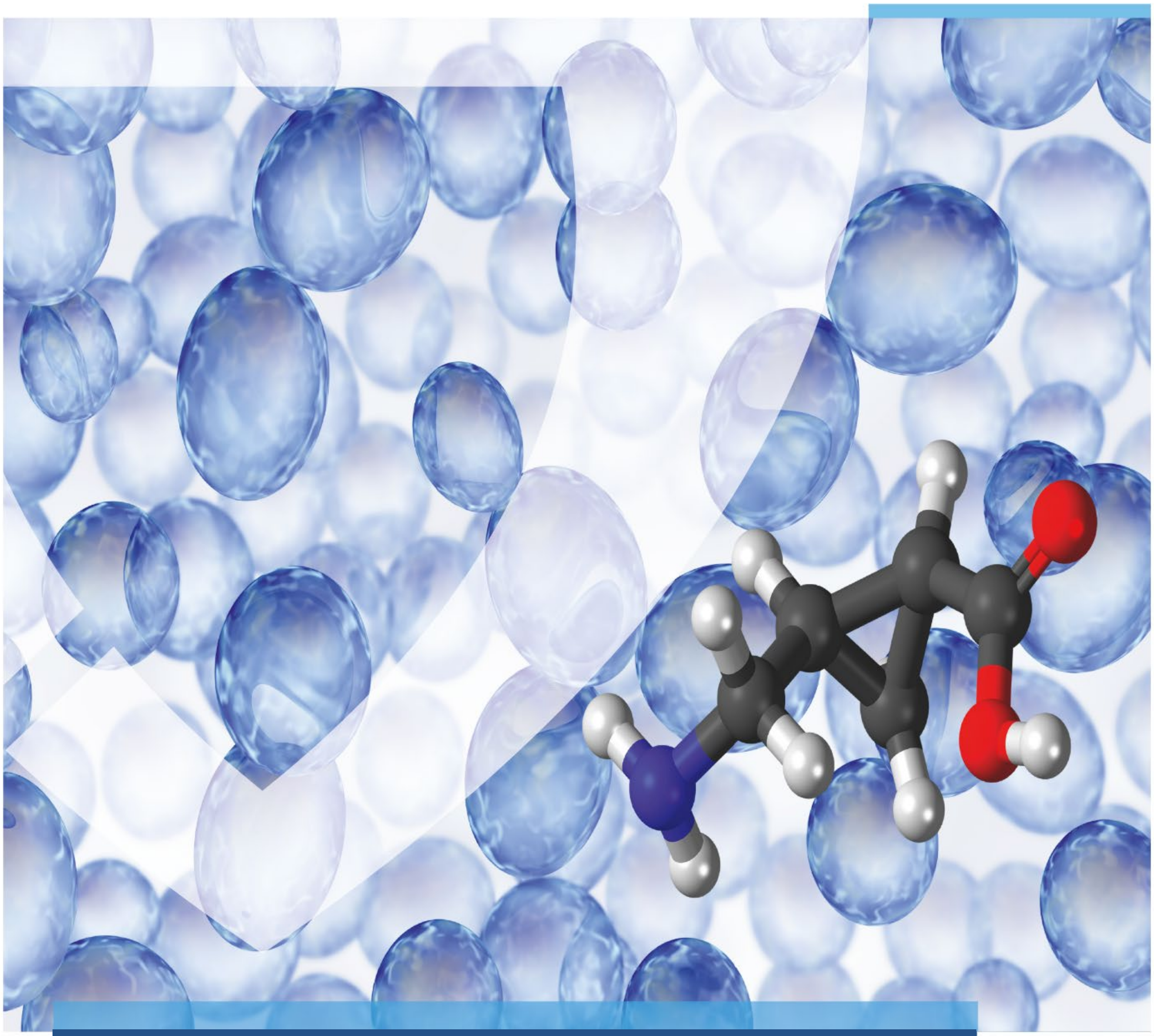
JACOBS UNIVERSITY



Study Program Handbook

Chemistry and Biotechnology

Bachelor of Science

Subject-specific Examination Regulations for Chemistry and Biotechnology (Fachspezifische Prüfungsordnung)

The subject-specific examination regulations for Chemistry and Biotechnology are defined by this program handbook and are valid only in combination with the General Examination Regulations for Undergraduate degree programs (General Examination Regulations = Rahmenprüfungsordnung). This handbook also contains the program-specific Study and Examination Plan (Chapter 6).

Upon graduation, students in this program will receive a Bachelor of Science (BSc) degree with a scope of 180 ECTS (for specifics see Chapter 6 of this handbook).

Version	**Valid as of**	**Decision**	**Details**
Fall 2022 – V1	Sep 01, 2022	Jun 26, 2019	V1 Originally approved by the Academic Senate
		May 05, 2022	V1.1 Correction of typos; Changes in Forms of Learning and Teaching in Advanced Biotechnology Lab; Module coordinator change in Jacobs Track Methods courses
		Aug 03, 2022	V1.2 Change in BQ-Modules „Ethics in Science and Technology", "Global Health" and "Global Existential Risks"
		Aug 17, 2022	V1.3 Changes in "Admission Requirements" and "Internship / Startup and Career Skills"
		Aug 31, 2022	V1.4 Merge of two modules "Physical Chemistry I + II"
		Sep 19, 2022	V1.5 Editorial change uniform specialization module text

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1 Program Overview

1.1 Concept

1.1.1 The Jacobs University Educational Concept

Jacobs University aims to educate students for both an academic and a professional career by emphasizing four core objectives: academic quality, self-development/personal growth, internationality and the ability to succeed in the working world (employability). Hence, study programs at Jacobs University offer a comprehensive, structured approach to prepare students for graduate education as well as career success by combining disciplinary depth and interdisciplinary breadth supplemental with skills education and extra-curricular elements.

In this context, it is Jacobs University's aim to educate talented young people from all over the world, regardless of nationality, religion, and material circumstances, to become citizens of the world who are able to take responsible roles for the democratic, peaceful, and sustainable development of the societies in which they live. This is achieved employing a high-level teaching as well as manageable study loads and supportive study conditions. Study programs and related study abroad programs convey academic knowledge as well as the ability to interact positively with other individuals and groups in culturally diverse environments. The ability to succeed in the working world is a core objective of the study programs of Jacobs University, both in terms of actual disciplinary subject matter and also with regard to the social skills and intercultural competence. Study-program-specific modules and additional specializations provide the necessary depth, interdisciplinary offerings and the minor option provide breadth while the university-wide general foundation and methods modules, mandatory German language requirements, and an extended internship period strengthen the employability of students. The concept of living and learning together on an international campus with many cultural and social activities supplements the students' education. In addition to that, Jacobs University offers professional advising and counseling.

Jacob University's educational concept is highly regarded both nationally and internationally. While the university has consistently achieved top marks over the last decade in Germany's most comprehensive and detailed university ranking by the Center for Higher Education (CHE), it has also been listed by the renowned Times Higher Education (THE) magazine as one of the top 300 universities worldwide (ranking group 251-300) in 2019, 2020 and 2021. The THE ranking is considered as one of the most widely observed university rankings. It is based on five major indicators: research, teaching, research impact, international orientation, and the volume of research income from industry.

1.1.2 Program Concept

Chemistry is the scientific discipline involved with elements and compounds composed of atoms, molecules, and ions, and it studies their composition, structure, behavior, and the changes they undergo during a reaction with other substances. Biotechnology is the application of biology to the solution of real-life challenges, where an element of profit is a prerequisite. The two disciplines are connected by their molecular approach and by their vast commercial importance. Both chemistry and biotechnology relate to many aspects of human life. They lie at the heart of some of the world's most advanced industries, for example, those producing goods, materials, fuels, or pharmaceuticals, as well as those focusing on sustainable energy development and even food and beverage. In particular, the chemical industry is rapidly transforming into a bio-based industry in line with the evolution of modern societies towards bio-based economies founded on sustainability and zero CO_2 emission. Fostering the synergies between chemistry and biotechnology is expected to strongly facilitate groundbreaking innovations and develop solutions for mankind's most urgent and foreseeable problems: energy, environment, food, and health. The study program Chemistry and Biotechnology (CBT) at Jacobs University supports this synergy already at the level of undergraduate education. The CBT program follows the guidelines of the GDCh[1] and the DECHEMA e.V.[2] GDCh is the central organization of chemistry in Germany and has published suggestions for studies in chemistry. DECHEMA e.V. is an expert network for chemical engineering and biotechnology.

At Jacobs University, we equip our CBT students with the knowledge, research techniques, and problem-solving skills necessary for a career in chemistry and/or biotechnology, and for further studies at the Master or PhD level. Simultaneously, we support their careers in the public or private sector, in research or management. The transdisciplinary CBT study program offers chemistry modules that include organic, inorganic, analytical, and physical chemistry; students are also taught the relevant aspects of mathematics, engineering, and industrial practice. The focus of biotechnology in this study program is to learn how industry can take advantage of biocatalysts and biomolecules in order to contribute to a more sustainable future. Biorefining, i.e the uses of renewable rather than fossil resources, is another major aspect of CBT; this will introduce students to the concept and practice of the "circular economy."

Early access to research is another central aspect of CBT. Over the course of the three-year study program, students take extensive laboratory courses and conduct their own research projects during their third year of study. Undergraduate students are strongly encouraged to engage in research projects with graduate students as early as their first or second semester at Jacobs University. Past students have contributed to and co-authored published journal articles by Jacobs University professors and their research groups.

As a consequence, students graduating with a B.Sc. degree in CBT from Jacobs University are in an excellent position to specialize in any field of chemistry, and additionally in the fields of chemical and industrial biotechnology, pharmaceutical and food technology, applied microbiology, or synthetic biology.

1 https://www.gdch.de/fileadmin/downloads/Ausbildung_und_Karriere/Schule_Studium_Ausbildung/PDF/GDCh_Studienkommission_2015.pdf

2 https://dechema.de/Empfehlungen_Ausbildung_Biotechnologie.html?highlight=Studium+Biotechnologie+Lehre

1.2 Specific Advantages of CBT at Jacobs University

- Combining chemistry and biotechnology in an undergraduate program is relatively recent, and Jacobs University is one of the few universities that offer this path. The connections and synergies between these fields become clear to the students already within the first year of study. Students also obtain an overview very early on of how these scientific fields affect society; this helps them to identify their own area of interest.
- Due to the combination of the two scientific fields, CBT students will be particularly strong in recognizing the potential of combining chemical catalysis with bioconversions in the context provided by established industrial sectors or in the creation of innovative approaches.

- The CBT program has a very strong practical component with excellent laboratory courses. This helps students gain the hands-on experience that they need to apply for high-level internships and graduate school positions. The Bachelor thesis consists of research work in the research groups of the Faculty in the Department of Life Sciences and Chemistry. The research carried out by CBT students regularly results in co-authorships of scientific publications.
- While the CBT program covers undergraduate education in Chemistry and Biotechnology, the broad experience of Jacobs University Life Sciences and Chemistry Faculty and the courses they offer also allow students to explore related subjects such as biophysics, bioinformatics, medicinal chemistry, chemical biology, drug design, marine science, food analytics, molecular immunology, biochemistry, cell biology, microbiology, and others.
- While the CBT program is essentially of an academic nature, students are exposed to practical aspects impacting industrial practice. They learn the fundamentals of engineering and economics that allow them to effectively communicate across a variety of professional roles and industries.

1.3 Program-Specific Educational Aims

1.3.1 Qualification Aims

The CBT program prepares students for an academic or professional career in the fields of Chemistry and/or Biotechnology:

- Throughout their studies, CBT students acquire profound and comprehensive theoretical knowledge in the fields of general, inorganic, and organic chemistry, biochemistry, microbiology, genetics, molecular biology, industrial microbiology, and process science, thereby gaining a thorough understanding of the principal concepts in these research and application areas. Furthermore, students learn how to abstract and transfer their knowledge to new research areas, an essential skill in the modern life sciences.
- Presentation skills are developed through scientific poster preparation and oral presentations. In this context, students are exposed to primary scientific literature.
- The theoretical education is complemented by practical training in laboratory courses in all the fields of the CBT major, both within chemistry and within biotechnology. In these courses, students acquire excellent technical skills and employ state-of-the-art methods. In addition, they learn how to accurately document and analyze scientific data through the writing of lab reports and the Bachelor thesis, all following publication-style rules.
- Through their involvement in research conducted at Jacobs University, students experience an authentic research environment that also teaches them to adhere to ethical standards and good laboratory practice. They further learn how to develop and defend their individual research project, and they acquire an early perspective on prospective careers.
- Intensive teamwork in laboratory courses and within research groups enables students to take responsibility for their own work, and they also learn how to constructively engage in international teams in an atmosphere of mutual acceptance and respect. Consequently, CBT graduates have acquired a high communication competence. They

are aware of intercultural differences and possess skills to deal with the challenges of a global job market.

1.3.2 Intended Learning Outcomes

The students will acquire skills and knowledge in the areas of

A: Chemistry and Biotechnology Related Knowledge

B: Chemistry and Biotechnology Related Intellectual Skills

C: Chemistry and Biotechnology Related Practical Skills

D: Transferable Skills

In each of these four fields, students will, by the end of the study program, be able to:

A1. recognize the fundamental properties, structures, and reactivity of chemical substances;

A2. explain the fundamental facts, principles, and theories for the principal areas of chemistry (analytical, organic, inorganic, and physical);

A3. apply physical principles to chemical and biotechnological concepts;

A4. recognize basic biochemical patterns of the structure and reactivity of molecules in nature;

A5. apply calculational tools to quantitative problems in Chemistry and Biotechnology;

A6. explain the concept of biomolecules and the use of biocatalysts for the synthesis of useful chemicals;

A7. identify possibilities to manipulate genes, enzyme activities, and metabolic pathways;

A8. explain the structure and genetic modification of microorganisms;

B1. apply chemical principles to formulate and analyze analytical and synthetic chemical problems;

B2. analyze and interpret experimental data, critically assess data in literature, and extract useful data from it;

B3. carry out directed research by selecting appropriate topics and procedures, and present the results;

B4. demonstrate appreciation of chemical and biotechnological topics relevant to environmental issues;

B5. use their knowledge to view issues in chemistry and biotechnology from a global perspective;

B6. reflect on the consequences of chemical and biotechnological activities on humanity and the environment;

C1. assess and manage the risks of chemical substances and laboratory procedures by evaluating their potential impact on the environment and the experimenter;

C2. assess and manage the risks of gene-modified organisms by evaluating their potential impact on the environment and the experimenter;

C3. conduct standard laboratory procedures involved in synthetic, analytic, and instrumental work;

C4. operate a range of chemical and biotechnological instrumentation with adequate hands-on experiences;

D1. communicate effectively both orally and in writing with professionals and/or a lay audience;

D2. possess information technology skills, especially in the areas of information retrieval, literature search, and the use of library databases;

D3. work independently and collaborate effectively with other people in a team;

D4. self-evaluate their own learning progress, and develop motivation and learning skills for lifelong learning.

1.4 Career Options

Career opportunities for CBT students are diverse and abundant. In general, the combination of chemistry and biotechnology increases employability, since biotechnological applications in chemical industry are increasingly important. Sustainability and environmental protection are topics of ever increasing importance in society and industry. In research and development, career opportunities cover the areas of chemicals, pharmaceuticals, fuels, nanotechnology, materials, and energy, to environmental monitoring and forensic science.

The educational concept of Jacobs University aims at fostering employability which refers to skills, capacities, and competencies that transcend disciplinary knowledge and allow graduates to quickly adapt to professional contexts. Jacobs University defines employability as encompassing, i.e., it focuses not only on technical skills and understanding but also on personal attributes, competencies, and qualities that enable students to become responsible members of their professional and academic fields as well as of the societies they live in.

Graduates of Jacobs University are equipped with the ability to find employment and to pursue a successful professional career, which means that graduates will be able to:

- acquire knowledge rapidly, and gather, evaluate, and interpret relevant information, and evaluate new concepts critically to derive scientifically founded judgements;
- apply their knowledge, understanding and methodological competences to their activity or profession to solve problems;
- present themselves and their ideas effectively;
- take responsibility for their own and their team's learning and development.

Graduates of Jacobs University are also equipped with a foundation to become globally responsible citizens, which includes the following attributes and qualities:

- Graduates have gained intercultural competence, and are aware of intercultural differences and possess skills to deal with intercultural challenges; they are familiar with the concept of tolerance;
- Graduates can rely on basic civic knowledge, are able to analyze global issues of an economic, political, scientific, social, or technological nature, and are able to evaluate situations and make decisions based on ethical considerations;

- Graduates are able and prepared to take responsibility for their professional community and society.

1.5 Admission Requirements

Admission to Jacobs University is selective and based on a candidate's school and/or university achievements, recommendations, self-presentation, and performance on required standardized tests. Students admitted to Jacobs University demonstrate exceptional academic achievements, intellectual creativity, and the desire and motivation to make a difference in the world.

The following documents need to be submitted with the application:

- Recommendation Letter
- Official or certified copies of high school/university transcripts
- Educational History Form
- Standardized test results (SAT/ACT) if applicable
- ZeeMee electronic resume (optional)
- Language proficiency test results (TOEFL, IELTS or equivalent)

Formal admission requirements are subject to higher education law and are outlined in the Admission and Enrollment Policy of Jacobs University.

For more detailed information about the admission visit: https://www.jacobs-university.de/study/undergraduate/application-information

1.6 More Information and Contact

For more information please contact the study program coordinator:

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visit the program website: https://www.jacobs-university.de/study/undergraduate/programs/chemistry-and-biotechnology

2 The Curricular Structure

2.1 General

The curricular structure provides multiple elements for enhancing employability, interdisciplinarity, and internationality. The unique Jacobs Track, offered across all undergraduate study programs, provides comprehensive tailor-made modules designed to achieve and foster career competency. Additionally, a mandatory internship of at least two months after the second year of study and the possibility to study abroad for one semester give students the opportunity to gain insight into the professional world, apply their intercultural competences and reflect on their role and ambitions for employment and in a globalized society.

All undergraduate programs at Jacobs University are based on a coherently modularized structure, which provides students with an extensive and flexible choice of study plans to meet the educational aims of their major as well as minor study interests and complete their studies within the regular period.

The framework policies and procedures regulating undergraduate study programs at Jacobs University can be found on the website (https://www.jacobs-university.de/academic-policies).

2.2 The Jacobs University 3C Model

Jacobs University offers study programs that comply with the regulations of the European Higher Education Area. All study programs are structured according to the European Credit Transfer System (ECTS), which facilitates credit transfer between academic institutions. The three-year under-graduate program involves six semesters of study with a total of 180 ECTS credit points (CP). The undergraduate curricular structure follows an innovative and student-centered modularization scheme - the 3C-Model - that groups the disciplinary content of the three study years according to overarching themes:

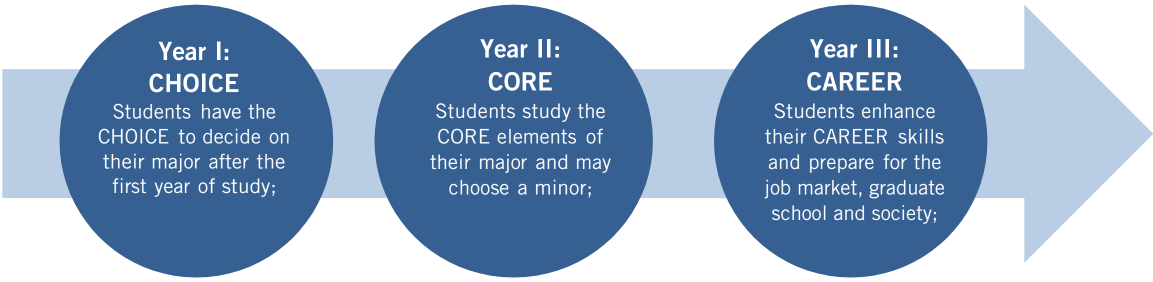


Figure 1: The Jacobs University 3C-Model

2.2.1 Year 1 – CHOICE

The first study year is characterized by a university-specific offering of disciplinary education that builds on and expands upon students' entrance qualifications. Students select introductory modules for a total of 45 CP from the CHOICE area of a variety of study programs, of which 15-30 CP will be from their intended major. As a unique asset, our curriculum structure allows students to select their major freely upon entering Jacobs University. The Academic Advising Coordinator offers curricular counseling to all Bachelor students independently of their major, while Academic Advisors support students in their decision making regarding their major study program as contact persons from faculty.

To pursue Chemistry and Biotechnology (CBT) as a major, the following CHOICE modules (30 CP) are mandatory:

- CHOICE Module: General Biochemistry (7.5 CP)
- CHOICE Module: General and Inorganic Chemistry (7.5 CP)
- CHOICE Module: Introduction to Biotechnology: Microbiology and Genetics (7.5 CP)
- CHOICE Module: General Organic Chemistry (7.5 CP)

The remaining CHOICE modules (15 CP) can be selected in the first year of study according to interest and/or with the aim of allowing a change of major up until the beginning of the second year, when the major becomes fixed (see 2.2.1.1 below).

We highly recommend the module 'General Cell Biology' (7.5 CP) to deepen knowledge in life sciences.

2.2.1.1 Major Change Option

Students can still change to another major at the beginning of the second year of study if they have taken the corresponding mandatory CHOICE modules in the first year of study. All students must participate in a seminar on the major change options in the O-Week and consult their Academic Advisor in the first year of study prior to changing their major.

CBT students who would like to retain an option for a major change are strongly recommended to register for the CHOICE modules of one of the following study programs in their first year. The module descriptions can be found in the respective Study Program Handbook.

- Biochemistry and Cell Biology (BCCB)
  CHOICE Module: General Cell Biology (7.5 CP)

- Medicinal Chemistry and Chemical Biology (MCCB)
  CHOICE Module: General Medicinal Chemistry and Chemical Biology (7.5 CP)

- Earth and Environmental Studies (EES)
  CHOICE Module: General Earth and Environmental Sciences (7.5 CP)
  CHOICE Module: General Geology (7.5 CP)

- Integrated Social and Cognitive Psychology (ISCP)
  CHOICE Module: Essentials of Cognitive Psychology (7.5 CP)
  CHOICE Module: Essentials of Social Psychology (7.5 CP)

- International Relations: Politics and History (IRPH)
  CHOICE Module: Introduction to International Relations Theory (7.5 CP)
  CHOICE Module: Introduction to Modern European History (7.5 CP)

2.2.2 Year 2 – CORE

In their second year, students take with a total of 45 CP from a selection of in-depth, discipline-specific CORE modules. Building on the introductory CHOICE modules and applying the methods and skills acquired so far (see 2.3.1), these modules aim to expand the students' critical understanding of the key theories, principles, and methods in their major for the current state of knowledge and best practice.

