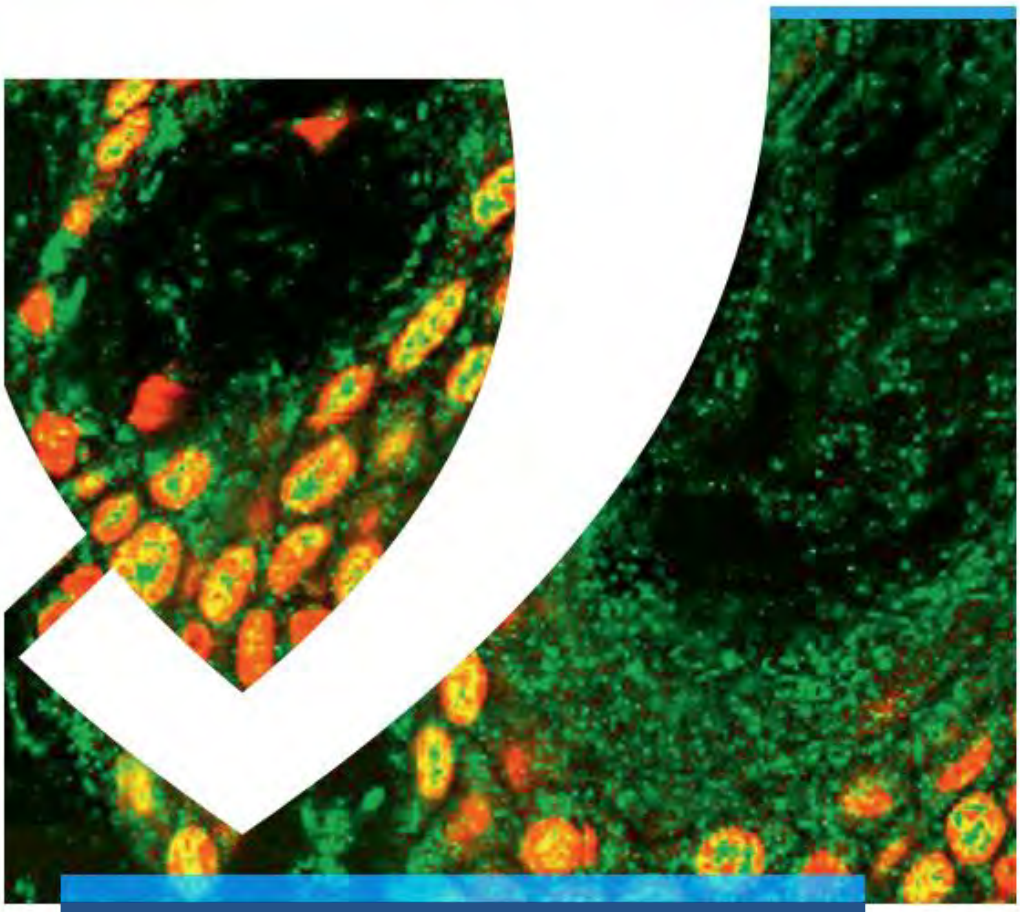
JACOBS UNIVERSITY



Study Program Handbook

Biochemistry and Cell Biology (BCCB)

Bachelor of Science

Subject-specific Examination Regulations for Biochemistry and Cell Biology (Fachspezifische Prüfungsordnung)

The subject-specific examination regulations for Biochemistry and Cell 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).

Version	Valid as of	Decision	Details
Fall 2019 – V2.4	Sep 01, 2019	Approved by the Academic Senate on June 26, 2019.	V1 Master version V1.1 Name change of various module components, editorial changes, indicative literature added. V1.2 Change of assessment types (RNA BioChem and Microbial Pathogenicity) V1.3 Bug fix V2.3 Replacement of CBT Specialization module Microbial Engineering with Environmental Microbiology and Biotechnology V2.4 Update of BQ-Area

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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 in 2019. 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

Biochemistry is the study of molecules and chemical processes in living organisms, while Cell Biology addresses the structure and physiology of cells, their components, and their interactions with the environment. The two fields are combined in one comprehensive degree program, which provides students with a broad understanding of the molecular and cellular mechanisms that form the basis of life, including the principles of inheritance and gene expression. This allows BCCB graduates to address important problems in today's society in their careers, be it by basic or applied research, for example, in the areas of biomedicine, biotechnology, or molecular biology. For this, the BCCB program at Jacobs University provides not only the theoretical

background, but also substantial practical training. Students are, furthermore, involved in hands-on research during their studies. As part of the Bachelor program, students receive a solid foundation in mathematics and the natural sciences Physics and Chemistry, which is an important basis for a deeper understanding of the content of the study program. In the classic teaching formats of lectures, seminars, and lab courses, various didactic approaches are implemented in the BCCB program, such as project work, game-based learning, working groups, learning by teaching, and oral or poster presentations of their own data and those of others. Together, these approaches allow students to actively engage in shaping their studies, and they lead to excellent learning outcomes. Overall, the BCCB program follows the recommendations "Subject-Specific Criteria for Bioscience Study programs" as defined by the German Conference of Biological Departments (KBF). The aim of the BCCB program is to provide a broad knowledge and competence base that qualifies students for career entry in the field of the Life Sciences and for further degree programs (MSc and/or PhD), which is what the typical BCCB graduate aims for. Our graduates often receive several competitive offers from universities and research institutions around the world to continue with graduate and PhD studies. In many cases, BCCB graduates qualify as co-authors of peer-reviewed publications in top scientific journals. BCCB, the largest major of the focus area Health at Jacobs University, regularly reaches top evaluations in rankings of study programs, such as the CHE or U-Multirank.

1.2 Specific Advantages of BCCB at Jacobs University

- The BCCB program at Jacobs University combines biochemistry and cell biology from the first day of study such that the connections between these fields become clear. In the first year, students rapidly obtain an overview of the entire field of molecular life science; this helps them identify their own area of interest.
- The BCCB program covers human and animal biochemistry, cell biology, molecular biology, and genetics, but is also strong in plant and microbial life science. The broad experience of Jacobs University Life Sciences Faculty, and the courses they offer, allow students to also explore related subjects such as biotechnology, biophysics, bioinformatics, organic chemistry, chemical biology, drug design, marine science, food analytics, molecular immunology, and others.
- The BCCB program has a very strong practical component, with excellent laboratory courses. This helps students gain the hands-on experience they need to apply for high-level internships and graduate school positions. The Bachelor thesis consists of research work in the research groups of the Life Sciences Faculty. The research carried out by BCCB students has regularly contributed to scientific publications.
- In the first fifteen years of its existence, the BCCB program has been highly successful with many students going on to graduate at high-level institutions around the world, including MSc and PhD programs (see also 1.4). Most BCCB students pursue graduate studies at the Master or PhD level, either in aspiration of an academic career or as further preparation for a leading position in related industry. As such and beyond, BCCB has an excellent track record in providing the scientific qualifications required for employability, particularly in the academic sector.

1.3 Program-Specific Educational Aims

1.3.1 Qualification Aims

The BCCB program prepares students for an academic or professional career in the field of Life Sciences:

- Throughout their studies, BCCB students acquire profound and comprehensive theoretical knowledge in the fields of biochemistry, molecular biology, and cell biology, thereby gaining a thorough understanding of the principal concepts in these research areas. Furthermore, students learn how to abstract and transfer their knowledge onto new research areas, an essential skill in modern life sciences.
- Presentation skills are developed through scientific poster preparation and oral presentations. In this context, students will be exposed to primary scientific literature and are eventually guided towards the development of research strategies, for example, for an application for a human mobility stipend grant or a PhD project.
- Theoretical education is complemented by rigorous practical training in comprehensive laboratory courses in the fields of biochemistry, cell biology, molecular biology, and microbiology. In these courses, which already start in the first semester, students acquire excellent technical skills and employ state-of-the-art methods. In addition, they learn how to accurately document and analyze scientific data through the writing of lab reports and the bachelor's thesis, all following publication-style rules. The philosophy of the BCCB program comprises working in an environment where scientific equipment is part of their daily encounters in closely-guided research projects.
- Through their extensive exposure to current topics in life science research conducted at Jacobs University, students experience an authentic research environment that also teaches them to adhere to ethical standards and good laboratory practice. They further learn how to develop and defend their individual research project, and acquire an early perspective on prospective job careers.
- Intensive teamwork in laboratory courses and within research groups enables students to take responsibility for their own work and how to constructively engage in international teams in an atmosphere of mutual acceptance and respect. Consequently, BCCB graduates develop high communication competence. They are aware of intercultural differences and possess skills to deal with the challenges of a global job market.

