Use of module (in other degree courses): No further use
9	Weighting for final grade: 3.33%
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Eckhard Rikowski
11	Miscellaneous information

Data logging and processing

Code	Work load	Credits	Semester	Availability	Duration
	180 hours	6	4^{th} semester	Every summer semester	1 semester

1	Activities	Contact time	Private study	Planned group size
	b) Seminar 2 CH b) Practical 2 CH	4 CH / 60 hours	120 hours	10 students

2 Learning outcomes / competencies

The students

- *can apply the knowledge from the "Laboratory automation" module to design and realise a computer-assisted measuring station independently in the scope of a project.*
- *can work with the topics of bus systems and interfaces as well as the evaluation and visualization of measurement results.*
- *Have a more in-depth understanding of the collection, analysis and visualization of measurement data with the help of the LabVIEW development environment as a result.*

3 Contents

- *Bus systems and interfaces*
- *Collection of measurement data*
- *Properties of measuring equipment (e.g., accuracy, resolution, sampling rate, bandwidth)*
- *Evaluation of measurement data*

  (statistics, filtering of digital signals, signals in time and frequency range)
- *Visualization of measurement results*
- *Realisation of computer-assisted measuring station in terms of software and hardware (the students can choose the project freely from a laboratory in the field of biotechnology and nanotechnology)*

4 Teaching methods

Seminars, PBL (problem-based learning)

5 Prerequisites for participation

Formal: *Pass grade in the Laboratory automation module exam.*

6 Examination forms

Paper

7 Requirements for awarding of credit points

Pass grade in module exam

8	Use of module (in other degree courses) -
9	Weighting for final grade *6/180*
10	Module advisor and principle lecturer *Prof. Dr.-Ing. Bernward Mütterlein*
11	Miscellaneous information *Up-to-date literature details will be provided at the start of the course*

Microanalytics and nanoanalytics II

Code	Work load	Credits	Semester	Availability	Duration
W 18	180 hours	6	5th sem.	Winter semester	1 semester

1	Activities a) 2 CH L b) 2 CH P	Contact time 45 hours	Private study 135 hours	Planned group size 10 students
2	Learning outcomes / competencies The students acquire theoretical and practical knowledge about the performance and the application limits of structural characterisation processes. The acquired knowledge will be applied to different situations and improved in the practical session. The students are in a position to employ characterisation processes tailored to the problem, interpret them and evaluate them qualitatively and quantitatively thanks to their theoretical understanding.			
3	Contents Overview of structural characterisation processes – Creation and properties of electron beam and x-ray radiation – X-ray scattering and electron beam diffraction (WAXS, SAXS, ED) – Crystal structure analysis, – Transmission electron microscopy (TEM) – Element analysis methods (EDX, WDX, Auger) – Ion beam processes (SIMS,SNMS) – Oscillation rheology			
4	Teaching methods Lecture, practical, seminar			
5	Prerequisites for participation Formal: 60 ECTS **Practical**: Successful completion of the practical session in the “Physics” and “Materials” modules and participation in a safety briefing			

6	Examination forms Written exam
7	Requirements for awarding of credit points Pass grade in module exam
8	Use of module (in other degree courses): No further use
9	Weighting for final grade: 3.33%
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Nicole Rauch
11	Miscellaneous information

Molecular biology

Code	Work load	Credits	Semester	Availability	Duration
WP 18	180 hours	6	4th sem.	Summer semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 3 CH lecture c) 1 CH practical	45 hours	135 hours	Subgroups of 10 students

2	Learning outcomes / competencies The students understand selected aspects of immunology and genetic engineering via the characterisation of cellular phenomena. They have an overview of their significance for medicine, technology and nanobiological phenomena. They can clarify molecular biological principles.
3	Contents Introduction to cells and nanobiology cell features, nanochannels, nanospheres, tree of life from nanostructures, genetic information, structure and function of proteins such as nano globulins Fundamental genetic mechanisms Structure and function of DNA, chromosomal DNA, preservation of DNA sequences, DNA replication, DNA repairs, PCR DNA recombination General recombination, sequence-specific recombination, The central dogma Transcription, translation, origins of life, regulation of gene expression, cultivation of cells, nanoscale inclusion bodies, fractioning of cells and biological nanoparticles, cloning and sequencing, protein analysis, investigation of gene expression, Immunology Antibodies and antigens, innate and acquired immunity, cancer, ELISA assay, fluorescence-activated cell sorting