To pursue CBT as a major, the following 45 CP of CORE modules need to be taken:

- CORE Module: Physical Chemistry (5 CP)
- CORE Module: Industrial Biotechnology (5 CP)
- CORE Module: Advanced Inorganic Chemistry (5 CP)
- CORE Module: Scientific Software and Databanks (5 CP)
- CORE Module: Advanced Organic/Analytical Chemistry Lab (5 CP)

- CORE Module: Advanced Organic Chemistry (5 CP)
- CORE Module: Bioprocess Engineering (5 CP)
- CORE Module: Advanced Biotechnology Lab (5 CP)
- CORE Module: Inorganic/Physical Chemistry Lab (5 CP)

For students pursuing a minor in another study program (see below) the modules Scientific Software and Databanks and Advanced Biotechnology Lab can be replaced by modules of the minor study program. The module Advanced Biotechnology Lab has to be then taken in the third year as a specialization module.

2.2.2.1 Minor Option

CBT students can take CORE modules (or more advanced Specialization modules) from a second discipline, which allows them to incorporate a minor study track into their undergraduate education, within the 180 CP required for a Bachelor degree. The educational aims of a minor are to broaden the students' knowledge and skills, support the critical reflection of statements in complex contexts, foster an interdisciplinary approach to problem-solving, and to develop an individual academic and professional profile in line with students' strengths and interests. This extra qualification will be highlighted in the transcript.

The Academic Advising Coordinator, Academic Advisor, and the Study Program Chair of the minor study program support students in the realization of their minor selection; the consultation with the Academic Advisor is mandatory when choosing a minor.

As a rule, a minor in another field of study requires a CBT student to:

- take mandatory CHOICE modules (15 CP) from the desired minor program in the first year
- substitute the mandatory elective CBT CORE modules "Scientific Software and Databases" and "Advanced Biotechnology Lab" and the mandatory elective METHODS module "Plant Metabolism and Natural Products" in the second year (15 CP in total) with the minor CORE or Specialization modules of the minor study program. The module "Advanced Biotechnology Lab" must be taken in the third year when selecting the minor option (see Specialization Modules below).

The requirements for each specific minor are described in the handbook of the study program offering the minor (chapter 3.2) and are marked in the respective Study and Examination Plans. An overview of accessible minors is found in the Major/Minor Combination Matrix which is published at the beginning of each academic year.

2.2.3 Year 3 – CAREER

During their third year, students prepare and make decisions about their career path after graduation. To explore available choices and to gain professional experience, students undertake a mandatory summer internship. The third year of studies allows CBT students to take Specialization modules within their discipline, but also focuses on the responsibility of students beyond their discipline (see Jacobs Track).

The fifth semester also opens a mobility window for a diverse range of study abroad options. Finally, the sixth semester is dedicated to fostering the students' research experience by involving them in an extended Bachelor thesis project.

2.2.3.1 Internship / Start-up and Career Skills Module

As a core element of Jacobs University's employability approach students are required to engage in a mandatory two-month internship of 15 CP that will usually be completed during the summer between the second and third year of study. This gives students the opportunity to gain first-hand practical experience in a professional environment, apply their knowledge and understanding to a professional context, reflect on the relevance of their major in employment and society, reflect on their own role in employment and society, and find professional orientation. The internship can also establish valuable contacts for the student's Bachelor thesis project, for the selection of a Master program, or further employment after graduation. The module is complemented by career advising and several career skills workshops throughout all six semesters that prepare students for the transition from student life to professional life. As an alternative to the full-time internship, students interested in setting up their own company can apply for a start-up option to focus on the development of their business plan.

For further information, please contact the Career Services Center (https://www.jacobs-university.de/career-services)

2.2.3.2 Specialization Modules

In the third year of their studies, students take 15 CP from major-specific or major-related, advanced Specialization Modules to consolidate their knowledge and to be exposed to state-of-the-art research in the areas of their interest. This curricular component is offered as a portfolio of modules, from which students can make free selections during their fifth and sixth semester. The default Specialization Module size is 5 CP, with smaller 2.5 CP modules being possible as justified exceptions.

To pursue CBT as a major, at least 10 of the 15 CP from the following major-specific Specialization Modules need to be taken:

- CBT Specialization: Organometallic Chemistry (5 CP)
- CBT Specialization: Environmental Microbiology and Biotechnology (5 CP)
- CBT Specialization: Chemical and Pharmaceutical Technology (5 CP)

A maximum of 5 CP can be taken from major-related modules instead of major-specific Specialization Modules:

- MCCB Specialization: Advanced Organic Synthesis (from MCCB) (5 CP)
- MCCB Specialization: Fluorine in Drug Development (2.5 CP)
- MCCB CORE: Medicinal Chemistry (5 CP)
- EES CORE: Environmental Science (7.5 CP)*
  *due to the size of the module students who take the module may exceed the workload of 30 CP per semester.

Students may also select 15 CP entirely from their major-specific Specialization Modules. For detailed information on the contents of the Specialization modules, the reader is referred to the respective module descriptions.

Students pursuing a minor (see above) must take the CORE module Advanced Biotechnology Lab (5 CP) instead of a specialization module.

2.2.3.3 Study Abroad

Students have the opportunity to study abroad for a semester to extend their knowledge and abilities, broaden their horizons and reflect on their values and behavior in a different context as well as on their role in a global society. For a semester abroad (usually the fifth semester), modules related to the major with a workload equivalent to 22.5 CP must be completed. Modules recognized as study abroad CP need to be pre-approved according to Jacobs University study abroad procedures. Several exchange programs allow students to directly enroll at prestigious partner institutions worldwide. Jacobs University's participation in Erasmus+, the European Union's exchange program, provides an exchange semester at a number of European universities that include Erasmus study abroad funding.

For further information, please contact the International Office (https://www.jacobs-university.de/study/international-office)

CBT students that wish to pursue a study abroad in their fifth semester are required to select their modules at the study abroad partners such that they can be used to substitute between 10-15 CP of major-specific Specialization modules and between 5-15 CP of modules equivalent to the non-disciplinary Big Questions modules or the Community Impact Project (see Jacobs Track). In their sixth semester, according to the study plan, returning study-abroad students complete the Bachelor Thesis/Seminar module (see next section), they take any missing Specialization modules to reach the required 15 CP in this area, and they take any missing Big Questions modules to reach 15 CP in this area. Study abroad students are allowed to substitute the 5 CP Community Impact Project (see Jacobs Track below) with 5 CP of Big Questions modules.

2.2.3.4 Bachelor Thesis/Seminar Module

This module is a mandatory graduation requirement for all undergraduate students. It consists of two module components in the major study program guided by a Jacobs faculty member: the Bachelor Thesis (12 CP) and a Seminar (3 CP). The title of the thesis will appear on the transcript.

Within this module, students apply the knowledge, skills, and methods they have acquired in their major discipline to become acquainted with actual research topics, ranging from the identification of suitable (short-term) research projects, preparatory literature searches, the realization of discipline-specific research, and the documentation, discussion, and interpretation of the results.

With their Bachelor Thesis, students demonstrate mastery of the contents and methods of the major-specific research field. Furthermore, students show the ability to analyze and solve a well-defined problem with scientific approaches, a critical reflection of the status quo in scientific literature, and the original development of their own ideas. With the permission of a Jacobs Faculty supervisor, the Bachelor Thesis can also have an interdisciplinary nature. In the seminar, students present and discuss their theses in a course environment and reflect on their theoretical or experimental approach and conduct. They learn to present their chosen research topics concisely and comprehensibly in front of an audience and to explain their methods, solutions and results with both specialists and non-specialists.

2.3 The Jacobs Track

The Jacobs Track, another important feature of Jacobs University's educational model, runs parallel to the disciplinary CHOICE, CORE, and CAREER modules across all study years and is an integral part of all undergraduate study programs. It reflects a university-wide commitment to an in-depth training in scientific methods, fosters an interdisciplinary approach, raises awareness of global challenges and societal responsibility, enhances employability, and equips students with extra augmented skills desirable in the general field of study. Additionally, it integrates (German) language and culture modules.

2.3.1 Methods and Skills modules

Methods and skills such as mathematics, statistics, programming, data handling, presentation skills, academic writing, and scientific and experimental skills are offered to all students as part of the Methods and Skills area in their curriculum. The modules that are specifically assigned to the study programs equip students with transferable academic skills. They convey and practice specific methods that are indispensable for each students' chosen study program. Students are required to take 20 CP in the Methods and Skills area. The size of all Methods and Skills modules is 5 CP.

To pursue CBT as a major, the following Methods and Skills modules (20 CP) need to be taken as mandatory modules:

Methods Module: Mathematical Concepts for the Sciences (5 CP)

Methods Module: Physics for the Natural Sciences (5 CP)

Methods Module: Analytical Methods (5 CP)

Methods Module: Plant Metabolites and Natural Products (5 CP)

The Module Plant Metabolites and Natural Products can be replaced with a CORE module from another study program in order to pursue a minor.

2.3.2 Big Questions modules

The modules in the Big Questions area (10 CP) intend to broaden the students' horizons with applied problem solving between and beyond their chosen disciplines. The offerings comprise problem-solving oriented modules that tackle global challenges from the perspectives of different disciplinary backgrounds and that allow, in particular, for a reflection of the acquired disciplinary knowledge in economic, societal, technological, and/or ecological contexts. Working together with students from different disciplines and cultural backgrounds, these modules cross the boundaries of traditional academic disciplines.

Students are required to take 10 CP from modules in the Area. This curricular component is offered as a portfolio of modules, from which students can make selections during their fifth and sixth semester, with the aim of achieving exposure to the full spectrum of economical, societal, technological, and/or ecological contexts. The size of Big Questions Modules is either 2.5 or 5 CP.

CBT students take Ethics in Science and Technology (5 CP) as a mandatory module. For the remaining 5 CP the students can select freely among the offered modules. However, it is recommended for CBT students to take the module "Sustainable Value Creation with Biotechnology. From Science to Business (2.5 CP)."

2.3.3 Community Impact Project

In their fifth semester students are required to take a 5 CP Community Impact Project (CIP) module. Students engage in on-campus or off-campus activities that challenge their social responsibility, i.e., they typically work on major-related projects that make a difference in the community life on campus, in its campus neighborhood, Bremen, or on a cross-regional level. The project is supervised by a faculty coordinator and mentors.

Study abroad students are allowed to substitute the 5-CP Community Impact Project with 5 CP of Big Questions modules.

2.3.4 Language Modules

Communication skills and foreign language abilites foster students' intercultural awareness and enhance their employability in an increasingly globalized and interconnected world. Jacobs University supports its students in acquiring and improving these skills by offering a variety of language modules at all proficiency levels. Emphasis is put on fostering the German language skills of international students as they are an important prerequisite for non-native students to learn about, explore, and eventually integrate into their host country and its professional environment. Students who meet the required German proficiency level (e.g., native speakers) are required to select modules in any other modern foreign language offered (Chinese, French or Spanish). Hence, acquiring 10 CP in language modules, with German mandatory for non-native speakers, is a requirement for all students. This curricular component is offered as a four-semester sequence of foreign language modules. The size of the Language Modules is 2.5 CP.

3 CBT as a Minor

The typical target group aiming at a Minor in CBT are students of the majors BCCB and MCCB with an interest in biotechnology and a deepened understanding of chemistry.

3.1 Qualification Aims

The students learn about physical-chemical laws of broad applications to their own major, deepen their knowledge of bioconversions and their industrial applications in the production of food, chemicals, fuels, and pharmaceuticals, and become familiar with concepts in inorganic chemistry relevant to structure and bonding, metal complexes, and spectroscopic properties.

3.1.1 Intended Learning Outcomes

With a minor in CBT, students are able to:

- Recognize fundamental properties, structures, and the reactivity of inorganic substances
- Apply calculational tools to quantitative problems in Chemistry and Biotechnology
- Explain the concept of biomolecules and the use of biocatalysts for the synthesis of useful chemicals
- Identify possibilities to manipulate genes, enzyme activities, and metabolic pathways

3.2 Module Requirements

A minor in CBT requires 30 CP. The default option to obtain a minor in CBT is marked in the Study and Examination Plans. It consists of the following CHOICE and CORE modules:

- CHOICE Module: General and Inorganic Chemistry (7.5 CP)
- CHOICE Module: Introduction to Biotechnology: Microbiology and Genetics (7.5 CP)
- CORE Module: Industrial Biotechnology (5 CP)
- CORE Module: Physical Chemistry (5 CP)
- CORE Module: Advanced Inorganic Chemistry (5 CP)

Students from majors other than BCCB or MCCB are strongly advised to have prior knowledge of organic chemistry, biomolecules, and the fundamentals of enzymatic reactions.

3.3 Degree

After successful completion, the minor in CBT will be listed on the final transcript under PROGRAM OF STUDY and BA/BSc – [name of the major] as "(Minor: Chemistry and Biotechnology)."

4 CBT Undergraduate Program Regulations

4.1 Scope of these Regulations

The regulations in this handbook are valid for all students who enter the CBT undergraduate program at Jacobs University in Fall 2021. In case of a conflict between the regulations in this handbook and the general Policies for Bachelor Studies, the latter applies (see http://www.jacobs-university.de/academic-policies).

In exceptional cases, certain necessary deviations from the regulations of this study handbook might occur during the course of study (e.g., change of the semester sequence, assessment type, or the teaching mode of courses).

In general, Jacobs University Bremen reserves therefore the right to change or modify the regulations of the program handbook also after its publication at any time and in its sole discretion.

4.2 Degree

Upon successful completion of the study program, students are awarded a Bachelor of Science degree in Chemistry and Biotechnology.

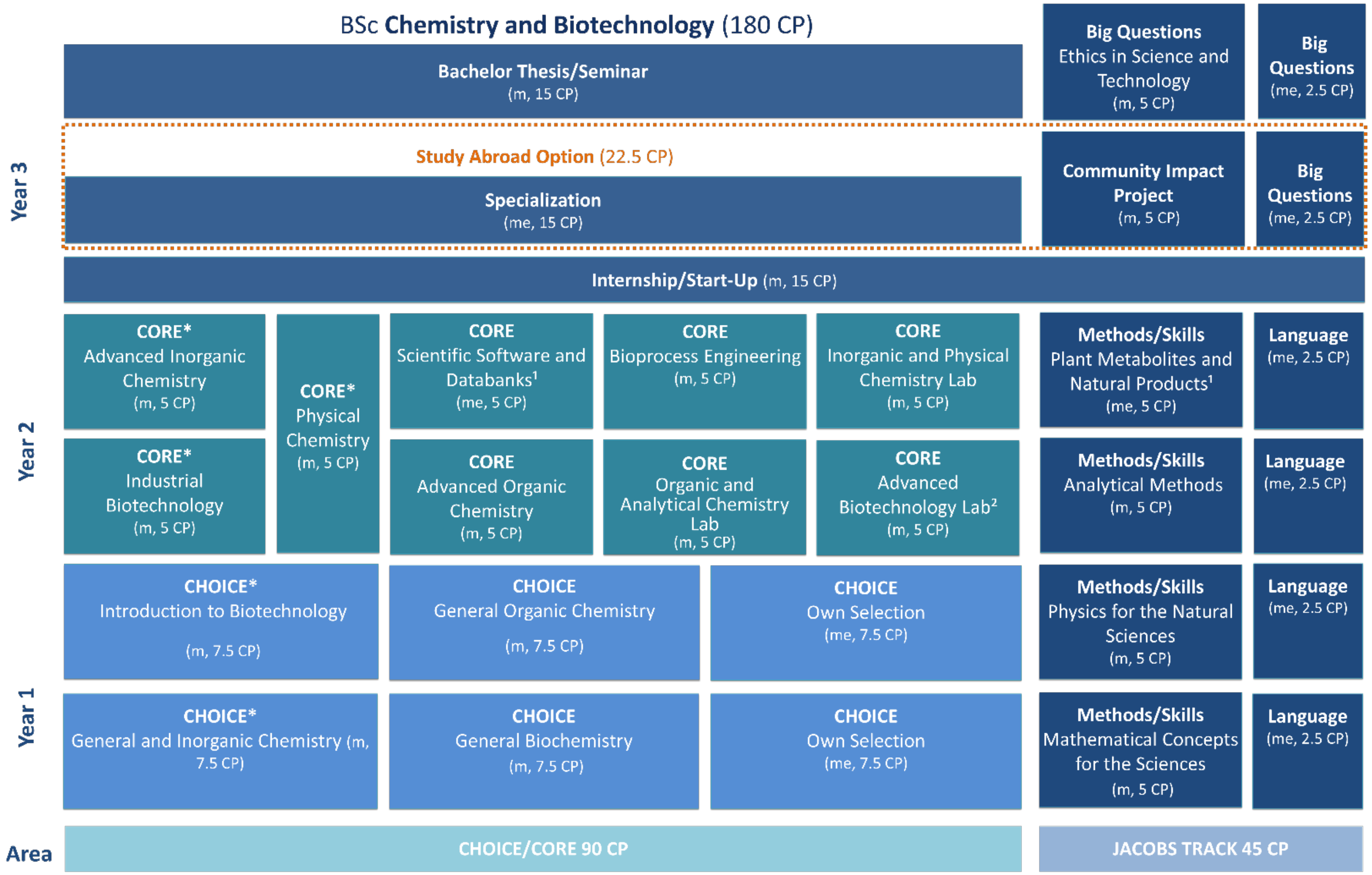
4.3 Graduation Requirements

In order to graduate, students need to obtain 180 credit points. In addition, the following graduation requirement applies:

Students need to complete all mandatory components of the program as indicated in the Study and Examination Plan in Chapter 6 of this handbook.

5 Schematic Study Plan for CBT

Figure 2 shows schematically the sequence and types of modules required for the study program. A more detailed description, including the assessment types, is given in the Study and Examination Plans in the following section.



* mandatory for minor students
m = mandatory
me = mandatory elective
¹ Module can be replaced with a CORE module from another study program in order to pursue a minor.
² Module can be replaced with a CORE module from another study program in order to pursue a minor, but has to be taken in Year 3, replacing one specialization module

Figure 2: Schematic Study Plan

6 Study and Examination Plan

Chemistry and Biotechnology BSc

Matriculation Fall 2022

	Program-Specific Modules	Type	Assessment	Period	Status[1]	Sem.	CP
Year 1 - CHOICE							**45**
Take the mandatory CHOICE modules listed below. This is a requirement for the CBT program.[2]							
	Unit: Chemistry and Biotechnology *(default minor)*						
CH-120	**Module: General and Inorganic Chemistry** *(default minor)*				**m**	**1**	**7.5**
CH-120-A	General and Inorganic Chemistry	Lecture	Written examination	Examination period			5
CH-120-B	General and Inorganic Chemistry Lab	Lab	Lab report	During the semester			2.5
CH-121	**Module: Introduction to Biotechnology: Microbiology and Genetics (default minor)**				**m**	**2**	**7.5**
CH-121-A	Introduction to Biotechnology	Lecture	Written examination	Examination period			5
CH-121-B	Biotechnology Lab	Lab	Written examination	Examination period			2.5
	Unit: Mixed unit (BCCB and MCCB)						
CH-100	**Module: General Biochemistry**				**m**	**1**	**7.5**
CH-100-A	General Biochemistry	Lecture	Written examination	Examination period			5
CH-100-B	General Biochemistry Lab	Lab	Lab report	During the semester			2.5
CH-111	**Module: General Organic Chemistry**				**m**	**2**	**7.5**
CH-111-A	General Organic Chemistry	Lecture	Written examination	Examination period			5
CH-111-B	General Organic Chemistry Lab	Lab	Lab report	During the semester			2.5
	Unit: CHOICE (own selection)					**1/2**	**15**
Take two further CHOICE modules from those offered for all other study programs.[2]							
Year 2 - CORE							**45**
Take all modules listed below or replace mandatory elective ("me") CORE/Methods modules (15 CP) by suitable CORE modules from other study programs.[2]							
.	**Unit: Inorganic and Physical Chemistry and Industrial Biotechnology**						
CO-440	**Module: Physical Chemistry** *(default minor)*				**m**	**3+4**	**5**
CO-440-A	Physical Chemistry	Lecture	Written examination / presentation	Examination period / During the semester		3+4	
CO-441	**Module: Industrial Biotechnology** *(default minor)*				**m**	**3**	**5**
CO-441-A	Industrial Biotechnology	Lecture	Written examination	Examination period			
CO-442	**Module: Advanced Inorganic Chemistry** *(default minor)*				**m**	**4**	**5**
CO-442-A	Advanced Inorganic Chemistry	Lecture	Written examination	Examination period			
	Unit: Organic and Analytical Chemistry (shared with MCCB)						
CO-423	**Module: Advanced Organic Chemistry**				**m**	**3**	**5**
CO-423-A	Advanced Organic Chemistry	Lecture	Written examination	Examination period			
CO-443	**Module: Scientific Software and Databases**				**me**[3]	**4**	**5**
CO-443-A	Scientific Software and Databases	Seminar	Term Paper	During the semester			
CO-424	**Module: Advanced Organic and Analytical Chemistry Lab**				**m**	**3**	**5**
CO-424-A	Advanced Organic Chemistry Lab	Lab	Lab report	During the semester			2.5
CO-424-B	Analytical Chemistry Lab	Lab	Lab report	During the semester			2.5
	Unit: Advanced Chemistry and Biotechnology						
CO-444	**Module: Bioprocess Engineering**				**m**	**4**	**5**
CO-444-A	Bioprocess Engineering	Lecture	Written examination	Examination period			
CO-445	**Module: Advanced Biotechnology Lab**				**m**[4]	**3**	**5**
CO-445-A	Advanced Biotechnology Lab	Lab	Written examination	During the semester			
CO-446	**Module: Inorganic and Physical Chemistry Lab**				**m**	**4**	**5**
CO-446-A	Inorganic Chemistry Lab	Lab	Lab Report	During the semester			2.5
CO-446-B	Physical Chemistry Lab	Lab	Project	During the semester			2.5
Year 3 - CAREER							**45**
CA-INT-900	**Module: Internship / Startup and Career Skills**				**m**	**4/5**	**15**
CA-INT-9000	Internship / Startup and Career Skills		Report and Presentation (Business Plan)	During the 5th semester			15
CA-CBT-800	**Module: Thesis / Seminar CBT**				**m**	**6**	**15**
CA-CBT-800-T	Thesis CBT	Thesis	Project/Thesis	15th of May			12
CA-CBT-800-S	Seminar CBT	Seminar	Presentation	During the semester			3
	Unit: Specialization CBT (at least one specialization module from Biotechnology)				**m**		**15**
l 15 CP of specialization modules							
CA-S-CBT-801	**Specialization Module:**				**me**	**5**	**5**
CA-CBT-801	Chemical and Pharmaceutical Technology	Lecture	Written examination	Examination period			
CA-S-CBT-802	**Specialization Module:**				**me**	**5**	**5**
CA-CBT-802	Organometallic Chemistry	Lecture	Oral examination	Examination period			
CA-S-CBT-804	**Specialization Module:**				**me**	**6**	**5**
CA-CBT-804	Environmental Microbiology and Biotechnology	Lecture	Written examination	Examination period			
Specialization electives from MCCB, EES and BCCB (see study program handbook for further information)					**me**	**5/6**	**5/7.5**