1.3.2 Intended Learning Outcomes

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

1. Apply basic concepts from the natural sciences (general chemistry, organic chemistry, and physics) and mathematics, including statistics
2. Explain the basic concepts within the fields of biochemistry and cell biology
3. Recognize general patterns of biochemical reactivity and metabolic pathways
4. Explain how the structure and biochemical properties of biomolecules define their cellular function
5. Explain general processes governing cellular and early developmental biology in health and diseased conditions;
6. Describe the molecular principles underlying gene expression and regulation

7. Apply state-of-the-art techniques to experimentally analyze biomolecules and cells
8. Collect, analyze, and evaluate relevant literature within the fields of biochemistry, molecular biology, and cell biology
9. Use their acquired theoretical knowledge and practical skills to design and implement experimental approaches to address scientific questions in the modern Life Sciences
10. Generate, analyze, and interpret data according to good scientific practice and ethical standards
11. Present their own results, and those of others, concisely and professionally both in writing and in front of an audience
12. Develop and advance solutions to problems in the Life Sciences and defend these in discussions with specialists and non-specialists
13. Explore related subjects such as biotechnology, biophysics, bioinformatics, organic chemistry, drug design, marine science, food analytics, and others
14. Acquire knowledge rapidly, and gather, evaluate, and interpret relevant information and evaluate new concepts critically to derive scientifically founded judgments
15. Evaluate situations and make decisions based on ethical considerations, and adhere to and defend ethical, scientific, and professional standards
16. Negotiate and mediate between different points of view and manage conflicts
17. Analyze global issues of an economic, political, scientific, social, or technological nature
18. Take responsibility in diverse and interdisciplinary teams, exhibiting tolerance and intercultural awareness
19. Take responsibility for their own and their team's learning, personal, and professional development and role in society, evaluating critical feedback and using self-analysis
20. Take responsibility for their professional community and society

1.4 Career Options

Most BCCB graduates move on to graduate education, and past graduates of this program have enrolled at prestigious universities around the world. To these belong MSc and PhD programs at Imperial College London, LMU Munich, University of Heidelberg, University of Göttingen, ETH Zurich, EPF Lausanne, European Molecular Biology Laboratories (EMBL), various International Max Planck Research Schools (IMPRS), the University of Oxford, the University of Cambridge, Cornell University, Duke University, New York University, Yale, MIT, and Harvard.

The applied curriculum of the BCCB program with many laboratory courses also enables graduates to find work as lab researchers, in other research-related positions, in product development, technical support, marketing or sales in biotech, food or pharmaceutical companies, as well as government agencies. Some graduates have also found non-traditional careers such as management, science policy, or science writing. Outside academia, past graduates of this program work for Arthrex, Catenion, Roche, Leroy Merlin, Boston Consulting Group, and the non-profit partnership Medicines for Malaria Venture.

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

For more information please contact the study program coordinator:

Prof. Dr. Christian Hammann
Professor of Biochemistry
Email: c.hammann@jacobs-university.de
Tel: +49 421 200-3247

or visit our program website: www.jacobs-university.de/bccb-program

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 opportunities 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:

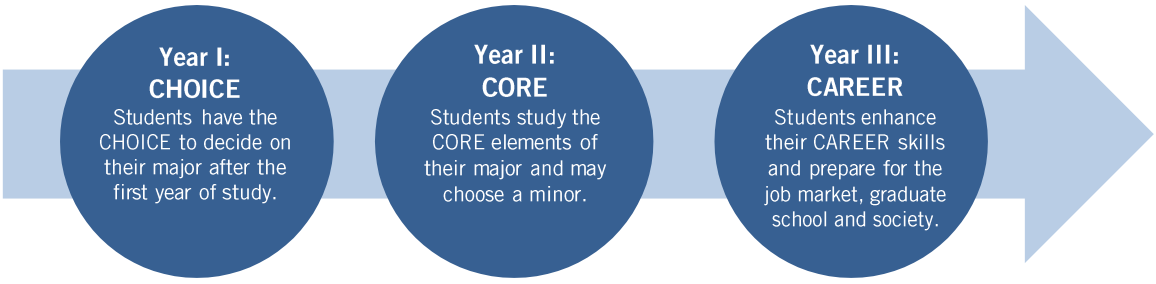

Figure 1: The Jacobs University 3C-Model

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 belong to 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 curriculum counseling to all Bachelor students independently of their major, while Academic Advisors, in their capacity as contact persons from the faculty, support students individually in deciding on their major study program.

To pursue Biochemistry and Cell Biology (BCCB) as a major, the following CHOICE modules (30 CP) need to be taken as mandatory modules:

- CHOICE Module: General Biochemistry (7.5 CP)
- CHOICE Module: General and Inorganic Chemistry (7.5 CP)
- CHOICE Module: General Cell Biology (7.5 CP)
- CHOICE Module: General Organic Chemistry (7.5 CP)

The mandatory CHOICE Modules of the BCCB major are planned out and consist of integrated lecture and laboratory course module components. The CHOICE General Biochemistry Module will explain how to apply and analyze basic concepts of biochemistry, while the CHOICE General Cell Biology Module introduces students to cells that are the minimal functional units of life. Both BCCB-specific modules find their essential foundations and complementation in the CHOICE General and Inorganic Chemistry and General Organic Chemistry Modules, in which the underlying principles of chemical reactions and organic molecules are conveyed. Thus, the macromolecular composition of cells, general principles of cellular and biochemical processes, as well as molecular biological codes provided by the genome, the transcriptome, and the proteome will be the focus of the complementary components of the mandatory BCCB CHOICE Modules at large. Physiology and pathological alterations bringing about diseases will be introduced alongside this. In-lab experiences will encompass the documentation, description, and discussion of experimental data, while awareness and the following of safety rules and regulations are explained and trained.

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

2.2.1.1 Major Change Option

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

BCCB 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.

- Chemistry
  CHOICE Module: Introduction to Biotechnology (7.5 CP)

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

- Psychology
  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)

Typically, students interested in BCCB will have a genuine interest in the molecular life sciences. Therefore, CHOICE Modules from the related majors "Chemistry and Biotechnology" (Chemistry) and "Medicinal Chemistry and Chemical Biology" (MCCB) are recommended as fitting complementation (see above). In the past, students have also declared interests in "Earth and Environmental Sciences" as well as "Psychology." These students would thus be advised to choose the respective CHOICE Modules during their first year of study. The BSc program "Earth and Environmental Sciences," for example, has been structured to allow BCCB students with an interest in marine environmental systems access to CHOICE and CORE modules.

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 students have already acquired so far (see 2.3.1), these modules aim to expand the students' critical understanding of the key theories, principles, and methods in their major for the current state of knowledge and best practice.

To pursue BCCB as a major, 35 CP from the following mandatory elective CORE modules need to be acquired:

- CORE Module: Advanced Biochemistry I (5 CP)
- CORE Module: Advanced Biochemistry II (5 CP)
- CORE Module: Advanced Biochemistry Lab (5 CP)
- CORE Module: Advanced Cell Biology I (5 CP)
- CORE Module: Advanced Cell Biology II (5 CP)
- CORE Module: Advanced Cell Biology Lab (5 CP)
- CORE Module: Microbiology (5 CP)

The mandatory CORE Modules of the BCCB program build on the BCCB CHOICE modules and are thought to deepen the knowledge in each of the two core fields of this major: biochemistry and cell biology. For either field, the CORE modules encompass two lectures and a laboratory course. To account for the wealth of information and the fast development in knowledge acquisition, as well as methodological advances in these rapidly enhancing scientific fields, the modules are staggered from the third to the fourth semester. The "Advanced Biochemistry I/II" modules cover energy production by living organisms, synthesis and degradation of biomolecules and principles of metabolism. Moreover, they address how genetic information is regulated, controlled and expressed in pro- and eukaryotic cells, and how DNA repair is realized at an advanced level. The "Advanced Cell Biology I/II" modules provide an in-depth view on the complexity of cellular systems, the regulation of key cellular processes and their integration in tissue formation and organismal organization, including regulatory mechanisms that allow for

coordinated early development in selected model organisms. These modules will also address principles of genetics and evolution and discuss consequences of alterations upon loss of homeostasis or stress, thereby approaching biomedical implications leading to disease.

In the laboratory modules, students will perform experiments to elucidate the relationship between structure, biochemical properties, and activity of biomolecules, both in vitro and in a cellular context. For example, proteins tagged by the green fluorescent protein (GFP) will be expressed and biochemically characterized in the Advanced Biochemistry Laboratory module while protein trafficking and functioning in different cellular compartments will be analyzed using GFP-tagged proteins in combination with different targeting signals in the Advanced Cell Biology Laboratory module. Methods range from standard techniques like chromatography, gel electrophoresis, spectrophotometry to genetic engineering of plasmid vectors, the genetic manipulation of cells and advanced laser scanning microscopy. Result documentation, analysis and discussion will be accomplished through publication-style laboratory reports.