4	Teaching methods Lecture with seminar elements, practical
5	Prerequisites for participation Formal: 60 ECTS. Student must also have achieved a pass grade in the Microbiology exam. Content-based: The student must have completed the Microbiology module.
6	Examination forms Written exam, practical session report
7	Requirements for awarding of credit points Pass grade in written exam / successful participation in practical session
8	Use of module (in other degree courses) None
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Kilian Hennes
11	Miscellaneous information None

Organic layers I

Code	Work load	Credits	Semester	Availability	Duration
	X hours	4	4th Sem.	Every summer semester	1 semester

1	Activities a) 3 CH lecture c) 1 CH practical	Contact time X CH / x hours	Private study X hours	Planned group size 10 students
2	Learning outcomes / competencies The students are able to form coating materials with the defined properties of the coating materials and the coating on a laboratory scale and select the suitable raw materials (bonding agents, pigments, solvents and additives). This includes the generation and use of nanoscale structures.			
3	Contents General information, definitions and history of organic layers			

	Pigments and nanoparticles in organic layers - White pigments, soots - Inorganic and organic coloured pigments - Glossy and anti-corrosion pigments, fillers - General pigment properties - Introduction of pigments to coating materials Additives for organic layers - Surface-active additives - Rheology additives, light stabilisers, biocides, catalysts, drying agents Solvents for organic layers - Evaporating behaviour, burning behaviour, dissolving behaviour - Surface tension, physiological properties - Quantification of solvent content of coating materials Lacquer systems and their composition - Conventional system containing solids - 1H high solids, 2K high solids, water lacquer, powder lacquer Colour and gloss of surfaces - Physical and sensory physiological background - Colorimetry and gloss measurement
4	Teaching methods Lecture, practical
5	Prerequisites for participation Formal: -. Content-based: -
6	Examination forms Written exam
7	Requirements for awarding of credit points Successful participation in practical sessions, pass grade in module exam
8	Use of module –
9	Weighting for final grade
10	Module advisor and principle lecturer

	Prof. Dr. rer. nat. Helmut Fobbe
11	Miscellaneous information –

Organic layers II

Code	Work load	Credits	Semester	Availability	Duration
	X hours	4	5th sem.	Every winter semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 3 CH lecture c) 1 CH practical	X CH / x hours	X hours	10 students

2	**Learning outcomes / competencies** The students are able to select, realise technically and optimise a suitable cleaning, pretreatment, application and drying/curing procedure for a defined coating task. In addition, they are in a position to define and perform suitable testing methods for coating materials and coatings.
3	**Contents** Pretreatment of surfaces - Mechanical preparation - Cleaning and degreasing with solvents and aqueous systems - Cleaning of plastic surfaces - Pickling of metals - Traditional pretreatment methods: phosphatising, chromating - Alternative pretreatment methods (chemical nanotechnology): sol-gel technology, generation of nanoceramic layers - Rinsing technique Application methods - Spraying without electrical charge (pneumatic, hydraulic) - Electrically supported spraying methods (guns, caps, discs) - Booth technique - Painting, roller application, flowing coating, rolling, pouring, immersing Special lacquering methods - Powder coating

	- Electro-deposition Drying and curing procedures - Thermal drying/curing: recirculating air, infrared radiation, electrical fields - Radiation curing: UV, ESH Testing of important properties of coating materials and coatings, e.g.: - Viscosity, rheological behaviour - Layer thickness, elasticity, hardness
4	Teaching methods Lecture, practical
5	Prerequisites for participation Formal: -. Content-based: -
6	Examination forms Written exam
7	Requirements for awarding of credit points Successful participation in practical sessions, pass grade in module exam
8	Use of module –
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. rer. nat. Helmut Fobbe
11	Miscellaneous information –

