Study Program Handbook

Medicinal Chemistry and Chemical Biology

Bachelor of Science

Subject-specific Examination Regulations for Medicinal Chemistry and Chemical Biology (Fachspezifische Prüfungsordnung) ¨

The subject-specific examination regulations for Medicinal Chemistry and Chemical Biology 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).

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Contents

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 with supplemental 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 in the democratic, peaceful, and sustainable development of the societies in which they live. This is achieved through high-quality teaching, 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 for all study programs at Jacobs University, both in terms of actual disciplinary subject matter and also of 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 students' education. In addition, Jacobs University offers professional advising and counseling.

Jacobs 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

Pharmaceutical drug innovation requires well-trained scientists with a deep and broad understanding of current drug development. In that light, Chemical Biology is providing new avenues into Medicinal Chemistry insight, and the combined fields are the inspiration for our B.Sc. degree in Medicinal Chemistry and Chemical Biology (MCCB). The program prepares students to lead tomorrow's advances by learning the core chemical concepts and applying them from the molecular to the physiological level. This more encompassing approach equips students to understand what is required to cure disease while bringing improvement to that process. The program is unique in the German academic landscape in that an interdisciplinary education between Chemistry and the Life Sciences is offered at the Bachelor level. With a degree in MCCB, clear paths to graduate study in Medicinal Chemistry, Chemical Biology, or Biochemistry, as well as Organic Chemistry or

Neuroscience are possible. Whether graduate school is in your sites or not, your B.Sc. degree in MCCB will prepare you for a job in the ever-evolving high-growth pharmaceutical sector.

The first semester of study includes a mandatory module: General Medicinal Chemistry and Chemical Biology. This module provides an introduction to the core goals of your education in the MCCB major and the rationale for your first year of study in the related areas of organic chemistry, biochemistry, and cell biology. Elective modules are additionally chosen to complement those themes and are determined by students' interests. The second year of study places a strong emphasis on expanding and deepening students' knowledge acquired in the modules of the CORE area, exemplary modules would be those in Medicinal Chemistry, Chemical Biology, Pharmaceutical Chemistry, Advanced Organic Chemistry, Physical Chemistry and Molecular Modelling, and High Throughput Screening. During the third, and final, year of study, specialization courses are chosen by the student to specifically support their career aspirations.

This flagship program within the Health focus area is based on a multidisciplinary approach encompassing life scientists, chemists, and biophysicists who are addressing the major health challenges of humanity through their research activities at Jacobs University. Student research activities are formalized within the third year of study but MCCB students are encouraged by the instructors to participate as early as their first year of study in our graduate level (Ph.D.) research projects via the mandatory elective (voluntary) Methods in Life Science and Chemical Research I and II. These opportunities mean that most graduating classes have students who are co-authors on peer reviewed research publications. This is one reason why graduates of the MCCB program find abundant opportunities for graduate level study.

If you would like to be part of these types of scientific endeavors, then the Jacobs University MCCB program offers an entry point to the science of pharmaceutical drug development. Career choices ranging from strictly scientific to regulatory affairs to legal counsel to start-ups are all possible, but the most common employment opportunities are found within the pharmaceutical industry.

1.2 Specific Advantages of MCCB at Jacobs University

- The Medicinal Chemistry and Chemical Biology (MCCB) Program provides an early academic opportunity for students who know they want a career focused on curing disease, and who wish to acquire a solid foundation for this career path starting at the B.Sc. degree level. Jacobs University offers this forward-looking program because the field of Chemical Biology (CB) has expanded tremendously in recent years and the resulting molecular understanding of disease will significantly accelerate drug discovery. To take advantage of this, the understanding and tools of Medicinal Chemistry (MC) must be integrated with those of Chemical Biology. This interdisciplinary program is an ideal choice for students who want to combine chemical and life science thematics.
- The Medicinal Chemistry-oriented modules of the program cater to the identification, synthesis, and development of new chemical compounds for therapeutic use. They also comprise the study of existing drugs, structure-activity relationships, the matching of drugs to targets by molecular docking, and the biological properties of drugs. The Chemical Biology modules detail and integrate the advances made within molecular biology, with a focus on how to probe the mechanism and function of living systems via chemical concepts, methods, and tools. This is often achieved by employing the synthetically produced compounds of a medicinal chemist. The connectivity of the two disciplines (MC and CB) is unambiguous and the synergistic understanding that comes from their integration cannot be underestimated.
- During the detailed planning of the course structure for the MCCB major, advice from advisory board members and various experts from academia, industry, and research

foundations was incorporated. A program was thus developed that is distinctive within Germany because of its early integration of medicinal chemistry and chemical biology.

- The MCCB program provides strong practical experience and begins in the first semester laboratory courses. Opportunities to participate in graduate level research projects are additionally encouraged, but voluntary, and formalized through independent research courses (Methods in Life Science and Chemical Research I and II). The summer break, between the fourth and fifth semesters, is dedicated to a research-based internship and the sixth semester is used to formalize the Bachelor thesis, which entails a research project and a written thesis with a faculty member. Specialization courses during the third-year of study allow the student to choose specific fields of interest within MCCB or from the adjacent subfields of chemistry, biochemistry, or biotechnology.
- The MCCB degree, with its highly relevant theoretical content and state-of-the-art laboratory training, allows you to enter graduate programs in Medicinal Chemistry, Biochemistry, or Organic Chemistry and related fields. Alternative career paths, directly after obtaining your MCCB B.Sc. degree, are possible within education, the pharmaceutical industry, regulatory authorities, or patent law offices. A more detailed overview of potential career paths is detailed later in this handbook, see section 1.4 Career Options

1.3 Program-Specific Educational Aims

1.3.1 Qualification Aims

The MCCB program offers an interdisciplinary education in biochemistry, cell and chemical biology, and organic and medicinal chemistry, with the overarching theme of curing disease. You will learn how biological systems can be manipulated by small molecules (chemical biology) with the aim of developing new molecules with the medicinal profile (medicinal chemistry) to fight specific diseases. These goals are reinforced through research centered learning and that foundation permits a critical use of the scientific method for innovative scientific solutions. In a synergistic manner, your classroom and laboratory exposure and engagement will advance your professional development by focusing and fine-tuning your oral and written communication skills for independent and team-based achievement.

1.3.2 Intended Learning Outcomes

By the end of the program, students will be able to

Theory

- (T1) recognize and discuss the concepts of bonding, acidity/basicity, conformation, and stereochemistry, as they relate to functional groups;
- (T2) explain and describe general reactivity patterns (organic or biochemical) and the corresponding reaction categories (chemical or metabolic);
- (T3) illustrate how chemical tools can be used to probe biological processes;
- (T4) explain the basic concepts within the fields of biochemistry and cell biology;
- (T5) describe, with examples from the major categories of biomolecules, how chemical structure defines cellular function;
- (T6) predict and discriminate the basic principles of drug action;
- (T7) judge and illustrate how the function of biomolecules can be influenced by small molecules, and how such small molecules are identified, developed, produced, and analyzed to manage disease;
- (T8) analyze the bioactivity potential, drug-target interactions, structure-activity relationships, or pharmacokinetics of small molecules and biologicals, and explain how these parameters are determined.
- (T9) test computer-based visualization to correlate protein conformation with drug interaction.
- (T10) calculate values from data and correlate data using statistical methods as applied to thermodynamics or large data sets;
- (T11) establish and propose analytical tools for pharmaceutical research;

- (T12) design scientific hypotheses and suggest experiments to validate them.

Practical Work

- (PW1) analyze or propose research challenges and plan experiments and analytical methods that allow for their solution within the fields of: medicinal chemistry, pharmaceutical chemistry, and chemical biology
- (PW2) propose, critically evaluate, and report on experimental data;
- (PW3) understand and explain basic experimental techniques within the fields of: organic chemistry, biochemistry, and cell biology;
- (PW4) demonstrate the ability to perform basic chemical syntheses;
- (PW5) develop or design simple binding or catalysis assays;
- (PW6) apply basic computational molecular modeling tasks and illustrate their value for drug-target interactions;
- (PW7) recognize or apply laboratory equipment or instruments routinely used for qualitative measurements, chromatography, and/or spectroscopy collection as they relate to the quality or characterization of small molecules or biomolecules;
- (PW8) collect and survey material safety data sheets or clinical trial data for research purposes;

Transferable Skills

- (TS1) analyze scientific or technical questions, provide perspective with what is known in the literature, suggest avenues to solve the questions at hand, and communicate the solutions;
- (TS2) concisely and professionally present or defend their own results, and those of others, in front of an audience;
- (TS3) understand and explain the relationship between experiments, and the data and trends therefrom for scientific hypothesis generation;
- (TS4) create and write scientific documents with knowledge of their purpose, structure, and conciseness;
- (TS5) demonstrate or apply a general set of scientific methods and skills used within the pharmaceutical industry;
- (TS6) engage ethically within the framework of planning, observing, recording, and communicating research within academia, a future work place, and the wider community;

- (TS7) identify, describe, and evaluate important parameters within the context of drug design;
- (TS8) understand the value of schematic, graphic, and tabular information for scientific writing;
- (TS9) take responsibility for their own learning, personal and professional development through the analysis of deficiencies;
- (TS10) apply numerical skills to solve quantitative problems;
- (TS11) collaborate with peers in a team and demonstrate intercultural and social competencies.

1.4 Career Options

Students who have completed the MCCB program will understand how the life of cells, organisms, and humans is organized at the chemical molecular level. This opens opportunities for graduate education (most often in biochemistry, medicinal chemistry, or organic chemistry), but also to a wide variety of career choices ranging from the strictly scientific (entry-level industrial positions in the chemical, pharmaceutical, biotechnology, or food industries) to education (elementary or high school), to regulatory affairs (analytical food testing laboratories, quality management, etc.) legal counsel (patent attorney, licensing, etc.) and to start-ups. The critical, goal-oriented, skills acquired from your in-depth analysis of chemical-biological problems may also be recognized by headhunters as transferable to non-scientific areas of employment. The mandatory MCCB summer internship, most often within the industrial research sector, is a professional growth experience that is invaluable for aiding students in their career decision making process.

The Career Services Center (CSC) as well as the Jacobs Alumni Office help students in their career development. The CSC provides students with high quality training and coaching in CV creation, cover letter formulation, interview preparation, effective presenting, business etiquette and employer research as well as in many other aspects, thus helping students identify and follow up rewarding careers after their time at Jacobs University. Furthermore, the Alumni Office helps students establish a long-lasting and global network which is useful when exploring job options in academia, industry, and elsewhere.

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/TestAS) if applicable
- ZeeMee electronic resume (optional)
- Language proficiency test results (TOEFL, IELTS or equivalent)

German language proficiency is not required; rather all applicants need to submit proof of English proficiency.

For any student who has acquired the right to study at a university in the country where she/he has acquired the higher education entrance qualification Jacobs University accepts the common international university entrance tests in placement of the entrance examination. Applicants with a subject-related entrance qualification (fachgebundene Hochschulreife) may be admitted only to the respective study programs.

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

1.6 More Information and Contact

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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 roles 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:

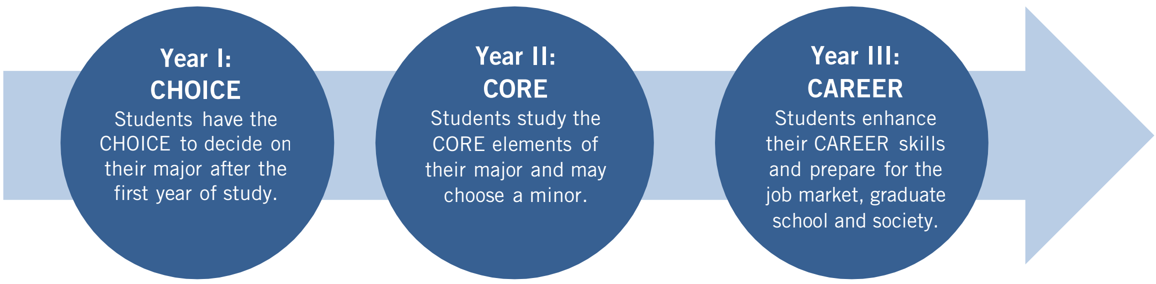


Figure 1: The Jacobs University 3C-Model

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 the 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. A unique feature of 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 the faculty.