	Jacobs Track Modules (General Education)	Type	Assessment	Period	Status[1]	Sem.	CP
Year 1							**15**
	Unit: Methods / Skills						**10**
JTMS-MAT-07	**Module: Mathematical Concepts for the Sciences**				**m**	**1**	**5**
JTMS-07	Mathematical Concepts for the Sciences	Lecture	Written examination	Examination period			5
JTMS-SCI-17	**Module: Physics for the Natural Sciences**				**m**	**2**	**5**
JTMS-17	Physics for the Natural Sciences	Lecture	Written examination	Examination period			5
	Unit: Language				**m**		**5**
	German is default language. Native German speakers take modules in another offered language.						
JTLA-xxx	**Module: Language 1**				**m**	**1**	**2.5**
JTLA-xxx	Language 1	Seminar	Various	Various	me		
JTLA-xxx	**Module: Language 2**				**m**	**2**	**2.5**
JTLA-xxx	Language 2	Seminar	Various	Various	me		
Year 2							**15**
	Unit: Methods / Skills						**10**
JTMS-SCI-16	**Module: Analytical Methods**				**m**	**3**	**5**
JTMS-16	Analytical Methods	Lecture	Written examination	Examination period			
JTMS-18	Plant Metabolites and Natural Products	Lecture	Written examination	Examination period			
	Unit: Language				**m**		**5**
	German is default language. Native German speakers take modules in another offered language.						
JTLA-xxx	**Module: Language 3**				**m**	**3**	**2.5**
JTLA-xxx	Language 3	Seminar	Various	Various	me		
JTLA-xxx	**Module: Language 4**				**m**	**4**	**2.5**
JTLA-xxx	Language 4	Seminar	Various	Various	me		
Year 3							**15**
	Unit: Big Questions						**10**
JTBQ-BQ-003	**Module: Ethics in the Sciences and Technology**				**m**	**5**	**5**
JTBQ-003	Module: Ethics in the Sciences and Technology	Lecture	Written examination / presentation	Examination period	m		5
Take a total of 5 CP of further Big Questions modules (each 2.5 or 5 CP) as mandatory elective		Various	Various	Various	me		5
	Unit: Community Impact Project						**5**
JTCI-CI-950	**Module: Community Impact Project**				**m**	**5**	**5**
JTCI-950	Community Impact Project	Project	Project	Examination period			

Total CP	**180**

[1] Status (m = mandatory, me = mandatory elective)

[2] For a full listing of all CHOICE / CORE / CAREER / Jacobs Track modules please consult the **CampusNet online catalogue** and /or the study program handbooks.

3 Module can be replaced with a CORE module from another study program in order to pursue a minor

[4] Module can be replaced with a CORE module from another study program in order to pursue a minor, but has to be taken in Year 3, replacing one specialization module

Figure 3: Study and Examination Plan

7 Chemistry and Biotechnology Modules

7.1 General and Inorganic Chemistry

Module Name		*Module Code*	*Level (type)*	*CP*
General and Inorganic Chemistry		CH-120	Year 1 (CHOICE)	7.5
Module Components				
Number	*Name*		*Type*	*CP*
CH-120-A	General and Inorganic Chemistry		Lecture	5
CH-120-B	General and Inorganic Chemistry Lab		Lab	2.5
Module Coordinator Prof. Dr. Ulrich Kortz	*Program Affiliation* • Chemistry and Biotechnology (CBT)		*Mandatory Status* Mandatory for CBT and BCCB	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None *Knowledge, Abilities, or Skills* • None	*Frequency* Annually (Fall)	*Forms of Learning and Teaching* • Lecture (35 hours) • Tutorial (10 hours) • Private study for the lecture (75 hours) • Lab (26 hours) • Private study for the lab (41.5 hours)	
		Duration 1 semester	*Workload* 187.5 hours	

Recommendations for Preparation

Early reading, extensive note taking and self-testing, work through practice problems, and fully understand the material before entering the laboratory and the risks associated with the daily goals.

Content and Educational Aims

This module provides a theoretical introduction to general and inorganic chemistry covering the areas of chemical foundations, atoms, molecules, ions, stoichiometry, types of chemical reactions and solution stoichiometry, gases, atomic structure and periodicity, bonding (general concepts), covalent bonding (orbitals), chemical equilibrium, acids and bases, and acid-base equilibria. Furthermore, students learn the practical foundation principles of chemistry, including basic laboratory techniques, the qualitative analysis of anions and cations, strong/weak acids and bases, titrations, the solubility of salts, crystallization, redox reactions, gravimetric analysis, volumetric analysis, complex formation, and the synthesis of nanoparticles.

Intended Learning Outcomes

By the end of the module, the student will be able to

- Discuss basic concepts in general and inorganic chemistry
- Recognize general properties of matter
- Engage in fundamental concepts in measurements and moles
- Identify basic types of chemical reactions
- Perform stoichiometric calculations
- Predict the general properties of gases

- Understand elements and trends in the periodic table
- Recognize and discuss basic concepts of chemical bonding
- Predict the reactivity of elements and compounds
- Find the locations and operating procedures of all safety equipment including the first aid kit, eyewash station, safety shower, fire extinguisher, and fire blanket
- Use lab equipment and be familiar with key aspects of working in a laboratory environment
- Correlate the theoretical concepts they learn in class and the actual experimental application of the various hypotheses, laws, techniques, materials, reactions, and instruments
- Perform qualitative and quantitative determination of unknowns and know how to handle and analyze chemical compounds
- Write proper lab reports
- Properly dispose of chemical waste

Indicative Literature

Zumdahl and Zumdahl, Chemistry, 9th edition, Brooks Cole, 2014;

Higson, Analytical Chemistry, Oxford University Press, 2005, or latest edition as appropriate, Parts 1 and 2;

Jeffrey et.al., Vogel's Textbook of Quantitative Chemical Analysis, Longman Group UK Limited, 5th edition, 1989;

Course Handout.

Usability and Relationship to Other Modules

- This module provides fundamental knowledge of chemistry and is a foundation for all other modules in CBT, BCCB, and MCCB
- Mandatory for a major in CBT and BCCB
- Mandatory for a minor in CBT
- Prerequisite for first-year CHOICE modules "Introduction to Biotechnology: Microbiology and Genetics" and "General Organic Chemistry"
- Prerequisite for second-year CORE modules "Physical Chemistry," "Advanced Inorganic Chemistry," "Scientific Software and Databases" and "Inorganic and Physical Chemistry Lab"
- Prerequisites for third-year Specialization modules "Supramolecular Chemistry," "Environmental Microbiology and Biotechnology" and "Organometallic Chemistry"
- Elective for all other undergraduate study programs

Examination Type: Module Component Examinations

Module Component 1: Lecture

Assessment Type: Written examination — Duration: 120 min, Weight: 67%

Scope: Intended learning outcomes of the lecture (1-9);

Module Component 2: Lab

Assessment Type: Lab reports, lab performance — Length: 4-6 pages per report, Weight: 33%

Scope: Intended learning outcomes of the laboratory course (4, 5, 10-15)

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.2 Introduction to Biotechnology: Microbiology and Genetics

<table>
<tr><td colspan="2">Module Name
Introduction to Biotechnology: Microbiology and Genetics</td><td>Module Code
CH-121</td><td>Level (type)
Year 1
(CHOICE)</td><td>CP
7.5</td></tr>
<tr><td colspan="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CH-121-A</td><td colspan="2">Introduction to Biotechnology</td><td>Lecture and tutorial</td><td>5</td></tr>
<tr><td>CH-121-B</td><td colspan="2">Biotechnology Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Elke Nevoigt</td><td colspan="2">Program Affiliation

• Chemistry and Biotechnology (CBT)</td><td colspan="2">Mandatory Status

Mandatory for CBT</td></tr>
<tr><td colspan="2" rowspan="2">Entry Requirements

Pre-requisites
☒ General and Inorganic Chemistry
☒ General Biochemistry

Co-requisites
☒ None

Knowledge, Abilities, or Skills
• General understanding of biomolecules and chemistry from the lectures General Biochemistry and General and Inorganic Chemistry</td><td>Frequency

Annually
(Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lecture and tutorial (45 hours)
• Lab (30 hours)
• Private study (65 hours)
• Exam preparation (47.5 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

187.5 hours</td></tr>
<tr><td colspan="5">Recommendations for Preparation

Read the manual for the laboratory course early and fully understand the material before entering the laboratory. Know the risks associated with the daily goals. Prepare MSDS sheets for the hazardous chemicals used in the lab course;</td></tr>
<tr><td colspan="5">Content and Educational Aims
Biotechnology is the application of biology. More specifically, it is the application of cells or their ingredients (e.g., enzymes) for the development of products or processes for human use. The major goal of the module Introduction to Biotechnology is to provide the relevant fundamentals in microbiology (cell structure, nutrition and growth, diversity/evolution, genetics, molecular biology, and genetic engineering). The focus is on prokaryotic and eukaryotic model microorganisms. A brief introduction to metabolism, enzymes, and metabolic engineering is also included. The laboratory course makes students familiar with the work in a molecular biotechnology lab. Besides amplifying their basic laboratory skills (e.g., preparation of buffers and solutions including respective calculations, pH-adjustment, pipetting, and centrifugation), students practice fundamental methods for isolation and analysis of nucleic acids (genomic DNA extraction, RNA degradation, use of polymerase chain reaction, and restriction endonucleases for diagnostic purposes, agarose gel electrophoresis, visualization and quantification of nucleic acids) as well as of proteins (preparation of protein extracts from cells and quantification of proteins in solution).</td></tr>
<tr><td colspan="5">Intended Learning Outcomes</td></tr>
</table>

By the end of the module, the student will be able to

- recall the structure of eukaryotic and prokaryotic microbial cells relevant in industry;
- discuss the structure and function of enzymes and their mode of action;
- recognize concepts of microbial metabolism and growth;
- identify levels at which the cellular metabolism can be regulated;
- evaluate the perspectives of modern biotechnology;
- employ hygiene and tidy laboratory work conditions;
- apply the basics of genetics and fundamental processes of molecular biology;
- acquire basic methods of recombinant DNA technology.

Indicative Literature

Madigan et. al., Brock Biology of Microorganisms, 15th edition, Pearson International, 2018;

Willey et al., Prescott's Microbiology, 11th edition, McGraw-Hill Education, 2019;

Brown, Gene Cloning and DNA Analysis, 7th edition, CreateSpace Independent Publishing Platform, 2018;

Clark and Pazdernik, Biotechnology: Applying the Genetic Revolution, Academic Cell, 2008;

Renneberg, Biotechnology for Beginners, 2nd edition, Academic Press, 2016.

Usability and Relationship to other Modules

- This module provides fundamentals in microbiology and molecular biology for students majoring in CBT
- It is the basis for the second-year modules Industrial Biotechnology and Bioprocess Engineering and for the specialization course Environmental Microbiology and Biotechnology
- Mandatory for a major and minor in CBT

Examination Type: Module Component Examinations

Component 1: Lecture

Assessment Type: Written examination

Duration: 90 min
Weight: 66%

Scope: Intended learning outcomes of the lecture (1-5)

Component 2: Lab

Assessment Type: Written examination

Duration: 60 min
Weight: 33%

Scope: Intended learning outcomes of the laboratory course (6-8)

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.3 General Biochemistry

<table>
<tr><td colspan="2">Module Name
General Biochemistry</td><td colspan="2">Module Code
CH-100</td><td>Level (type)
Year 1 (CHOICE)</td><td>CP
7.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CH-100-A</td><td colspan="3">General Biochemistry</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-100-B</td><td colspan="3">General Biochemistry Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Sebastian Springer</td><td colspan="3">Program Affiliation

• Biochemistry and Cell Biology (BCCB)</td><td colspan="2">Mandatory Status

Mandatory for BCCB and CBT</td></tr>
<tr><td rowspan="2" colspan="3">Entry Requirements

Pre-requisites | Co-requisites | Knowledge, Abilities, or Skills

☒ None | ☒ None | • High school level of chemistry, mathematics, physics and biology.</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Private study (90 hours)
• Safety instructions (1 hours)
• Reading lab manuals (6 hours)
• MSDS preparation (4 hours)
• Experimental work in the laboratory, including seminars (27.5 hours)
• Lab report writing (24 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

187.5 hours</td></tr>
</table>

Recommendations for Preparation

For this module, students should revise chemistry, mathematics, physics and biology at the high school level and ideally bring basic self-directed study skills at the high school level.
Students need to read the relevant chapters in the recommended textbooks and all course materials provided by the instructors (e.g., manuals for the laboratory course).
For participation in the laboratory course, students must have attended the general safety instructions, fire safety instructions and the mandatory safety instructions to the laboratory course (chemical and S1 safety). In addition, Material Safety Data Sheets have to be prepared.

Content and Educational Aims

The CHOICE General Biochemistry Module aims at students with a good High School knowledge of chemistry, mathematics, physics, and biology as well as basic self-directed study skills at high school level. The module consists of two module components, one lecture and one laboratory course.
In the lecture, students gain solid first-year level understanding of biochemistry and learn how to apply and analyze basic concepts of biochemistry.
In the laboratory course, students develop their practical skills and acquire basic proficiency in the use of laboratory equipment. The experiments parallel the lecture content and allow students to apply methods testing for the chemical properties of biomolecules. Furthermore, students learn how to document, describe, and discuss experimental data.
In both module components, students also acquire meta-skills such as self-organization and teamwork.

Intended Learning Outcomes

By the end of this module, students will be able to

1. explain the chemical basics of the life sciences;
2. identify major classes of biological molecules;
3. describe the structure and function of proteins;
4. summarize the basic principles of anabolic and energy metabolism;
5. list the techniques and strategies in molecular life sciences;
6. relate gained knowledge and inductive reasoning to unknown topics in the molecular life sciences;
7. integrate new scientific information into the framework of the knowledge already obtained;
8. perform basic experiments in a Biosafety Level S1 Laboratory;
9. follow experimental procedures outlined in a laboratory manual;
10. relate an experimental setup to the aim of an experiment;
11. formulate expectations and hypotheses to be tested;
12. understand how different biomolecules can be analyzed by testing for their biochemical properties;
13. develop scientific writing skills regarding the depiction and description of experimental data as well as their interpretation in publication-style lab reports;
14. correctly cite literature and know how to avoid plagiarism.

Indicative Literature

Becker et al., The World of the Cell. Benjamin/Cummings Series in the Life Sciences, latest edition.

Horton et al., Principles of Biochemistry, Prentice Hall, latest edition.

Alberts et al., Essential Cell Biology, Garland, latest edition.

General Introduction Manual and Lab Day Manuals provided by instructor

Usability and Relationship to other Modules

- The General Biochemistry Module provides an essential foundation for the study of BCCB. It is a pre-requisite for the General Cell Biology CHOICE Module and the BCCB CORE Modules Microbiology, Infection and Immunity; and Advanced Biochemistry I. It is also a pre-requisite for the Chemistry CHOICE Module
- Introduction to Biotechnology
- Mandatory for a major in BCCB and CBT
- Mandatory for a minor in BCCB
- It is an elective module for all other undergraduate study programs.

Examination Type: Module Component Examinations

Module Component 1: Lecture

Assessment Type: Written examination | Duration: 120 min
Weight: 67 %

Scope: All intended learning outcomes of the lecture (1-7)

Module Component 2: Lab

Assessment Type: Lab Reports | Duration: Approx. 10 pages per report
Weight: 33%

Scope: All intended learning outcomes of the laboratory course (8-14)

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.4 General Organic Chemistry

<table>
<tr><td colspan="3">Module Name
General Organic Chemistry</td><td>Module Code
CH-111</td><td>Level (type)
Year 1
(CHOICE)</td><td>CP
7.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CH-111-A</td><td colspan="3">General Organic Chemistry</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-111-B</td><td colspan="3">General Organic Chemistry Lab</td><td>Laboratory</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Thomas Nugent</td><td colspan="3">Program Affiliation

• Medicinal Chemistry and Chemical Biology (MCCB)</td><td colspan="2">Mandatory Status

Mandatory for BCCB, CBT and MCCB</td></tr>
<tr><td rowspan="2">Entry Requirements

Pre-requisites

☒ General and Inorganic Chemistry
or
General Medicinal Chemistry and Chemical Biology</td><td rowspan="2">Co-requisites

☒ None</td><td rowspan="2">Knowledge, Abilities, or Skills

• Recognize organic functional groups
• familiar with orbitals
• exposed to the concept of equilibria
• laboratory safety and awareness</td><td>Frequency

Annually
(Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Tutorial of the lecture (10 hours)
• Private study for the lecture (80 hours)
• Laboratory (25.5 hours)
• Private for the study laboratory (37 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

187.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Early reading, extensive note taking and self-testing, work through practice problems, fully understand the material before entering laboratory and the risks associated with the daily goals.</td></tr>
<tr><td colspan="6">Content and Educational Aims

This module provides an introduction to Organic Chemistry and begins with general reactivity patterns and the supportive concepts of resonance, conjugation and aromaticity, which come from applying knowledge of orbitals. Carbanion, alcohol, and amine nucleophiles are introduced and this allows carbonyl additions resulting in: alcohol, acetal, imine, enamine, oxime, and 29harmacop formation to be discussed. The student is then exposed to the relationships between equilibria and rates of reaction to better understand mechanistic investigations. This is followed by an introduction to conformational analysis and stereochemistry which allow the transition states within the subsequent chapters on substitution, elimination, and addition reactions to be understood.
In a parallel manner, The student will learn that a chemistry laboratory is for exploring chemical reactions. However, before doing so we must demonstrate: safety aspects, common hazards, and the structure and content required for a laboratory report. After this, the essential techniques are shown for: setting up, monitoring (TLC, color change, etc.), and quenching (neutralize active chemicals) reactions. In parallel, the student will purify the products (chromatography, crystallization, separatory funnel extractions, etc.), and use basic methods to identify the products. While doing so, the student is exposed to the common equipment (rotary evaporator, melting point apparatus, etc.) within the laboratory. Reactions based on nucleophilic substitution, elimination, bromination to an alkene, electrophilic aromatic substitution, and the isolation of a natural product, characterize the experimental exposure within this laboratory.</td></tr>
</table>

Intended Learning Outcomes

By the end of the module, the student should be able to:

- understand bond strength and angles using knowledge of orbitals;
- recognize resonance effects versus inductive effects;
- understand basic mechanisms and arrow pushing in organic chemistry;
- differentiate some nucleophiles and electrophiles and their orbital connectivity to HOMO and LUMO concepts;
- distinguish high and low energy conformations of molecules and recall their value for transition states;
- identify basic symmetry elements, stereocenters, and be able to recognize the stereochemical outcome of selected reactions;
- identify and recall specific structures and reactions discussed during class;
- in addition to knowing the fire exit locations, students will be able to find the location and know the operating procedures of all safety equipment including the first aid kit, eyewash station, safety shower, fire extinguisher, and fire blanket in the laboratory;
- handle and dispose of chemicals safely and show competence in locating and retrieving material safety data sheet (MSDS) information;
- perform acid-base extractions;
- monitor and quench organic reactions;
- identify standard laboratory equipment;
- set up reactions with assistance.

Indicative Literature

J. Clayden,N. Greeves, S. Warren. Organic Chemistry, 2nd Edition, Oxford University Press, 2012.

Usability and Relationship to other Modules

- Mandatory for a major in MCCB, BCCB and CBT
- This module provides the foundation knowledge required for your 2nd year CORE modules
- Prerequisite for the CORE modules "Medicinal Chemistry, "Chemical Biology", "Pharmaceutical Chemistry" and „Advanced Organic Chemistry“

Examination Type: Module Component Examinations

Module Component 1: Lecture

Assessment Type Written examination — Duration: 180 min, Weight: 67%

Scope: The first seven intended learning outcomes are connected to the lecture

Module Component 2: Lab

Assessment Type Lab Reports — Length: Five to fifteen pages per report, Weight: 33%

Scope: The last six intended learning outcomes are connected to the laboratory

Completion: To pass this module, both module component examinations have to be passed with at least 45%.