Physical effects on nanostructures

Code	Work load	Credits	Semester	Availability	Duration
W	180 hours	6	4th semester	Summer semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 2 CH L	45 hours	135 hours	20 students

	b) 1 CH T c) 1 CH P			

2	Learning outcomes / competencies In this module the students learn about the basic physical effects on nanoscale structures. They can estimate the size of the effects with simple physical-mathematical models. The students are in a position to develop simple functional units to solve new technical problems by combining several physical effects.
3	Contents of the lecture: - Light as an electromagnetic wave, diffraction, interference, polarisation, interaction between light and matter, total reflection - Basics of quantum mechanics to describe free and bound electrons in a box potential, tunnel effect, harmonic oscillator, band models and application on metals and semiconductors. Effects of doping semiconductors, conductivity of nanolayers, TCO layers and applications (e.g., for liquid-crystal displays, OLEDs and organic solar cells). - Light interference in thin layers and holographic grids, evanescent wave fields and plasma resonance incl. applications, optical properties of nanoscaling structures. - Generation light with quantum dots. - Light microscopy for observing and measuring fluorescent light in quantum dots, etc. - Confocal laser scanning microscopy and manipulation of microparticles and nanoparticles with optical tweezers. - Treatment of relevant physical effects and applications on nanostructures in connection with electrons (confinement effects). - Tunnel microscopy (in practical session). - Types of liquid crystals, manufacturing and measuring of a liquid-crystal display and an organic solar cell (in the practical session). - Surface plasmon resonance experiment (in the practical session). - Optical tweezer experiment (in the practical session).
4	Teaching methods Seminar teaching
5	Prerequisites for participation Formal: 60 ECTS and pass grades in the Physics I and II and Mathematics I modules. Practical: Successful completion of the practical session in the Physics modules and participation in a safety briefing on practical sessions (offered at the beginning of the practical session).
6	Examination forms Ongoing exams through the semester, portfolio, paper or written exam
7	Requirements for awarding of credit points Pass grade in module exam
8	Use of module (in other degree courses): No further use
9	Weighting for final grade: 3.33%
10	Module advisor and principle lecturer

	Prof. Dr.rer.nat. Burkhard Neumann
11	Miscellaneous information: Up-to-date literature details will be provided at the start of the course

Control engineering and cybernetics

Code	Work load	Credits	Semester	Availability	Duration
W 21	180 hours	6	4th semester	Summer semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) Lecture: 2 CH b) Practical: 2 CH	45 hours	135 hours	a) Lecture: All b) Practical: 16 students

2 Learning outcomes / competencies

Acquisition of basic knowledge on the functional of biological, bionic and technical control circuits. Comparison of regulation and control. Structure of single-loop control circuits. Principle of negative feedback for stabilising systems and positive feedback for destabilising them. Introduction to the representation, modelling and simulation of control circuits in the time and frequency range. Evaluation of stability criteria. Selection and dimensioning of continuous controllers for a specified quality control. Simulation of closed control circuit for verification of results. Revision of command action and disturbance reaction. Prospects for multiple-size controllers. Describing controllers based on nature’s examples.

3 Contents

- Introduction to control/regulation
- Single-loop control circuit as per DIN
- Examples of regulations from biology, bionics and technology
- Analysis, modelling and synthesis of systems in the time range
- Requirements on regulations
- Elementary and composite transfer elements in the time and frequency range
- Linearisation of non-linear transfer elements
- Function block diagrams, stability criteria
- Controller design and realisation of standard controllers P, I, PI, PD and PID
- Optimisation of control circuits: rule of thumb processes, compensation in the frequency range, evolutionary optimisation
- Modelling and simulation of control circuits
- Determination and evaluation of quality control
- Controllers based on nature’s examples

4	Teaching methods Lecture (50%), practical session (50%)
5	Prerequisites for participation Formal: 60 ECTS and participation in a safety briefing for the practical session Content-based: Must have completed the Mathematics module.
6	Examination forms Written exam or paper
7	Requirements for awarding of credit points Pass grade in module exam
8	Use of module (in other degree courses) Bachelor in Applied Computer Science, Bachelor in Biotechnology and Nanotechnology
9	Weighting for final grade: 3.33%
10	Module advisor and principle lecturer Prof. Ulrich Lehmann
11	Miscellaneous information • Nachtigall, Werner: Bionik. Grundlagen und Beispiele für Ingenieure und Naturwissenschaftler. 2., vollst. neu bearb. Aufl. – Berlin; Heidelberg; New York; • Czihak, Langer, Ziegler (Hrsg.): Biologie. 5. Auflage Springer-Verlag Berlin, Heidelberg, New York 1992. p. 439, 579 to 583, 670, 673, 729. • Bishop, R. H.; Dorf, R.C.: Modern Control Systems. Reading, M.A., Addison-Wesley Publishing Company, 1995 • Busche, Peter: Elementare Regelungstechnik (Allgemeine Darstellung ohne Mathematik). Würzburg: Vogel Verlag, 1995