The mandatory module "Microbiology" addresses the diversity of microorganisms, their manifold biochemically diverse life styles and adaptations to various environments. This includes the exploration how microbes contribute to the cycling of elements on our planet, and the analysis of host-pathogen interactions. Students will also learn about strategies to fight microbial contaminations and pathogens.

Students may decide to complement their studies by taking the discipline-specific mandatory elective CORE modules (10 CP)

- CORE Module: Microbiology Lab (2.5 CP)
- CORE Module: Infection and Immunity (7.5)

In the "Microbiology Lab", students will identify environmental bacteria through biochemical and sequence analyses. The lecture module "Infection and Immunity" (7.5 CP) explores microbial biology and pathogenicity as well as host-pathogen interactions in light of the human immune system as an efficient defense mechanism.

Alternatively, BCCB students may substitute the mandatory elective CORE modules "Microbiology Lab", "Infection and Immunity" as well the mandatory elective Methods/Skills module of the third semester with 15 CP from CORE modules from a second field of studies according to interest with the aim to pursue a minor (see 2.2.2.1).

2.2.2.1 Minor Option

BCCB 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 a student`s final 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 BCCB students to:

- select CHOICE modules (15 CP) from the desired minor program in the first year and
- substitute the mandatory elective BCCB CORE modules "Microbiology Lab" and "Infection and Immunity" and the mandatory elective methods module in the third semester (15 CP total) 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 for their career after graduation. To explore available choices fitting individual interests, and to gain professional experience, students take a mandatory summer internship (see 2.2.3.1). The third year of studies allows BCCB students to further sharpen their profile with a selection of discipline-specific, research-oriented specialization modules that can be combined to enhance their individual competences in the natural sciences, strategy development for novel research approaches or managerial capabilities. Furthermore, the third year also focuses on the responsibility of students beyond their discipline (see Jacobs Track).

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

2.2.3.1 Internship / Start-up and Career Skills Module

As a core element of Jacobs University's employability approach students are required to engage in a mandatory two-month internship of 15 CP that will usually be completed during the summer between the second and third 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 personal role in employment and society, and develope 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 their business plans.

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

For organizational aspects consult with your Academic Advisor and the BCCB SPC for reasonable choices to conduct a prosperous internship.

2.2.3.2 Specialization Modules

In the third year of their studies, students take 15 CP from major-specific or major-related, advanced Specialization modules to consolidate their knowledge and to be exposed to state-of-the-art research in the areas of their interest. This curricular component is offered as a portfolio of modules, from which students can make free selections during their fifth and sixth semester. The BCCB program embraces five comprehensive 5 CP modules that focus on building professional skills to enable an academic career in the molecular life sciences and beyond.

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

- BCCB Specialization: Experimental Strategy Design (5 CP)
- BCCB Specialization: RNA Biochemistry (5 CP)
- BCCB Specialization: Biomedicine (5 CP)
- MCCB Specialization: Current Topics in the Molecular Life Sciences (5 CP)
- Chemistry Specialization: Microbial Engineering (5 CP)

The specialization modules in the BCCB program aim at critical discussions and evaluations of current advances in different research fields of the molecular life sciences to unravel and apply the fascinating complexity of biological systems in basic and applied sciences. Although from different perspectives, the BCCB Specialization Modules will address scientific challenges in the 21st century and how scientists tackle them. The module contents will enable students to formulate hypotheses, develop a strategy to approach any research question experimentally, predict possible experimental outcomes, and how the experiments need to be controlled in order to finally draw a conclusion from their own data or the results of others. In this context, the regulatory frameworks governing activities in the bioscience field will be discussed and the principles for creating and realizing research projects in the fast progressing fields of life sciences will be outlined. The module contents will take into consideration the societal context in a world with increasing cultural and socio-economic diversity, for example, by critically deducing today's challenges in designing research projects in the basic sciences and also by aiming at translation in the clinics.

Hypothesis-driven research is the central element in "Experimental Strategy Design," where students will expand their methodological knowledge through literature analysis, assessing the benefits and limitations of state-of-the art-techniques, which will enable them to eventually design their own research strategy to answer a given scientific question. The module "RNA Biology" will comprehensively address the structural and functional versatility of this biopolymer, ranging from the discrimination of different RNA types, to methodological advances in next generation sequencing and genome editing by CRISPR/Cas. The "Biomedicine" module will analyze how biological processes can go wrong in disease, which molecular regulators are targeted in designing therapeutic approaches and new treatment options, and how diagnostic tools can be developed. In "Current Topics," students will analyze recent scientific articles in a seminar-style format where students present the authors' rationale and experimental design and debate the experimental outcomes through in-class discussions. "Microbial Engineering" will demonstrate how cells, particularly microorganisms, are increasingly used as cellular factories to produce proteins, biofuels, small-molecule pharmaceuticals, commodities, and fine-chemicals. Methods for designing and improving 'synthetic' microbial cell factories will be taught.

2.2.3.3 Study Abroad

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

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

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

BCCB students will typically choose institutions for study abroad where they can apply their factual knowledge and expand their experimental skills to broaden their methodological expertise. Furthermore, this option offers students to explore additional research fields complementary to the BCCB curriculum, such as evolutionary developmental biology, neurobiology, structural biology, virology, etc.

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 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 BCCB as a major, the following mandatory Methods and Skills (15 CP) need to be taken:

- Methods Module: Mathematical Concepts for the Sciences (5 CP, Semester 1)
- Methods Module: Physics for the Natural Sciences (5 CP, Semester 2)
- Methods Module: Plant Metabolites and Natural Products (5 CP, Semester 4)

For the remaining 5 CP BCCB students can choose between the two Methods modules

- Methods Module: Programming in Python (5 CP, Semester 3)
- Methods Module: Analytical Methods (5 CP, Semester 3)

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 fifth and sixth 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 fifth semester students are required to take a 5 CP Community Impact Project (CIP) module. Students engage in on-campus or off-campus activities that challenge their social responsibility, i.e., they typically work on major-related projects that make a difference in the community life on campus, in 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 BCCB as a Minor

The typical target group aiming at a Minor in BCCB are students with a genuine interest in neighboring disciplines that can be any of the following: bioinformatics, biotechnology, chemistry, environmental sciences, physics, or psychology. All of these fields of study connect to the scientific questions asked, approached, and solved in the molecular life sciences for which BCCB provides the basic scientific foundations. Students who are mainly interested in the theoretical foundations of the field are invited to follow the enriching experience in BCCB by enrolling with a Minor.

3.1 Qualification Aims

In the BCCB CHOICE modules, students will receive an overview about the different classes of biomolecules and how their intricate interplay defines cellular architecture and function. They will also acquire basic experimental skills to develop a general understanding of core methodology. These foundations are complemented by the study of microbiology, host pathogen interactions, and immune defense to demonstrate the complexity of the field and relate fundamental research to key challenges in modern societies, for example, multiple drug resistance in bacteria and immunotherapy in cancer treatment. Understanding the basic principles underlying molecular life sciences and their applications is a key asset that will enable students to become a reasonable politician, to enroll in decision-making boards, and to

empower society with respect to the biological revolution, which is only at the beginning of exploitation.

3.1.1 Intended Learning Outcomes

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

1. Explain the basic concepts within the fields of biochemistry and cell biology
2. Explain how the structure and biochemical properties of biomolecules define their cellular function
3. Explain general processes governing cellular and early developmental biology in health and diseased condition
4. Describe the molecular principles underlying gene expression and regulation
5. Apply state-of-the-art techniques to experimentally analyze biomolecules and cells
6. Generate, analyze, and interpret data according to good scientific practice and ethical standards
7. Rapidly acquire knowledge, and gather, evaluate, and interpret relevant information, and critically evaluate new concepts to derive scientifically founded judgements
8. Evaluate situations and make decisions based on ethical considerations, and adhere to and defend ethical, scientific, and professional standards
9. Take responsibility in diverse and interdisciplinary teams, exhibiting tolerance and intercultural awareness
10. Take responsibility for their own and their team's learning, personal and professional development, and role in society, evaluating critical feedback and using self-analysis

3.2 Module Requirements

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

- CHOICE Module: General Biochemistry (7.5 CP)
- CHOICE Module: General Cell Biology (7.5 CP)
- CORE Module: Microbiology (5 CP)
- CORE Module: Microbiology Seminar (2.5 CP)
- CORE Module: Infection and Immunity (7.5 CP)

3.3 Degree

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

4 BCCB Undergraduate Program Regulations

4.1 Scope of these Regulations

The regulations in this handbook are valid for all students who entered the Biochemistry and Cell Biology undergraduate program at Jacobs University in Fall 2020. In case of a conflict between the regulations in this handbook and the general Policies for Bachelor Studies, the latter apply (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). Jacobs University Bremen reserves therefore the right to modify the regulations of the program handbook.