7.5 Physical Chemistry

<table>
<tr><td colspan="2">Module Name
Physical Chemistry</td><td>Module Code
CO-440</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-440-A</td><td colspan="2">Physical Chemistry</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Detlef Gabel</td><td colspan="2">Program Affiliation

• Chemistry and Biotechnology (CBT)</td><td colspan="2">Mandatory Status

Mandatory for CBT, mandatory elective for Physics and MCCB</td></tr>
<tr><td colspan="2" rowspan="2">Entry Requirements

Pre-requisites

☒ General and Inorganic Chemistry

or

☒Modern Physics

Co-requisites

☒ None

Knowledge, Abilities, or Skills

• None beyond formal prerequisites</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (45 hours)
• Private study (45 hours)
• Exam preparation (35 hours</td></tr>
<tr><td>Duration

2 semesters</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="5">Recommendations for Preparation
None</td></tr>
<tr><td colspan="5">Content and Educational Aims

The module provides an introduction to Physical Chemistry and focusses on thermodynamics, kinetics, intermolecular forces, surfaces, and electrochemistry. It also provides an introduction to quantum chemistry. This knowledge is essential to understand when chemical reactions can take place and how fast they can occur, and how molecules interact with each other and the solvent.</td></tr>
<tr><td colspan="5">Intended Learning Outcomes

By the end of the module, the student will be able to

1. use the gas laws to predict the behavior of perfect and real gases;
2. differentiate between enthalpy, entropy, and Gibbs energy;
3. correlate Gibbs energy with equilibrium constants;
4. derive the velocities of reactions of zero, first, and the second order;
5. derive the velocities of enzyme reactions and coupled reactions;
6. explain and apply the concept of activation energy;
7. calculate the velocity of reactions as a function of temperature;
8. recognize phase transitions from measurable properties;
9. explain and apply fundamentals in electrochemistry;
10. explain how given molecules and their functional groups can interact with each other and their surroundings;
11. recognize the different approaches to quantum chemical calculations;
12. use an electronic lab book and share their own results with others through it;
13. derive the fundamental equations of importance in physical chemistry;
14. demonstrate presentation skills;</td></tr>
</table>

Indicative Literature

Atkins and de Paula, Elements of Physical Chemistry, 7th edition. Oxford: Oxford University Press, 2017.

Usability and Relationship to other Modules

- Pre/corequisite for the Inorganic and Physical Chemistry lab
- Mandatory for a Major and a Minor in CBT
- Mandatory elective specialization module for third year Physics and MCCB major students;

Examination Type: Module Examination

Assessment Component 1: Written examination — Duration: 120 min. Weight: 75%

Scope: Intended learning outcomes of the module (1-12)

Assessment Component 2: Presentation — Duration 15 min Weight 25%

Scope: Intended learning outcomes of the module (13-14)

Completion: This module is passed with an assessment-component weighted average grade of 45% or higher.

7.6 Industrial Biotechnology

Module Name			*Module Code*	*Level (type)*	*CP*
Industrial Biotechnology			CO-441	Year 2 (CORE)	5
Module Components					
Number	*Name*			*Type*	*CP*
CO-441-A	Industrial Biotechnology			Lecture	5
Module Coordinator Prof. Dr. Elke Nevoigt	***Program Affiliation*** • Chemistry and Biotechnology (CBT)			***Mandatory Status*** Mandatory for CBT Mandatory Elective for BCCB	
Entry Requirements *Pre-requisites* ☒ Introduction to Biotechnology or ☒ Cell Biology	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • None beyond formal prerequisites	***Frequency*** Annually (Fall)	***Forms of Learning and Teaching*** • Lecture (45 hours) • Private study (45 hours) • Exam preparation (35 hours)	
			Duration 1 semester	***Workload*** 125 hours	

Recommendations for Preparation

None.

Content and Educational Aims

This module provides insight into how biotechnology impacts chemical production. The replacement of both chemical catalysts by enzymes and cells and of fossil resources by renewable raw materials are two aspects that are increasingly pushed by the chemical industry in order to achieve a more sustainable production of bulk and fine chemicals, building blocks for chemical industry as well as food ingredients, bioplastics, and biofuels. Using a number of commercially successful examples as well as current R&D efforts of chemical industry, students will be introduced to the advantages and practice of implementing cells or enzymes for the production of industrially relevant products. Moreover, the module describes the utilization of biomass and biomass waste streams as feedstock for the production of the above mentioned compounds.

Intended Learning Outcomes

By the end of the module, the student will be able to

- evaluate the use of renewable as opposed to fossil resources as raw materials for chemical production;
- explain the impact of using enzymes and cells in the chemical and pharmaceutical industry;
- evaluate the value and applications of industrial enzymes;
- express the concept of a cell factory;
- list important commercial products made by microorganisms;
- assess the limitations of natural organisms for chemical production;
- evaluate the feasibility of a bio-based process compared to its chemical counterpart;
- identify possibilities to modify the characteristics of an enzyme
- sketch the basic concept of metabolic engineering;

Indicative Literature

Glazer and Nikaido, Microbial Biotechnology: Fundamentals of Applied Microbiology,2nd edition, Cambridge University Press, 2007;
Lehninger, Principles of Biochemistry: International Edition, WH Freeman, 2017;
Ratledge and Kristiansen, Basic Biotechnology, 3rd edition, Cambridge University Press, 2006;
Schmidt, Pocket Guide for Biotechnology and Genetic Engineering, 2003;
Madigan et. al., Brock Biology of Microorganisms, 15th edition, Pearson International, 2018;
Willey et al., Prescott's Microbiology, 11th edition, McGraw-Hill Education, 2019;

Usability and Relationship to other Modules

- Mandatory for a major and a minor in CBT
- The module Industrial Biotechnology is complementary to the Advanced Biotechnology Lab and synergistic to the Specialization course Environmental Microbiology and Biotechnology;

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min.
Weight: 100%

Scope: All intended learning outcomes of the module

7.7 Advanced Inorganic Chemistry

<table>
<tr><td colspan="3">Module Name
Advanced Inorganic Chemistry</td><td>Module Code
CO-442</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-442-A</td><td colspan="3">Advanced Inorganic Chemistry</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Ulrich Kortz</td><td colspan="3">Program Affiliation

• Chemistry and Biotechnology (CBT)</td><td colspan="2">Mandatory Status

Mandatory for CBT</td></tr>
<tr><td colspan="3">Entry Requirements</td><td>Frequency

Annually (Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Tutorial (10 hours)
• Private study for lecture (80 hours)</td></tr>
<tr><td>Pre-requisites

☒ General and Inorganic Chemistry</td><td>Co-requisites

☒ None</td><td>Knowledge, Abilities, or Skills

• None beyond formal prerequisites</td><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Early reading, extensive note taking and self-testing, work through practice problems, and fully understand the material before entering the laboratory and the risks associated with the daily goals.</td></tr>
<tr><td colspan="6">Content and Educational Aims

This module introduces advanced concepts of inorganic chemistry, such as Molecular Structure and Bonding (VB theory, MO theory, and semiconductors), Symmetry and Group Theory, Structures of Solids (metals, and ionic solids), d-metal Complexes (structure and symmetry, bonding and electronic structure, and reactions of complexes), the Electronic Spectra of Complexes (electronic spectra of atoms vs complexes, and the bonding and spectra of M-M bonded compounds).</td></tr>
<tr><td colspan="6">Intended Learning Outcomes

By the end of the module, the student will be able to

• discuss advanced concepts of inorganic and organometallic chemistry;
• master various topics such as the synthesis of inorganic compounds, bonding, structure, etc.;
• explain coordination compounds, their nomenclature and isomerism;
• determine the electronic structure of d-metal complexes and explain their properties (correlate between electronic structure and properties);
• explain the elements in the periodic table and the periodic properties of these elements.
• predict the geometries of inorganic compounds;
• determine the structure and symmetry of molecules and correlate between symmetry and properties;
• categorize the point group of molecules and identify character tables;</td></tr>
<tr><td colspan="6">Indicative Literature

Atkins et. al, Shriver and Atkins’ Inorganic Chemistry, 5th edition, Oxford University Press, 2009;</td></tr>
</table>

Huheey et al., Inorganic Chemistry, 4^{th} edition., Addison Wesley, 1997;

Miessler et al., Inorganic Chemistry, 4rd edition, Pearson, 2003;

Vincent, Molecular Symmetry and Group Theory, Wiley, 2011.

Usability and Relationship to other Modules

- This module provides advanced knowledge and deeper understanding of inorganic chemistry, and exposes students to various analytical instruments used beyond inorganic chemistry and chemistry in general;
- Mandatory for a major and minor in CBT

Examination Type: Module Examination

Assessment Type: written examination

Duration: 120 minutes
Weight: 100%

Module achievement: students have to give a presentation (10-15 min) during the lecture in order to be eligible to participate in the written examination. The presentation is not numerically graded (pass/fail).

Scope: All intended learning outcomes of the module;

7.8 Advanced Organic Chemistry

Module Name		*Module Code*	*Level (type)*	*CP*
Advanced Organic Chemistry		CO-423	Year 2 (CORE)	5
Module Components				
Number	*Name*		*Type*	*CP*
CO-423-A	Advanced Organic Chemistry		Lecture	5
Module Coordinator Prof. Dr. Thomas Nugent	*Program Affiliation* • Medicinal Chemistry and Chemical Biology (MCCB)		*Mandatory Status* Mandatory for CBT and MCCB	

Entry Requirements			*Frequency*	*Forms of Learning and Teaching*
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Fall)	• Lecture (35 hours) • Tutorial (10 hours) • Private study (80 hours)
☒ General Organic Chemistry	☒ Adv. Organic and Analytical Laboratory	• Transition state analysis • Selectivity in synthesis • Expanded reaction knowledge	*Duration* 1 semester	*Workload* 125 hours

Recommendations for Preparation

Review concepts from General Organic Chemistry, early reading, extensive note taking and self-testing, work through practice problems, fully understand the material before entering class, attend voluntary tutorials

Content and Educational Aims

This module builds on the General Organic Chemistry module by broadening reaction type exposure and evaluating transition states to appreciate product selectivity during synthesis. To allow these possibilities, the concepts of regiochemistry, chemoselectivity, diastereoselectivity, and enantioselectivity are addressed. This in turn allows synthetic pathways for more complicated molecules to be proposed and evaluated. The student will additionally know the general reactivity patterns of carbocations, radicals, and anions and in some instances know when to apply that knowledge. These combined conceptual points will be expressed during discussions of aromatic substitution, Michael reactions (conjugate addition), aldol, Claisen, and Diels-Alder reactions.

Intended Learning Outcomes

By the end of this module component, students should be able to

- understand the value of the order of reactions within multi-step synthesis.
- design three step reaction sequences.
- appreciate retrosynthetic approaches to synthesize selected molecules.
- discern chemoselective and regioselective challenges.
- recognize the stereochemical outcomes of selected reactions.
- evaluate and apply transition state analysis to selected reactions.
- complete some reaction mechanisms.
- will know common carbonyl group reaction transformations.
- identify and recall specific structures and reactions discussed during class

Indicative Literature J. Clayden,N. Greeves, S. Warren. Organic Chemistry, 2nd Edition, Oxford University, 2012.
Usability and Relationship to other Modules • Completion of this module allows the student to understand the common concepts, reactions, and reactivity patterns of organic chemistry. It enhances the learning outcomes for CORE modules Medicinal Chemistry, Chemical Biology, and Pharmaceutical Chemistry, but is not a pre-requisite for those modules. • Mandatory for a major in MCCB and CBT.
Examination Type: Module Examination Assessment Type Written examination Duration: 180 min Weight: 100% Scope: All intended learning outcomes of the module.

7.9 Scientific Software and Databases

Module Name			Module Code	Level (type)	CP
Scientific Software and Databases			CO-443	Year 2 (CORE)	5
Module Components					
Number	*Name*			*Type*	*CP*
CO-443-A	Scientific Software and Databases			Lecture	5
Module Coordinator Prof. Dr. Detlef Gabel	*Program Affiliation* • Chemistry and Biotechnology (CBT)			*Mandatory Status* Mandatory elective for CBT, BCCB and MCCB	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • None	*Frequency* Annually (Spring)	*Forms of Learning and Teaching* • Lecture (20 hours) • Seminar (15 hours) • Homework and self-study (50 hours) • Preparation of term paper (45 hours)	
			Duration 1 semester	*Workload* 125 hours	
Recommendations for Preparation First-year modules in General Chemistry, Organic Chemistry, Biochemistry, and Biotechnology					

Content and Educational Aims

The students will be familiarized with software to visualize scientific information in chemistry and life sciences. They will be familiarized with the sources used to draw the relevant scientific information, and the retrieval of primary sources of data. They will be familiarized with software to present results, and with software to numerically evaluate data.

Intended Learning Outcomes

By the end of this module, students should be able to

- use software to write reports and scientific papers;
- use software to evaluate and handle numerical data;
- use software to present data graphically;
- use Entrez as a source of information on the life sciences;
- use software to draw chemical structures;
- use SciFinder to find information on research subjects, chemical structures and substructures, reactions to and from given structures, and patents;
- use the Cambridge Data System to retrieve data on crystal structures;
- use software to visualize data for small molecules;
- use PDB to retrieve and three-dimensionally visualize data on protein structures and interactions;
- use software to visualize protein structures and the interaction of small molecules with proteins;
- use GenBank to retrieve information on gene sequences and the similarities between genes;
- use metabolic data banks to retrieve information on metabolic pathways;
- use data banks to obtain information about clinical trials;
- use data banks to obtain data on toxicity and the side effects of drugs;
- retrieve the primary sources of information of such data.

Indicative Literature

Handout provided by instructor.

Usability and Relationship to other Modules

- Mandatory elective for a major in CBT and MCCB
- Module can be replaced with a CORE module from another study program in order to pursue a minor, but has to be taken in Year 3, replacing one specialization module

Examination Type: Module Examination

Assessment Type: Term paper

Duration: 3000 words
Weight: 100%

Scope: All intended learning outcomes of the module.

7.10 Advanced Organic and Analytical Chemistry Lab

<table>
<tr><td colspan="3">Module Name
Advanced Organic and Analytical Chemistry Laboratory</td><td>Module Code
CO-424</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-424-A</td><td colspan="3">Advanced Organic Chemistry Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>CO-424-B</td><td colspan="3">Analytical Chemistry Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr.Thomas Nugent</td><td colspan="3">Program Affiliation

• Medicinal Chemistry and Chemical Biology (MCCB)</td><td colspan="2">Mandatory Status

Mandatory for CBT and MCCB</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒Analytical Methods ☒Advanced Organic Chemistry
Knowledge, Abilities, or Skills: • Laboratory safety</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lab (51 hours)
• Private study lab (74 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Fully understand the material before entering laboratory and the risks associated with the daily goals.</td></tr>
<tr><td colspan="6">Content and Educational Aims
A chemical laboratory is a place for exploration, and the second semester of organic laboratory places you squarely in that environment. Here you will set up your own reactions and be taught why an atmosphere of nitrogen, free of moisture, is required when using more reactive reagents. You will also expand your techniques, e.g., employing distillation, and be exposed to important instrumentation, e.g., nuclear magnetic resonance, for product identification. Importantly, you will begin to appreciate the entire process of designing and then performing a reaction. Starting from your reaction table displaying the required stoichiometry and weight or volume of the starting materials, to the order and timing of compound additions, to the isolation of your pure product whose structure you can support via chromatographic and/or spectroscopic evidence. On completing this laboratory you will have an appreciation for the manipulation of common organic functional groups and by extension, some of the challenges of synthesizing a pharmaceutical drug.
Analytical chemistry is an important applied area of chemistry. This part of the laboratory module will introduce students an introduction to experimental analytical chemistry. The use of spectrometers and chromatographic equipment will be demonstrated to students followed by set experiments to be performed independently by the students. A set of six dedicated experiments on UV/Vis-, NMR-, and IR spectroscopy, mass spectrometry, gas chromatography and HPLC will be performed by the students in small groups (2-3 students) under supervision. Subsequently students are asked to record their data, interpret their experimental findings, estimate errors, and report them.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes
By the end of this module component, students will be able to:
• independently set-up, monitor, and quench organic reactions;
• inform yourself about chemical hazards;
• dispose of chemicals properly;
• identify and use standard organic laboratory equipment;
• suggest purification methods for organic compounds;
• familiar with more advanced organic laboratory techniques;</td></tr>
</table>

- obtain a ^{1}H NMR spectrum with assistance;
- illustrate knowledge on instrumental methods including spectroscopic and separation techniques;
- explain and understand the physical principles behind spectroscopic and separation techniques;
- measure and analyze real samples;
- apply knowledge on instrumental techniques to solve qualitative and quantitative experimental analytical problems;
- interpret spectroscopic data and deduce chemical structures from that data;
- compare spectroscopic data and predict spectral properties from chemical structures;
- calculate quantitative values from analytical results;
- prepare scientific reports and critical analysis on the experimental findings of analytical results.

Indicative Literature

J. Clayden,N. Greeves, S. Warren. Organic Chemistry, 2nd Edition, Oxford University, 2012.

Usability and Relationship to other Modules

- These laboratories are critical for establishing the skills required to perform the thesis research and the introduced techniques and instruments provide the hands-on knowledge that complement the theoretical content learned in the CORE year modules.
- Mandatory for a major in MCCB and CBT

Examination Type: Module Examination

Assessment Type Lab reports	Length: 3-15 pages Weight: 100%

Scope: All intended learning outcomes of the module.

7.11 Bioprocess Engineering

Module Name		*Module Code*	*Level (type)*	*CP*
Bioprocess Engineering		CO-444	Year 2 (CORE)	5
Module Components				
Number	*Name*		*Type*	*CP*
CO-444-A	Bioprocess Engineering		Lecture and tutorial	5
Module Coordinator N.N.	*Program Affiliation* • Chemistry and Biotechnology (CBT)		*Mandatory Status* Mandatory for CBT	

Entry Requirements			*Frequency*	*Forms of Learning and Teaching*
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Spring)	• Lecture and tutorial (45 hours) • Private study (45 hours) • Exam preparation (35 hours)
☒ Introduction to Biotechnology ☒ Industrial Biotechnology	☒ None	• None beyond formal prerequisites	*Duration* 1 semester	*Workload* 125 hours

Recommendations for Preparation

None

Content and Educational Aims

Biotechnological advances in the laboratory require appropriate strategies for implementation in industrial practice. One main pre-requisite for its exploitation is the ability to efficiently scale up any processes involved for final product delivery to the market. Process biotechnology is concerned with the design, dovetailing, performance evaluation, and final implementation of unit operations. Examples are fermentation, solid-liquid separation, extraction and leaching, adsorption and chromatography. Every production scheme has to be validated in terms of product quality and processing costs. Software packages may be employed to illustrate processing alternatives.

Intended Learning Outcomes

By the end of this module, students should be able to

- describe the concept of bioeconomy;
- explain the impact of biorefining in the chemical industry;
- recognize how process biotechnology works;
- explain heat transfer and mass transfer phenomena;
- evaluate the feasibility of process schemes;
- discuss the potential of biorefineries for sustainable chemical production;
- bridge chemistry with biology and technology;
- apply simple modelling tools to understand the performance of biotechnological processes;

Indicative Literature

Doran, Bioprocess Engineering Principles,2nd edition, Academic Press, 2012;

Day et. al., Bioseparations Science and Engineering, Oxford University Press, 2002.

Usability and Relationship to other Modules

• Mandatory for a major in CBT
Examination Type: Module Examination Assessment Type: Written examination — Duration: 120 min. Weight: 100% Scope: All intended learning outcomes of the module;

7.12 Advanced Biotechnology Lab

Module Name	*Module Code*	*Level (type)*	*CP*
Advanced Biotechnology Lab	CO-445	Year 2 (CORE)	5

Module Components

Number	*Name*	*Type*	*CP*
CO-445-A	Advanced Biotechnology Lab	Lab Course	5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Dr. Mathias Klein	• Chemistry and Biotechnology (CBT)	Mandatory for CBT

Entry Requirements

Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	*Frequency*	*Forms of Learning and Teaching*
☒ none	☒Industrial Biotechnology	• None beyond formal prerequisites	Annually (Fall)	• Lab and seminars (60 hours) • Private study (35 hours) • Exam preparation (30 hours)
			Duration 2 weeks (intersession)	*Workload* 125 hours

Recommendations for Preparation

Read manual for the laboratory course early on and fully understand the material before entering the laboratory. Know the risks associated with the daily goals. Prepare MSDS sheets for the hazardous chemicals used in the lab course.

Content and Educational Aims

A breakthrough in modern biotechnology is the recombinant production of proteins (e.g., pharmaproteins as well as industrial and diagnostic enzymes). The major advantages of heterologous protein production over the isolation of these proteins from natural sources are i) significantly higher yields, ii) safer production, iii) higher purity of the protein and iv) the possibility of producing protein variants with improved characteristics. Today, about 50% of all approved pharmaproteins are produced in microbial hosts. The full pipeline requires the cloning of the respective protein-encoding sequence into a suitable expression vector, the transformation of the microbial production host, the expression of the relevant protein, the optimization of process conditions and downstream processing. The final steps include quality control and theformulation of the target product;
The first part of this course aims at familiarizing future biotechnologists with fundamental techniques for recombinant protein expression in the microbial host *E. coli*. The second part will include training in state-of-the-art methods for bioprocess engineering and downstream bioprocessing. The students will follow the path from cloning a protein-coding sequence through protein expression and product recovery.

Intended Learning Outcomes

By the end of the module, the student will be able to

- employ methods for the cultivation of microorganisms on solid and in liquid media;
- apply tidy and sterile working techniques according to good microbiological techniques (GMT);

- apply and explain basic molecular biology techniques (plasmid isolation and analysis, agarose gel electrophoresis, restriction-ligation cloning, and PCR) as well as the transformation of the bacterium *Escherichia coli*;
- apply and evaluate methods to generate protein variants by random mutagenesis and site directed mutagenesis;
- discuss concepts of generating and analyzing mutant protein libraries;
- apply different biomass separation and concentration methods (centrifugation, ultra-centrifugation filtration, and ultrafiltration);
- apply different cell disruption methods;
- differentiate and apply several purification methods (affinity, ion exchange, hydrophobic interaction, size-exclusion, and reversed phase chromatography);
- operate product (biomolecule) characterization and quantification (SDS Polyacrylamide Gel Electrophoresis (SDS PAGE), Western Blot, and spectrophotometric protein determination assays);
- appraise the importance and application of biomolecules in our daily lives;

Indicative Literature

Arnold, Directed Evolution: Creating Biocatalysts for the Future, In Chemical Engineering Science 51 (23): 5091-5102l, 1996;

Tsien, The Green Fluorescent Protein. Annual Reviews of Biochemistry 67:509-544, 1998;

Course handout provided by the instructor.

Usability and Relationship to other Modules

- The Advanced Biotechnology Lab is complementary to the lectures Industrial Biotechnology and Bioprocess Engineering;
- Mandatory for a major in CBT

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min.
Weight: 100%

Scope: All intended learning outcomes of the module;

7.13 Inorganic and Physical Chemistry Lab

Module Name		*Module Code*	*Level (type)*	*CP*
Inorganic and Physical Chemistry Lab		CO-446	Year 2 (CORE)	5
Module Components				
Number	*Name*		*Type*	*CP*
CO-446-A	Inorganic Chemistry Lab		Lab	2.5
CO-446-B	Physical Chemistry Lab		Lab	2.5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Prof. Dr. Ulrich Kortz	• Chemistry and Biotechnology (CBT)	Mandatory for CBT

Entry Requirements			*Frequency*	*Forms of Learning and Teaching*
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Spring)	• Lab (51 hours) • Private study lab (74 hours)
☒ General and Inorganic Chemistry		• None beyond formal prerequisites	*Duration* 1 semester	*Workload* 125 hours

Recommendations for Preparation

Early reading, extensive note taking and self-testing, work through practice problems, and fully understand the material before entering the laboratory and the risks associated with the daily goals.