Sensor technology / biosensors

Code	Work load	Credits	Semester	Availability	Duration
W 24	180 hours	6	5th/6th sem.	As required	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) 3 CH L b) 1 CH T	45 hours	135 hours	10-20 students

2	Learning outcomes / competencies Acquisition of basic knowledge of sensor signal processing and sensor electronics as well as knowledge of different measuring principles and models of (sensors and) biosensors. The

	students can construct biosensors with simple materials and objects and understand the complexity of the measuring methods that will be used to get results. This allows them to employ the different measuring principles in practice and get a grasp for the feasibility of occurring problems, be they in biotechnology or in laboratory medicine.
3	Contents: Metrological basics: - Analogue and digital sensor signal processing (operational amplifier applications, analogue and digital conversion procedures) - Semiconductor sensors for gas and liquid analysis, especially ion-sensitive and gas-sensitive FETs, electrochemical, piezoelectrical and optoelectronic sensors, thermistors, enzyme/antibody electrodes; use of fluorescence and plasmon resonance for determining layer thicknesses or charging/binding of antibodies Structure of biosensors: - Enzymes; cell organelles, microorganisms; - Receptrodes, immunosensors, ABC technology - Biosensors as lab-on-a-chip or for point-of-care diagnostics Molecular design of enzymes, custom manufacturing and use with the aid of molecular-biological standard techniques Use of synthetic biology for custom use of cellulose metabolic pathways. Examples of current use of selected biosensors in laboratory medicine, diagnostics and for process control in biotechnology. The seminar demonstrates the use of alginates taking the enveloping of yeast cells in a polymer matrix as an example. An electrochemical method will be used to measure the substrate uptake during the fermentation of a model substance and the specific take-up rate calculated.
4	Teaching methods Traditional lecture with seminaristic contributions from the students The practical session should be performed independently using original literature.
5	Prerequisites for participation Formal: 60 ECTS Content-based: Successful completion of the “Materials”, “Electronics” and “Microbiology” modules
6	Examination forms Paper with presentation and protocol of the tutorials in the portfolio procedure
7	Requirements for awarding of credit points Pass grade in module exam
8	Use of module (in other degree courses): No further use
9	Weighting for final grade: 3.33%
10	Module advisor and principle lecturer: Prof. Dr. Eva Eisenbarth, Prof. Dr. Klaus Stadtlander
11	Miscellaneous information: Up-to-date literature list will be provided at beginning of course

Spectroscopic processes and biomedical applications

Code	Work load	Credits	Semester	Availability	Duration
	120 hours	4	4th or 5th semester	Every summer semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) Lecture (2 CH) b) Seminar (2 CH)	45 hours	75 hours	20 students

2 Learning outcomes / competencies

By attending the lecture and taking part in the seminar, the students will learn the basics of molecular spectroscopic methods and bioanalytics. The aim is to be able to evaluate applications for the clinical-chemical analytics and medical diagnostics. The students have knowledge of the development of new instrumental analytical methods and the equipment and components used such as radiation sources (thermal radiation sources, lasers, x-ray tubes) and detectors. To be able to describe the effects of different types of radiation on bodily materials and in the wider sense on biomaterials and the associated advantages and risks.