4.2 Degree

Upon successful completion of this study program, students are awarded a Bachelor of Bachelor of Science degree in Biochemistry and Cell Biology.

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.

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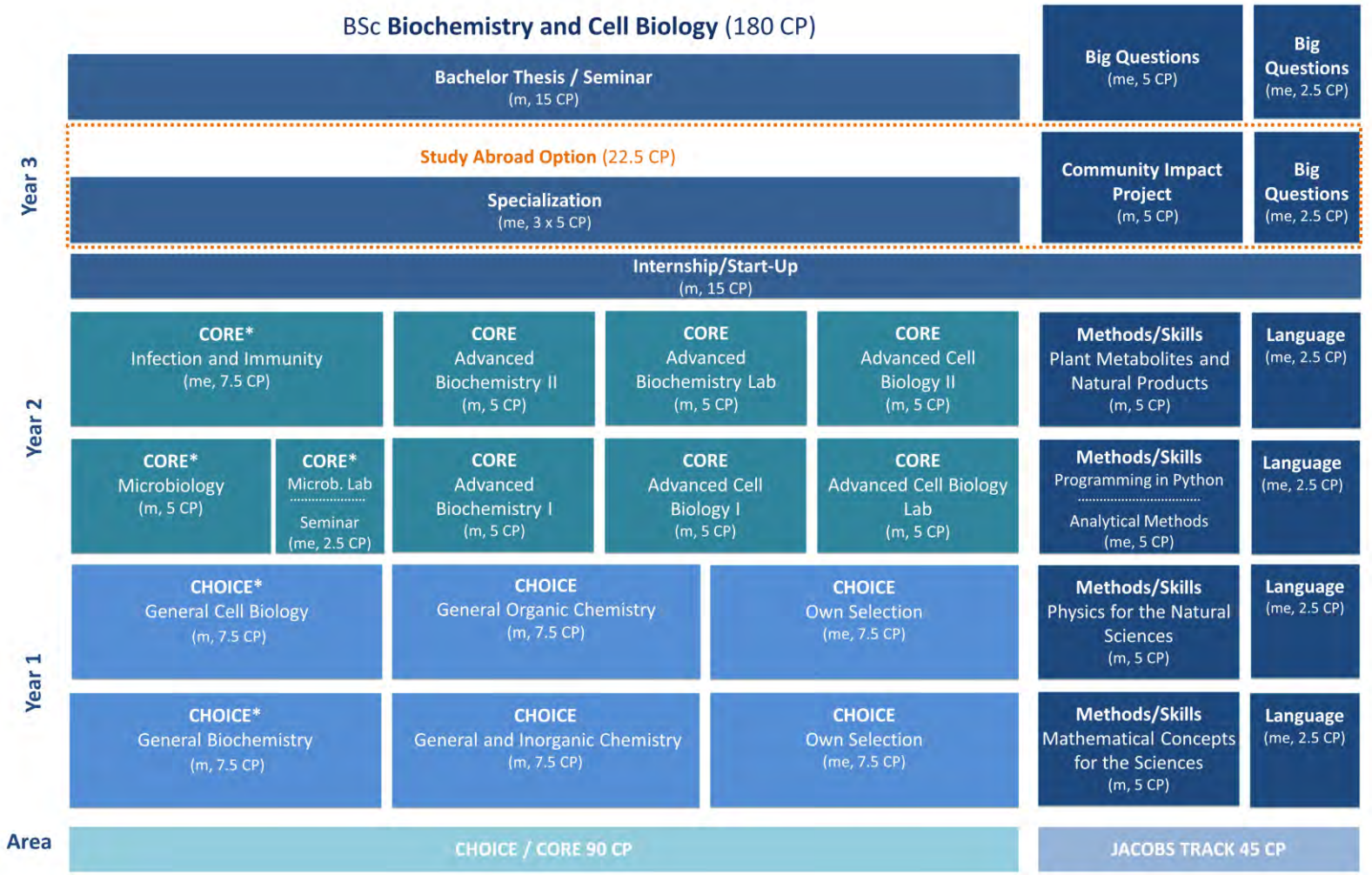
5 Schematic Study Scheme for BCCB

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 Scheme for BCCB

6 Study and Examination Plan

Biochemistry and Cell Biology

Matriculation Fall 2019

	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 BCCB program.							
	Unit: General BCCB (Default minor)						**15**
CH-100	**Module: General Biochemistry** (Default minor)				**m**	**1**	**7.5**
CH-100-A	General Biochemistry	Lecture	Written examination	Examination period			5
CH-100-B	General Biochemistry Lab	Lab	Lab report	During the semester			2.5
CH-101	**Module: General Cell Biology** (Default minor)				**m**	**2**	**7.5**
CH-101-A	General Cell Biology	Lecture	Written examination	Examination period			5
CH-101-B	General Cell Biology Lab	Lab	Lab report	During the semester			2.5
	Unit: Chemistry						**15**
CH-120	**Module: General and Inorganic Chemistry**				**m**	**1**	**7.5**
CH-120-A	General and Inorganic Chemistry	Lecture	Written examination	Examination period			5
CH-120-B	General and Inorganic Chemistry Lab	Lab	Lab report	During the semester			2.5
CH-111	**Module: General Organic Chemistry**				**m**	**2**	**7.5**
CH-111-A	General Organic Chemistry	Lecture	Written examination	Examination period			2,5
CH-111-B	General Organic Chemistry Lab	Lab	Lab report	During the semester			5
	Unit: CHOICE (own selection)					**1/2**	**15**
Students 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 (10CP) with suitable CORE modules from other study programs[2]							
	Unit: Microbiology, Infection and Immunity						**15**
CO-400	**Module: Microbiology (Default minor)**				**m**	**3**	**5**
CO-400-A	Microbiology	Lecture	Written examination	Examination period			
CO-408	**Module: Microbiology Lab**				**me[3]**	**3**	**2.5**
CO-408-A	Microbiology Lab	Lab	Lab report	During the semester			
CO-409	**Module: Microbiology Seminar (for minor students only, default minor)***				**me**	**3**	**2.5**
CO-409-A	Microbiology Seminar	Seminar	Presentation	Examination period			
CO-401	**Module: Infection and Immunity (Default minor)**				**me[3]**	**4**	**7.5**
CO-401-A	Immunology	Lecture	Written examination	Examination period			5
CO-401-B	Microbial Pathogenicity	Lecture	Oral examination	During the semester			2.5
	Unit: Advanced Biochemistry						**15**
CO-402	**Module: Advanced Biochemistry I**				**m**	**3**	**5**
CO-402-A	Metabolic Pathways	Lecture	Written examination	Examination period			5
CO-403	**Module: Advanced Biochemistry II**				**m**	**4**	**5**
CO-403-A	Molecular Genetics	Lecture	Written examination	Examination period			5
CO-404	**Module: Advanced Biochemistry Lab**				**m**	**4**	**5**
CO-404-A	Advanced Biochemistry Laboratory Course	Lab	Lab report	During the semester			5
	Unit: Advanced Cell Biology						**15**
CO-405	**Module: Advanced Cell Biology I**				**m**	**3**	**5**
CO-405-A	From Cells to Tissues	Lecture	Written examination	Examination period			5
CO-407	**Module: Advanced Cell Biology Lab**				**m**	**3**	**5**
CO-407-A	Cellular Compartments	Lab	Lab report	During the semester			5
CO-406	**Module: Advanced Cell Biology II**				**m**	**4**	**5**
CO-406-A	From Genes to Organisms	Lecture	Written examination	Examination period			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 or Businessplan	During the 5th semester			15
CA-BCCB-800	**Module: Bachelor Thesis and Seminar BCCB**				**m**	**6**	**15**
CA-BCCB-800-T	Thesis BCCB	Thesis	Thesis	15th of May			12
CA-BCCB-800-S	Seminar BCCB	Seminar	Presentation	During the semester			3
	Unit: Specialization BCCB				**m**		**15**
	Take a total of 15 CP of specialization modules						
CA-S-BCCB-802	**Specialization Module: Experimental Strategy Design**				**me**	**5**	**5**
CA-BCCB-802	Experimental Strategy Design	Seminar	Term Paper	During the semester			
CA-S-BCCB-803	**Specialization Module: RNA Biochemistry**				**me**	**5**	**5**
CA-BCCB-803	RNA Biochemistry	Seminar	Oral examination	During the semester			
CA-S-BCCB-804	**Specialization Module: Biomedicine**				**me**	**6**	**5**
CA-BCCB-804	Biomedicine	Seminar	Poster Presentation	During the semester			
CA-S-xxx	**Specialization electives (from Chemistry and MCCB) (see BCCB study program handbook)[2]**				**me**	**5/6**	**5**
Total CP							**180**