To pursue an MCCB major, the following CHOICE modules (30 CP) need to be taken as mandatory modules during the first year of study:

- CHOICE Module: General Medicinal Chemistry and Chemical Biology (7.5 CP)
- CHOICE Module: General Biochemistry (7.5 CP)
- CHOICE Module: General Organic Chemistry (7.5 CP)
- CHOICE Module: General Cell Biology (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).

The recommended third CHOICE module, during your first semester of study, is General and Inorganic Chemistry (7.5 CP), and during your second semester is General Biotechnology (7.5 CP). In total, the first-year modules lay the foundation for the second year of education within the MCCB major.

2.2.1.1 Major Change Option

Students can change to another major at the beginning of the second year of studies if they have taken the corresponding mandatory CHOICE modules in their first year of studies. By default, an MCCB major also has all of the mandatory courses needed to change to the BCCB major. 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 studies prior to changing their major.

MCCB students that 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 and Inorganic Chemistry

- Chemistry and Biotechnology (CBT)
  CHOICE module: General and Inorganic Chemistry (7.5 CP)
  CHOICE Module: Introduction to Biotechnology (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)

- Earth and Environmental Studies (EES)
  CHOICE Module: General Earth and Environmental Sciences (7.5 CP)
  CHOICE Module: General Geology (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 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 thus far (see 2.3.1), these modules aim to expand students' critical understanding of the key theories, principles, and methods in their major for the current state of knowledge and best practice.

To pursue the MCCB as a major, the following mandatory elective CORE modules (30 CP) must be taken:

- CORE Module: Medicinal Chemistry (5.0 CP)
- CORE Module: Chemical Biology (5.0 CP)
- CORE Module: Advanced Organic Chemistry (5.0 CP)
- CORE Module: Pharmaceutical Chemistry (5.0 CP)
- CORE Module: Advanced Organic and Analytical Laboratory (5.0 CP)
- CORE Module: Medicinal Chemistry and Chemical Biology Laboratory (5.0 CP)

Students can decide to either complement their studies by taking the following mandatory elective CORE modules (15 CP) within MCCB:

- CORE Module: Scientific Software and Databases (5.0 CP)
- CORE Module: High Throughput Screening (5.0 CP)
- CORE Module: Physical Chemistry and Molecular Modelling (5.0 CP)

or they may substitute these modules with CORE modules from a second field of study according to interest and/or with the aim to pursue a minor.

2.2.2.1 Minor Option

MCCB 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's 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, this requires MCCB students to:

- select CHOICE modules (15 CP in total) from the desired minor program during the first year of study and
- substitute the three mandatory elective CORE MCCB modules (15 CP) in the second year with the default minor CORE modules of the minor study program.

The requirements for the specific minors 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.

For an overview of accessible minors, please check 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 MCCB students to take Specialization modules within their discipline, but also focuses on the responsibility of students beyond their discipline (see Jacobs Track).

The 5th semester also opens a mobility window for a diverse range of study abroad options. Finally, the 6th 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 years of study. This gives students the opportunity to gain first-hand practical experience in a professional environment, apply their knowledge and understanding in a professional context, reflect on the relevance of their major to employment and society, reflect on their own role in employment and society, and find a professional orientation. The internship can also establish valuable contacts for the students' Bachelor's thesis project, for the selection of a Master program graduate school or further employment after graduation. This 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 developing of their business plans.

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 5th and 6th semester. The default specialization module size is 5 CP, with smaller 2.5 CP modules being possible as justified exceptions.

To pursue MCCB as a major, at least 15 CP from the following mandatory elective Specialization Modules need to be taken:

- Specialization: Fluorine in Drug Development (2.5 CP)
- Specialization: Advanced Organic Synthesis (5.0 CP)

- Specialization: Current Topics in the Molecular Life Sciences (5 CP)
- CORE (CBT): Physical Chemistry (5.0 CP)
- CORE (BCCB): Advanced Biochemistry I (5 CP)
- CORE (BCCB): Advanced Biochemistry II (5 CP)
- CORE (BCCB): Infection and Immunity (7.5 CP)

Available for MCCB students minoring in CBT who meet the pre-requisites

- Specialization (CBT): Organometallic Chemistry (5.0 CP)

Available for MCCB students who have taken CHOICE (CBT): Introduction to Biotechnology

- Specialization (CBT): Chemical & Pharmaceutical Technology (5.0 CP)

Further Specialization courses are available, if the course pre-requisites have been met, and are most often found within the adjacent majors of Biochemistry and Cell Biology or CBT. Specialization courses are designed to allow an MCCB student to become more focused on a particular subject of their choice within the MCCB program or an affiliated program. The intention is to simultaneously support their personal development and career choices.

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 5th 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).

MCCB students that wish to pursue a study abroad in their 5th 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 6th 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 students' transcripts.

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 their 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 comprehensively in front of an audience and to explain their methods, solutions, and results to both specialists and non-specialists.

2.3 The Jacobs Track

The Jacobs Track, an integral part of all undergraduate study programs, is another important feature of Jacobs University's educational model. The Jacobs Track 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 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 each 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 MCCB as a major, the following Methods and Skills modules (20 CP) must 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)

2.3.2 Big Questions modules

The modules in the Big Questions area (10 CP) intend to broaden students' horizons with applied problem solving between and beyond their chosen disciplines. The offerings in this area comprise problem-solving oriented modules that tackle global challenges from the perspectives of different disciplinary backgrounds that allow, in particular, a reflection of 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 free selections during their 5th and 6th semester with the aim of being exposed to the full spectrum of economic, societal, technological, and/or ecological contexts. The size of Big Questions Modules is either 2.5 or 5 CP.

2.3.3 Community Impact Project

In their 5th 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 the 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 abilities 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 MCCB as a Minor

The MCCB program encourages students in neighboring majors to consider a minor in MCCB. To do so, the student must take unit 1 of the CHOICE and CORE years.

3.1 Qualification Aims

The MCCB program offers an interdisciplinary education with the overarching theme of curing disease. To achieve a minor in MCCB you will learn how biological systems can be manipulated by small molecules (chemical biology) with the aim of developing drug molecules (medicinal chemistry). These learning points are further supported by the insights from human physiology as they pertain to pharmaceutical and medicinal topics (pharmaceutical chemistry). Students completing the MCCB minor will have acquired a solid foundation in the science of how innovative medicines can be developed.

3.1.1 Intended Learning Outcomes

With a minor in MCCB, students will be able to:

- judge and illustrate how the function of biomolecules can be influenced by small molecules, and how such small molecules are identified, developed, produced, and analyzed to manage disease;
- analyze the bioactivity potential, drug-target interactions, structure-activity relationships, or pharmacokinetics of small molecules and biologicals, and explain how these parameters are determined.
- design scientific hypotheses and suggest experiments to validate them;
- analyze scientific or technical questions, put them in perspective with what to known in the literature, suggest avenues to solve the questions at hand, and communicate the solutions;
- identify, describe, and evaluate important parameters within the context of drug design;
- take responsibility for their own learning, personal and professional development by analysis of deficiencies;
- collaborate with peers in a team and demonstrate intercultural and social competencies.

3.2 Module Requirements

A minor in MCCB requires 30 CP. The default option to obtain this minor is marked in the Study and Examination Plan of chapter 6. It includes the following MCCB CHOICE and CORE modules:

15 CP of the following CHOICE modules:

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

15 CP of the following CORE modules:

- CORE Module: Medicinal Chemistry (5.0 CP)
- CORE Module: Chemical Biology (5.0 CP)
- CORE Module: Pharmaceutical Chemistry (5.0 CP)

Upon consultation with the Academic Advisor and the MCCB Study Program Coordinator, individual CORE modules from the default minor can be replaced by other advanced modules (CORE or Specialization) from the MCCB major.

Students should be aware that the second year CORE modules have pre-requisites that would have to be taken before being allowed to take those courses. It is important to plan accordingly during the first year of study with the academic advisor or the study program coordinator of MCCB to ensure this possibility remains open.

3.3 Degree

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

4 MCCB Undergraduate Program Regulations

4.1 Scope of these Regulations

The regulations in this handbook are valid for all students who entered Medicinal Chemistry and Chemical Biology undergraduate program at Jacobs University in Fall 2021. In case of 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 MCCB.

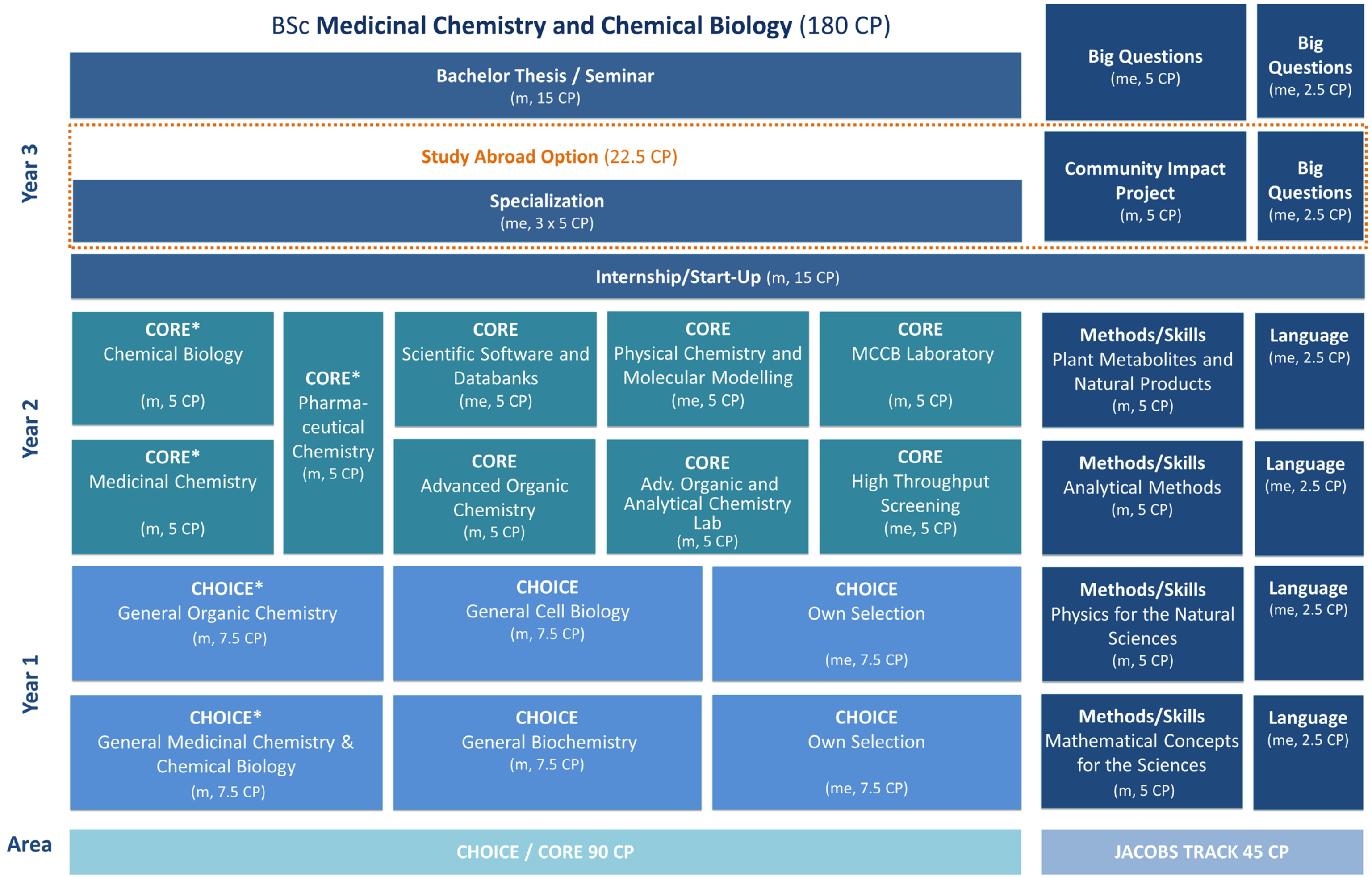
4.3 Graduation Requirements

In order to graduate, students need to obtain 180 CP. In addition, the following graduation requirements apply:

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 MCCB

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 (default minor)
m = mandatory
me = mandatory elective

Figure 2: Schematic Study Plan for MCCB

Medicinal Chemistry and Chemical Biology (MCCB)

Matriculation Fall 2021

	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 MCCB program.							
	Unit 1: Foundations of Medicinal Chemistry & Chemical Biology *(default minor)*						**15**
CH-110	**Module: General Medicinal Chemistry & Chemical Biology** *(default minor)*				**m**	**1**	**7.5**
CH-110-A	General Medicinal Chemistry & Chemical Biology	Lecture	Written examination	Examination period			5
CH-110-B	General Medicinal Chemistry & Chemical Biology Tutorial	Tutorial					2.5
CH-111	**Module: General Organic Chemistry** *(default minor)*				**m**	**2**	**7.5**
CH-111-A	General Organic Chemistry	Lecture	Written examination	Examination period			5
CH-111-B	General Organic Chemistry Laboratory	Lab	Lab Reports	During the semester			2.5
	Unit 2: General Biochemistry and Cell Biology						**15**
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 Laboratory	Lab	Lab reports	During the semester			2.5
CH-101	**Module: General Cell Biology**				**m**	**2**	**7.5**
CH-101-A	General Cell Biology	Lecture	Written examination	Examination period			5
CH-101-B	General Cell Biology Laboratory	Lecture	Lab Reports	During the semester			2.5
	Unit 3: CHOICE (own selection)				**me**		**15**
Take two further CHOICE modules from those offered for all other study programs[2]							
Year 2 - CORE							**45**
Take all CORE modules listed below or replace the mandatory elective (me) modules (15 CP) with suitable CORE modules from other study programs[2]							
	Unit 1: Medicinal Chemistry & Chemical Biology *(default minor)*						**15**
CO-420	**Module: Medicinal Chemistry** *(default minor)*				**m**	**3**	**5**
CO-420-A	Medicinal Chemistry	Lecture	Written examination Presentation	Examination period During the semester			
CO-421	**Module: Chemical Biology** *(default minor)*				**m**	**4**	**5**
CO-421-A	Chemical Biology	Lecture	Written examination	Examination period			
CO-422	**Module: Pharmaceutical Chemistry (default minor)**				**m**	**3+4**	**5**
CO-422-A	Pharmaceutical Chemistry I	Lecture	Oral examination	Examination period		3	2.5
CO-422-B	Pharmaceutical Chemistry II	Lecture				4	2.5
	Unit 2: Organic and Analytical Chemistry						**15**
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 Databanks**				**me**	**4**	**5**
CO-443-A	Scientific Software and Databanks	Seminar	Report	During the semester			
CO-424	**Module: Advanced Organic and Analytical Chemistry Lab**				**m**	**3**	**5**
CO-424-A	Advanced Organic Chemistry Laboratory	Lab	Lab Reports	During the semester			2.5
CO-424-B	Analytical Chemistry Laboratory	Lab	Lab Reports				2.5
	Unit 3: Drug Screening and Docking						**15**
CO-425	**Module: High Throughput Screening**				**me**	**3**	**5**
CO-425-A	High Throughput Screening	Lecture	Written examination	Examination period			
CO-426	**Module: Physical Chemistry and Molecular Modelling**				**me**	**4**	**5**
CO-426-A	Physical Chemistry and Molecular Modelling	Lecture	Written examination	Examination period			
CO-427	**Module: MCCB Laboratory**				**m**	**4**	**5**
CO-427-A	Medicinal Chemistry & Chemical Biology Laboratory	Lab	Lab Reports	During the semester			5
Year 3 - CAREER							**45**
CA-INT-900	**Module: Internship / Startup and Career Skills**				**m**	**4/5**	**15**
CA-INT-900-0	Internship / Startup and Career Skills	Internship	Report/Business Plan	During the 5th semester			
CA-MCCB-800	**Module: Seminar / Thesis MCCB**				**m**	**6**	**15**
CA-MCCB-800-T	Thesis MCCB	Thesis	Thesis and Presentation	15th of May			12
CA-MCCB-800-S	Seminar MCCB	Seminar		During the semester			3
	Unit: Specialization MCCB				**m**		**15**
Take a total of 15 CP of specialization modules							
CA-S-MCCB-801	Advanced Organic Synthesis	Lecture	Oral examination	Examination period	me	6	5
CA-S-MCCB-802	Fluorine in Drug Development	Lecture	Oral examination	Examination period	me	5	2.5
CA-S-MCCB-803	Current Topics in the Molecular Life Sciences	Seminar	Presentation	During the semester	me	5	5
CA-S-xxx	Specialization electives (from CBT and BCCB) (see study program handbook)[2]		Various	Various	me	5/6	5
Total CP							**45**

	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**		**Final exam**		**m**	**1**	**5**
JTMS-07	Mathematical Concepts for the Sciences	Lecture	Written examination	Examination period			
JTMS-SCI-17	**Module: Physics for the Natural Sciences**		**Final exam**		**m**	**2**	**5**
JTMS-17	Physics for the Natural Sciences	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 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-SCI-18	**Module: Plant Metabolites and Natural Products**				**m**	**4**	**5**
JTMS-18	Plant Metabolites and Natural Products	Lecture	Written examination	Examination period			
	Unit: Language						**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	**Module: Big Questions**				**m**	**5/6**	
Take a total of 10 CP of Big Questions modules (each 2.5 or 5 CP) as mandatory elective		various	Various	Various	**me**		10
	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.

Figure 3: Study and Examination Plan

1 Medicinal Chemistry and Chemical Biology Modules

1.1 General Medicinal Chemistry and Chemical Biology

Module Name	*Module Code*	*Level (type)*	*CP*
General Medicinal Chemistry and Chemical Biology	CH-110	Year 1 (CHOICE)	7.5

Module Components

Number	*Name*	*Type*	*CP*
CH-110-A	General Medicinal Chemistry and Chemical Biology	Lecture	5.0
CH-110-B	General Medicinal Chemistry and Chemical Biology Tutorial	Tutorial	2.5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Nikolai Kuhnert	• Medicinal Chemistry and Chemical Biology (MCCB)	Mandatory for MCCB

Entry Requirements

Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*
☒ None	☒ None	• Basic knowledge in Life Sciences and Chemistry

Frequency	*Forms of Learning and Teaching*
Annually (Fall)	• Lecture (52.5 hours) • Tutorial (15 hours) • Private study for the Lecture (120 hours)

Duration	*Workload*
1 semester	187.5 hours (lecture)

Recommendations for Preparation

Early reading, extensive note taking and self-testing, work through practice problems, attend the tutorials.

Content and Educational Aims

Understanding the interaction between molecules and biological organisms requires a robust knowledge of nature's ways and its capacity to form and use bio-active molecules. The module will guide students through the breath-taking diversity of nature's compounds (primary and secondary metabolites), and cellular and metabolic processes in organisms including their functional purposes and regulatory mechanisms. The basic principles underlying small molecule-biological target interactions are described in detail including key experimental techniques for their investigation. The fundamental chemistry and structures of vital biomolecules are introduced and include an introduction to proteins, lipids, nucleic acids and carbohydrates. Additionally, the concepts of chemistry, e.g., chemical equilibrium, covalent and non-covalent bonding, stereochemistry, conformation of molecules, thermodynamics, kinetics, and the reactivity of key functional groups encountered in natural products and synthetic compounds aimed at manipulating biological processes, are introduced. Imbedded within the module are a series of lectures illustrating the concepts that are thematic to medicinal chemistry and chemical biology. The lecture is further accompanied by a 2.5 ECTS credit tutorial.

Intended Learning Outcomes

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

- describe functional groups, chemical equilibria, and acidity/basicity in organic molecules;
- discuss aspects of stereochemistry and conformation using a given organic molecules;
- identify functional groups and recognize their associated non-covalent interactions;
- relate organic structure to biological activity;
- show an understanding of organic structure, binding, and biological applications;
- recognize and give examples for key primary metabolites (amino acids, proteins, carbohydrates, lipids, and nucleic acids);
- distinguish primary from secondary metabolism;
- demonstrate an understanding of the basic principles of drug action;
- explain key concepts in chemical biology.

Indicative Literature

T. W. Grahm Solomons, C. B. Fryhle, S. A. Snyder. Organic Chemistry, 11th Edition, John Wiley & Sons, 2014, ISBN: 978-1-118-32379-3,

G. L. Patrick. An Introduction to Medicinal Chemistry, 5th Edition, Oxford University Press; 2013; ISBN 978-0-19-969739-7.

D. Van Vranken, G. A. Weiss. Introduction to Bioorganic Chemistry and Chemical Biology, 1st Edition, Wiley, 2013, ISBN-13: 978-0815342144.

Usability and Relationship to other Modules

- mandatory for a major in MCCB
- mandatory for a minor in MCCB
- strongly recommended for BCCB and CBT students.
- Prerequisite for second year CORE modules “Medicinal Chemistry”, “Chemical Biology”, “Pharmaceutical Chemistry”,”Physical Chemistry and Molecular Modelling” and “High Throughput Screening”
- Elective for all other undergraduate study programs

.

Examination Type: Module Examination

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

Scope: All intended learning outcomes of the module.

1.2 General Organic Chemistry

Module Name General Organic Chemistry	*Module Code* CH-111	*Level (type)* Year 1 (CHOICE)	*CP* 7.5

Module Components

Number	*Name*	*Type*	*CP*
CH-111-A	General Organic Chemistry	Lecture	5
CH-111-B	General Organic Chemistry Lab	Laboratory	2.5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Thomas Nugent	• Medicinal Chemistry and Chemical Biology (MCCB)	Mandatory for BCCB, CBT, MCCB

Entry Requirements *Pre-requisites*	 *Co-requisites*	 *Knowledge, Abilities, or Skills*	*Frequency*	*Forms of Learning and Teaching*
☒ General and Inorganic Chemistry or General Medicinal Chemistry and Chemical Biology	☒ None	• Recognize organic functional groups • familiar with orbitals • exposed to the concept of equilibria • laboratory safety and awareness	Annually (Spring)	• 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)
			Duration 1 semester	*Workload* 187.5 hours

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.

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 harmacop 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.

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%.

1.3 General Biochemistry

Module Name General Biochemistry	*Module Code* CH-100	*Level (type)* Year 1 (CHOICE)	*CP* *7.5*

Module Components			
Number	*Name*	*Type*	*CP*
CH-100-A	General Biochemistry	Lecture	5
CH-100-B	General Biochemistry Lab	Lab	2.5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Sebastian Springer	• Biochemistry and Cell Biology (BCCB)	Mandatory for BCCB and CBT

Entry Requirements			*Frequency*	*Forms of Learning and Teaching*
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Fall)	• 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)
☒ None	☒ None	• High school level of chemistry, mathematics, physics and biology.	*Duration* 1 semester	*Workload* 187.5 hours

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%.