3 Contents

- Basics of the interaction of electromagnetic radiation of different wavelengths with matter
- Phenomena of absorption and emission, scattering, thermal effects, damage to biomolecules via radiation, protection against UV radiation
- Optical methods (UV/VIS, NIR, IR and Raman spectroscopy) in connection with the analytics of relevant biochemical substances
- Applications oximetry, measuring of stock compositions with NIR spectroscopy, cancer diagnostics, non-invasive transcutaneous measurements (example: bilirubin, blood sugar)
- IR and Raman microscopy for histological applications (microscopy of biopsies and imaging of microtome sections), clinical-chemical analytics (bodily fluids such as blood, plasma, serum, urine and gallstone analytics), use in microbiology (classification of bacteria, yeasts), examination of cell cultures (stages of the cell cycle), biotechnological examinations
- Breath gas analytics, monitoring of anaesthetic gases, indoor air monitoring in operating theatres
- Laser applications, laser safety
- Photodynamic therapy
- Imaging procedures: optical tomography including functional imaging, computer-

	assisted tomography, magnet resonance imaging, positron emission tomography
4	Teaching methods *Lecture and seminar*
5	Prerequisites for participation Formal: *None* Content-based: *Participation in the Instrumental analytics module*
6	Examination forms Paper with presentation
7	Requirements for awarding of credit points *Pass grade in module exam*
8	Use of module (in other degree courses) *None*
9	Weighting for final grade
10	Module advisor Prof. Dr. rer. nat. H.M. Heise
11	Miscellaneous information

Environmental biotechnology

Code	Work load	Credits	Semester	Availability	Duration
	XX hours	6	5th sem.	Every semester	1 semester

	Activities	Contact time	Private study	Planned group size
1	a) Lecture b) Practical tutorial c) Excursions	2 CH / 2 hours 1 CH / 1 hours 1 CH / 1 hours	60 hours	10-20 students

2	Learning outcomes / competencies In-depth knowledge of bioprocess engineering in the environment. The students have an overview with detailed knowledge of the possible and employed procedures. They understand the relationships between the usage site, the cells used and their substrate supply without forgetting the cost pressure throughout the entire procedure. They understand the differences between the individual processes with their advantages and can estimate and decide which process would be best suited to which step depending on

	requirements.
3	Contents **Introduction**: Biotechnological procedures in environmental technology, development of environmental protection in the biotechnological field. Consideration of climate change, avoidance/use of carbon dioxide, use of nanotechnology **Microbiological basics**: Fungi, algae, purple bacteria and archaea, mycorrhiza; nutritional, temperature and pH requirements of microorganisms, growth and metabolism of special microorganisms **Waste media technology**: communal and industrial waste treatment, aerobic and anaerobic processes, nitrification and denitrification, sewage sludge treatment; biological waste air purification (biofilters, biowashers); latest solutions **Biodegradation**: Biological soil rehabilitation: soil contamination, biological in-site, on-site and off-site processes; composting; **Biotechnology** in the mining and oil industry: Leaching of low-grade ores, metal harvesting with biosorption, desulphurisation with microorganisms **Microbial energy production**: Methane fermentation, composting, solar energy harvesting with algae/purple bacteria, hydrogen production with single-celled organisms and their energy consumption. Currently realised biotechnological energy harvesting possibilities **Carbon dioxide problems**: Avoidance of high CO_2 production and/or use/fixation of this gas and its binding in biomasses with the aid of green algae or purple bacteria; currently employed procedures
4	Teaching methods *Lecture with student contributions, excursions, practical tutorials.*
5	Prerequisites for participation Formal: 60 ECTS Content-based: Successful completion of the “Biology” and “Microbiology” modules.
6	Examination forms *Portfolio procedure*
7	Requirements for awarding of credit points *Successful presentation / essay / protocol of the tutorials (30%, 40%, 30%)*
8	Use of module (in other degree courses)
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. K. Stadtlander

11	Miscellaneous information — Literature *Peter Kunz: Umweltbioverfahrenstechnik, Vieweg-Verlag* *Ottow/Bidlingmaier: Umweltbiotechnologie, G.Fischer Verlag* *E.Madsen: Environmental Microbiology, Blackwell Publishing*

Environmental chemistry

Code	Work load	Credits	Semester	Availability	Duration
	X hours	X	X semester	Every summer and winter semester	X semester(s)

	Activities	Contact time	Private study	Planned group size
1	a) Lecture 3 CH b) Seminar 1 CH	X CH / x hours	X hours	X students