	Jacobs Track Modules (General Education)	Type	Assessment	Period	Status[1]	Sem.	CP
	Unit: Skills / Methods						**10**
JTMS-MAT-07	**Module: Mathematical Concepts for the Sciences**				**m**	**1**	**5**
JTMS-07	Mathematical Concepts for the Sciences	Lecture	Written examination	Examination period			
JTMS-SCI-17	**Module: Physics for the Natural Sciences**				**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.						
Module Code	**Module: Language 1**				**me**	**1**	**2.5**
Component number	Language 1	Seminar	Various	Various	me		
Module Code	**Module: Language 2**				**me**	**2**	**2.5**
Component number	Language 2	Seminar	Various	Various	me		
							15
	Unit: Skills / Methods						**10**
	Module: Select from the following Skills/Methods modules offered in the Fall term or replace the mandatory elective (me) module (5CP) with suitable CORE modules from other study programs.						
JTMS-SKI-14	**Programming in Python**				**me[3]**	**3**	**5**
JTMS-14	Programming in Python	Lecture	Written examination	Examination period			
JTMS-SCI-16	**Analytical Methods**				**me[3]**	**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				**m**		**5**
	German is default language. Native German speakers take modules in another offered language.						
Module Code	**Module: Language 3**				**me**	**3**	**2.5**
Component number	Language 3	Seminar	Various	Various	me		
Module Code	**Module: Language 4**				**me**	**4**	**2.5**
Component number	Language 4	Seminar	Various	Various	me		
							15
	Unit: Big Questions						**10**
	Module: Big Questions				**m**	**5/6**	
Take a total of 10 CP of Big Questions modules with each 2.5 or 5 CP		Lecture	Various	Examination period	**me**		10
	Unit: Community Impact Project						**5**
JTCIP-	**Module: Community Impact Project**				**m**	**5**	**5**
Component number	Community Impact Project	Project	Project	Examination period			

[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.

* Students minoring in BCCB take the module "Microbiology Seminar" (see handbook for details)

Figure 3: Study and Examination Plan

7 Module Description

7.1 General Biochemistry

<table>
<tr><td colspan="2">Module Name
General Biochemistry</td><td>Module Code
CH-100</td><td>Level (type)
Year 1 (CHOICE)</td><td>CP
7.5</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
CH-100-A | General Biochemistry Lecture | Lecture | 5
CH-100-B | General Biochemistry Lab | Lab | 2.5</td></tr>
<tr><td>Module Coordinator

Sebastian Springer</td><td colspan="2">Program Affiliation

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

Mandatory for BCCB and Chemistry</td></tr>
<tr><td colspan="2">Entry Requirements

Pre-requisites
☒ None

Co-requisites
☒ None

Knowledge, Abilities, or Skills
• High school level of chemistry, mathematics, physics and biology.</td><td>Frequency

Annually (Fall)

Duration

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

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

Workload

187.5 hours</td></tr>
<tr><td colspan="5">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.</td></tr>
<tr><td colspan="5">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.</td></tr>
</table>

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 Chemistry
- 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, both module component examinations have to be passed with at least 45%.

7.2 General Cell Biology

<table>
<tr><td colspan="2">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="5">Module Components

Number | Name | Type | CP
CH-101-A | General Cell Biology Lecture | Lecture | 5
CH-101-B | General Cell Biology Lab | Lab | 2.5</td></tr>
<tr><td>Module Coordinator

Susanne Illenberger</td><td colspan="2">Program Affiliation

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

Mandatory for BCCB and MCCB</td></tr>
<tr><td colspan="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 colspan="2"></td><td>Duration

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

187.5 hours</td></tr>
<tr><td colspan="5">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 Chemistry 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, both module component examinations have to be passed with at least 45%.

7.3 General and Inorganic Chemistry

<table>
<tr><td colspan="2">Module Name
General and Inorganic Chemistry</td><td>Module Code
CH-120</td><td>Level (type)
Year 1 (CHOICE)</td><td>CP
7.5</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
CH-120-A | General and Inorganic Chemistry | Lecture | 5
CH-120-B | General and Inorganic Chemistry Lab | Lab | 2.5</td></tr>
<tr><td>Module Coordinator

Ulrich Kortz</td><td colspan="2">Program Affiliation

• Chemistry</td><td colspan="2">Mandatory Status

Mandatory for Chemistry and BCCB students</td></tr>
<tr><td colspan="2">Entry Requirements

Pre-requisites
☒ None

Co-requisites
☒ None

Knowledge, Abilities, or Skills
• None</td><td>Frequency

Annually (Fall)

Duration

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

• Lecture (35 hours)
• Tutorial (10 hours)
• Private study for the lecture (75 hours)
• Lab (26 hours)
• Private study for the lab (41.5 hours)

Workload

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

Early reading, extensive note taking and self-testing, work through practice problems, and fully understand the material before entering the laboratory and the risks associated with the daily goals.</td></tr>
<tr><td colspan="5">Content and Educational Aims

This module provides a theoretical introduction to general and inorganic chemistry covering the areas of chemical foundations, atoms, molecules, ions, stoichiometry, types of chemical reactions and solution stoichiometry, gases, atomic structure and periodicity, bonding (general concepts), covalent bonding (orbitals), chemical equilibrium, acids and bases, and acid-base equilibria. Furthermore, students learn the practical foundation principles of chemistry, including basic laboratory techniques, the qualitative analysis of anions and cations, strong/weak acids and bases, titrations, the solubility of salts, crystallization, redox reactions, gravimetric analysis, volumetric analysis, complex formation, and the synthesis of nanoparticles.</td></tr>
<tr><td colspan="5">Intended Learning Outcomes

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

1. Discuss basic concepts in general and inorganic chemistry
2. Recognize general properties of matter
3. Engage in fundamental concepts in measurements and moles
4. Identify basic types of chemical reactions
5. Perform stoichiometric calculations
6. Predict the general properties of gases
7. Understand elements and trends in the periodic table
8. Recognize and discuss basic concepts of chemical bonding
9. Predict the reactivity of elements and compounds
10. Find the locations and operating procedures of all safety equipment including the first aid kit, eyewash station, safety shower, fire extinguisher, and fire blanket
11. Use lab equipment and be familiar with key aspects of working in a laboratory environment
12. Correlate the theoretical concepts they learn in class and the actual experimental application of the various hypotheses, laws, techniques, materials, reactions, and instruments</td></tr>
</table>

13. Perform qualitative and quantitative determination of unknowns and know how to handle and analyze chemical compounds
14. Write proper lab reports
15. Properly dispose of chemical waste

Indicative Literature

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

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

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

Course Handout.

Usability and Relationship to Other Modules

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

Examination Type: Module Component Examinations

Module Component 1: Lecture

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

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

Module Component 2: Lab

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

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

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

7.4 General Organic Chemistry

<table>
<tr><td colspan="2">Module Name
General Organic Chemistry</td><td>Module Code
CH-111</td><td>Level (type)
Year 1 (CHOICE)</td><td>CP
7.5</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
CH-111-A | General Organic Chemistry | Lecture | 5
CH-111-B | General Organic Chemistry Laboratory | Laboratory | 2.5</td></tr>
<tr><td>Module Coordinator

Thomas Nugent</td><td colspan="2">Program Affiliation

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

Mandatory for BCCB, Chemistry, MCCB</td></tr>
<tr><td colspan="2">Entry Requirements

Pre-requisites
☒ General and Inorganic Chemistry or General Medicinal Chemistry and Chemical Biology

Co-requisites
☒ None

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

Annually (Spring)

Duration

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

• Lecture (35 hours)
• Tutorial of the lecture (10 hours)
• Private study for the lecture (80 hours)
• Laboratory (25.5 hours)
• Private for the study laboratory (37 hours)

Workload

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

Early reading, extensive note taking and self-testing, work through practice problems, fully understand the material before entering laboratory and the risks associated with the daily goals.</td></tr>
<tr><td colspan="5">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 30harmacop formation to be discussed. The student is then exposed to the relationships between equilibria and rates of reaction to better understand mechanistic investigations. This is followed by an introduction to conformational analysis and stereochemistry which allow the transition states within the subsequent chapters on substitution, elimination, and addition reactions to be understood.
In a parallel manner, The student will learn that a chemistry laboratory is for exploring chemical reactions. However, before doing so we must demonstrate: safety aspects, common hazards, and the structure and content required for a laboratory report. After this, the essential techniques are shown for: setting up, monitoring (TLC, color change, etc.), and quenching (neutralize active chemicals) reactions. In parallel, the student will purify the products (chromatography, crystallization, separatory funnel extractions, etc.), and use basic methods to identify the products. While doing so, the student is exposed to the common equipment (rotary evaporator, melting point apparatus, etc.) within the laboratory. Reactions based on nucleophilic substitution, elimination, bromination to an alkene, electrophilic aromatic substitution, and the isolation of a natural product, characterize the experimental exposure within this laboratory.</td></tr>
<tr><td colspan="5">Intended Learning Outcomes

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

1. understand bond strength and angles using knowledge of orbitals;
2. recognize resonance effects versus inductive effects;
3. understand basic mechanisms and arrow pushing in organic chemistry;</td></tr>
</table>

4. differentiate some nucleophiles and electrophiles and their orbital connectivity to HOMO and LUMO concepts;
5. distinguish high and low energy conformations of molecules and recall their value for transition states;
6. identify basic symmetry elements, stereocenters, and be able to recognize the stereochemical outcome of selected reactions;
7. identify and recall specific structures and reactions discussed during class;
8. 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;
9. handle and dispose of chemicals safely and show competence in locating and retrieving material safety data sheet (MSDS) information;
10. perform acid-base extractions;
11. monitor and quench organic reactions;
12. identify standard laboratory equipment;
13. set up reactions with assistance.