1.4 General Cell Biology

<table>
<tr><td colspan="3">Module Name
General Cell Biology</td><td>Module Code
CH-101</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-101-A</td><td colspan="3">General Cell Biology</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-101-B</td><td colspan="3">General Cell Biology Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Susanne Illenberger</td><td colspan="3">Program Affiliation

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

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

Pre-requisites: ☒ General Biochemistry
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• General understanding of biomolecules from the General Biochemistry lecture</td><td>Frequency

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

• Lecture (35 hours)
• Tutorials (15 hours)
• Private study (75 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>
<tr><td colspan="6">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).
Students should participate in the weekly (voluntary) tutorials that accompany the lecture series.
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.</td></tr>
</table>

Content and Educational Aims

The CHOICE General Cell Biology Module introduces students to cells as the minimal functional units of life. The module consists of two module components, one lecture and one laboratory course:

The lecture focuses on the molecular architecture of cells and the general principles of cellular processes. Students learn how genetic information is encoded, organized, and inherited. They will explore how cellular compounds are synthesized, delivered, and degraded within the cell, and how these processes govern cellular physiology and communication. A comprehensive overview of the field of molecular cell biology will be provided through a combination of historical outlines, information about experimental approaches in the molecular life sciences and the analysis of key cellular processes including: DNA replication, protein synthesis, intracellular transport, cellular movements, cell division, Mendelian genetics, signal transduction, cellular communication, and the biology of neurons. Finally, students will learn how alterations in key molecules, e.g. by mutation, may lead to diseases, such as cancer and neurodegeneration.

The experiments in the laboratory course parallel the lecture content in that they introduce students to the molecular investigation of cells. Students will apply basic techniques to analyze genomic DNA (nuclease treatment, PCR). The use of different modes of light microscopy will be introduced by observing movement and endocytosis in the ciliate *Paramecium caudatum* as well as the microscopic analysis of different muscle specimen. Furthermore, yeast cultures will be analyzed through cell counts and spectrophotometry.

In both module components, students also acquire meta-skills such as self-organization and teamwork.

Intended Learning Outcomes

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

1. draw, label and describe cellular structures and processes;
2. recognize cellular structures depicted by different modes of microscopy;
3. use proper terminology and scientific language to explain cellular processes;
4. relate the class examples to more general principles governing cellular physiology;
5. provide examples for methodological approaches to investigate the molecular composition of cells and to monitor cellular processes;
6. predict the outcome of simple experimental approaches in molecular cell biology;
7. apply their knowledge to solve more distantly related problems in molecular cell biology;
8. perform experiments in a Biosafety Level S1 Laboratory, partially under semi-sterile conditions;
9. show practical laboratory skills (use of equipment, carry out methods etc.);
10. follow experimental procedures in the fields of molecular cell biology as outlined in a laboratory manual;
11. use technical equipment and plan basic experiments;
12. relate an experimental setup to the aim of an experiment;
13. formulate expectations and hypotheses to be tested;
14. generally explain the principles of molecular biology and cellular analyses;
15. depict, describe, and interpret experimental data in publication-style lab reports;
16. correctly cite literature and know how to avoid plagiarism.

Indicative Literature

Alberts et al., Molecular Biology of the Cell, Garland Science, latest edition.

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

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

Optional: Lodish et al., Molecular Cell Biology, Macmillan Education, latest edition.

General Introduction Manual and Lab Day Manuals provided by instructor.

Usability and Relationship to other Modules

- The General Cell Biology Module provides an essential foundation for the study of BCCB. It is a pre-requisite for the BCCB CORE Modules Microbiology, Infection and Immunity and Advanced Cell Biology I.

- It is also a pre-requisite for the MCCB CORE Module Chemical Biology and one of two possible pre-requisites for the CBT CORE Module Industrial Biotechnology.
- Mandatory for a major and 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

Length: Approx. 10 pages per report

Weight: 33%

Scope: All intended learning outcomes of the laboratory course (8-16).

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

1.5 Medicinal Chemistry

Module Name			*Module Code*	*Level (type)*	*CP*
Medicinal Chemistry			CO-420	Year 2 (CORE)	*5*
Module Components					
Number	*Name*			*Type*	*CP*
CO-420-A	Medicinal Chemistry			Lecture	5
Module Coordinator Detlef Gabel	*Program Affiliation* • Medicinal Chemistry and Chemical Biology (MCCB)			*Mandatory Status* Mandatory for MCCB Mandatory elective for CBT	
Entry Requirements			*Frequency* Annually (Fall)	*Forms of Learning and Teaching* • Lecture (35 hours) • Tutorial of the lecture (10 hours) • Private study for the lecture (80 hours)	
Pre-requisites ☒ General Biochemistry ☒ General Organic Chemistry	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • 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, 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 harmacophore 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.

1.6 Chemical Biology

<table>
<tr><td colspan="3">Module Name
Chemical Biology</td><td>Module Code
CO-421</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-421-A</td><td colspan="3">Chemical Biology</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Klaudia Brix
Thomas Nugent</td><td colspan="3">Program Affiliation

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

Mandatory for a MCCB major
Mandatory for a MCCB minor</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites

☒ General Medicinal Chemistry and Chemical Biology
☒ General Organic Chemistry

Co-requisites

☒ None

Knowledge, Abilities, or Skills

• Basic knowledge in biochemistry, cell biology, and organic chemistry
• Understanding of structure-function relationships at the molecular and cellular levels</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 lecture (80 hours)</td></tr>
<tr><td>Duration

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

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

• Read the chapters in the recommended textbooks that cover the respective topics of this lecture course (see syllabus)
• attend the lab meetings of research groups in the Department of Life Sciences and Chemistry
• visit the Molecular Life Sciences Seminar series in which researchers from other institutions are invited to give talks</td></tr>
<tr><td colspan="6">Content and Educational Aims
Chemical biology combines the fields of chemistry and biology. In particular, chemical techniques such as targeted drug design and small molecule synthesis are applied to study and interfere with biological systems. In such approaches, the aim is to analyze, quantify and modify regulatory mechanisms of cellular and organ systems. Therefore, a general understanding of physiological processes is crucial. This module will focus on cellular decision making by enzymes that mediate biological processes and enable cellular functions as diverse as cell differentiation, proliferation, tissue regeneration, and cell death. The group of enzymes chosen are the hundreds of proteolytic enzymes that enable the most important post-translational modification, proteolysis. Proteases are critical – vital or deadly – from the beginning of life until its end they regulate the cell cycle, they involve in developmental processes, and they bring about catabolism. Proteolytic cleavages allow the activation and inactivation of cellular programs through the maturation, activation, inactivation, or destruction of the key molecules involved. Proteases are involved in as many diseases as molecules exist, and because their action is irreversible, they are prime targets to treat diseases with pharmaceutical drugs. From bench to bedside will be the over-arching theme of this module. In keeping with this notion, G protein-coupled receptors constitute another important group of molecules that have more recently been targeted in pharmacology. The use of biologics is another recent paradigm shift in the treatment of diseases and pharmaceutical exploitation. These topics will be</td></tr>
</table>

discussed in order to broaden the understanding of the application aspects of medicinal chemistry and chemical biology.

Intended Learning Outcomes

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

- explain physiological mechanisms and organ functions;
- understand how to tackle disease by interfering with irreversible biological processes;
- interfere with biological processes that involve signaling by GPCRs;
- identify diseases that are brought about by alterations in enzymes or caused by altered signaling pathways;
- understand molecular targeting by drugs based on protein structure;
- understand how diseases are treated with pharmaceutical reagents that inhibit enzymes;
- distinguish the challenges and chances that arise when choosing a drug target to be exploited for clinical application;
- critically discuss experimental design to answer key research questions;
- abstract complex data for building scientific hypotheses.

Indicative Literature

K. Brix, W. Stöcker. Proteases: Structure and Function, Springer, 2013, ISBN 978-3-7091-1939-6.

Usability and Relationship to other Modules

- It is complementary to the Biomedicine module of the BCCB major.
- This module complements the thematics noted within the CORE modules: Medicinal Chemistry and Pharmaceutical Chemistry.
- Mandatory for a major in MCCB
- One of three default second year CORE modules for a minor in MCCB

Examination Type: Module Examination

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

Scope: All intended learning outcomes of the module.

1.7 Pharmaceutical Chemistry

Module Name	*Module Code*	*Level (type)*	*CP*
Pharmaceutical Chemistry	CO-422	Year 2 (CORE)	5

Module Components

Number	*Name*	*Type*	*CP*
CO-422-A	Pharmaceutical Chemistry I	Lecture	2.5
CO-422-B	Pharmaceutical Chemistry II	Lecture	2.5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Nikolai Kuhnert	• Medicinal Chemistry and Chemical Biology (MCCB)	Mandatory for MCCB major Mandatory for MCCB minor

Entry Requirements

Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*
☒ General Medicinal Chemistry and Chemical Biology ☒ General Organic Chemistry	☒ None	• Basic knowledge in Life Sciences

Frequency	*Forms of Learning and Teaching*
Annually (Fall)	• Lecture (35 hours) • Tutorial of the lecture (10 hours) • Private study for the Lecture (80 hours)

Duration	*Workload*
2 semesters	125 hours

Recommendations for Preparation

Students should have a basic background knowledge of chemistry, organic chemistry and biochemistry acquired during the first year CHOICE modules, in particular in general MCCB and Organic Chemistry. Students should have a fundamental understanding of organic structure, knowledge of functional groups (naming and properties), chemical bonding and aspects of stereochemistry and conformational changes. A sound knowledge of chemical equilibria and non-covalent interactions is expected. A basic knowledge of human physiology from high school biology and biochemical pathways and metabolism is advantageous.
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

Pharmaceutical chemistry deals with all aspects of drugs used in pharmaceutical and medical practice. Grouped according to therapeutic areas, the chemical structures, structural requirements for drug action, mode of action, basic pharmacology and synthesis will be introduced. Therapeutic areas include selected drugs acting on the: peripheral nervous, central nervous, endocrine, cardiovascular, renal, and digestive systems, and will be discussed along with anti-infective drugs (antibiotics and antivirals).
Furthermore, general topics overarching all pharmaceutical applications such as drug analysis, identification, separation, formulation, bioavailability, pharmacokinetics, pharmacodynamics, receptor theory, basic physiology and legal standards will be introduced. The module provides an overview of current knowledge on drugs in daily medicinal use and creates the basic foundation of knowledge required in all future drug development.

Intended Learning Outcomes

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

- illustrate knowledge on drug molecules used in clinical practice;
- demonstrate knowledge on further aspects of pharmaceutical chemistry;
- predict the mode of action and clinical applications from structure;
- compare organic structures, correlate their structure to activity and estimate function;
- explain the relevance of pharmacological parameters and develop an appreciation of dosage regimes and side effects;
- transfer knowledge of clinically used drugs, their structure, and mode of action to the drug development process;
- explain basic concepts of human physiology and apply it to pharmaceutical and medicinal chemistry topics.

Indicative Literature

L. Brunton, B. Knollmann, R. Hilal-Dandan. Goodman and Gilman's The Pharmaceutical Basis of Therapeutics , 12th edition, McGraw-Hill Education Ltd, 2011, ISBN 978-0-07-162442-8)

British National Formulary (BNF, latest edition).