2	Learning outcomes / competencies The participants acquire in-depth knowledge of environmental and occupational health and safety law, can evaluate air hygiene and photochemistry problems and assess contamination with organic hazardous materials and heavy metals.
3	Contents 1 Environmental law ⅄ Emission control law ⅄ Directives and technical instructions ⅄ Guideline values and limit value systems ⅄ Hazardous stuff and occupational health and safety law 2 Chemistry of the atmosphere ⅄ Structure and composition of the atmosphere ⅄ Classical air hygiene: sulphur dioxide, nitrogen oxides, air quality in Germany, emission prognoses, smog, acid rain ⅄ Photochemistry and radical chemistry: photochemistry of CO_2, odd hydrogen, hydrocarbon radicals, halogens, ozone chemistry (Chapman cycle, catalytic reduction cycles, reservoir gases, the hole in the ozone layer, effects of the reduction of ozone in the stratosphere, ground-level ozone) ⅄ Forest decline 3 Hydrocarbons ⅄ Polychlorinated dibenzodioxins and dibenzofurans (PCDD/F) ⅄ Polychlorinated biphenyls (PVB) and related substances ⅄ Polycyclic aromatic hydrocarbons (PAHs)

	⅄ Chlorinated solvents ⅄ Pesticides and insecticides 4 Heavy metals ⅄ Work protection problems ⅄ Individual metals (Cd, Pb, Hg, Co, Mn, Ni, Cr) ⅄ German survey The lecture topics will be explored in more detail in the seminar.
4	Teaching methods *Lecture and seminar as well as excursions (e.g., Ministry of the Environment)*
5	Prerequisites for participation Formal: *None* Content-based: *None*
6	Examination forms Paper with presentation
7	Requirements for awarding of credit points *Pass grade in module exam*
8	Use of module (in other degree courses) *None*
9	Weighting for final grade
10	Module advisor and principle lecturer Prof. Dr. rer. nat. D. Ihrig
11	Miscellaneous information

Cell biology					
Code	Work load	Credits	Semester	Availability	Duration
W 27	180 hours	6	4th semester	Lecture: Every summer semester Practical: Every summer semester	1 semester

<table>
<tr><td>1</td><td>Activities
a) 2 CH L
b) 2 CH P</td><td>Contact time
45 hours</td><td>Private study
135 hours</td><td>Planned group size
10 students</td></tr>
<tr><td>2</td><td colspan="4">Learning outcomes / competencies
Teaching objectives
Acquisition of knowledge of characteristic properties of eukaryotic cells, the internal organisation of cells, cells in culture and in tissue, cell-cell interaction and modern cell culture techniques.
Competencies
The student leans different techniques for culturing cells and how to apply them. They are in a position to culture and characterise primary and established cell lines. They know all routine work required for the operation of a cell laboratory up to safety level S1.</td></tr>
<tr><td>3</td><td colspan="4">Contents
Types of cell and tissue
Ontogenesis; cell chemistry, cells in vivo and in vitro, internal organisation of cells, cell junctions
Cell behaviour in tissue: - Cell communication, - The extracellular matrix
Histology
Creation of cell cultures: Cultivation methods, cell culture media and their additives, histological and cytological staining methods
- Equipping a cell culture laboratory
Signal transduction
Hybridoma cells</td></tr>
<tr><td>4</td><td colspan="4">Teaching methods
Lecture with practical</td></tr>
<tr><td>5</td><td colspan="4">Prerequisites for participation
Formal: 60 ECTS
Content-based: The student must have passed the Biology and Microbiology modules.</td></tr>
<tr><td>6</td><td colspan="4">Examination forms:
Written exam</td></tr>
<tr><td>7</td><td colspan="4">Requirements for awarding of credit points
Pass grade in written exam and tutorial attendance certificate

Preliminary test as a prerequisite for participation in the practical session.</td></tr>
<tr><td>8</td><td colspan="4">Use of module (in other degree courses): No further use</td></tr>
<tr><td>9</td><td colspan="4">Weighting for final grade: 3.33%</td></tr>
<tr><td>10</td><td colspan="4">Module advisor and principle lecturer
Prof. Dr. Eva Eisenbarth</td></tr>
<tr><td>11</td><td colspan="4">Miscellaneous information</td></tr>
</table>