Indicative Literature

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

Usability and Relationship to other Modules

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

Examination Type: Module Component Examinations

Module Component 1: Lecture

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

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

Module Component 2: Lab

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

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

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

7.5 Microbiology

Module Name	***Module Code***	***Level (type)***	***CP***
Microbiology	CO-400	Year 2 (CORE)	5.0

Module Components

Number	*Name*	*Type*	*CP*
CO-400-A	Microbiology	Lecture	5

Module Coordinator	***Program Affiliation***	***Mandatory Status***
Matthias Ullrich	• Biochemistry and Cell Biology (BCCB)	Mandatory for BCCB

Entry Requirements			***Frequency***	***Forms of Learning and Teaching***
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Fall)	• Lecture (35 hours) • Tutorials (15 hours) • Private study (75 hours)
☒ General Biochemistry and General Cell Biology	☒ Microbiology Lab or Seminar	• Basic knowledge of biochemistry and cell biology	***Duration***	***Workload***
			1 semester	125 hours

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 general principles by which cells multiply and interact with each other.

Content and Educational Aims

This Microbiology CORE module consists of one lecture.

There is no higher life form without microbes, but there are plenty of microbes without higher life forms. Microorganisms are present wherever life is possible. Microbes conduct the most diverse biochemical processes and are found anywhere in our natural and manmade surroundings. The lecture introduces principles of the world of microorganisms, discussing their diversity and analyzing how microbes act in the environment or on human health. Bacteria, archaea, fungi, protozoa, and viruses are dealt with in the context of human health, environmental processes, or food manufacturing. Taxonomy will be analyzed with respect to different characteristics, including presence and activity within various cellular compartments, or special biochemical features. The lecture addresses the diverse biochemical life styles of microbes from photosynthesis via biofilms and methanogenesis to pathogenicity. The role of microbes for the cycling of elements on our planet will be exemplarily demonstrated for carbon, nitrogen, and sulfur. Basic differences between microbes and their hosts will be delineated in order to equip students with knowledge about how to defeat microorganisms. The lecture furthermore deals with different ways to investigate and control microbial contaminations, and how microbes influence our everyday life, but also political processes and even social behavior.

Intended Learning Outcomes

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

- explain the principles governing the world of microorganisms;
- apply knowledge of biochemical and cellular processes to microbial metabolism;
- illustrate the cellular interactions of microbes with their environment;
- analyze how pathogens cause diseases to infer the establishment of therapeutic strategies;
- categorize the diversity of microorganisms, their biochemical life styles, and microbial fitness;
- examine the characteristics of microbial habitats and establish differences between oxygenic and anoxygenic life processes;

- determine cellular and environmental factors contributing to the evolutionary adaptions of microbes;
- outline microbial biochemical cycles of elements such as oxygen, carbon, nitrogen, or sulfur;

Indicative Literature

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

Various current research articles.

Usability and Relationship to Other Modules

- This module builds on the pre-required BCCB CHOICE Modules General Biochemistry and General Cell Biology.
- Mandatory for a major in BCCB
- Mandatory for a minor in BCCB
- Elective module for all other undergraduate study programs

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes

7.6 Microbiology Lab

<table>
<tr><td colspan="2">Module Name
Microbiology Lab</td><td>Module Code
CO-400</td><td>Level (type)
Year 2 (CORE)</td><td>CP
2.5</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
CO-400-B | Microbiology Lab | Lab | 2.5</td></tr>
<tr><td>Module Coordinator

Matthias Ullrich</td><td colspan="2">Program Affiliation

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

Mandatory elective for BCCB</td></tr>
<tr><td colspan="2">Entry Requirements

Pre-requisites

☒ General Biochemistry and General Cell Biology

Co-requisites

☒ Microbiology

Knowledge, Abilities, or Skills

• Basic knowledge of biochemistry and cell biology
• Basic laboratory skills in biochemistry and cell biology
• S1 safety instructions</td><td>Frequency

Annually (Fall)

Duration

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

• Safety instructions (1 hour)
• Reading lab manuals (6 hours)
• Experimental work in the laboratory, including seminars (27.5 hours)
• Lab report writing (28 hours)

Workload

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

Students should have a sound background in biochemistry and cell biology that they acquired by attending the respective CHOICE modules. Students should have acquired basic skills in experimental molecular biology techniques from the respective CHOICE laboratory courses.</td></tr>
<tr><td colspan="5">Content and Educational Aims

This Microbiology Lab Course CORE module consists of one laboratory course.

Microbial taxonomy and physiology will be analyzed with respect to different characteristics, including presence and activity within various environmental habitats, or special biochemical features. Students will learn how to sample, analyze, isolate, handle, characterize, and taxonomically identify unknown microorganisms using diverse classical and state-of-the-art molecular techniques. Focus will be placed on the cellular characteristics of bacterial organisms, their biochemical properties and capabilities, as well as their resistance towards antibiotics. For this, each student will be assigned to one microbial aquatic habitat, will have to take a sample, and process it individually. The participants will learn how to identify an unknown bacterium, how to determine its growth rate, and how to compare its taxonomic marker genes with genomic databases. The individual experimental results will be summarized in a manuscript-style lab report.</td></tr>
<tr><td colspan="5">Intended Learning Outcomes

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

• apply their theoretical knowledge to the skilled use of methods in microbiology and microbial biochemistry;
• apply methods in microbiology and microbial biochemistry;
• handle microorganisms in a sterile and safe manner;
• record and transfer experimental data;
• identify microorganisms;</td></tr>
</table>

- master classical and molecular tools to characterize microbes;
- interpret growth and resistance data for individual microbial organisms.

Indicative Literature

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

Laboratory manuals provided by the instructor.

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
- Elective module for all other undergraduate study programs

Examination Type: Module Examination

Assessment Type: Lab Reports

Length: Approx. 10 pages per report
Weight: 100%

Scope: All intended learning outcomes of the laboratory course

7.7 Microbiology Seminar

<table>
<tr><td colspan="3">Module Name
Microbiology Seminar</td><td>Module Code
CO-400</td><td>Level (type)
Year 2 (CORE)</td><td>CP
2.5</td></tr>
<tr><td colspan="6">Module Components

Number | Name | Type | CP
CO-400-B | Microbiology Seminar | Lab | 2.5</td></tr>
<tr><td colspan="2">Module Coordinator

Matthias Ullrich</td><td colspan="2">Program Affiliation

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

Mandatory for BCCB minors</td></tr>
<tr><td colspan="3">Entry Requirements

Pre-requisites
☒ General Biochemistry and General Cell Biology

Co-requisites
☒ Microbiology

Knowledge, Abilities, or Skills
• Basic knowledge of biochemistry and cell biology
• Basic laboratory skills in biochemistry and cell biology
• S1 safety instructions</td><td>Frequency

Annually (Fall)

Duration

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

• Tutorials (6 hours)
• Private study (25 hours)
• Preparation and conducting an oral presentations (31.5 hours)

Workload

62.5 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 general principles by which cells multiply and interact with each other.</td></tr>
<tr><td colspan="6">Content and Educational Aims

This Microbiology Seminar CORE module consists of one seminar course.

There is no higher life form without microbes, but there are plenty of microbes without higher life forms. Microorganisms are present wherever life is possible. Microbes conduct the most diverse biochemical processes and are found anywhere in our natural and manmade surroundings. The seminar familiarizes students to understand principles of the world of microorganisms, and innovative strategies for the investigation of environmental processes and optimization of microbial food manufacturing. The seminar addresses diverse research papers dealing with biochemical life styles of microbes and their pathogenicity. Furthermore, students will learn how to investigate and control microbial contaminations. The seminar will be concluded by student presentations on their individual literature research results.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes

By the end of this module, students will be able to
• apply their theoretical knowledge to understand the use of microbiological methods in state-of-the-art research publications;
• examine alternative ways for application of basic methods in microbiology and microbial biochemistry;
• interpret the level of sterility and sterile research work from published data
• interpret experimental data in microbiology;</td></tr>
</table>

- express the own understanding of the subject matter, the experimental approach chosen, and the interpretation of data by the authors from research publications.