Usability and Relationship to other Modules

- This module forms the co-foundation (with Medicinal Chemistry) for future modules in, for example, Phsyical Chemistry and Molecular Modelling and Chemical Biology.
- Mandatory for a major in MCCB
- One of three default second year CORE modules for a minor in MCCB

Examination Type: Module Examination

Assessment Type Oral examination — Duration: 40 min; Weight: 100%

Scope: All intended learning outcomes of the module.

1.8 Advanced Organic Chemistry

<table>
<tr><td colspan="3">Module Name
Advanced Organic Chemistry</td><td>Module Code
CO-423</td><td>Level (type)
Year 2 (CORE)</td><td>ECTS
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>ECTS</td></tr>
<tr><td>CO-423-A</td><td colspan="3">Advanced Organic Chemistry</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

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: ☒ General Organic Chemistry
Co-requisites: ☒ Adv. Organic and Analytical Laboratory
Knowledge, Abilities, or Skills:
Transition state analysis
Selectivity in synthesis
Expanded reaction knowledge</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>
<tr><td colspan="6">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</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td colspan="6">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</td></tr>
<tr><td colspan="6">Indicative Literature</td></tr>
</table>

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.

1.9 Scientific Software and Databases

<table>
<tr><td colspan="3">Module Name
Scientific Software and Databases</td><td>Module Code
CO-443</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-443-A</td><td colspan="3">Scientific Software and Databases</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Detlef Gabel</td><td colspan="3">Program Affiliation

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

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

Pre-requisites — ☒ None
Co-requisites — ☒ None
Knowledge, Abilities, or Skills — • None</td><td>Frequency

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

• Lecture (20 hours)
• Seminar (15 hours)
• Homework and self-study (50 hours)
• Preparation of term paper (45 hours)</td></tr>
<tr><td>Duration
1 semester</td><td colspan="2">Workload
125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation

First-year modules in General Chemistry, Organic Chemistry, Biochemistry, and Biotechnology</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td colspan="6">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.</td></tr>
</table>

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.

1.10 Advanced Organic and Analytical Chemistry Lab

Module Name			*Module Code*	*Level (type)*	*CP*
Advanced Organic and Analytical Chemistry Laboratory			CO-424	Year 2 (CORE)	*5*
Module Components					
Number	*Name*			*Type*	*CP*
CO-424-A	Advanced Organic Chemistry Lab			Lab	2.5
CO-424-B	Analytical Chemistry Lab			Lab	2.5
Module Coordinator Thomas Nugent	*Program Affiliation* • Medicinal Chemistry and Chemical Biology (MCCB)			*Mandatory Status* Mandatory for CBT and MCCB	
Entry Requirements *Pre-requisites* ☒ None	 *Co-requisites* ☒Analytical Methods ☒Advanced Organic Chemistry	 *Knowledge, Abilities, or Skills* • Laboratory safety	*Frequency* Annually (Fall) *Duration* 1 semester	*Forms of Learning and Teaching* • Lab (51 hours) • Private study lab (74 hours) *Workload* 125 hours	

Recommendations for Preparation

Fully understand the material before entering laboratory and the risks associated with the daily goals.

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.

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;

- 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.

1.11 High Throughput Screening (HTS)

<table>
<tr><td colspan="3">Module Name
High Throughput Screening (HTS)</td><td>Module Code
CO-425</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-425-A</td><td colspan="3">High Throughput Screening</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Mathias Winterhalter</td><td colspan="3">Program Affiliation

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

Mandatory elective for MCCB</td></tr>
<tr><td rowspan="2">Entry Requirements

Pre-requisites

☒ General Medicinal Chemistry and Chemical Biology</td><td rowspan="2">

Co-requisites

☒ None</td><td rowspan="2">

Knowledge, Abilities, or Skills

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

Annually (Fall)</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)</td></tr>
<tr><td>Duration

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

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

There are a number of specialized books that describe parts of this rapidly growing area of research and the corresponding technical know-how, but no standard textbook condenses all of the material needed for this module. Please see the syllabus for specific content guidance. A willingness to learn some physical chemistry concepts will be required.</td></tr>
<tr><td colspan="6">Content and Educational Aims
This module uses analytical and physical chemistry concepts. The students will be introduced to the recent innovation of High Throughput Screening (HTS), which is possible due to the latest advancements in: robotics, data processing/control software, high-speed computer technology, liquid handling devices, and detector sensing. Using HTS researchers can conduct millions of chemical, genetic, or pharmacological tests in a short period of time, and this can allow rapid identification of: active compounds, antibodies, or genes that modulate a particular biomolecular pathway. Our entry point will be the miniaturization of the analytical tools and the advantages and limits therefrom for the respective techniques. This is followed by examples of the current state of the art (primary literature examples). The discussed material bridges the gap between basis science at the typical lab scale and the rapid development of the new screening platform technologies. By the end of this module, students will know the basic principles of HTS and how to get access to this technology.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes
By the end of the module, the student will be able to
• explain how and when common analytical tools can be used for HTS
• understand the physical and technical limitations required for miniaturization and parallelization
• choose suitable analytical tool to obtain thermodynamic parameters needed for optimization
• design simple assays
• realize the fundamental value of statistical analysis for large data sets
• appreciate the value of quality control</td></tr>
<tr><td colspan="6">Indicative Literature</td></tr>
</table>

GS Sittampalam, A. Grossman, K. Brimacombe et al. Assay Guidance Manual, Eli Lilly & Company and the National Center for Advancing Translational Sciences;2003, https://www.ncbi.nlm.nih.gov/pubmed/22553861

JA Bittker, NT Ross (Eds), High Throughput Screening Methods: Evolution and Refinement (Chemical Biology), Royal Society of Chemistry, 2016, ISBN-13: 978-1782624714 or ISBN-10: 1782624716.

T Chen, A Practical Guide to Assay Development and High-Throughput Screening in Drug Discovery, Taylor & Francis Inc., 2009, ISBN-10: 1420070509 or ISBN-13: 978-1420070507.

Usability and Relationship to other Modules

- This module extends and complements the learning outcomes for the second year modules.
- This module is mandatory elective for MCCB but is highly recommended.
- This module extends and complements some of the learning outcomes from the parallel taught CORE modules in Medicinal Chemistry and Pharmaceutical Chemistry.
- Mandatory elective for a major in MCCB
- Elective for all other undergraduate study programs

Examination Type: Module Examination

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

Scope: All intended learning outcomes of the module

1.12 Physical Chemistry and Molecular Modelling

Module Name	*Module Code*	*Level (type)*	*CP*
Physical Chemistry and Molecular Modelling	CO-426	Year 2 (CORE)	*5*

Module Components

Number	*Name*	*Type*	*CP*
CO-426-A	Physical Chemistry and Molecular Modelling	Lecture	5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Ulrich Kleinekathöfer	• Medicinal Chemistry and Chemical Biology (MCCB)	Mandatory elective for MCCB

Entry Requirements			*Frequency*	*Forms of Learning and Teaching*
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Spring)	• Lecture (35 hours) • Tutorial (10 hours) • Private study (80 hours)
☒ Medicinal Chemistry	☒ None	• Basics of protein structure • Newton's equation including applications	*Duration* 1 semester	*Workload* 125 hours

Recommendations for Preparation

Reviewing the basics of and principles of biochemistry and Newtonian physics.

Content and Educational Aims

This module aims to provide an introduction to the field of protein structure and computational drug discovery. The module starts with the basics of molecular structure and the properties of small molecules, and then proceeds to protein structure including its visualization. Moreover, the basics of statistical thermodynamics are introduced due to their importance in the computational modelling of biomolecular processes. Subsequently, a primer on molecular dynamics is provided, including some hands-on examples.
The second part of the module focuses on computational biophysical methods in drug discovery. Various cheminformatics methods for the analysis and generation of small molecule libraries will be covered. The main part will comprise of structure-based drug design with a focus on molecular docking and virtual screening. In addition the theoretical concepts of these methods, the setup, execution and analysis of structure-based drug design projects will be presented, and in-depth hands-on training using different programs will be provided. Finally, combining several of the learned methods at once, small group settings will be used to convey a realistic account of how bioactive molecules are identified using computer-based methods.

Intended Learning Outcomes

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

- demonstrate basic conceptual knowledge of molecular structure and properties;
- visualize and be familiar with protein structures;
- appreciate basic statistical thermodynamics;
- engage in entry-level molecular dynamics simulations, molecular docking, and virtual screening;
- generate protein structures using homology modeling methods;
- recognize chemical similarity, molecular descriptors, drug-likeness, and lead-likeness;
- provide examples of small molecule library design, protomers, tautomers, enantiomers, and chirality.

Indicative Literature Not specified
Usability and Relationship to other Modules • This module builds on the CORE module Medicinal Chemistry and does so by providing an introductory understanding for the statistical thermodynamics required for computational modelling. • Mandatory elective for a major in MCCB • Elective for all other undergraduate study programs
Examination Type: Module Examination Assessment Type Written examination — Duration: 180 min Weight: 100% Scope: All intended learning outcomes of the module

1.13 Medicinal Chemistry and Chemical Biology Laboratory

<table>
<tr><td colspan="3">Module Name
Medicinal Chemistry and Chemical Biology Laboratory</td><td>Module Code
CO-427</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-427-A</td><td colspan="3">Medicinal Chemistry and Chemical Biology Laboratory</td><td>Laboratory</td><td>5.0</td></tr>
<tr><td>Module Coordinator

Nikolai Kuhnert / Thomas Nugent</td><td colspan="3">Program Affiliation

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

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

Pre-requisites: ☒ Medicinal Chemistry
☒ Organic and Analytical Chemistry Lab

Co-requisites: ☒ Chemical Biology

Knowledge, Abilities, or Skills:
• Laboratory safety</td><td>Frequency

Annually (Spring)</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 the laboratory and the risks associated with the daily goals.</td></tr>
<tr><td colspan="6">Content and Educational Aims
This laboratory module offers a series of experiments encompassing the fields of medicinal chemistry, pharmaceutical chemistry, and chemical biology. It follows that an array of experiments from the drug development pathway are examined, starting from chemical synthesis and isolation, and natural sources of a drug molecule, to enzyme inhibition assays and aspects of ADME, including permeation experiments and the identification of metabolites in vitro and from body fluids. Drug quality control as carried out in pharmaceutical practice is additionally included. On the chemical biology side, experiments include the use of labelled biomolecules as probes and the quantification of small molecule target interactions. The module uses a multitude of experimental techniques already introduced in other mandatory laboratory courses such as synthesis, UV/VIS spectroscopy, HPLC, MS, and fluorimetry, in addition to specialized techniques using plate readers, PAMPA plates, and calorimetry.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes
By the end of this module component, students will be able to:
• plan an experiment studying interactions between small molecules and biomolecules;
• describe and identify a series of selected experimental instrumental techniques;
• record and critically evaluate numerical experimental data;
• read and engage in unfamiliar experimental approaches;
• explain the broader scientific approach to drug development and the probing of cellular function.</td></tr>
<tr><td colspan="6">Indicative Literature
Not specified</td></tr>
<tr><td colspan="6">Usability and Relationship to other Modules</td></tr>
</table>

- These laboratories provide the skills and techniques required to perform the most often chosen thesis research topics. 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

Examination Type: Module Examination

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

Scope: All intended learning outcomes of the module

1.14 Advanced Organic Synthesis

Module Name	*Module Code*	*Level (type)*	*CP*
Advanced Organic Synthesis	CA-S-MCCB-801	Year 3 (CAREER-Specialization)	*5*

Module Components

Number	*Name*	*Type*	*CP*
CA-MCCB-801	Advanced Organic Synthesis	Lecture	5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Thomas Nugent	• Medicinal Chemistry and Chemical Biology (MCCB)	Mandatory elective for CBT and MCCB

Entry Requirements

Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*
☒ Advanced Organic Chemistry	☒ None	• 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.