Content and Educational Aims

In its Advanced Inorganic Chemistry Lab, this module allows students to apply advanced concepts of inorganic chemistry, such as Molecular Structure and Bonding (VB theory, MO theory, and semiconductors), Symmetry and Group Theory, Structures of Solids (metals and ionic solids), d-metal Complexes (structure and symmetry, bonding and electronic structure, and the reactions of complexes), the Electronic Spectra of Complexes (electronic spectra of atoms versus complexes and the bonding and spectra of M-M bonded compounds) by performing experiments designed to prove the abovementioned concepts. It also provides students with the opportunity to perform experiments such as the synthesis, separation, purification, and characterization of inorganic main-group and transition metal compounds. Quantitative analysis (gravimetric and spectrometric). Kinetics of inorganic reactions. Instrumentation used: FT-IR, UV-vis, AA, TGA, XRD, and NMR;
The physical chemistry laboratory provides an overview of the function of typical laboratory instruments used for physical chemistry characterization. First, students gain hands-on experience to create solutions, and second to decide which instrument is best suited and to use typical instruments such as UV-vis, fluorimenter, Zetapotential, particle sizer, pH meter, conductometer, Osmometer, etc;
Furthermore, students learn to use a lab book (electronic lab book I-labber), as well as learning to describe the goal of an experiment, document the results, and perform simple statistical analysis.

Intended Learning Outcomes

By the end of the module, the student will be able to

1. synthesize and characterize inorganic and organometallic complexes;
2. correlate between the theoretical concepts introduced in class and the actual experimental application of the various hypotheses, laws, techniques, materials, reactions, and instruments;
3. use analytical instruments such as a Uv-vis spectrophotometer, infrared spectrophotometer, thermogravimetric analyzer, atomic absorption spectrophotometer, x-ray diffractrometer, and nuclear magnetic resonance spectrometer;
4. plot and analyze data obtained from an analytical experiment and correlate it with the theory;
5. communicate the results of scientific experiments in technical graphics, and written reports;
6. prepare electrolyte solutions, using the pH meter, and conductometry;
7. perform osmotic pressure measurement;
8. perform viscosity measurements;
9. perform spectroscopic measurement (UV-vis, and fluorescence emission);
10. perform particle sizing;
11. describe the outline of an experiment, and provide a protocol of the experiment together with a statistical analysis;
12. document an experiment in a lab book (or electronic lab book-i-labber);

Indicative Literature

A manual/handout will be provided by the instructor;

Atkins and de Paula, Elements of Physical Chemistry, 7th edition. Oxford: Oxford University Press, 2017.

Usability and Relationship to other Modules

- Mandatory for a major in CBT

Examination Type: Module Component Examinations

Module Component 1: Lab 1

Assessment Type: Lab reports

Length: 4-8 pages per assignment

Weight: 50%

Scope: Intended learning outcomes of Inorganic Chemistry Lab (ILOs 1-5)

Module Component 2: Lab 2

Assessment Type: Project (lab performance)

Weight: 50%

Scope: Intended learning outcomes of Physical Chemistry Lab (ILOs 4-12)

Module achievements: 66% of the assignments passed.

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

7.14 Chemical and Pharmaceutical Technology

Module Name		*Module Code*	*Level (type)*	*CP*
Chemical and Pharmaceutical Technology		CA-S-CBT-801	Year 3 (Specialization)	5
Course Components				
Number	*Name*		*Type*	*CP*
CA-CBT-801	Chemical and Pharmaceutical Technology		Lecture and tutorial	5
Module Coordinator N.N.	*Program Affiliation* • Chemistry and Biotechnology (CBT)		*Mandatory Status* Mandatory elective for CBT and MCCB	
Entry Requirements *Pre-requisites* ☒ Introduction to Biotechnology	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • None beyond formal prerequisites	*Frequency* Annually (Fall)	*Forms of Learning and Teaching* • Lecture and tutorial (45 hours) • Private study (65 hours) • Exam preparation (15 hours)
			Duration 1 semester	*Workload* 125 hours
Recommendations for Preparation None.				

Content and Educational Aims

During the course students will acquire knowledge of the pre-formulation and formulation of drugs and chemicals, pharmaceutical and chemical unit operations and manufacturing, the packaging and quality control of pharmaceuticals, and chemical dosage forms;

The module includes:

- Chemical properties of drugs and chemicals of importance to drug formulation, and how these are characterized
- The principles of drug and chemical formulation and active component release
- Excipients and their properties
- Important pharmaceutical and chemical unit operations
- The manufacturing and packaging of pharmaceutical dosage forms and chemicals in other fields of application
- Quality assurance and quality evaluation

Intended Learning Outcomes

By the end of this module, students should be able to:

- discuss the principles of pharmaceutical and chemical technology;
- explain formulation processes;
- identify properties that are relevant to successful formulation;
- explain heat transfer and mass transfer phenomena;
- evaluate the feasibility of process schemes;
- recognize sustainable chemicals in food, agriculture, pharmacy, and industrial chemistry;
- bridge chemistry and engineering;
- apply simple modeling tools to understand the performance of formulation processes;

Indicative Literature

Fishburn et al., An Introduction to Pharmaceutical Formulation, Pergamon, 1965;
Kamm et. al., Biorefineries - industrial processes and products: status quo and future directions, Wiley-VCH, 2006.

Usability and Relationship to other Modules

- Mandatory elective specialization module for third year CBT students

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 120 min.
Weight: 100%

Scope: All intended learning outcomes of the module.

7.15 Medicinal Chemistry

Module Name Medicinal Chemistry			*Module Code* CO-420	*Level (type)* Year 2 (CORE)	*CP* 5
Module Components					
Number	*Name*			*Type*	*CP*
CO-420-A	Medicinal Chemistry			Lecture	5
Module Coordinator Prof. Dr. Detlef Gabel	*Program Affiliation* • Medicinal Chemistry and Chemical Biology (MCCB)			*Mandatory Status* Mandatory for MCCB Mandatory elective for CBT	
Entry Requirements *Pre-requisites* ☒ General Biochemistry ☒ General Organic Chemistry	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • None beyond formal prerequisites	*Frequency* Annually (Fall)	*Forms of Learning and Teaching* • Lecture (35 hours) • Tutorial of the lecture (10 hours) • Private study for the lecture (80 hours)	
			Duration 1 semester	*Workload* 125 hours	
Recommendations for Preparation Early reading, extensive note taking and self-testing, work through practice problems, fully understand the material before entering class, and attend voluntary tutorials					

Content and Educational Aims

This module provides an insight into the design of drugs, their interactions with targets, and the role of selected targets in selected diseases. It will introduce the concepts of isosteres and bioisosteres. The physical basis of interactions between drugs and targets will be explained. Methods for determining the site and binding strength of drugs to targets will be presented. The optimization of a lead compound to a drug will be detailed. Assay systems for drug optimizations will be presented. The path of drugs from the design to clinical use will be followed. The concept of 51harmacophore will be presented. Stereochemical aspects of drug design will be discussed. Rules for drug design and fragment-based drug design will be explained. The ADME concept will be introduced. LD50 and ED50, as well as dose-response curves, will be presented. Structure-activity relationships will be discussed.

Intended Learning Outcomes

By the end of the module, the student will be able to

- propose a series of isosteres and bioisosteres for common functional groups;
- understand the principles of testing affinities of drugs to targets;
- analyze the interaction potential of drugs with their targets;
- sketch the path of a drug from lead structure to clinical trial;
- differentiate between conventional and fragment-based drug design;
- propose ways to identify targets on which specific molecules act
- estimate the changes in structure and its effect on ADME;
- extract information about structure-activity relationships from a given research paper on drug design;
- explain the testing methods employed in the paper;
- explain changes in interaction potentials for given modifications of a compound;
- explain the role of the drug in the disease and identify the role of the target.

Indicative Literature

- B.E. Blass. Basic Principles of Drug Discovery and Development, 2015, ISBN 978-0124115088.
- G.L. Patrick. An Introduction to Medicinal Chemistry, 2013, ISBN 978-0199697397

Usability and Relationship to other Modules

- This module is of central importance because it provides the first medicinal chemistry foundation that is then expanded on by other second year (CORE) modules, e.g., Phsyical Chemistry and Molecular Modelling, Chemical Biology, Pharmaceutical Chemistry, and High Throughput Screening.
- Mandatory for a major in MCCB
- Mandatory for a minor in MCCB
- Serves as a mandatory elective specialization module for 3rd year CBT major students.
- Pre-requisite for second year CORE module **“Medicinal Chemistry and Chemical Biology Laboratory”**

Examination Type: Module Examination

Assessment Component 1: Written examination — Duration: 75 min
Weight: 67%

Scope: Items 1 to 7 of the above learning outcomes of the module.

Assessment Component 2: Oral presentation — Duration 20 minutes
Weight 33%

Items 8-11 of the above learning outcomes of the module

Completion: This module is passed with an assessment-component weighted average grade of 45% or higher.

7.16 Environmental Microbiology and Biotechnology

<table>
<tr><td colspan="4">Module Name
Environmental Microbiology and Biotechnology</td><td>Module Code
CA-S-CBT-804</td><td>Level (type)
Year 3 (Specialization)</td><td>CP
5</td></tr>
<tr><td colspan="7">Module Components</td></tr>
<tr><td>Number</td><td colspan="4">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CA-S-CBT-804</td><td colspan="4">Environmental Microbiology and Biotechnology</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Dr. Boran Kartal</td><td colspan="4">Program Affiliation

• Chemistry and Biotechnology (CBT)</td><td colspan="2">Mandatory Status
Mandatory elective for CBT and BCCB</td></tr>
<tr><td rowspan="2">Entry Requirements

Pre-requisites

☒ General and Inorganic Chemistry
☒ General Biochemistry
☒ Introduction to Biotechnology

or

☒ Microbiology (for BCCB students)</td><td rowspan="2">Co-requisites

☒ none</td><td rowspan="2" colspan="2">Knowledge, Abilities, or Skills
Basic knowledge of Microbiology, Molecular Biology, Biotechnology</td><td>Frequency

Annually (Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lecture and presentations (45 hours)
• Private study (45 hours)
• Exam preparation (35 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 Hours</td></tr>
<tr><td colspan="7">Recommendations for Preparation

Taking the CORE Modules Industrial Biotechnology (CBT) and Microbiology (BCCB) is helpful. Recall the contents of General Biochemistry Module.</td></tr>
<tr><td colspan="7">Content and Educational Aims

The topics of the Environmental Microbiology and Biotechnology module are the elemental cycles (Carbon, Nitrogen, Sulfur and Iron) that take place in nature. In these “cycles” microorganisms, the most abundant living things on earth, convert different forms of elements to one and other [e.g. methane oxidizing bacteria oxidize methane (CH_4) to carbon dioxide (CO_2)]. In this module, the metabolic pathways that the microorganisms use to convert their substrates and the methodology to detect these microorganisms are described to the students in detail. Furthermore, the application of these microorganisms in wastewater treatment will be discussed.</td></tr>
</table>

Intended Learning Outcomes

Upon completion of this module, students will be able to:

1. Explain the biogeochemical processes within Carbon, Nitrogen, Sulphur and Iron cycles.
2. Name and classify the microorganisms responsible for the conversion of elements at different redox states (e.g. NO_3^- reduction to N_2 or CH_4 oxidation to CO_2)
3. Describe the key types of energy metabolism of microorganisms (e.g. denitrification, photosynthesis, methanogenesis, fermentation, ammonium and methane oxidation, etc.).
4. Identify the impact of human activities on the natural cycles.
5. Classify the biodiversity of prokaryotes and the evolutionary relations between ecologically relevant species including the current theories and concepts concerning microbial evolution.
6. Compare and contrast conventional and advanced techniques that are used to detect microbiological activities in nature.
7. Summarize the most up-to-date developments in the field of microbiology.
8. Critically read and discuss scientific literature.

Indicative Literature

Madigan et al, Brock Biology of Microorganisms, 15th edition, Pearson, 2018;
Nelson and Cox, Lehninger, Principles of Biochemistry, 7th edition, W.H. Freeman, Macmillan Learning, 2017

Usability and Relationship to other Modules

- This module can be used as an mandatory elective module for students majoring in BCCB provided that the prerequisites are fulfilled;
- Mandatory elective specialization module for third year CBT major students;

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 120 min.
Weight: 100%

Scope: All intended learning outcomes of the module

7.17 Organometallic Chemistry

Module Name	*Module Code*	*Level (type)*	*CP*
Organometallic Chemistry	CA-S-CBT-802	Year 3 (Specialization)	*5*

Module Components

Number	*Name*	*Type*	*CP*
CA-CBT-802	Organometallic Chemistry	Lecture	5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Prof. Dr. Detlef Gabel	• Chemistry and Biotechnology (CBT)	Mandatory elective for CBT and MCCB

Entry Requirements

Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	*Frequency*	*Forms of Learning and Teaching*
☒ General and Inorganic Chemistry ☒ General Organic Chemistry	☒ None	• None beyond formal prerequisites	Annually (Fall)	• Lecture (35 hours) • Private study (75 hours) • Exam preparation (15 hours)

Duration	*Workload*
1 semester	125 hours

Recommendations for Preparation

- Organometallic Chemistry, Gary O. Spessard, G. L. Miessler, Oxford University Press, 3rd Revised Edition, 2016;
- The Organometallic Chemistry of the Transition Metals, R. H. Crabtree, Wiley, 6th Edition, 2014;
- Bioorganometallic Chemistry Applications in Drug Discovery, Biocatalysis, and Imaging, Gérard Jaouen, Michèle Salmain, Wiley-VCH Verlag GmbH, 2015;
- Organometallics, Albrecht Salzer, Christoph Elschenbroich, Wiley-VCH Verlag GmbH, 3rd Revised Edition, 2003.

Content and Educational Aims

This course deals with all aspects of organometallic chemistry. The main topics are synthesis, bonding and structures, stability, reactions and the use of Main Group Metal and Transition Metal Organyls, electron deficient systems, s- and p-bonding, sandwich complexes, heterogenous and homogenous catalysis, industrially important processes, for example, Fischer-Tropsch-Reactions, Wacker Oxidation, Hydroformylation, Reppe-Synthesis, and coupling reactions. The role of bioorganometallics in biochemistry, medicinal chemistry, and cellular imaging will be highlighted.

Intended Learning Outcomes

By the end of the module, the student will be able to know about

- classification and electronegativity considerations;
- fundamentals of structure and bonding;
- energy, polarity, and reactivity of the M-C bond;
- NMR characterization of organometallics;

- Main-Group organometallics (lithium, magnesium, aluminium, and tin);
- transition metal organyls: concept of s-donor, s-donor/p-acceptor, s, and p -donor/p-acceptor ligands;
- transition metal organyls: concept of metal-carbene and carbyne complexes;
- isolobal concept;
- metathesis and polymerization reactions and industrial processes;
- concept of C-C bond formation (coupling reactions);
- use of organometallics in medicine (enzyme inhibitors);
- concept of metalloproteins;
- concept of organometallic bioprobes for cellular imaging;

Indicative Literature

Gary et al., Organometallic Chemistry, Oxford University Press, 3rd Revised Edition, 2016;

Jaouen et. al., Bioorganometallic Chemistry Applications in Drug Discovery, Biocatalysis, and Imaging, Wiley-VCH Verlag GmbH, 2015;

Salzer and Elschenbroich, Organometallics, Wiley-VCH Verlag, 3rd Revised Edition, 2003.

Usability and Relationship to other Modules

- Mandatory elective specialization module for third year CBT MCCB major students (if pre-requisites are met);

Examination Type: Module Examination

Assessment Type: Oral examination

Duration: 40 minutes
Weight: 100%

Scope: All intended learning outcomes of the module.

7.18 Advanced Organic Synthesis

Module Name			*Module Code*	*Level (type)*	*CP*
Advanced Organic Synthesis			CA-S-MCCB-801	Year 3 (Specialization)	5
Module Components					
Number	*Name*			*Type*	*CP*
CA-MCCB-801	Advanced Organic Synthesis			Lecture	5
Module Coordinator Prof. Dr. Thomas Nugent	*Program Affiliation* • Medicinal Chemistry and Chemical Biology (MCCB)			*Mandatory Status* Mandatory elective for CBT and MCCB	
Entry Requirements *Pre-requisites* ☒ Advanced Organic Chemistry	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • Broad organic chemistry concepts	*Frequency* Annually (Spring)	*Forms of Learning and Teaching* • Lecture (35 hours) • Tutorial of the lecture (10 hours) • Private study for the lecture (80 hours)	
			Duration 1 semester	*Workload* 125 hours	
Recommendations for Preparation Review the concepts within Advanced Organic Chemistry					

Content and Educational Aims

Building on your basic knowledge of functional group transformations and stereochemistry, strategies for the synthesis of complex building blocks, natural products, or pharmaceutical drugs will be discussed from the primary literature. In this context, you will learn the importance of the order and type of transformation (retrosynthetic analysis) required for brevity in synthesis. Critical reaction steps, examples of which could be, enantioselective hydrogenation, biaryl coupling, aldol reactions, etc., will be discussed at length to define current transition state knowledge and substrate limitations. In doing so, you will learn the how and why of organic reaction product selectivity. In a parallel manner, functional group compatibility, pKa, the use of modern reagents, radical clock chemistry, the nuances of chemo-, regio-, diastereo-, and enantiocontrol through the use of proximal functional groups vs enantioselective catalysis, etc. will be discussed when and where appropriate.

Intended Learning Outcomes

By the end of the module, the student will be able to

- collect and assess appropriate items from the primary literature to determine reactions feasibility;
- apply and use transition states to determine product selectivity;
- discern and discuss the possible stereochemical outcomes of a reaction;
- determine the viability of a sequence of reaction steps;
- differentiate spectator functional group compatibility or lack thereof;
- understand the challenges of complex molecule synthesis;
- use retrosynthetic analysis to suggest syntheses of molecules;
- offer suggestions for the synthesis of simple natural products.

Indicative Literature

J. Clayden,N. Greeves, S. Warren. Organic Chemistry, 2nd Edition, Oxford University, 2012.
Solomon and Fryhle, Organic Chemistry, Edition 8, 21.12 Special Topic G: Transition Metal Organometallic Compounds, p 1055-1065.

O. Reiser Chem. Rev. 1999, 99, 1191-1223.

S. Mukherjee, J. W. Yang, S. Hoffmann, B. List Chem. Rev. 2007, 107, 5471-5569.

C. D. Johnson Acc. Chem. Res. 1993, 26, 476-482.

K. Gilmore and I. V. Alabugin Chem. Rev. 2011, 111, 6513–6556.

R. Noyori, T. Ohkuma Angew. Chem. Int. Ed. 2001, 40, 40-73.

J. Paradies Coordination Chem. Rev. 2019, 380, 170–183.

J. Reed, T. Hudlicky Acc. Chem. Res. 2015, 48, 674-687.

Usability and Relationship to other Modules

- This module is for students who continue to be curious and want to extends their studies in organic synthesis and may be considering graduate level education in Medicinal Chemistry or Organic Chemistry.
- Mandatory elective specialization module for third year CBT and MCCB major students.

Examination Type: Module Examination

Assessment Type: Oral examination Duration: 40 min
Weight: 100%
Scope: All intended learning outcomes of the module.

7.19 Environmental Science

Module Name		*Module Code*	*Level (type)*	*CP*
Environmental Science		CO-460	Year 2 (CORE)	7.5
Module Components				
Number	*Name*		*Type*	*CP*
CO-460-A	Marine Environments		Lecture	2.5
CO-460-B	Environmental Geochemistry		Lecture	2.5
CO-460-C	Environmental Mineralogy		Lecture	2.5
Module Coordinator Prof. Dr. Andrea Koschinsky-Fritsche, Prof. Dr. Laurenz Thomsen	*Program Affiliation* • Earth and Environmental Sciences (EES)		*Mandatory Status* Mandatory elective for EES and CBT	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • Basics of Earth and Enviromental Sciences and Geosciences	*Frequency* Annually (Spring) *Duration* 1 semester	*Forms of Learning and Teaching* • Lectures (52.5 hours) • Private study (135 hours) *Workload* 187.5 hours
Recommendations for Preparation Please review the content of the EES CHOICE modules CH-130 and CH-131.				
Content and Educational Aims This module provides an exploration of the evolution of the Earth's environment and of the progressive exploitation of environmental resources by humankind. Students will study the different physical, chemical and biological processes that generate the Earth's environment and that support life in the different environmental compartments. The importance of Environmental Science is based on the need for sustainable development and environmental management as a key to a secure future of humankind. The courses as part of the module aim to review the large-scale global processes that shape the terrestrial and marine systems with their specially adapted ecosystems. They illustrate how anthropogenic interactions such as resource extraction, energy consumption, and pollution interfere with these natural processes, which ecosystems respond to these changes and introduce concepts and strategies of remediation. The students will learn to distinguish between natural and anthropogenic environmental change and learn to read from the geological record to understand present changes and predict the impacts of future global change. The courses in the module will consider both terrestrial systems such as freshwater and soil systems, as well as marine systems from coastal to deep-ocean environments, always in the context of their special environmental parameters and related environmental vulnerability or resilience.				

Intended Learning Outcomes

By the end of this module, students will be able to:

- critically assess the natural and human-driven systems and processes that provide resources, produce energy and affect the climate and our Earth surface environment;
- connect environmental conditions to the development of specific adapted terrestrial and marine ecosystems;
- use numerical tools and publicly available scientific data to demonstrate important concepts about the Earth, its climate, and resources;
- use mineralogical and geochemical tools to identify the status and composition of an environmental system and its dynamics;
- distinguish between natural and anthropogenic factors that are responsible for patterns of global warming, ocean deoxygenation and acidification, contamination and other environmental changes in the past century;
- apply sedimentological, chemical and biological data as proxies to reconstruct ancient environments and climates;
- suggest mitigation strategies to remediate water, soil and air pollution, negative changes in the marine system, and global warming;
- demonstrate awareness of the difficulties involved in the detection of any unusual environmental change signal above the background noise of natural variability.