Indicative Literature

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

Various current research articles.

Usability and Relationship to Other Modules

- This module builds on the pre-required BCCB CHOICE Modules General Biochemistry and General Cell Biology.
- Mandatory for a minor in BCCB
- Elective module for all other undergraduate study programs

Examination Type: Module Examination

Assessment Type: Presentation — Duration: 30 min, Weight: 100%

Scope: All intended learning outcomes of the seminar

7.8 Infection and Immunity

<table>
<tr><td colspan="2">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="5">Module Components</td></tr>
<tr><td>CO-401-A</td><td colspan="2">Immunology</td><td>Lecture</td><td>5</td></tr>
<tr><td>CO-401-B</td><td colspan="2">Microbial Pathogenicity</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Sebastian Springer</td><td colspan="2">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="5">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="5">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. 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</td></tr>
</table>

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

7.9 Advanced Biochemistry I

<table>
<tr><td>Module Name
Advanced Biochemistry I</td><td>Module Code
CO-402</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="4">Module Components

Number Name | Type | CP
CO-402-A | Metabolic Pathways | Lecture | 5</td></tr>
<tr><td>Module Coordinator

Christian Hammann</td><td colspan="2">Program Affiliation

• Biochemistry and Cell Biology (BCCB)</td><td>Mandatory Status

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

Pre-requisites

☒ General Biochemistry and General Cell Biology

Co-requisites

☒ None

Knowledge, Abilities, or Skills

• Knowledge of biochemical compounds
• Ability to write chemical equations</td><td>Frequency

Annually (Fall)

Duration

1 semester</td><td>Forms of Learning and Teaching

• Lecture (35 hours)
• Private study (90 hours)

Workload

125 hours</td></tr>
<tr><td colspan="4">Recommendations for Preparation

Revision of the module content of the pre-required CHOICE modules</td></tr>
<tr><td colspan="4">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".</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td colspan="4">Indicative Literature

Nelson and Cox, Lehninger Principles of Biochemistry, Freeman Macmillan, latest edition.</td></tr>
</table>

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.

7.10 Advanced Biochemistry II

<table>
<tr><td colspan="3">Module Name
Advanced Biochemistry II</td><td>Module Code
CO-403</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components

Number | Name | Type | CP
CO-403-A | Molecular Genetics | Lecture | 5</td></tr>
<tr><td>Module Coordinator

Christian Hammann</td><td colspan="3">Program Affiliation

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

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

Pre-requisites
☒ Advanced Biochemistry I

Co-requisites
☒ None

Knowledge, Abilities, or Skills
• Knowledge of biochemical compounds
• Ability to write chemical equations
• Knowledge about metabolic principles
• Ability to determine kinetic and thermodynamic parameters</td><td>Frequency

Annually (Spring)

Duration

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

• Lecture (35 hours)
• Private study (90 hours)

Workload

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

Revision of the module content of the pre-required CORE module</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td colspan="6">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;</td></tr>
</table>

- 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.

7.11 Advanced Biochemistry Lab

<table>
<tr><td colspan="2">Module Name
Advanced Biochemistry Lab</td><td>Module Code
CO-404</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
CO-404-A | Advanced Biochemistry Lab | Lab | 5</td></tr>
<tr><td>Module Coordinator

Sebastian Springer</td><td colspan="2">Program Affiliation

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

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

Pre-requisites
☒ Advanced Biochemistry I

Co-requisites
☒ Advanced Biochemistry II

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

Annually (Spring)

Duration

1 semester</td><td>Forms of Learning and Teaching

• Safety instructions (2 hours)
• Private study (24 hours),
• Reading lab manual (6 hours)
• MSDS preparation (4 hours)
• Experimental work in the laboratory (50 hours)
• Seminars (5 hours)
• Lab report writing (34 hours)

Workload

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

For this module, it is important that students already know and understand biochemistry at an advanced level, and general chemistry and cell biology at first year level. They also need to be able to analyze (and partially, create) logical connections between scientific contents.
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 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>
<tr><td colspan="5">Content and Educational Aims

Understanding the relationships between the structure, biochemical properties, and activity of biomolecules is at the core of the discipline of biochemistry. This module focuses on the activity and the biological roles of proteins. Students will isolate and purify proteins, conduct enzyme activity assays, determine enzyme kinetics, and study the actions of small molecules on proteins. Methods include spectrophotometry, fluorimetry, chromatography, and gel electrophoresis. Students document their results in publication-style reports.</td></tr>
</table>

Intended Learning Outcomes

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

- explain and practically apply various techniques in the biochemistry laboratory;
- perform all calculations required to prepare the experiments;
- organize the laboratory workflow to be safe, equitable, and reproducible;
- act safely in the laboratory;
- assess the method most suitable for a given scientific problem;
- exchange results, discuss them with their peers, and defend them in front of an audience;
- write up their results in a coherent laboratory report.

Indicative Literature

Laboratory Manuals (updated yearly)

Usability and Relationship to other Modules

- This module builds on the pre-required BCCB CORE module Advanced Biochemistry I
- Mandatory for a major in BCCB.

Examination Type: Module Examination

Assessment Type: Lab Reports — Duration: 5 x 10 pages, Weight: 100%

Scope: All intended learning outcomes of the module.

7.12 Advanced Cell Biology I

<table>
<tr><td colspan="2">Module Name
Advanced Cell Biology I</td><td>Module Code
CO-405</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
CO-405-A | From Cells to Tissues | Lecture | 5</td></tr>
<tr><td>Module Coordinator

Klaudia Brix</td><td colspan="2">Program Affiliation

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

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

Pre-requisites: ☒ General Cell Biology, General Biochemistry
Co-requisites: ☒ None
Knowledge, Abilities, or Skills: • Basic knowledge of cell biology and biochemistry</td><td>Frequency

Annually (Fall)

Duration

1 semester</td><td>Forms of Learning and Teaching

• Lectures (35 hours)
• Private Study (90 hours)

Workload

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

• Revision of the module content of the pre-required CHOICE modules.
• Visit the Molecular Life Sciences Seminar series in which researchers from other institutions give invited talks.</td></tr>
<tr><td colspan="5">Content and Educational Aims

This lecture builds on the CHOICE module "General Cell Biology" and intends to provide a detailed and advanced understanding of the complexity of cellular systems. The module will analyze the molecular architecture of cells, the regulation of key cellular processes and their integration in tissue formation and enabling physiological tasks of our bodily organs. In this context, protein folding, targeting, and trafficking will be evaluated. The principles of compartmentalization by biological membranes of eukaryotic cells will be explained by looking at certain cell types of different tissues and bodily organs. By way of introducing the physiology of multi-cellular organisms, a detailed understanding of the underlying molecular principles and cellular mechanisms that enable cells, tissues, and bodies to maintain their function will be of central interest in this lecture. Finally, the consequences of cellular alterations (e.g., loss of homeostasis, stress, failure of quality control) will be tested and biomedical implications will be integrated wherever possible.</td></tr>
<tr><td colspan="5">Intended Learning Outcomes

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

• explain key molecular mechanisms and regulatory processes in cell biology in detail;
• identify specific cell types common or unique to specific tissues;
• explain cellular interactions in tissues and organs;
• examine tissue morphogenesis and organ functions for an advanced understanding of physiological bodily functions;
• evaluate experimental designs used to answer key cell biological questions;
• critically compare model systems used in cell biological research approaches;
• enhance personal competence in abstracting complex data and devising scientific hypotheses.</td></tr>
<tr><td colspan="5">Indicative Literature

Alberts et al., Molecular Biology of the Cell, Garland Science, latest edition.
Pollard et al., Cell Biology, Saunders, latest edition.
Mescher, Junqueira's Basic Histology: Text and Atlas, McGraw-Hill Companies Inc., latest edition.</td></tr>
</table>

Usability and Relationship to other Modules

- This module builds on the pre-required BCCB CHOICE modules General Cell Biology and General Biochemistry.
- It is a pre-requisite for the Advanced Cell Biology II module. Further, it is the pre-requisite for the BCCCB CAREER Specialization Module Biomedicine.
- Mandatory for a major in BCCB.

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module.