1.15 Fluorine and Drug Development

Module Name			*Module Code*	*Level (type)*	*CP*
Fluorine and Drug Development			CA-S-MCCB-802	Year 3 (CAREER-Specialization)	*2.5*
Module Components					
Number	*Name*			*Type*	*CP*
CA-MCCB-802	Fluorine and Drug Development			Lecture	2.5
Module Coordinator Gerd-Volker Röschenthaler	***Program Affiliation*** • Medicinal Chemistry and Chemical Biology (MCCB)			***Mandatory Status*** Mandatory elective for MCCB	
Entry Requirements			***Frequency*** Annually (Fall)	***Forms of Learning and Teaching*** • Lecture (17.5 hours) • Tutorial lecture (5 hours) • Private study lecture (40 hours)	
Pre-requisites ☒ Advanced Organic Chemistry	*Co-requisites* ☒ None	*Knowledge, Abilities, or Skills* • 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.

1.16 Current Topics in the Molecular Life Sciences

Module Name	*Module Code*	*Level (type)*	*CP*
Current Topics in the Molecular Life Sciences	CA-S-MCCB-803	Year 3 (CAREER-Specialization)	*5*

Module Components

Number	*Name*	*Type*	*CP*
CA-MCCB-803	Current Topics in the Molecular Life Sciences	Seminar	5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Sebastian Springer	• Medicinal Chemistry and Chemical Biology (MCCB)	Mandatory elective for BCCB and MCCB.

Entry Requirements

Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	*Frequency*	*Forms of Learning and Teaching*
☒ Advanced Biochemistry II ☒ Advanced Cell Biology II Or ☒ Chemical Biology ☒ Medicinal Chemistry	☒ None	• Advanced knowledge in cell biology • Advanced self-directed study skills • Basic presentation skills	Annually (Fall)	• Lecture (10 hours) • Preparation of presentation (30 hours) • Seminar (15 hours) • Private study (69 hours) • Presentation (45 minutes)
			Duration 1 semester	*Workload* 125 hours

Recommendations for Preparation

For this module, it is important that students already know and understand biochemistry and cell biology at the second-year level. They also need to be able to analyze (and partially, create) logical connections between scientific contents.

Content and Educational Aims

Cutting-edge science is complex and requires excellent communication and exchange of information among researchers. Communication in science takes many forms, some specific to science (such as the scientific manuscript or paper), and some shared with all academic disciplines (such as the engaging oral presentation of results or data). In this module, two specific forms, manuscripts and presentations, are explained in detail. Students will be taught how manuscripts are written and reviewed, and how scientific talks should be planned and structured. They will then organize the data from a high-impact scientific paper of their own choice into a slide show according to the rules of professional speaking.
Students will take the prepared slide file and turn it into an one-hour oral presentation. They will then be coached in successive sessions by the instructor, and by their own peers, to develop their own style of speaking and presenting. The entire class will then benefit from professional-level presentations of cutting-edge scientific literature of general interest.

Intended Learning Outcomes

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

- explain how publications in the Molecular Life Sciences are structured;
- explain how publications in the Molecular Life Sciences are put together and written by the authors;
- explain how publications in the Molecular Life Sciences are pre-reviewed and how they undergo changes during the review process;
- analyze a scientific paper of their own choice in detail and how to evaluate its logical reasoning;
- professionally and coherently explain scientific experiments to a professional audience;
- test scientific conclusions for their logical rigor and discuss this with peers;
- report on some of the latest and most modern developments in the molecular life sciences;
- present scientific results (own or others') in front of an audience;
- arrange the contents of a scientific paper, and their own work, into a series of slides and to construct a 'story' that will keep an audience engaged;
- plan an oral presentation for diverse audiences;
- design slides to explain a specific set of scientific contents;
- give a presentation at a professional level, which is useful for any kind of occupation where teaching, the exchange of ideas, and leadership are expected;
- critique and to support the learning work of others (peer instruction).

Indicative Literature

G. Reynolds: Presentation Zen: Simple Ideas on Presentation Design and Delivery. Addison-Wesley, 3rd edition, 2019. ISBN 978-0135800911. (Jacobs IRC HF5718.22 .R49 2008)

G. Reynolds: Presentation Zen Design. New Riders Publications, 2010. ISBN 978-0321934154. (Jacobs IRC HF5718.22 .R49 2010)

N. Duarte: Slide:ology : the art and science of creating great presentations. ISBN 978-0596522346. (Jacobs IRC HF5718.22 .D83 2008).

C. Witt: Real Leaders Don't Do PowerPoint: How to Sell Yourself and Your Ideas. Crown Business, 2009. ISBN 978-0307407702.

Usability and Relationship to other Modules

- This module builds on the pre-required BCCB CORE modules Advanced Biochemistry II and Advanced Cell Biology II.
- Mandatory elective Specialization module for third year BCCB and MCCB major students.

Examination Type: Module Examination

Assessment Type Presentation

Duration: 45 minutes
Weight: 100%

Scope: All intended learning outcomes of the module.

1.17 Infection and Immunity

<table>
<tr><td colspan="3">Module Name
Infection and Immunity</td><td>Module Code
CO-401</td><td>Level (type)
Year 2 (CORE)</td><td>CP
7.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>CO-401-A</td><td colspan="3">Immunology</td><td>Lecture</td><td>5</td></tr>
<tr><td>CO-401-B</td><td colspan="3">Microbial Pathogenicity</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

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

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

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

Pre-requisites
☒ General Biochemistry and General Cell Biology

Co-requisites
☒ None

Knowledge, Abilities, or Skills
• Basic knowledge in biochemistry and cell biology
• Basic self-directed study skills</td><td>Frequency

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

• Lectures (52.5 hours)
• Private study (135 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

Students should have a sound background in biochemistry and cell biology that they acquired by attending the respective CHOICE modules. They should understand the basic structure and function of biomolecules, and the general principles by which cells multiply and interact with each other. Furthermore, students should have acquired basic skills in experimental molecular biology techniques from the respective CHOICE laboratory courses.</td></tr>
<tr><td colspan="6">Content and Educational Aims
Infectious diseases of all types have always been and still are a major threat to our civilization. Our immune system defends us against pathogens such as viruses, bacteria, worms, and fungi, and it also contributes to protection against cancer and other diseases. The module brings pathogenicity and immunity and their relationship into close context and enables a thorough understanding of the underlying complexities.

The human immune system is central to fighting disease. Immunology is thus one of the central sciences underlying medicine and at the same time a fascinating application of the principles of molecular life sciences to a complex organismic phenomenon. The Immunology lecture provides a second-year undergraduate-level introduction to the entire field of immunology that is based on knowledge in general biochemistry and cell biology. Students will get to know the molecular agents of the system (receptors and metabolic processes), with intracellular processes (antigen presentation and innate intracellular defense), cell-specific phenomena (cell differentiation, maturation, and trafficking), the function of the organs of the immune system, and organismic phenomena such as the acute phase response. The lecture then turns towards the mechanisms of disease and disease-specific immunity, focusing on autoimmunity, HIV infection, and cancer as three major examples. In addition, pathogen evasion of the immune response is discussed as an important feature. Finally, immunotherapy approaches are thoroughly discussed. Altogether, the lecture enables students to understand the functioning of the immune system, its role in preventing, fighting, and (sometimes) causing diseases, as well as the possibilities that arise from the manipulation of the immune system through vaccination and adoptive transfer.

The Microbial Pathogenicity lecture will familiarize students with basic principles of microbial pathogenicity, methods used to investigate pathogens, and a selection of infectious diseases caused by microbes and viruses.</td></tr>
</table>

The lecture is meant to explore potential ways to treat and heal infected individuals and how to utilize our knowledge of pathogens for the successful treatment of diseases. Aside of state-of-the-art methods on how to identify virulence and pathogenicity factors, the lecture will introduce specific examples of diseases and the pathogens that cause them. For each disease, the lecture will address the pathogen's discovery, how it employs virulence factors, how it infects and transmits, and how the respective infection can be treated. Students will learn how to distinguish between different types of microbial infections and will understand how the immune system copes with various types of infection both qualitatively and quantitatively. The Emerging problems of multiple antibiotic resistance will also be covered in this lecture. Ultimately, participants will appraise the role of microbial infections as global challenges for the future development of our human societies.

Intended Learning Outcomes

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

- explain the topics of the lecture at the level presented;
- apply this understanding to relate the basic knowledge to current problems in research and medicine;
- analyze and discriminate immunological challenges posed by specific pathogens;
- correlate pathogen exposure with the characteristic answer of the immune system;
- judge the success rates, likelihoods, and time lines of different immunological treatments currently available, in development, or being envisioned;
- apply knowledge of biochemical and cellular processes to understand principles in infection biology;
- analyze infectious diseases, their principles and mechanisms;
- evaluate the applicability of molecular methods to assess microbial pathogenicity;
- distinguish between how bacteria, fungi, viruses or parasitic pathogen infect a host;
- identify and investigate microbial pathogens and their role in symptom development;
- prioritize measures on how to cope with a microbial infection;
- correlate basic principles of immunology and pathogenicity;
- deduce the impact of a virulence or pathogenicity factor on the functioning of the immune system;
- outline basic steps on how to identify and treat a microbial infection.

Indicative Literature

Murphy and Weaver, Janeway's Immunobiology, 9th edition, Garland Science, 2017 or the latest edition as appropriate.

Madigan et. al., Brock Biology of Microorganisms, 15th Edition, Pearson International, 2018, or the latest edition as appropriate.

Various research articles related to the individual infectious diseases and their pathogens

Usability and Relationship to other Modules

- This module builds on the pre-required BCCB CHOICE Modules General Biochemistry and General Cell Biology.
- Mandatory elective for a major in BCCB
- Mandatory for a minor in BCCB
- Serves as a mandatory elective 3rd year Specialization module for MCCB students
- Elective module for all other undergraduate study programs.

Examination Type: Module Component Examinations

Module Component 1: Lecture 1
Assessment Type: Written examination
Duration: 120 min
Weight: 67%

Module Component 2: Lecture 2
Assessment Type: Oral examination
Duration: 20 min
Weight: 33%

Scope: All intended learning outcomes

1.18 Advanced Biochemistry I

Module Name	*Module Code*	*Level (type)*	*CP*
Advanced Biochemistry I	CO-402	Year 2 (CORE)	*5*

Module Components

Number	*Name*	*Type*	*CP*
CO-402-A	Metabolic Pathways	Lecture	5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Christian Hammann	• Biochemistry and Cell Biology (BCCB)	Mandatory for BCCB Mandatory elective for MCCB

Entry Requirements

Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	*Frequency*	*Forms of Learning and Teaching*
☒ General Biochemistry and General Cell Biology	☒ None	• Knowledge of biochemical compounds • Ability to write chemical equations	Annually (Fall)	• Lecture (35 hours) • Private study (90 hours)
			Duration 1 semester	*Workload* 125 hours

Recommendations for Preparation

Revision of the module content of the pre-required CHOICE modules

Content and Educational Aims

The module intends to provide a detailed understanding of the biochemical reactions that underlie energy production and consumption in living systems. The thermodynamics and kinetics of ligand binding to proteins and enzyme catalysis are explained and enzymatic catalysis is explored at the molecular and atomic level. The module will further introduce advanced methods to study the molecules involved in enzymatic catalysis. These concepts are applied to explain the principles of metabolism. In this context, the module describes how energy is produced by living organisms, and how key types of biomolecules are synthesized and degraded. Thus, all important classes of biomolecules are covered (with exception of nucleic acids that are covered in Advanced Biochemistry II). A special focus will be placed on common schemes and the adjustment of metabolism under different cellular conditions. Note: Photosynthesis as a key metabolic pathway will be discussed in the module "Methods for Plant Metabolism and Natural Products".