Indicative Literature

Schwedt, G (1997). The Essential Guide to Environmental Chemistry. Hoboken: Wile

Langmuir, D. (1996). Aqueous Environmental Geochemistry. New Jersey: Prentice Hall.

Klein, C. Philpotts, A. (2016). Earth Materials: Introduction to Mineralogy and Petrology. Cambridge: Cambridge University Press.

Usability and Relationship to other Modules

- This module prepares and relates to CO-462, CO-461, CA-S-EES-802.
- Mandatory elective for major in EES.
- Mandatory for a minor in EES and CBT
- Elective for all other undergraduate study programs.
- This module serves as a mandatory elective specialization module for CBT students: due to the size of the module students who take the module may exceed the workload of 30 CP per semester.

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 180 min — Weight: 100%

Scope: All indented learning outcomes of the module

7.20 Fluorine in Drug Development

Module Name		*Module Code*	*Level (type)*	*CP*
Fluorine in Drug Development		CA-S-MCCB-802	Year 3 (Specialization)	2.5
Module Components				
Number	*Name*		*Type*	*CP*
CA-MCCB-802	Fluorine in Drug Development		Lecture	2.5

Module Coordinator	***Program Affiliation***	***Mandatory Status***
Prof. Dr. Gerd-Volker Röschenthaler	• Medicinal Chemistry and Chemical Biology (MCCB)	Mandatory elective for MCCB and CBT

Entry Requirements			***Frequency***	***Forms of Learning and Teaching***
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Fall)	• Lecture (17.5 hours) • Tutorial lecture (5 hours) • Private study lecture (40 hours)
☒ Advanced Organic Chemistry	☒ None	• recognize organic functional groups • familiar with organic mechanisms • exposed to the concept of dynamic processes	***Duration*** 1 semester	***Workload*** 67.5 hours

Recommendations for Preparation

None.

Content and Educational Aims

Fluoroorganic compounds are almost completely foreign to the biosphere. No central biological processes rely on fluorinated metabolites. Many modern pharmaceuticals contain at least one fluorine atom, which usually has a very specific function. New molecules fluorinated in a strategic position are crucial for the development of pharmaceuticals with desired actions and optimal pharmacological profiles. Among the hundreds of marketed active drug components, there are more than 150 fluorinated compounds. We start by illustrating how the presence of fluorine atoms modifies the properties of a bioactive compound at various biochemical steps, and possibly facilitates its emergence as a pharmaceutical agent. Recent advances in the development of fluorinated analogues of natural products have led to new pharmaceuticals such as fluorinated nucleosides, alkaloids, macrolides, steroids, and amino acids. The Discovery and development of fluorine-containing drugs and drug candidates are described, including fluorinated prostanoids (for glaucoma), fluorinated conformational restricted glutamate analogues (for CNS disorder), fluorinated MMP inhibitors (e.g. for cancer metastasis intervention), fluorotaxoids (for cancer), trifluoroartemisinin (for malaria), and fluorinated nucleosides (for viral infections). Synthetic routes and diagnostic tools, such as ^{19}F (also for imaging) NMR and ^{18}F PET, will be discussed in the module.

Intended Learning Outcomes

By the end of the module, the student will be able to:

- analyze and apply the unique properties of organofluorine compounds;
- evaluate ecological impact and physiological properties;
- identify fluorochemicals, e.g. by ^{19}F NMR spectroscopy;
- suggest synthetic approaches for complex organofluorine compounds;
- comprehend applications of organofluorine compounds as polymer xhemistry, materials, pharmaceuticals and agrochemicals;

Indicative Literature

P. Kirsch. Modern Organofluorine Chemistry, 2nd ed, Wiley-VCH, 2013, ISBN 978-3-527-33166-6. G. Haufe, F. R. Leroux. Fluorine in Life Sciences. Pharmaceuticals Medicinal, Diagnostics, and Agrochemicals (Eds. G. Haufe,F. Leroux) Academic Press, 2019, ISBN 9878-0-12-812733-9.

Usability and Relationship to other Modules

- This module is for students who continue to be curious and want to extend their studies in organic synthesis and may be considering graduate level education in Medicinal Chemistry or Organic Chemistry.
- Mandatory elective specialization module for third year MCCB students.

Examination Type: Module Examination

Assessment Type: Oral examination Duration: 20 min
Weight: 100%

Scope: All intended learning outcomes of the module.

7.21 Internship / Startup and Career Skills

Module Name	*Module Code*	*Level (type)*	*CP*
Internship / Startup and Career Skills	CA-INT-900	Year 3 (CAREER)	15

Module Components

Number	*Name*	*Type*	*CP*
CA-INT-900-0	Internship	Internship	15

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Sinah Vogel & Dr. Tanja Woebs (CSC Organization); SPC / Faculty Startup Coordinator (Academic responsibility)	• CAREER module for undergraduate study programs	Mandatory for all undergraduate study programs except IEM

Entry Requirements *Pre-requisites*	*Co-requisites*	*Knowledge, Abilities, or Skills*	*Frequency*	*Forms of Learning and Teaching*
☒ at least 15 CP from CORE modules in the major	☒ None	• Information provided on CSC pages (see below) • Major specific knowledge and skills	Annually (Spring/Fall)	• Internship/Start-up • Internship event • Seminars, info-sessions, workshops and career events • Self-study, readings, online tutorials
			Duration 1 semester	*Workload* 375 Hours consisting of: • Internship (308 hours) • Workshops (33 hours) • Internship Event (2 hours) • Self-study (32 hours)

Recommendations for Preparation

- Please see the section "Knowledge Center" at JobTeaser Career Center for information on Career Skills seminar and workshop offers and for online tutorials on the job market preparation and the application process. For more information, please see https://www.jacobs-university.de/employability/career-services
- Participating in the internship events of earlier classes

Content and Educational Aims

The aims of the internship module are reflection, application, orientation, and development: for students to reflect on their interests, knowledge, skills, their role in society, the relevance of their major subject to society, to apply these skills and this knowledge in real life whilst getting practical experience, to find a professional orientation, and to develop their personality and in their career. This module supports the programs' aims of preparing students for gainful, qualified employment and the development of their personality.

The full-time internship must be related to the students' major area of study and extends lasts a minimum of two consecutive months, normally scheduled just before the 5th semester, with the internship event and submission of the internship report in the 5th semester. Upon approval by the SPC and CSC, the internship may take place at other times, such as before teaching starts in the 3rd semester or after teaching finishes in the 6th semester. The Study Program Coordinator or their faculty delegate approves the intended internship a priori by reviewing the tasks in either the Internship Contract or Internship Confirmation from the respective internship institution or company. Further regulations as set out in the Policies for Bachelor Studies apply.

Students will be gradually prepared for the internship in semesters 1 to 4 through a series of mandatory information sessions, seminars, and career events.
The purpose of the Career Services Information Sessions is to provide all students with basic facts about the job market in general, and especially in Germany and the EU, and services provided by the Career Services Center.
In the Career Skills Seminars, students will learn how to engage in the internship/job search, how to create a competitive application (CV, Cover Letter, etc.), and how to successfully conduct themselves at job interviews and/or assessment centers. In addition to these mandatory sections, students can customize their skill set regarding application challenges and their intended career path in elective seminars.
Finally, during the Career Events organized by the Career Services Center (e.g. the annual Jacobs Career Fair and single employer events on and off campus), students will have the opportunity to apply their acquired job market skills in an actual internship/job search situation and to gain their desired internship in a high-quality environment and with excellent employers.

As an alternative to the full-time internship, students can apply for the StartUp Option. Following the same schedule as the full-time internship, the StartUp Option allows students who are particularly interested in founding their own company to focus on the development of their business plan over a period of two consecutive months. Participation in the StartUp Option depends on a successful presentation of the student's initial StartUp idea. This presentation will be held at the beginning of the 4th semester. A jury of faculty members will judge the student's potential to realize their idea and approve the participation of the students. The StartUp Option is supervised by the Faculty StartUp Coordinator. At the end of StartUp Option, students submit their business plan. Further regulations as outlined in the Policies for Bachelor Studies apply.

The concluding Internship Event will be conducted within each study program (or a cluster of related study programs) and will formally conclude the module by providing students the opportunity to present on their internships and reflect on the lessons learned within their major area of study. The purpose of this event is not only to self-reflect on the whole internship process, but also to create a professional network within the academic community, especially by entering the Alumni Network after graduation. It is recommended that all three classes (years) of the same major are present at this event to enable networking between older and younger students and to create an educational environment for younger students to observe the "lessons learned" from the diverse internships of their elder fellow students.

Intended Learning Outcomes

By the end of this module, students should be able to

- describe the scope and the functions of the employment market and personal career development;
- apply professional, personal, and career-related skills for the modern labor market, including self-organization, initiative and responsibility, communication, intercultural sensitivity, team and leadership skills, etc.;
- independently manage their own career orientation processes by identifying personal interests, selecting appropriate internship locations or start-up opportunities, conducting interviews, succeeding at pitches or assessment centers, negotiating related employment, managing their funding or support conditions (such as salary, contract, funding, supplies, work space, etc.);
- apply specialist skills and knowledge acquired during their studies to solve problems in a professional environment and reflect on their relevance in employment and society;
- justify professional decisions based on theoretical knowledge and academic methods;
- reflect on their professional conduct in the context of the expectations of and consequences for employers and their society;
- reflect on and set their own targets for the further development of their knowledge, skills, interests, and values;
- establish and expand their contacts with potential employers or business partners, and possibly other students and alumni, to build their own professional network to create employment opportunities in the future;
- discuss observations and reflections in a professional network.

Indicative Literature

Not specified

Usability and Relationship to other Modules • Mandatory for a major in BCCB, CBT, CS, EES, GEM, IBA, IRPH, ISCP, Math, MCCB, Physics, RIS, and SMP. • This module applies skills and knowledge acquired in previous modules to a professional environment and provides an opportunity to reflect on their relevance in employment and society. It may lead to thesis topics.
Examination Type: Module Examination Assessment Type: Internship Report or Business Plan and Reflection — Length: approx. 3.500 words Scope: All intended learning outcomes — Weight: 100%

7.22 Bachelor Thesis and Seminar

Module Name			*Module Code*	*Level (type)*	*CP*
Bachelor Thesis and Seminar			CA-CBT-800	Year 3 (CAREER)	15
Module Components					
Number	*Name*			*Type*	*CP*
CA-CBT-800-T	Thesis			Thesis	12
CA-CBT-800-S	Thesis Seminar			Seminar	3
Module Coordinator Study Program Chair	***Program Affiliation*** • All undergraduate programs			***Mandatory Status*** Mandatory for all undergraduate programs	
Entry Requirements			***Frequency*** Annually (Spring)	***Forms of Learning and Teaching*** • Self-study/lab work (350 hours) • Seminars (25 hours)	
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	***Duration***	***Workload***	
☒ Students must be in their third year and have taken at least 30 CP from CORE modules in their major.	☒ None	• comprehensive knowledge of the subject and deeper insight into the chosen topic; • ability to plan and undertake work independently; • skills to identify and critically review literature.	1 semester	375 hours	

Recommendations for Preparation

- Identify an area or a topic of interest and discuss this with your prospective supervisor in a timely manner.
- Create a research proposal including a research plan to ensure timely submission.
- Ensure you possess all required technical research skills or are able to acquire them on time.
- Review the University's Code of Academic Integrity and Guidelines to Ensure Good Academic Practice.

Content and Educational Aims

This module is a mandatory graduation requirement for all undergraduate students to demonstrate their ability to address a problem from their respective major subject independently using academic/scientific methods within a set time frame. Although supervised, this module requires students to be able to work independently and systematically and set their own goals in exchange for the opportunity to explore a topic that excites and interests them personally and that a faculty member is interested in supervising. Within this module, students apply their acquired knowledge about their major discipline and their learned skills and methods for conducting research, ranging from the identification of suitable (short-term) research projects, preparatory literature searches, the realization of discipline-specific research, and the documentation, discussion, interpretation, and communication of research results.

This module consists of two components, an independent thesis and an accompanying seminar. The thesis component must be supervised by a Jacobs University faculty member and requires short-term research work, the results of which must be documented in a comprehensive written thesis including an introduction, a justification of the methods, results, a discussion of the results, and a conclusion. The seminar provides students with the opportunity to practice their ability to present, discuss, and justify their and other students' approaches, methods, and results at various stages of their research in order to improve their academic writing, receive and reflect on formative feedback, and therefore grow personally and professionally.

Intended Learning Outcomes

On completion of this module, students should be able to

1. independently plan and organize advanced learning processes;
2. design and implement appropriate research methods, taking full account of the range of alternative techniques and approaches;
3. collect, assess, and interpret relevant information;
4. draw scientifically-founded conclusions that consider social, scientific, and ethical factors;
5. apply their knowledge and understanding to a context of their choice;
6. develop, formulate, and advance solutions to problems and debates within their subject area, and defend these through argument;
7. discuss information, ideas, problems, and solutions with specialists and non-specialists.

Usability and Relationship to other Modules

- This module builds on all previous modules in the undergraduate program. Students apply the knowledge, skills, and competencies they have acquired and practiced during their studies, including research methods and their ability to acquire additional skills independently as and if required.

Examination Type: Module Component Examinations

Module Component 1: Thesis
Assessment type: Thesis
Length: approx. 6.000 – 8.000 words (15 – 25 pages), excluding front and back matter.
Scope: All intended learning outcomes, mainly 1-6.
Weight: 80%

Module Component 2: Seminar
Assessment type: Presentation
Duration: approx. 15 to 30 minutes
Weight: 20%

Scope: The presentation focuses mainly on ILOs 6 and 7, but by nature of these ILOs it also touches on the others.

Completion: To pass this module, the examination of each module component has to be passed with at least 45%.

Two separate assessments are justified by the size of this module and the fact that the justification of solutions to problems and arguments (ILO 6) and discussion (ILO 7) should at least have verbal elements. The weights of the types of assessments are commensurate with the sizes of the respective module components.

7.23 Jacobs Track Modules

7.23.1 Methods and Skills Modules

7.23.1.1 Mathematical Concepts for the Sciences

Module Name		*Module Code*	*Level (type)*	*CP*
Mathematical Concepts for the Sciences		JTMS-MAT-07	Year 1 (Methods)	5
Module Components				
Number	*Name*		*Type*	*CP*
JTMS-07	Mathematical Concepts for the Sciences		Lecture	5
Module Coordinator(s) Dr. Keivan Mallahi Karai, Prof. Dr. Tobias Preußer	*Program Affiliation* • Jacobs Track – Methods and Skills		*Mandatory Status* Mandatory for BCCB, CBT, EES and MCCB	
Entry Requirements *Pre-requisites* ☒ None	*Co-requisites* ☒ None *Knowledge, Abilities, or Skills* • none	*Frequency* Annually (Fall)	*Forms of Learning and Teaching* • Lectures (35 hours) • Private study (90 hours)	
		Duration 1 semester	*Workload* 125 hours	
Recommendations for Preparation Review basic mathematical concepts and tools.				
Content and Educational Aims In this module, students develop and strengthen quantitative problem-solving skills that are important in the natural sciences. Hands-on exercises and group work are integrated in the lectures to maximize feedback between the students and the instructor. The module starts with a review of elementary mathematical concepts such as functions and their graphs, units and dimensions, and series and convergence. Vectors and matrices are introduced using linear equations, and then motivated further in the context of basic analytical geometry. An extended section on calculus proceeds from basic differentiation and integration to the solution of differential equations, always guided by applications in the natural sciences. The module is concluded by a data-oriented introduction to descriptive statistics and basic statistical modeling applied to laboratory measurements and observations of natural systems.				

Intended Learning Outcomes

By the end of this module, students will be able to

- identify important types of quantitative problems in the natural sciences;
- select and use key solution strategies, methods, and tools;
- explain and apply linear algebra concepts and techniques;
- analyze models and observations of natural systems using derivatives and integrals;
- classify differential equations, find equilibria, and apply standard solution methods;
- process data by means of descriptive statistics and basic regression techniques.

Indicative Literature

E. N. Bodine, S. Lenhart, and L. J. Gross (2014). Mathematics for the Life Sciences. Princeton: Princeton University Press.

D. Cherney, T. Denton, A. Waldron (2013, June). Linear Algebra. Retrieved from: https://www.math.ucdavis.edu/~linear/.

K.F. Riley, M.P. Hobson, and S.J. Bence (2002). Mathematical methods for physics and engineering, Cambridge: Cambridge University Press.

M. Corral. Vector Calculus (2008). Retrieved from: http://www.mecmath.net/calc3book.pdf.

Usability and Relationship to other Modules

- The module is a mandatory / mandatory elective module of the Methods and Skills area that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Mandatory for a major in BCCB, CBT, EES, and MCCB
- Elective for all other study programs.

Examination Type: Module Examination

Assessment type: Written examination — Duration: 120 min; Weight: 100%

Scope: All intended learning outcomes of this module.

7.23.1.2 Physics for the Natural Sciences

<table>
<tr><td colspan="3">Module Name
Physics for the Natural Sciences</td><td>Module Code
JTMS-SCI-17</td><td>Level (type)
Year 1 (Methods)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTMS-17</td><td colspan="3">Physics for the Natural Sciences</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Jürgen Fritz</td><td colspan="3">Program Affiliation

• Jacobs Track – Methods and Skills</td><td colspan="2">Mandatory Status

Mandatory for BCCB, CBT, EES and MCCB</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• High school math
• Basic high school physics</td><td>Frequency

Annually (Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Private study including homework (90 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
</table>

Recommendations for Preparation

Review high school math (especially calculus, geometry and vector analysis) and high school physics (basics of motion, forces and energy). Level and content follows the along standard textbooks for calculus-based first year general university physics, such as Young & Freedman: University Physics; Halliday, Resnick & Walker: Fundamentals of Physics; or others.

Content and Educational Aims

Physics is the most fundamental of all natural sciences and serves as a basis for other sciences and engineering disciplines. This module introduces non-physics majors to the basic principles, facts, and experimental evidence from physics, as it is needed especially for the life sciences, geosciences, and chemistry.
Emphasis is placed on general principles and general mathematical concepts for a basic understanding of physical phenomena. Basic mathematics (geometry, calculus, vector analysis) is used to develop a quantitative and scientific description of physical phenomena. A voluntary tutorial is offered to discuss homework or topics of interest in more detail.
The lecture provides an overview of the basic fields of physics such as mechanics (motion, force, energy, momentum, oscillations, fluid mechanics), thermodynamics (temperature, heat, 1st law, ideal gas and kinetic gas theory, thermodynamic processes, entropy), electromagnetism (charge, electric field, potential, current, magnetic field, induction), optics (oscillations, waves, sound, reflection and refraction, lenses and optical instruments, interference and diffraction), and modern physics (particle-wave duality, atoms and electrons, absorption and emission, spin, NMR, ionizing radiation, radioactivity).

Intended Learning Outcomes

By the end of the module, students will be able to:

- recall the basic facts and experimental evidence in mechanics, thermodynamics, electromagnetism, optics and modern physics;
- use the basic concepts of motion, force, energy, oscillations, heat, and light to describe natural and technical phenomena;

- apply basic problem-solving strategies from physics to test the plausibility of ideas or arguments, such as reducing different natural phenomena to their underlying physical principles, or using analogies, approximations, estimates or extreme cases;
- apply basic calculus, geometry, and vector analysis for a quantitative description of physical systems.

Indicative Literature

Young & Freedman, University Physics, with Modern Physics, Pearsson, latest edition.

Halliday, Resnick, Walker, Fundamentals of Physics, Extended Version, Wiley, latest edition.

Zinke-Allmang et al., Physics for the Life Sciences, Nelson Education, latest edition.

Usability and Relationship to other Modules

- The module is a mandatory / mandatory elective module of the Methods and Skills area that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Mandatory for a major in BCCB, CHEM, EES, and MCCB.
- Elective for all other study programs except physics majors.

Examination Type: Module Examination

Assessment type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module.

7.23.1.3 Analytical Methods

<table>
<tr><td colspan="3">Module Name
Analytical Methods</td><td>Module Code
JTMS-SCI-16</td><td>Level (type)
Year 2 (Methods)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTMS-16</td><td colspan="3">Analytical Methods</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Nikolai Kuhnert</td><td colspan="3">Program Affiliation

• Jacobs Track – Methods and Skills</td><td colspan="2">Mandatory Status

Mandatory for MCCB and CBT
Mandatory elective for BCCB and EES</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills: • Basic knowledge in Life Sciences</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (35 hours)
• Tutorial (10 hours)
• Private study (80 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
</table>

Recommendations for Preparation

Students should have a sound background knowledge in general chemistry and MCCB as well as organic chemistry acquired by attending the respective CHOICE courses. They should have understood the basic principles of chemical bonding and chemical structures as well as the basic concepts of quantification and experimental measurement.

Content and Educational Aims

Analytical science is an important applied area of all chemical and life sciences. Analytical science deals with the separation, identification, and quantification of any chemical compound. It therefore provides an interface between the traditional areas of organic, inorganic, and physical chemistry with life sciences and all other areas of science requiring the identification and quantification of chemical compounds. It provides the methods and toolbox for all experimental sciences. Analytical chemistry provides the tools for all areas of experimental chemistry and a good foundation of analytical techniques is not only expected of any chemist but also for scientists at the interface to the life sciences. The course will give an introduction to analytical chemistry with selected applications. This will include an introduction to analytical terms and definitions, basic statistic treatment of experimental data, qualitative and quantitative analysis and instrumental analysis with an emphasis on spectroscopic techniques such as UV/Vis, NMR, mass spectrometry, IR and Raman spectroscopy, and fluorimetry. Furthermore, separation techniques such as HPLC and GC will be introduced. A series of lectures covering application in drug analysis, clinical chemistry, forensics, and toxicology will complement the course.

Intended Learning Outcomes

By the end of this module, students will be able to

- illustrate knowledge of instrumental methods including spectroscopic techniques and separation techniques;
- explain and understand physical principles behind spectroscopic techniques and separation techniques and apply them to practically-orientated issues;
- apply knowledge of instrumental techniques to solve qualitative and quantitative analytical problems;
- interpret spectroscopic data and deduce chemical structures from these data;
- compare spectroscopic data and predict spectral properties from chemical structures;
- calculate quantitative values from analytical results;

- plan analytical experiments to solve chemical problems;
- calculate and estimate errors in analytical procedures by applying statistical methods;
- test scientific hypotheses;
- prepare scientific reports and critical analysis on experimental findings of analytical results.

Indicative Literature

Clayden, Greeves, Warren, Organic Chemistry, 2nd Edition, 2012 (ISBN 978-0-19-927029-3).

P.W. Atkins, Physical Chemistry 9th edition, 2006 (ISBN 9780198700722).

R. Kellner, J. Mermet, M. Otto, M. Valcarel, M. Widmer, Analytical Chemistry: A Modern Approach to Analytical Science, 2nd ed., 2004(ISBN: 978-3-527-30590-2).

Usability and Relationship to other Modules

- It complements the Analytical Chemistry laboratory course and provides the experimental tool box for all fields of chemistry and the associated life sciences.
- Mandatory for a major in CBT and MCCB.
- Mandatory elective for a major in BCCB and EES.

Examination Type: Module Examination

Assessment type: Written examination — Duration: 180 min, Weight: 100%

Scope: All intended learning outcomes of the module

7.23.1.4 Plant Metabolism and Natural Products

Module Name	*Module Code*	*Level (type)*	*CP*
Plant Metabolism and Natural Products	JTMS-SCI-18	Year 2 (Methods)	5

Module Components

Number	*Name*	*Type*	*CP*
JTMS-18	Plant Metabolism and Natural Products	Lecture	5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Prof. Dr. Matthias Ullrich	• Jacobs Track – Methods and Skills	Mandatory for BCCB, MCCB and CBT Mandatory elective for EES

Entry Requirements			*Frequency*	*Forms of Learning and Teaching*
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Spring)	• Lecture (35 hours) • Private study (90 hours)
☒ None	☒ None	• Comprehensive high school knowledge of chemistry, mathematics, physics, biochemistry, and cell biology	*Duration* 1 semester	*Workload* 125 hours

Recommendations for Preparation

Students should have a sound background knowledge in chemistry, mathematics, physics, biochemistry and cell biology.

Read the chapter "Plant Form and Function" (Joanne Chory) in the recommended textbook of Neil A. Campbell and Jane B. Reece, BIOLOGY, Benjamin Cummings, Pearson Education, current edition.

Content and Educational Aims

Understanding general principles of biochemical processes in living cells requires a rigorous and robust knowledge of nature's ways and capacities to form and use primary and secondary metabolites from inorganic materials via the autotrophic (producer) mode of algae and plants. This module introduces methods to assess and understand the breath-taking diversity of plant biochemical and cellular processes, plant metabolism, as well as plant-borne substances including their purposes and functions. An array of compounds produced by plants that are relevant to human health and nutrition will be introduced. This is done by demonstrating natural functions of biomolecules in plant metabolism or during regulation of biochemical processes. Methods to asses and quantify photosynthesis and the Calvin cycle will be introduced, as will be those needed to understand the phytohormone-based language of plants. State-of-the-art methods on how to analyze the fascinating types of interactions with other organisms is explained. Plant genetic engineering is introduced, and its methodology are explained in detail. Modern aspects of agriculture, food production, and the application of natural products in medicine will complete this methods survey of plant metabolism and natural products.

Intended Learning Outcomes

By the end of this module, students will be able to

- apply knowledge of biochemical and cellular processes to understand principles in the world of plants and algae;
- illustrate a plant's basic metabolic and biochemical features of plants;
- describe plant cells and plant tissue characteristics;
- explain how photosynthesis and the Calvin cycle enable autotrophic life;
- delineate how plants interact with their biotic and abiotic environment;
- explain the basic principles of Environmental Biochemistry;
- classify plant hormones, their roles, and the importance of their homeostasis;
- interpret the bioactivity potential of natural products;
- outline processes in plant biochemistry and plant genetics;
- describe natural product biosynthesis;
- illustrate how plants use basic building blocks to create complex structures;
- relate biological activities of natural products with their use for medicinal purposes;
- transfer the acquired knowledge to novel natural products;
- explain the importance of functional groups in natural products for bioactivity.

Indicative Literature

Urry et. al., Campell Biology, Pearson, latest edition.

Buchanan, Biochemistry and Molecular Biology of Plants, Wiley, latest edition.

Madigan et.al., Brock Biology of Microorganisms, latest edition.

Usability and Relationship to other Modules

- The module is a mandatory / mandatory elective module of the Methods and Skills area that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- This Methods module is mandatory for BCCB, MCCB, and CBT major students.
- Mandatory elective for a major in EES.
- It complements the non-photosynthesis learning components of BCCB's general education. It furthermore provides essential background knowledge for medicinal chemistry, chemical biology, chemistry, and biotechnology.
- For CBT major students: the module can be replaced with a CORE module from another study program to pursue a minor.
- It is elective for all other study programs.

Examination Type: Module Examination

Assessment type: Written examination — Duration: 120 min, Weight: 100%

Scope: All intended learning outcomes of the module.

7.23.2 Big Questions Modules

7.23.2.1 Water: The Most Precious Substance on Earth

Module Name			*Module Code*	*Level (type)*	*CP*
Water: The Most Precious Substance on Earth			JTBQ-BQ-002	Year 3 (Jacobs Track)	5
Module Components					
Number	*Name*			*Type*	*CP*
JTBQ-002	Water: The Most Precious Substance on Earth			Lecture/Tutorial	5
Module Coordinator Prof. Dr. Michael Bau and Dr. Doris Mosbach	*Program Affiliation* • Big Questions Area: All undergraduate study programs except IEM			*Mandatory Status* Mandatory elective for students of all undergraduate study programs, except IEM	
Entry Requirements			*Frequency*	*Forms of Learning and Teaching*	
Pre-requisites ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • The ability and openness to engage in interdisciplinary issues of global relevance • Media literacy, critical thinking, and a proficient handling of data sources	Annually (part I: Fall; part II: Spring)	• Lectures (17.5 hours) • Project work (90 hours) • Private study (17.5 hours)	
			Duration 2 semesters	*Workload* 125 hours	
Recommendations for Preparation Critically following media coverage on the module's topics in question.					

Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students' horizons with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society.

Water is the basic prerequisite for life on our planet, but it has become a scarce resource and a valuable commodity. Water is of fundamental importance to the world's economy and global food supply, in addition to being a driving force behind geopolitical conflict. In this module, the profound impact of water on all aspects of human life will be addressed from very different perspectives: from the natural and environmental sciences and engineering, and from the social and cultural sciences.

Following topical lectures in the Fall semester, students will work on projects on the occasion of the World Water Day (March 22) in small teams comprised of students from various disciplines and with different cultural backgrounds. This teamwork will be accompanied by related tutorials.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students will be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- advance a knowledge-based opinion on the complex module topics: on the physio-chemical properties of water, its origin and history, on the importance of water as a resource, on physical and economic freshwater scarcity, on the risks of water pollution and the challenges faced by waste water treatment, on the concept of virtual water, on the bottled water industry, and on the cultural values and meanings of water;
- formulate coherent written and oral contributions (e.g., to panel discussions) on the topic;
- perform well-organized teamwork;
- present a self-designed project in a university-wide context.

Indicative Literature

Finney, John (2015). Water. A Very Short Introduction. Oxford: Oxford University Press.

Zetland, David (2011). The End of Abundance: Economic Solutions to Water Scarcity. California: Aguanomics Press.

United Nation (January 2016): Sustainable Development Goals. Retrieved from https://www.ipcc.ch

Usability and Relationship to other Modules

- This module is a mandatory elective module in the Big Questions area, which is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Component 1: Written examination — Duration: 60 min, Weight: 50%

Assessment Component 2: Team project — Weight: 50%

Scope: All intended learning outcomes of the module

Completion: This module is passed with an assessment-component weighted average grade of 45% or higher.

7.23.2.2 Ethics in Science and Technology

<table>
<tr><td colspan="3">Module Name

Ethics in Science and Technology</td><td>Module Code

JTBQ-BQ-003</td><td>Level (type)

Year 3 (Jacobs Track)</td><td>CP

5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-003</td><td colspan="3">Ethics in Science and Technology</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Alexander Lerchl</td><td colspan="3">Program Affiliation

• Big Questions Area: All undergraduate study programs, except IEM</td><td colspan="2">Mandatory Status

Mandatory for CBT
Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• The ability and openness to engage in interdisciplinary issues of global relevance
• Media literacy, critical thinking, and a proficient handling of data sources</td><td>Frequency

Each semester

(Fall & Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lectures (35 hours)
• Private study (90 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Critically following media coverage of the scientific topics in question.</td></tr>
</table>

Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students' horizons with applied problem solving that extends beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society.

Ethics is an often neglected, yet essential part of science and technology. Our decisions about right and wrong influence the way in which our inventions and developments change the world. A wide array of examples will be presented and discussed, e.g., the foundation of ethics, individual vs. population ethics, artificial life, stem cells, animal rights, abortion, pre-implantation diagnostics, legal and illegal drugs, the pharmaceutical industry, gene modification, clinical trials and research with test persons, weapons of mass destruction, data fabrication, and scientific fraud.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students will be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- summarize and explain ethical principles;
- critically look at scientific results that seem too good to be true;
- apply the ethical concepts to virtually all areas of science and technology;
- discover the responsibilities of society and of the individual for ethical standards;
- understand and judge the ethical dilemmas in many areas of the daily life;
- discuss the ethics of gene modification at the level of cells and organisms;
- reflect on and evaluate clinical trials in relation to the Helsinki Declaration;
- distinguish and evaluate the ethical guidelines for studies with test persons.

Indicative Literature

Not specified.

Usability and Relationship to other Modules

- Mandatory for CBT
- This module is a mandatory elective module in the Big Questions area that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 120 min

Weight: 100%

Scope: All intended learning outcomes of the module.

7.23.2.3 Global Health – Historical context and future challenges

<table>
<tr><td colspan="3">Module Name

Global Health – Historical context and future challenges</td><td>Module Code

JTBQ-BQ-004</td><td>Level (type)

Year 3 (Jacobs Track)</td><td>CP

5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-004</td><td colspan="3">Global Health – Historical context and future challenges</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Dr. Andreas M. Lisewski</td><td colspan="3">Program Affiliation

• Big Questions Area: All undergraduate study programs, except IEM</td><td colspan="2">Mandatory Status

Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• The ability and openness to engage in interdisciplinary issues of global relevance
• Media literacy, critical thinking, and a proficient handling of data sources</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lectures (35 hours)
• Private study (90 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Critically following media coverage on the module's topics in question.</td></tr>
</table>

Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal and environmental contexts of the global issues and challenges of the coming decades. The BQ modules intend to raise awareness of those challenges and broaden the students' horizon with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules are relevant for every university graduate in order to become an informed and responsible citizen in a global society.

The module gives a historical, societal, technical, and medicinal overview over the past, present and future milestones and challenges of global health. Main topics include health systems, public health, health/disease monitoring and response, past and recent breakthroughs in medicine and healthcare, as well as recent health-related developments in technology and economy. Special focus is put on children, maternal and adolescent health, as their health is critical to the well-being of next generations. Further topics cover epidemiology and demographics, such as the connection between a society's economic development level and its population health status, demographic and epidemiologic transitions, measures of health status and disease burden, and health-related global development goals. An overall guiding aspect is human health in our increasingly interconnected civilization that is however reaching its global limits on key resources and that is therefore becoming more prone to disruptions. Discussed in this context are today's urgent global health issues, such as newly emergent and re-emergent infectious diseases, biosafety and complex humanitarian crises caused by unforeseen epidemics and pandemics.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students will be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- identify the historical context and today's function of global health institutions, surveillance and response systems;
- evaluate and compare global indicators of disease burden, especially by using online databases and repositories
- break down global development goals directly related to global health
- discuss and differentiate present and future challenges of public and global health responses to novel disease outbreaks in a global society network context

Indicative Literature

- Richard Skolnik, Global Health 101, 4th Edition, Jones & Bartlett Publishers, 2019
- Solomon Benatar (*Editor*), Global Health - Ethical Challenges, 2nd Edition, Cambridge University Press, 2021

Usability and Relationship to other Modules

- The module is a mandatory elective module of the Big Questions area, that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules)
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute such knowledge and competences to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 120 min.
Scope: All intended learning outcomes of the module — Weight: 100%

Module achievement: Oral presentation of selected literature and media topics on global health (topics are given but can also be suggested by students for approval).

The module achievement ensures sufficient knowledge about key global health concepts, challenges and current topics

7.23.2.4 Global Existential Risks

<table>
<tr><td colspan="3">Module Name

Global Existential Risks</td><td>Module Code

JTBQ-BQ-005</td><td>Level (type)

Year 3 (Jacobs Track)</td><td>CP

5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-005</td><td colspan="3">Global Existential Risks</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Dr. Andreas M. Lisewski</td><td colspan="3">Program Affiliation

• Big Questions Area: All undergraduate study programs except IEM</td><td colspan="2">Mandatory Status

Mandatory elective for students of all undergraduate study programs except IEM</td></tr>
<tr><td rowspan="2">Entry Requirements

Pre-requisites

☒ None</td><td rowspan="2">

Co-requisites

☒ None</td><td rowspan="2">

Knowledge, Abilities, or Skills

• The ability and openness to engage in interdisciplinary issues of global relevance
• Media literacy, critical thinking, and a proficient handling of data sources</td><td>Frequency

Annually

(Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lectures (35 hours)
• Tutorial of the lecture (10 hours)
• Private study (80 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Critically following media coverage on the module's topics in question.</td></tr>
<tr><td colspan="6">Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students' horizons with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society.

The more we develop science and technology, the more we also learn about catastrophic and, in the worst case, even existential global dangers that put the entire human civilization at risk of collapse. These doomsday scenarios therefore directly challenge humanity's journey through time as an overall continuous and sustainable process that progressively leads to a more complex but still largely stable human society. The module presents the main</td></tr>
</table>

known varieties of existential risks, including, for example, astrophysical, planetary, biological, and technological events or critical transitions that have the capacity to severely damage or even eradicate earth-based human civilization as we know it. Furthermore, this module offers a description of the characteristic features of these risks in comparison to more conventional risks, such as natural disasters, and a classification of global existential risks based on parameters such as range, intensity, probability of occurrence, and imminence. Finally, this module reviews several hypothetical monitoring and early warning systems as well as analysis methods that could potentially be used in strategies, if not to eliminate, then at least to better understand and ideally to minimize imminent global existential risks. This interdisciplinary module will allow students to look across relevant and diverse subject fields, thus enabling them to initiate and to contribute substantially to discussions about these special risks.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students will be able to

- identify and explain the known spectrum of global existential risks, including physical, biological, and technological risks
- differentiate and classify these risks according to their characteristics in range (scope), intensity (severity), probability of occurrence, and imminence
- distinguish and identify main directions and potential biases in media coverage of global existential risks
- prepare, present, explain and discuss today's key topics in global existential risks from both academic literature and from public media

Indicative Literature

Nick Bostrom, Milan M. Cirkovic (eds.):. Global Catastrophic Risks,Oxford University Press,2011.

Martin Rees: Our Final Hour – A Scientist's Warning,Basic Books,2009.

Martin Rees: On the Future – Prospects for Humanity, Princeton University Press, 2021.

Usability and Relationship to other Modules

- This module is a mandatory elective module in the Big Questions area, which is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 120 min.
Scope: All intended learning outcomes of the module — Weight: 100%

Module achievement: Oral presentation of selected literature and media topics on our civilization's existential risks (topics are given but can also be suggested by students for approval)

The module achievement ensures sufficient knowledge about key risks and challenges for humanity's survival.

7.23.2.5 Future: From Predictions and Visions to Preparations and Actions

<table>
<tr><td colspan="3">Module Name

Future: From Predictions and Visions to Preparations and Actions</td><td>Module Code

JTBQ-BQ-006</td><td>Level (type)

Year 3 (Jacobs Track)</td><td>CP

2.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-006</td><td colspan="3">Future: From Predictions and Visions to Preparations and Actions</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Joachim Vogt</td><td colspan="3">Program Affiliation

• Big Questions Area: All undergraduate study programs, except IEM</td><td colspan="2">Mandatory Status

Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• The ability and openness to engage in interdisciplinary issues of global relevance
• Media literacy, critical thinking, and a proficient handling of data sources</td><td>Frequency

Annually
(Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (17.5 hours)
• Private study (45 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

62.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Critically following media coverage of the module’s topics in question.</td></tr>
</table>

Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students' horizons with applied problem solving that extend beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society.

This module addresses selected topics related to the future as a general concept in science, technology, culture, literature, ecology, and economy, and it consists of three parts. The first part (Future Continuous) discusses forecasting methodologies rooted in the idea that key past and present processes are understood and continue to operate such that future developments can be predicted. General concepts covered in this context include determinism, uncertainty, evolution, and risk. Mathematical aspects of forecasting are also discussed. The second part (Future Perfect) deals with human visions of the future as reflected in the arts and literature, ranging from ideas of utopian societies and technological optimism to dystopian visions in science fiction. The third part (Future Now) concentrates on important current developments—such as trends in technology, scientific breakthroughs, the evolution of the Earth system, and climate change—and concludes with opportunities and challenges for present and future generations.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, student should be able to

- use their factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- distinguish and qualify important approaches to forecasting and prediction;
- summarize the history of utopias, dystopias, and the ideas presented in classical science fiction;
- characterize current developments in technology, ecology, society, and their implications for the future.

Indicative Literature

United Nations (2015, September) Millennium Development Goals. Retrieved from http://www.un.org/millenniumgoals.

United Nation (2016, January): Sustainable Development Goals. Retrieved from http://catalog.jacobs-university.de/search~S0

United Nations University. https://unu.edu

US National Intelligence Council (2017). Global Trends. Retrieved from https://www.dni.gov/index.php/global-trends-home.

International Panel on Climate Change. Retrieved from https://www.ipcc.ch.

World Inequality Lab (2017, December). World Inequality Report 2018. Retrieved from https://wir2018.wid.world.

World Health Organization. Retrieved from http://www.who.int.

World Trade Organization. Retrieved from *https://www.wto.org*

Gapminder. Retrieved from https://www.gapminder.org.

World Bank. Retrieved from http://www.worldbank.org.

Usability and Relationship to other Modules

- This module is a mandatory elective module in the Big Questions area, which is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Written examination	Duration: 60 min Weight: 100%
Scope: All intended learning outcomes of the module	

7.23.2.6 Climate Change

<table>
<tr><td colspan="3">Module Name

Climate Change</td><td>Module Code

JTBQ-BQ-007</td><td>Level (type)

Year 3 (Jacobs Track)</td><td>CP

2.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-007</td><td colspan="3">Climate Change</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Laurenz Thomsen and Prof. Dr. Vikram Unnithan</td><td colspan="3">Program Affiliation

• Big Questions Area: All undergraduate study programs, except IEM</td><td colspan="2">Mandatory Status

Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements</td><td>Frequency

Annually

(Spring)</td><td colspan="2" rowspan="2">Forms of Learning and Teaching

• Lecture (17.5 hours)
• Private study (45 hours)</td></tr>
<tr><td></td></tr>
<tr><td>Pre-requisites

☒ None</td><td>Co-requisites

☒ None</td><td>Knowledge, Abilities, or Skills

• The ability and openness to engage in interdisciplinary issues of global relevance
• Media literacy, critical thinking, and a proficient handling of data sources</td><td>Duration

1 semester</td><td colspan="2">Workload

62.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Critically following media coverage of the module's topics in question.</td></tr>
</table>

Content and Educational Aims

All “Big Questions” (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students’ horizon with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society.

This module will give a brief introduction into the development of the atmosphere throughout Earth's history from the beginning of the geological record up to modern times, and will focus on geological, cosmogenic, and anthropogenic changes. Several major events in the evolution of the Earth that had a major impact on climate will be discussed, such as the evolution of an oxic atmosphere and ocean, the onset of early life, snowball Earth, and modern glaciation cycles. In the second part, the module will focus on the human impact on present climate change and global warming. Causes and consequences, including case studies and methods for studying climate change, will be presented and possibilities for climate mitigation (geo-engineering) and adapting our society to climate change (such as coastal protection and adaption of agricultural practices to more arid and hot conditions) will be discussed.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students should be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- advance a knowledge-based opinion on the complex module topics, including: impact of climate change on the natural environment over geological timescales and since the industrial revolution, and the policy framework in which environmental decisions are made internationally;
- work effectively in a team environment and undertake data interpretation;
- discuss approaches to minimize habitat destruction.

Indicative Literature

The course is based on a self-contained, detailed set of online lecture notes.

Ruddiman, William F. Earth's Climate (2001). Past and future. New York: Macmillan.

Usability and Relationship to other Modules

- This module is a mandatory elective module in the Big Questions area, which is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Written examination	Duration: 60 min.
Scope: All intended learning outcomes of the module	Weight: 100%

7.23.2.7 Extreme Natural Hazards, Disaster Risks, and Societal Impact

<table>
<tr><td colspan="3">Module Name
Extreme Natural Hazards, Disaster Risks, and Societal Impact</td><td>Module Code
JTBQ-BQ-008</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
2.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-008</td><td colspan="3">Extreme Natural Hazards: Disaster Risks, and Societal Impact</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator
Prof. Dr. Laurenz Thomsen</td><td colspan="3">Program Affiliation
• Big Questions Area: All undergraduate study programs, except IEM</td><td colspan="2">Mandatory Status
Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="3">Entry Requirements</td><td>Frequency
Annually
(Fall)</td><td colspan="2">Forms of Learning and Teaching
• Lecture (17.5 hours)
• Private study (45 hours)</td></tr>
<tr><td>Pre-requisites
☒ None</td><td>Co-requisites
☒ None</td><td>Knowledge, Abilities, or Skills
• The ability and openness to engage in interdisciplinary issues of global relevance
• Media literacy, critical thinking, and a proficient handling of data sources</td><td>Duration
1 semester</td><td colspan="2">Workload
62.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation
Critically following media coverage of the module's topics in question.</td></tr>
<tr><td colspan="6">Content and Educational Aims
All "Big Questions" (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students' horizons with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society.