Intended Learning Outcomes

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

- explain advanced theoretical concepts of metabolism;
- outline advanced biochemical experimental methods that provide an entry point into independent experimental work;
- outline key biochemical pathways and selected reaction mechanisms;
- predict the outcome of metabolic pathways under variable conditions;
- qualitatively and quantitatively solve thermodynamic equations;
- qualitatively and quantitatively analyze kinetic data of enzymatic reactions;
- apply their knowledge to novel problems;
- find, understand, and interpret additional specific information from the literature and web resources.

Indicative Literature Nelson and Cox, Lehninger Principles of Biochemistry, Freeman Macmillan, latest edition. Stryer et. al., Biochemistry, Freeman Macmillan, latest edition.
Usability and Relationship to other Modules • This module builds on the pre-required BCCB CHOICE Modules General Biochemistry and General Cell Biology. • It is a pre-requisite for the BCCB CORE modules Advanced Biochemistry Laboratory and Advanced Biochemistry II, as well as the BCCB CAREER Specialization module RNA Biochemistry. • Mandatory for a major in BCCB • Serves as a mandatory elective third year Specialization module for MCCB students
Examination Type: Module Examination Assessment Type: Written examination — Duration: 120 min, Weight: 100% Scope: All intended learning outcomes of the module.

1.19 Advanced Biochemistry II

Module Name	*Module Code*	*Level (type)*	*CP*
Advanced Biochemistry II	CO-403	Year 2 (CORE)	*5*

Module Components

Number	*Name*	*Type*	*CP*
CO-403-A	Molecular Genetics	Lecture	5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Christian Hammann	• Biochemistry and Cell Biology (BCCB)	Mandatory for BCCB Mandatory elective for MCCB

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)
☒ General Biochemistry ☒ General Cell Biology	☒ None	• Knowledge of biochemical compounds • Ability to write chemical equations • Knowledge about metabolic principles • Ability to determine kinetic and thermodynamic parameters	*Duration* 1 semester	*Workload* 125 hours

Recommendations for Preparation

Revision of the module content of the pre-required CORE module

Content and Educational Aims

The module intends to propvide a detailed understanding of the biochemical mechanisms that underlie the realization of genetic information in living systems. Initially, the focus lies on the structure, biosynthesis, and degradation of nucleotides and nucleic acids. Molecular mechanisms are elucidated, by which genetic information is regulated, controlled, and expressed in bacterial and eukaryotic cells, with an emphasis on replication, transcription, and translation. Furthermore, this module gives an insight in DNA damage and repair mechanisms and it introduces advanced concepts such as epigenetic regulation and control. Molecular mechanisms contributing to an altered use of genetic information in living systems are exemplified (e.g., homologous recombination, (alternative) splicing or chemical modifications, and processing of both, RNAs and proteins). Advanced methods to study these processes are introduced and examples of experimental results obtained by these methods are discussed. A special focus is placed on common principles and the cellular integration of regulatory processes governing these pathways.

Intended Learning Outcomes

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

- illustrate the biosynthesis and degradation of nucleotides and discriminate different types of nucleic acid structures;
- outline the flow and control of genetic information in living systems;

- explain the mechanisms of replication, transcription and translation;
- discriminate regulatory processes on the different levels of the flow of information;
- outline advanced biochemical experimental methods that provide an entry point into independent experimental work;
- interpret experimental data obtained by these methods;
- predict the outcome of information pathways under variable conditions;
- summarize epigenetic control mechanisms;
- assess which repair mechanisms act on which type of DNA damage;
- rate the impact of the different mechanisms acting in the altered use of genetic information;
- apply their knowledge to novel problems;
- find, understand, and interpret additional specific information from the literature and web resources.

Indicative Literature

Nelson and Cox, Lehninger Principles of Biochemistry, Freeman Macmillan, latest edition.

Stryer et. al., Biochemistry, Freeman Macmillan, latest edition.

Usability and Relationship to other Modules

- This module builds on the pre-required BCCB CORE module Advanced Biochemistry I. It is a co-requisite for the BCCB CORE module Advanced Biochemistry Laboratory.
- Further, it is the pre-requisite for BCCB CAREER Specialization modules Current Topics in the Molecular Life Sciences, RNA Biochemistry and Experimental Strategy Design.
- Mandatory for a major in BCCB.
- Serves as a mandatory elective third year Specialization module for MCCB major students who took Advanced Biochemistry I.

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module.

1.20 Organometallic Chemistry

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

Module Components

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

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Detlef Gabel	• Chemistry and Biotechnology (CBT)	Mandatory elective 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) • Private study (75 hours) • Exam preparation (15 hours)
☒ General and Inorganic Chemistry ☒ General Organic Chemistry	☒ None	• None beyond formal prerequisites	*Duration* 1 semester	*Workload* 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.

1.21 Chemical and Pharmaceutical Technology

<table>
<tr><td colspan="3">Module Name
Chemical and Pharmaceutical Technology</td><td>Module Code
CA-S-CBT-801</td><td>Level (type)
Year 3
(CAREER-Specialization)</td><td>CP
5.0</td></tr>
<tr><td colspan="6">Course Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CA-CBT-801</td><td colspan="3">Chemical and Pharmaceutical Technology</td><td>Lecture and tutorial</td><td>5</td></tr>
<tr><td>Module Coordinator

Marcelo Fernandez Lahore</td><td colspan="3">Program Affiliation

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

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

Pre-requisites: ☒ Introduction to Biotechnology
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 and tutorial (45 hours)
• Private study (65 hours)
• Exam preparation (15 hours)</td></tr>
<tr><td>Duration

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

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

None.</td></tr>
</table>

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.

1.22 Physical Chemistry

<table>
<tr><td colspan="3">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="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-440-A</td><td colspan="3">Physical Chemistry I</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>CO-440-B</td><td colspan="3">Physical Chemistry II</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Detlef Gabel</td><td colspan="3">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 rowspan="2">Entry Requirements

Pre-requisites

☒ General and Inorganic Chemistry

or

☒Modern Physics</td><td rowspan="2">

Co-requisites

☒ None</td><td rowspan="2">

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="6">Recommendations for Preparation

None;</td></tr>
<tr><td colspan="6">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="6">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;</td></tr>
</table>

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;

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 1: 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.

1.23 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

Predrag Tapavicki & Christin Klähn (CSC Organization); SPC / Faculty Startup Coordinator (Academic responsibility);

Program Affiliation

- CAREER module for undergraduate study programs

Mandatory Status

Mandatory for all undergraduate study programs except IEM

Entry Requirements

Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*
☒ at least 15 CP from CORE modules in the major	☒ None	• Information provided on CSC pages (see below) • Major specific knowledge and skills

Frequency

Annually (Spring/Fall)

Forms of Learning and Teaching

- 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

- Reading the information in the menu sections titled “Internship Information,” “Career Events,” “Create Your Application,” and “Seminars & Workshops” at the Career Services Center website: https://jacobs-university.jobteaser.com/en/users/sign_in?back_to_after_login=%2F
- Completing all four online tutorials about job market preparation and the application process, which can be found here: https://jacobs-university.jobteaser.com/en/users/sign_in?back_to_after_login=%2F
- 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%

1.24 Bachelor Thesis and Seminar

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

Bachelor Thesis and Seminar</td><td>Module Code

CA-MCCB-800</td><td>Level (type)

Year 3 (CAREER)</td><td>CP

15</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>CA-MCCB-800-T</td><td colspan="3">Thesis</td><td>Thesis</td><td>12</td></tr>
<tr><td>CA-MCCB-800-S</td><td colspan="3">Thesis Seminar</td><td>Seminar</td><td>3</td></tr>
<tr><td>Module Coordinator

Study Program Chair</td><td colspan="3">Program Affiliation

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

Mandatory for all undergraduate programs</td></tr>
<tr><td>Entry Requirements

Pre-requisites

☒ Students must be in their third year and have taken at least 30 CP from CORE modules in their major.</td><td>

Co-requisites

☒ None</td><td>

Knowledge, Abilities, or Skills

• 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.</td><td>Frequency

Annually (Spring)

Duration

1 semester</td><td colspan="2">Forms of Learning and Teaching

• Self-study/lab work (350 hours)
• Seminars (25 hours)

Workload

375 hours</td></tr>
<tr><td colspan="6">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.</td></tr>
</table>

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, both module component examinations have 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.

1.25 Jacobs Track Modules

1.25.1 Methods and Skills Modules

1.25.1.1 Mathematical Concepts for the Sciences

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

Mathematical Concepts for the Sciences</td><td>Module Code

JTMS-MAT-07</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-07</td><td colspan="3">Mathematical Concepts for the Sciences</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator(s)

Marcel Oliver, Tobias Preußer</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 rowspan="2">Entry Requirements

Pre-requisites

☒ None</td><td rowspan="2">

Co-requisites

☒ None</td><td rowspan="2">

Knowledge, Abilities, or Skills
• none</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

Review basic mathematical concepts and tools.</td></tr>
</table>

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.

1.25.1.2 Physics for the Natural Sciences

Module Name			*Module Code*	*Level (type)*	*CP*
Physics for the Natural Sciences			JTMS-SCI-17	Year 1 (Methods)	*5*
Module Components					
Number	*Name*			*Type*	*CP*
JTMS-17	Physics for the Natural Sciences			Lecture	5.0
Module Coordinator Jürgen Fritz	***Program Affiliation*** • Jacobs Track – Methods and Skills			***Mandatory Status*** Mandatory for BCCB, CBT, EES and MCCB	
Entry Requirements			***Frequency*** Annually (Spring)	***Forms of Learning and Teaching*** • Lecture (35 hours) • Private study including homework (90 hours)	
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*			
☒ None	☒ None	• High school math • Basic high school physics	***Duration*** 1 semester	***Workload*** 125 hours	

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.

1.25.1.3 Analytical Methods

Module Name	*Module Code*	*Level (type)*	*CP*
Analytical Methods	JTMS-SCI-16	Year 2 (Methods)	5

Module Components

Number	*Name*	*Type*	*CP*
JTMS-16	Analytical Methods	Lecture	5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Nikolai Kuhnert	• Jacobs Track – Methods and Skills	Mandatory for MCCB and CBT Mandatory elective for BCCB and EES

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)
☒ None	☒ None	• Basic knowledge in Life Sciences	*Duration* 1 semester	*Workload* 125 hours

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

1.25.1.4 Plant Metabolism and Natural Products

<table>
<tr><td colspan="3">Module Name
Plant Metabolism and Natural Products</td><td>Module Code
JTMS-SCI-18</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-18</td><td colspan="3">Plant Metabolism and Natural Products</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Matthias Ullrich</td><td colspan="3">Program Affiliation

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

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

Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• Comprehensive high school knowledge of chemistry, mathematics, physics, biochemistry, and cell biology</td><td>Frequency

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

• Lecture (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

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.</td></tr>
<tr><td colspan="6">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.</td></tr>
</table>

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.

1.25.2 Big Questions Modules

1.25.2.1 Water: The Most Precious Substance on Earth

<table>
<tr><td colspan="3">Module Name
Water: The Most Precious Substance on Earth</td><td>Module Code
JTBQ-BQ-002</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-002</td><td colspan="3">Water: The Most Precious Substance on Earth</td><td>Lecture/Tutorial</td><td>5</td></tr>
<tr><td>Module Coordinator

M. Bau and D. Mosbach</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 (part I: Fall; part II: Spring)</td><td colspan="2">Forms of Learning and Teaching

• Lectures (17.5 hours)
• Project work (90 hours)
• Private study (17.5 hours)</td></tr>
<tr><td>Duration

2 semesters</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. 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.