Extreme natural events increasingly dominate global headlines, and understanding their causes, risks, and impacts, as well as the costs of their mitigation, is essential to managing hazard risk and saving lives. This module presents a unique, interdisciplinary approach to disaster risk research, combining natural science and social science methodologies. It presents the risks of global hazards and natural disasters such as volcanoes, earthquakes, landslides, hurricanes, precipitation floods, and space weather, and provides real-world hazard and disaster case studies from Latin America, the Caribbean, Africa, the Middle East, Asia, and the Pacific.</td></tr>
</table>

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, student should be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- advance a knowledge-based opinion on the complex module topics, including how natural processes affect and interact with our civilization, especially those that create hazards and disasters;
- distinguish the methods scientists use to predict and assess the risk of natural disasters;
- discuss the social implications and policy framework in which decisions are made to manage natural disasters;
- work effectively in a team environment.

Indicative Literature

The course is based on a self-contained, detailed set of online lecture notes.

Ismail-Zadeh, Alik, et al., eds (2014). Extreme natural hazards, disaster risks and societal implications. In *Special Publications of the International Union of Geodesy and Geophysics Vol. 1.* Cambridge: Cambridge University Press.

Usability and Relationship to other Modules

- The module is a mandatory elective module of the Big Questions area, that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules)
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute such knowledge and competences to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Written examination	Duration: 60 min.
Scope: All intended learning outcomes of the module	Weight: 100%

7.23.2.8 International Development Policy

<table>
<tr><td colspan="2">Module Name

International Development Policy</td><td>Module Code

JTBQ-BQ-009</td><td>Level (type)

Year 3 (Jacobs Track)</td><td>CP

2.5</td></tr>
<tr><td colspan="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-009</td><td colspan="2">International Development Policy</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Claas Knoop</td><td colspan="2">Program Affiliation

• Big Questions Area: All undergraduate study programs, except IEM</td><td colspan="2">Mandatory Status

Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="2" rowspan="2">Entry Requirements

Pre-requisites: ☒ None

Co-requisites: ☒ None

Knowledge, Abilities, or Skills:
• The ability and openness to engage in interdisciplinary issues of global relevance
• Media literacy, critical thinking, and a proficient handling of data sources</td><td>Frequency

Annually

(Fall)</td><td colspan="2">Forms of Learning and Teaching

• Lecture (17.5 hours)
• Presentations
• Private study (45 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

62.5 hours</td></tr>
<tr><td colspan="5">Recommendations for Preparation

Critically following media coverage of the module’s topics in question.</td></tr>
</table>

Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students' horizon with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society.

We live in a world where still a large number of people still live in absolute poverty without access to basic needs and services, such as food, sanitation, health care, security, and proper education. This module provides an introduction to the basic elements of international development policy, with a focus on the relevant EU policies in this field and on the Sustainable Development Goals/SDGs of the United Nations. The students will not only learn about the tools applied in modern development policies, but also about the critical aspects of monitoring and evaluating the results of development policy. Module-related oral presentations and debates will enhance the students' learning experience.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, the student should be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- breakdown the complexity of modern development policy;
- identify, explain, and evaluate the tools applied in development policy;
- formulate well-justified criticism of development policy;
- summarize and present a module-related topic in an appropriate verbal and visual form.

Indicative Literature

Francis Fukuyama (2006). The end of history and the last man. New York: Free Press.

Kingsbury, McKay, Hunt (2008). International Development.Issues and challenges. London: Palgrave.

A.Sumner, M.Tiwari (2009) After 2015: International Development Policy at a crossroad. New York: Palgrave Macmillan.

Graduate Institute of International Development, G. Carbonnier eds. (2001). International Development Policy: Energy and Development. New York:Palgrave Macmillan.

John Donald McNeil. International Development: Challenges and Controversy. Sentia Publishing,e-book.

Usability and Relationship to other Modules

- This module is a mandatory elective module in the Big Questions area, which is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).

- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Presentation
Scope: All intended learning outcomes of the module

Duration: 10 minutes per student
Weight: 100%

7.23.2.9 Sustainable Value Creation with Biotechnology. From Science to Business

<table>
<tr><td colspan="3">Module Name

Sustainable Value Creation with Biotechnology. From Science to Business</td><td>Module Code

JTBQ-BQ-011</td><td>Level (type)

Year 3

(Jacobs Track)</td><td>CP

2.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-011</td><td colspan="3">Sustainable Value Creation with Biotechnology. From Science to Business</td><td>Lecture /Tutorial</td><td>2.5</td></tr>
<tr><td>Module Coordinator

N.N.</td><td colspan="3">Program Affiliation

• Jacobs Track - Big Questions</td><td colspan="2">Mandatory Status

Mandatory elective for students of all undergraduate study except IEM</td></tr>
<tr><td rowspan="2">Entry Requirements

Pre-requisites

☒ None</td><td rowspan="2">Co-requisites

☒ None</td><td rowspan="2">Knowledge, Abilities, or Skills

• The ability and openness to engage in interdisciplinary issues on bio-based value creation
• media literacy, critical thinking and a proficient handling of data sources</td><td>Frequency

Annually

(Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lecture and Tutorial (17.5 hours)
• Private study (45 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

62.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation
https://www.ctsi.ucla.edu/researcher-resources/files/view/docs/EGBS4_Kolchinsky.pdf
https://link.springer.com/article/10.1057/jcb.2008.27

https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf</td></tr>
</table>

Content and Educational Aims

All “Big Questions” (BQ) modules deal with the economic, technological, societal and environmental contexts of the global issues and challenges of the coming decades. The BQ modules intend to raise awareness of those challenges and broaden the students’ horizon with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become an informed and responsible citizen in a global society.

This module has a particular focus on the role that Biotechnology and Biorefining is expected to play in social, economic and environmental contexts.

To deliver such a vision the module will prepare students to extract value form Biotechnology and associated activities. This will be done in the form of business cases that will be systematically developed by students alongside the development of the module. In this way, students will develop entrepreneurial skills while understanding basic business-related activities that are not always present in a technical curriculum. Case development will also provide students with the possibility of understanding the social, economic, environmental impact that Biotechnology and Biorefining can deliver in a Bio-Based Economy. The knowledge and skills gained through this module are in direct and indirect support of the UN 2030 Agenda for Sustainable Development: “Transforming our World”.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, the students should be able to

- design and develop a Business Case based on the tools provided by modern Biotechnology;
- explain the interplay between Science, Technology and Economics / Finance;
- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- work effectively in a team environment and undertake data interpretation and analysis;
- discuss approaches to value creation in the context of Biotechnology and Sustainable Development;
- explain the ethical implications of technological advance and implementation;
- demonstrate presentation skills.

Indicative Literature

Springham, D., V. Moses & R.E. Cape (1999). Biotechnology – The Science and the Business. 2nd. Ed. Boca Raton: CRC Press.

Kornberg, Arthur (2002). The Golden Helix: Inside Biotech Ventures. Sausalito, CA: University Science Books.

UNESCO, Director-General. (2017). UNESCO moving forward the 2030 Agenda for Sustainable Development. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000247785

Usability and Relationship to other Modules

- The module is a mandatory elective module in the Big Questions area, which is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute their knowledge and competencies to class discussions and activities.

Examination Type: Module Examination

Assessment Component 1: Term Paper Scope: Intended learning outcomes of the module (1-6)	Length:1.500 – 3.000 words Weight: 75%
Assessment Component 2: Presentation Scope: Intended learning outcomes of the module (2-7)	Duration: 10-15 min. Weight: 25%

7.23.2.10 Gender and Multiculturalism. Debates and Trends in Contemporary Societies

Module Name			*Module Code*	*Level (type)*	*CP*
Gender and Multiculturalism. Debates and Trends in Contemporary Societies			JTBQ-BQ-013	Year 3 (Jacobs Track)	5
Module Components					
Number	*Name*			*Type*	*CP*
JTBQ-013	Gender and Multiculturalism: Debates and Trends in Contemporary Societies			Lecture	5
Module Coordinator Dr. Jessica Price	*Program Affiliation* • Big Questions Area: All undergraduate study programs			*Mandatory Status* Mandatory elective for students of all undergraduate study programs, except IEM	
Entry Requirements			*Frequency*	*Forms of Learning and Teaching*	
Pre-requisites ☒ None	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • The ability and openness to engage in interdisciplinary issues of global relevance • Media literacy, critical thinking and a proficient handling of data sources	Annually (Fall)	• Lectures (17.5 hours) • Project work (90 hours) • Private study (17.5 hours)	
			Duration 1 semester	*Workload* 125 hours	
Recommendations for Preparation					
Critical following of the media coverage on the module's topics in question.					
Content and Educational Aims					

All "Big Questions" (BQ) modules deal with the economic, technological, societal and environmental contexts of the global issues and challenges of the coming decades. The BQ modules intend to raise awareness of those challenges and broaden the students' horizon with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules are relevant for every university graduate in order to become an informed and responsible citizen in a global society.

The objective of this module is to introduce and familiarize students with the current debates, trends and analytical frameworks pertaining how gender is socially constructed in different cultural zones. Through lectures, group discussions and reflecting upon cultural cases, students will familiarize themselves with the current trends and the different sides of ongoing cultural and political debates that shape cultural practices, policies and discourses. The module will zoom-in on topics such as: cultural identity; the social construction of gender; gender fluidity and its backlash; gender and human rights; multiculturalism as a perceived threat in plural societies, among others. Students will be provided with opportunities for reflection and to ultimately develop informed opinions concerning topics that are continue to define some of the most contested cultural debates of contemporary societies. Furthermore, participants will engage their ideas in "hands on" projects aimed at moving the needle from mere reflection by conducting "action-research" that will inform the outcomes of their course projects.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students will be able to

- use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- summarize and evaluate the current cultural, political and legal debates concerning the social construction of gender in contemporary societies;
- reflect and develop informed opinions concerning the current debates and trends that are shaping ideas of whether multiculturalism ideals are realistic in pluralist western societies, or whether multiculturalism is a failed project;
- identify, explain and evaluate the role that societal forces, such as religion, socio-economic, political and migratory factors play in the construction of gendered structures in contemporary societies;
- develop a well-informed perspective concerning the interplay of science and culture in the debates around gender fluidity;
- deconstruct and reflect on the intersectionality between populist/nationalist discourses and gender discrimination;
- reflect and propose societal strategies and initiatives that attempt to answer the big questions presented in this module regarding gendered and cross-culturally-based inequalities;
- complete a self-designed project, collect and distill information from an "action-research" perspective;summarizing the process in a suitable reporting format;
- consider the application of an algorithm for group formation (not mandatory);
- overcome general teamwork problems in order to perform well-organized project work.

Indicative Literature

Biological Limits of Gender Construction Author(s): J. Richard Udry

Source: American Sociological Review , Jun., 2000, Vol. 65, No. 3 (Jun., 2000), pp. 443- 457. Published by: American Sociological Association Stable URL: https://www.jstor.org/stable/2657466

The Development of Gendered Interests and Personality Qualities From Middle Childhood Through Adolescence: A Biosocial Analysis. Susan M. McHale, Aryn M. Dotterer, Ji-Yeon Kim, Ann C. Crouter and Alan Booth. Child Development, March/April 2009, Volume 80, Number 2, Pages 482–495

Factors influencing attitudes to violence against women. Michael Flood and Bob Pease. Trauma, Violence, & ABuse, Vol. 10, No. 2, April 2009 125-142 dOi: 10.1177/1524838009334131. 2009 sAge Publications

Gender and Anti-immigrant Attitudes in Europe. Aaron Ponce (2017) Socius: Sociological Research for a Dynamic World. Volume 3: 1–17. Reprints and permissions: sagepub.com/journalsPermissions.nav

Usability and Relationship to other Modules

- The module is a mandatory elective module of the Big Questions area, that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules)
- Students are encouraged to relate the content of their previous modules to the topics of this module and contribute such knowledge and competences to class discussions and activities.

Examination Type: Module Examination

Assessment Type: Team Project Scope: All intended learning outcomes of the module	Weight: 100%

7.23.2.11 The Challenge of Sustainable Energy

<table>
<tr><td colspan="3">Module Name

The Challenge of Sustainable Energy</td><td>Module Code

JTBQ-BQ-014</td><td>Level (type)

Year 3 (Jacobs Track)</td><td>CP

2.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td colspan="4">Number</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-014</td><td colspan="3">The Challenge of Sustainable Energy</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Karen Smith Stegen</td><td colspan="3">Program Affiliation

• Big Questions Area: All undergraduate study programs</td><td colspan="2">Mandatory Status

Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites
☒ None

Co-requisites
☒ None

Knowledge, Abilities, or Skills
• Ability to read texts from a variety of disciplines</td><td>Frequency

Annually
(Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lectures and Group Exercises</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

62.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Reflect on their own behavior and habits with regard to sustainability.</td></tr>
<tr><td colspan="6">Content and Educational Aims

All “Big Questions” (BQ) modules deal with the economic, technological, societal and environmental contexts of the global issues and challenges of the coming decades. The BQ modules intend to raise awareness of those challenges and broaden the students’ horizon with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules are relevant for every university graduate in order to become an informed and responsible citizen in a global society.

How can wide-scale social, economic and political change be achieved? This module examines this question in the context of encouraging “sustainability”. To address global warming and environmental degradation, humans must adopt more sustainable lifestyles. Arguably, the most important change is the transition from conventional fuels to renewable sources of energy, particularly at the local, country and regional levels. The main challenge to achieving an “energy transition” stems from human behavior and not from a lack of technology or scientific expertise. This module thus examines energy transitions from the perspective of the social sciences, including political science, sociology, psychology, economics and management. To understand the drivers of and obstacles to technology transitions, students will learn the “Multi-Level Perspective”. Some of the key questions explored</td></tr>
</table>

in this module include: What is meant by sustainability? Are renewable energies “sustainable”? How can a transition to renewable energies be encouraged? What are the main social, economic, and political challenges? How can these (potentially) be overcome? The aim of the course is to provide students with the tools for reflecting on energy transitions from multiple perspectives.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

By the end of this module, students will be able to

- articulate the history of the sustainability movement and the major debates;
- identify different types of renewable energies;
- explain the multi-level perspective (MLP), which models technology innovations and transitions;
- summarize the obstacles to energy transitions;
- compare a variety of policy mechanisms for encouraging renewable energies.

Usability and Relationship to other Modules

- The module is a mandatory elective module of the Big Questions area that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- For students interested in sustainability issues, this module complements a variety of modules from different programs, such as “International Resource Politics” (IRPH/SMP), “Environmental Science” (EES), “General Earth and Environmental Sciences” (EES), and “Renewable Energies” (Physics).

Examination Type: Module Examination

Assessment Type: Written Examination

Duration: 60 min
Weight: 100%

Scope: All intended learning outcomes of the module

7.23.2.12 State, Religion and Secularism

<table>
<tr><td colspan="3">Module Name

State, Religion and Secularism</td><td>Module Code

JTBQ-BQ-015</td><td>Level (type)

Year 3 (Jacobs Track)</td><td>CP

2.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td colspan="4">Number</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-015</td><td colspan="3">State, religion and secularism</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Manfred O. Hinz</td><td colspan="3">Program Affiliation

• Big Questions Area: All undergraduate study programs</td><td colspan="2">Mandatory Status

Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• Ability to read texts from a variety of disciplines</td><td>Frequency

Annually

(Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lectures and Group Exercises</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

62.5 Hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Reflect on the situation and role in respective home-country</td></tr>
<tr><td colspan="6">Content and Educational Aims

The relationship between state and religion has been a matter of concern in most if not all societies. Is religion above the state, or is it to the state to determine the place of religion? What does secularity mean? To what extent will religion accept secularity? Where does the idea of secularity come from? The course State, religion, secularism will search for answers to questions of this nature. After introducing to the topic and looking at some legal attempts to regulate the relationship between state and religion, the focus will be, on the one hand, on Christianity and secularity and, on Islam and secularity, on the other. Depending on the interest of participants, other religions and their relationships to states of relevance can be added.</td></tr>
</table>

Intended Learning Outcomes

By the end of this course, students should be able

- To understand the basic problems that have led to different models to regulate the relationship between the state and religion;
- To reflect critically the situation of state and religion in selected countries;
- To assess the values behind the concept of democracy and human rights;
- To use the acquired knowledge to strengthen the capacity towards respect for others and tolerance.

Usability and Relationship to other Modules

- The module is a mandatory elective module of the Big Questions area that is part of the Jacobs Track (Methods and Skills modules; Community Impact Project module; Language modules; Big Questions modules).
- For students interested in State, Religion and secularism, this module complements modules from other programmes, such as IRPH and SMP

Examination Type: Module Examination

Assessment Type: Term paper

Length:1.500 – 3.000 words
Weight: 100%

Scope: All intended learning outcomes of the module.

7.23.3 Community Impact Project

<table>
<tr><td colspan="3">Module Name
Community Impact Project</td><td>Module Code
JTCI-CI-950</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTCI-950</td><td colspan="3">Community Impact Project</td><td>Project</td><td>5</td></tr>
<tr><td>Module Coordinator

CIP Faculty Coordinator</td><td colspan="3">Program Affiliation

• All undergraduate study programs except IEM</td><td colspan="2">Mandatory Status

Mandatory for all undergraduate study programs except IEM</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ at least 15 CP from CORE modules in the major
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• Basic knowledge of the main concepts and methodological instruments of the respective disciplines</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching

• Introductory, accompanying, and final events: 10 hours
• Self-organized teamwork and/or practical work in the community: 115 hours</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">Workload

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

Develop or join a community impact project before the 5th semester based on the introductory events during the 4th semester by using the database of projects, communicating with fellow students and faculty, and finding potential companies, organizations, or communities to target.</td></tr>
<tr><td colspan="6">Content and Educational Aims

CIPs are self-organized, major-related, and problem-centered applications of students’ acquired knowledge and skills. These activities will ideally be connected to their majors so that they will challenge the students’ sense of practical relevance and social responsibility within the field of their studies. Projects will tackle real issues in their direct and/or broader social environment. These projects ideally connect the campus community to other communities, companies, or organizations in a mutually beneficial way.
Students are encouraged to create their own projects and find partners (e.g., companies, schools, NGOs), but will get help from the CIP faculty coordinator team and faculty mentors to do so. They can join and collaborate in interdisciplinary groups that attack a given issue from different disciplinary perspectives.
Student activities are self-organized but can draw on the support and guidance of both faculty and the CIP faculty coordinator team.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes

The Community Impact Project is designed to convey the required personal and social competencies for enabling students to finish their studies at Jacobs as socially conscious and responsible graduates (part of the Jacobs mission) and to convey social and personal abilities to the students, including a practical awareness of the societal context and relevance of their academic discipline.

By the end of this project, students should be able to
• understand the real-life issues of communities, organizations, and industries and relate them to concepts in their own discipline;</td></tr>
</table>

- enhance problem-solving skills and develop critical faculty, create solutions to problems, and communicate these solutions appropriately to their audience;
- apply media and communication skills in diverse and non-peer social contexts;
- develop an awareness of the societal relevance of their own scientific actions and a sense of social responsibility for their social surroundings;
- reflect on their own behavior critically in relation to social expectations and consequences;
- work in a team and deal with diversity, develop cooperation and conflict skills, and strengthen their empathy and tolerance for ambiguity.

Indicative Literature

Not specified

Usability and Relationship to other Modules

- Students who have accomplished their CIP (6th semester) are encouraged to support their fellow students during the development phase of the next year's projects (4th semester).

Examination Type: Module Examination

Project, not numerically graded (pass/fail)
Scope: All intended learning outcomes of the module

7.23.4 Language Modules

The descriptions of the language modules are provided in a separate document, the "Language Module Handbook" that can be accessed from here: https://www.jacobs-university.de/study/learning-languages

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8 Appendix

8.1 Intended Learning Outcomes Assessment-Matrix

Chemistry and Biotechnology					Gen. Biochemistry	Gen. and Inorganic Chem.	General Organic Chemistry	Intro. to Biotechnology	Industrial Biotechnology	Physical Chemistry	Adv. Inorganic Chemistry	Scientific Software & Db	Adv. Organic Chemistry	Org. & Analytical Chem. Lab	Bioprocess Engineering	Advanced Biotechnology Lab	Inorg. & Phys. Chem. Lab	Chemical & Pharma. Tech.	Environ. Microbiol. and Biotech	Organometallic Chemistry	Internship/Start-up	Bachelor Thesis/Seminar	JT Methods/Skills	JT Big Questions	JT Commun. Impact Proj.	JT Language
Semester					1	1	2	2	3	3	4	4	4	3	4	3	4	5	5	5	5	6	1-4	5	5	1-4
Mandatory/mandatory elective					m	m	m	m	m	m	m	m#	m	m	m	m	m	me	me	me	m	m	m/me	me/m	m	m
Credits					7.5	7.5	7.5	7.5	5	5	5	5	5	5	5	5	5	5	5	5	15	15	20	10	5	10
	Competencies*																									
Program Learning Outcomes	**A**	**E**	**P**	**S**																						
A1	x	x			x	x	x				x		x							x						
A2	x	x				x	x			x	x		x													
A3	x	x								x				x		x	x	x	x	x			x			
A4	x	x			x			x	x						x			x					x			
A5	x	x			x			x	x	x					x	x							x			
A6	x	x			x			x	x						x	x						x	x			
A7	x	x						x	x						x	x	x		x				x			
A8	x	x						x	x										x							
B1	x	x				x	x			x	x		x	x				x	x			x	x			
B2	x	x								x		x		x		x	x		x				x			
B3	x	x																				x				
B4	x	x	x			x	x									x	x							x		
B5	x	x	x					x	x		x		x		x				x		x					
B6	x	x	x					x	x										x					x		
C1	x	x	x			x	x	x						x	x	x	x					x		x		
C2	x	x	x					x	x						x		x					x		x		
C3	x	x			x	x	x	x						x		x	x					x				
C4	x	x				x	x	x						x			x					x				
D1		x	x	x																	x	x				
D2	x		x	x					x			x														
D3		x	x	x	x	x	x	x						x		x	x					x				
D4		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Assessment Type																										
Oral examination																				x						
Written examination					x	x	x	x	x	x	x		x		x			x	x							
Project																						x			x	
Essay																										
(Lab) report					x	x	x	x						x		x	x				x					
Poster presentation																										
Presentation										x												x				
Thesis																						x				
Various												x											x	x		x
module achievements/bonus achievements						x		x									x									x
me: can be exchanged for a module of a Minor																										
*Competencies: A-scientific/academic proficiency; E-competence for qualified employment; P-development of personality; S-competence for engagement in society																										

Figure 4: Intended Learning Outcomes Assessment-Matrix