1.25.2.2 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
5.0</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 /Projects</td><td>5.0</td></tr>
<tr><td>Module Coordinator

A. 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">Entry Requirements</td><td rowspan="2">Frequency

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

• Lectures (35 hours)
• Project work (55 hours)
• Private study (35 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></tr>
<tr><td colspan="3"></td><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>
<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 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.</td></tr>
</table>

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;
- complete a self-designed project;
- overcome general teamwork problems;
- perform well-organized project work.

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 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.

1.25.2.3 Global Health – Historical context and future challenges

Module Name			*Module Code*	*Level (type)*	*CP*
Global Health – Historical context and future challenges			JTBQ-BQ-004	Year 3 (Jacobs Track)	5
Module Components					
Number	*Name*			*Type*	*CP*
JTBQ-004	Global Health – Historical context and future challenges			Lecture	5
Module Coordinator A. M. Lisewski	*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 *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	*Frequency* Annually (Fall) *Duration* 1 semester	*Forms of Learning and Teaching* • Lectures (35 hours) • Private study (90 hours) *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. This module gives a historical, societal, technical, scientific, and medical overview of the past and future milestones and challenges of global health. Particular focus is put on future global health issues in a world that is interconnected both through mobility and communication networks. This module presents the main milestones along the path to modern health systems, including the development of public hygiene, health monitoring and disease response, and health-related breakthroughs in science, technology, and the economy. Focus is given to pediatric, maternal, and adolescent health, as these are the areas most critical to the well-being of future generations. This module also provides key concepts in global health, epidemiology, and demographics, such as the connection between a society's economic level and its population's health status, measures of health status, demographic and epidemiologic transitions, and modern issues such as the growing fragmentation (at a personal level) of disease conditions and the resulting emergence of personalized medicine. Finally, attention is also given to less publicly prominent global health issues, such as re-emerging diseases, neglected tropical diseases, and complex humanitarian crises.					

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;
- explain the historical context of current global health surveillance, response systems, and institutions;
- discuss and evaluate the imminent and future challenges to public hygiene and response to disease outbreaks in the context of a global societal network.

Indicative Literature

Richard Skolnik (2015). Global Health 101 (Essential Public Health). Burlington: Jones and Bartlett Publishers, Inc.

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

1.25.2.4 Global Existential Risks

Module Name			*Module Code*	*Level (type)*	*CP*
Global Existential Risks			JTBQ-BQ-005	Year 3 (Jacobs Track)	2.5
Module Components					
Number	*Name*			*Type*	*CP*
JTBQ-005	Global Existential Risks			Lecture	2.5
Module Coordinator M. A. Lisewski	*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 *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		*Frequency* Annually (Spring)	*Forms of Learning and Teaching* • Lectures (17.5 hours) • Private study (45 hours)
				Duration 1 semester	*Workload* 62.5 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.

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 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 explore this topic across diverse subject fields.

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 factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
- explain the varieties of global existential risks;
- discuss approaches to minimize these risks;
- formulate coherent written and oral contributions on this topic.

Indicative Literature

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

Murray Shanahan (2015). The Technological Singularity. Cambridge:The MIT Press.

Martin Rees (2003) Our Final Hour. New York: Basic Books.

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%

1.25.2.5 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

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 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

• 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>
<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 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.</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 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

1.25.2.6 Climate Change

Module Name		*Module Code*	*Level (type)*	*CP*
Climate Change		JTBQ-BQ-007	Year 3 (Jacobs Track)	2.5
Module Components				
Number	*Name*		*Type*	*CP*
JTBQ-007	Climate Change		Lecture	2.5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
L. Thomsen/ V. Unnithan	• Big Questions Area: All undergraduate study programs, except IEM	• Mandatory elective for students of all undergraduate study programs, except IEM

Entry Requirements			*Frequency*	*Forms of Learning and Teaching*
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Spring)	• Lecture (17.5 hours) • Private study (45 hours)
☒ None	☒ None	• The ability and openness to engage in interdisciplinary issues of global relevance • Media literacy, critical thinking, and a proficient handling of data sources	*Duration* 1 semester	*Workload* 62.5 hours

Recommendations for Preparation

Critically following media coverage of 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' 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%

1.25.2.7 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

L. 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" 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)
• 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>
<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>
<tr><td colspan="6">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;</td></tr>
</table>

- 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%

1.25.2.8 International Development Policy

<table>
<tr><td colspan="3">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="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>JTBQ-009</td><td colspan="3">International Development Policy</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

C. Knoop</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

• 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="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’ 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.</td></tr>
</table>

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%

1.25.2.9 Sustainable Value Creation with Biotechnology. From Science to Business

Module Name			*Module Code*	*Level (type)*	*CP*
Sustainable Value Creation with Biotechnology. From Science to Business.			JTBQ-BQ-011	Year 3 (Jacobs Track)	2.5
Module Components					
Number	*Name*			*Type*	*CP*
JTBQ-011	Sustainable Value Creation with Biotechnology. From Science to Business			Lecture - Tutorial	2.5
Module Coordinator Marcelo Fernandez Lahore	***Program Affiliation*** • Jacobs Track - Big Questions			***Mandatory Status*** • Mandatory elective for students of all undergraduate study except IEM	
Entry Requirements			***Frequency*** Annually (Spring)	***Forms of Learning and Teaching*** • Lecture and Tutorial (17.5 hours) • Private study (45 hours)	
Pre-requisites ☒ None	*Co-requisites* ☒ None	*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	***Duration*** 1 semester	***Workload*** 62.5 hours	
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					

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 — Length:1.500 – 3.000 words; Weight: 75%

Scope: Intended learning outcomes of the module (1-6)

Assessment Component 2: Presentation — Duration: 10-15 min.

Weight: 25% Scope: Intended learning outcomes of the module (2-7)

1.25.2.10 Gender and Multiculturalism. Debates and Trends in Contemporary Societies

<table>
<tr><td colspan="3">Module Name
Gender and Multiculturalism. Debates and Trends in Contemporary Societies</td><td>Module Code
JTBQ-BQ-013</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
5.0</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-013</td><td colspan="3">Gender and Multiculturalism: Debates and Trends in Contemporary Societies</td><td>Lecture</td><td>5.0</td></tr>
<tr><td>Module Coordinator

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

• Lectures (17.5 hours)
• Project work (90 hours)
• Private study (17.5 hours)</td></tr>
<tr><td>Duration

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

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

Critical following of the 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. 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</td></tr>
</table>

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

Weight: 100%

Scope: All intended learning outcomes of the module

1.25.2.11 The Challenge of Sustainable Energy

Module Name	*Module Code*	*Level (type)*	*CP*
The Challenge of Sustainable Energy	JTBQ-BQ-014	Year 3 (Jacobs Track)	2.5

Module Components

Number		*Type*	*CP*
JTBQ-014	The Challenge of Sustainable Energy	Lecture	2.5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
K. Smith Stegen	• Big Questions Area: All undergraduate study programs	Mandatory elective for students of all undergraduate study programs, except IEM

Entry Requirements

Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*
☒ None	☒ None	• Ability to read texts from a variety of disciplines

Frequency	*Forms of Learning and Teaching*
Annually (Spring)	• Lectures and Group Exercises

Duration	*Workload*
1 semester	62.5 hours

Recommendations for Preparation

Reflect on their own behavior and habits with regard to sustainability.

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 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

1.25.2.12 State, Religion and Secularism

Module Name	*Module Code*	*Level (type)*	*CP*
State, Religion and Secularism	JTBQ-BQ-015	Year 3 (Jacobs Track)	2.5

Module Components

Number		*Type*	*CP*
JTBQ-015	State, religion and secularism	Lecture	2.5

Module Coordinator	*Program Affiliation*	*Mandatory Status*
Manfred O. Hinz	• Big Questions Area: All undergraduate study programs	Mandatory elective for students of all undergraduate study programs, except IEM

Entry Requirements			*Frequency*	*Forms of Learning and Teaching*
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Spring)	• Lectures and Group Exercises
☒ None	☒ None	• Ability to read texts from a variety of disciplines	*Duration*	*Workload*
			1 semester	62.5 Hours

Recommendations for Preparation

Reflect on the situation and role in respective home-country

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.

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.

1.25.3 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</td></tr>
</table>

- understand the real-life issues of communities, organizations, and industries and relate them to concepts in their own discipline;
- 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

1.25.4 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

2 Appendix

2.1 Intended Learning Outcomes Assessment-Matrix

Medicinal Chemistry and Chemical Biology					General MCCB	General Org Chem	General Biochemistry	General Cell Bio	Medicinal Chemistry	Chemical Biology	Pharmaceutical Chem	Adv Org Chem	Sci Software & Databanks	Adv Org & Analytical Lab	High Throughput Screen	Physical Chem & Molecular Mod	MCCB Lab	Plant Metabolites & Nat Prod	Methods in Analyt Science	Summer Internship	Adv Org Synth	Flourine & Drug Dev	Organometallic Chemistry	Supramolecular Chemistry	Seminar MCCB/CBT	Thesis MCCB	JT Methods/Skills	JT Community Impact	JT Big Questions	JT Language
Semester					1	2	1	2	3	4	3/4	3	4	3	3	4	4	4	3	4-5	5	6	5	5	6	6	1-4	5	5	1-4
Mandatory/mandatory elective					m	m	m	m	m	m	me	m	m	m	me	me	m	m	m	m	me	me	me	me	m	m	m	m	m	m
Credits					7.5	7.5	7.5	7.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	15	5.0	5.0	5.0	5.0	3.0	12.0	20.0	5.0	10.0	10.0
	Competencies*																													
Program Learning Outcomes	**A**	**E**	**P**	**S**																										
T1	x	x			x	x			x			x									x	x	x	x						
T2	x	x			x	x						x									x									
T3	x	x			x		x	x		x	x						x	x					x	x			x			
T4	x	x					x	x																						
T5	x	x			x		x	x		x							x	x									x			
T6	x	x							x		x																			
T7	x	x			x				x	x	x											x	x	x						
T8	x	x			x				x	x	x																			
T9	x	x														x														
T10	x	x											x		x	x														
T11	x	x												x	x				x			x	x	x			x			
T12	x	x																			x	x	x	x						
PW1	x	x												x			x									x				
PW2	x	x												x			x									x				
PW3	x	x				x	x	x						x																
PW4	x	x				x								x			x													
PW5	x	x													x		x													
PW6	x	x											x			x														
PW7	x	x				x	x	x						x			x													
PW8	x	x				x	x	x					x	x			x													
TS1	x	x	x	x					x	x	x	x			x	x			x		x	x			x	x		x	x	
TS2	x	x	x	x					x	x	x														x					
TS3	x	x	x	x					x	x	x	x		x	x	x	x		x		x	x	x	x			x		x	
TS4	x	x		x				x						x			x			x						x				
TS5	x	x				x	x	x						x			x		x								x			
TS6	x	x	x	x		x	x	x	x	x	x		x	x			x			x					x	x		x	x	x
TS7	x	x		x					x		x											x		x						
TS8	x	x		x				x					x							x						x				
TS9	x	x	x	x				x	x	x	x									x					x	x		x	x	x
TS10	x	x			x	x	x	x						x			x		x								x			
TS11	x	x	x	x		x	x	x						x		x	x			x					x	x		x	x	x
Assessment Type																														
Oral examination											x										x	x								
Written examination					x	x	x	x	x	x		x	x	x	x	x		x	x											
Project																				x								x		
Essay (thesis)																										x				
(Lab) report						x	x	x									x													
Poster presentation																														
Presentation																														
Various																									x		x		x	x
Module achievements/bonus achievements									x	x																				x

*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