7.13 Advanced Cell Biology Lab

<table>
<tr><td colspan="2">Module Name
Advanced Cell Biology Lab</td><td>Module Code
CO-407</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
CO-407-A | Cellular Compartments | Lab | 5</td></tr>
<tr><td>Module Coordinator

Klaudia Brix</td><td colspan="2">Program Affiliation

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

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

Pre-requisites

☒ General Cell Biology and General Biochemistry

Co-requisites

☒ Advanced Cell Biology I

Knowledge, Abilities, or Skills

• Basic knowledge in general safety for experimental work in molecular life sciences laboratories
• S1 safety instructions
• Laser safety instructions
• MSDS preparation</td><td>Frequency

Annually (Fall)

Duration

Blocked course, Intersession</td><td colspan="2">Forms of Learning and Teaching

• Safety instructions (2 hours)
• Private Study (24 hours),
• Reading lab manual (6 hours)
• MSDS preparation (4 hours)
• Experimental work in the laboratory (50 hours)
• Seminars (5 hours)
• Lab report writing (34 hours)

Workload

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

• Mandatory attendance of biosafety instructions regarding S1 laboratories
• Mandatory attendance of laser safety instructions due to experimental work with a laser scanning microscope
• Mandatory preparation of material safety data sheets regarding specific chemicals used in the experiments
• Mandatory attendance of experiment-accompanying, imaging and lab report writing seminars during lab course time
• Visit lab meetings of research groups in the field of Molecular Life Science (voluntary)</td></tr>
</table>

Content and Educational Aims

This module focuses on the cellular architecture and the subcellular targeting of proteins. The laboratory module has four major parts. CHO cells are transfected with plasmids coding for targeted and non-targeted green fluorescent protein (GFP). This part includes an introduction into cell culture techniques. Then, the localization of these proteins is investigated by microscopy and subcellular fractionation followed by SDS-PAGE and immunoblotting. In the third part, normal CHO cells are vital-stained and immunolabeled. Mouse tissue sections are immunolabeled for compartmental and cell surface proteins to include histological aspects of protein targeting and trafficking. Conventional and confocal fluorescence microscopy is employed to examine the microscopic specimen; image analysis tools will be used. The theoretical background of the experiments will be prepared by self-study of the laboratory manual and through compilation of material safety data sheets (MSDS). In-lab seminars will explain the theory behind the experiments and the expected outcomes. Trouble-shooting sessions will solve problems on the spot. The students will document and assess their experimental data in reports that follow the format of a scientific manuscript.

Intended Learning Outcomes

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

- explain key regulatory processes in cell biology;
- discover the structure-function relationship of biomolecules at the cellular level;
- gain detailed insight into the experimental analysis of cells on the practical level;
- employ the regulatory framework of genetic engineering in the bioscience field;
- test research questions of protein targeting and trafficking experimentally;
- consider the basic principles of image analysis;
- enhance personal competence in experimental skills in a research-oriented manner;
- enhance personal competence in reporting their own scientific data in publication-style laboratory reports.

Indicative Literature

Comprehensive Lab Manual provided by the instructor.
Literature list in lab manual.

Usability and Relationship to other Modules

- This module builds on the pre-required BCCB CHOICE modules General Cell Biology and General Biochemistry.
- Mandatory for a major in BCCB.

Examination Type: Module Examination

Assessment Type: Lab report — Length: 20 pages, Weight: 100%

Scope: All intended learning outcomes of the module.

7.14 Advanced Cell Biology II

<table>
<tr><td colspan="2">Module Name
Advanced Cell Biology II</td><td>Module Code
CO-406</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
CO-406-A | From Genes to Organism | Lecture | 5</td></tr>
<tr><td>Module Coordinator

Susanne Illenberger</td><td colspan="2">Program Affiliation

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

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

Pre-requisites

☒ Advanced Cell Biology I

Co-requisites

☒ None

Knowledge, Abilities, or Skills

• Basic knowledge of cell biology
• Basic knowledge of biochemistry</td><td>Frequency

Annually (Spring)

Duration

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

• Lectures (35 hours)
• Private study (90 hours)

Workload

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

• Read the chapters in the recommended textbooks that cover the respective topics of the lecture (see syllabus)
• Read additional literature as indicated by instructor
• Visit journal clubs or lab meetings of research groups in the field of Molecular Life Science
• Attend the Molecular Life Sciences Seminar series</td></tr>
<tr><td colspan="5">Content and Educational Aims

This module builds on the CHOICE module "General Cell Biology" and the CORE module "Advanced Cell Biology I". In this lecture, students will apply their understanding of cellular processes to explain how these processes combine at the organismal level. First, the cellular energy status, proliferation, apoptosis, and cell communication will be analyzed at an advanced level, focusing on regulatory mechanisms that allow for the coordinated execution of these processes. In the context of early organismal development, the contribution of morphogens, homeotic genes and epigenetics in selected model organisms will be discussed. Secondly, students will learn how inherited traits define evolutionary fitness and how recombination and mutation contribute to evolution and natural selection. In the end, the current ideas about the evolution of the cell and the tree of life will be discussed.</td></tr>
<tr><td colspan="5">Intended Learning Outcomes

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

• explain key molecular mechanisms and regulatory cellular processes in detail;
• relate individual cellular processes to one another in early organismal development;
• critically compare model systems used in developmental biology;
• correlate alterations in molecular functions to consequences in organismal development;
• explain the general principles underlying natural selection and evolution;
• apply simple calculations to predict changes in allele frequency;
• deduce common principles in cell communication and regulation;
• enhance personal competence in abstracting complex cellular processes.</td></tr>
<tr><td colspan="5">Indicative Literature

Alberts et al., Molecular Biology of the Cell, Garland Science, latest edition.</td></tr>
</table>

Campbell et al., Biology - A Global Approach (Global Edition), Pearson Education Ltd., latest edition.

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

Graur, Molecular and Genome Evolution, Oxford University Press / Sinauer, latest edition.

Usability and Relationship to other Modules

- This module builds on the pre-required BCCB CORE module Advanced Cell Biology I.
- It is one of the pre-requisites for BCCB CAREER specialization modules Current Topics in the Molecular Life Sciences, Experimental Strategy Design and Biomedicine.
- Mandatory for a major in BCCB.

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module.

7.15 Experimental Strategy Design

<table>
<tr><td colspan="2">Module Name
Experimental Strategy Design</td><td>Module Code
CA-S-BCCB-802</td><td>Level (type)
Year 3 (CAREER-Specialization)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
CA-BCCB-802 | Experimental Strategy Design | Lecture and Seminar | 5</td></tr>
<tr><td>Module Coordinator

Susanne Illenberger</td><td colspan="2">Program Affiliation

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

Mandatory elective for BCCB</td></tr>
<tr><td colspan="3">Entry Requirements

Pre-requisites
☒ Advanced Cell Biology II
☒ Advanced Biochemistry II

Co-requisites
☒ None

Knowledge, Abilities, or Skills
• Advanced knowledge in cell biology, molecular biology and biochemistry
• Ability to read and understand scientific literature
• Preferably basic research experience (e.g., from internship)</td><td>Frequency

Annually (Fall)

Duration

1 semester</td><td>Forms of Learning and Teaching

• Lectures (18 hours)
• Literature Analysis (7 hours)
• In-class discussions (9 hours)
• Group discussion (30 hours)
• Group presentation (1 hours)
• Private study, additional readings (35 hours)
• Term paper (25 hours)

Workload

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

• Recapitulate the methods already applied in the BCCB laboratory modules.
• Recapitulate additional methodology (practical and theoretical) employed in the internship.
• Visit journal clubs or lab meetings of research groups in the field of Molecular Life Science
• Attend the Molecular Life Sciences Seminar series to experience how scientists present their data</td></tr>
<tr><td colspan="5">Content and Educational Aims

One of the most challenging tasks in modern science is to design the optimal experimental strategy to unravel the fascinating complexity of biological systems. On one hand, this strategy may involve the isolation and characterization of a single molecule, while on the other hand it could require the genetic manipulation and functional analysis of a whole organism. This module provides a problem-oriented introduction to the general design of hypothesis-driven research strategies in modern molecular life sciences. Research strategies will be developed based on the students' previous experiences and thus first discuss the methods that were already applied in second year BCCB modules and internships. Advanced State-of-the-Art methodology will be explored through the analysis of current scientific literature. In small groups, students will then outline an experimental approach to a particular task towards the characterization of a novel protein (e.g., expression, cellular interactions, and cellular function). This also involves the formulation of a working hypothesis, the prediction of experimental outcomes and depiction of hypothetical results. The groups will present their experimental strategies and their "data" to the whole class for critical discussion. Based on the feedback received, students will individually write a short publication about their scientific findings.</td></tr>
</table>

Intended Learning Outcomes

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

- explain routine and advanced methodology;
- evaluate the advantages and limitations of different methods;
- formulate and test hypotheses for experimental research based on current knowledge and literature;
- predict the experimental outcomes of experiments;
- study and critically analyze scientific literature;
- design a coherent experimental strategy in Molecular Life Science;
- present experimental data in both, oral and written form;
- enhance personal competence in scientific discussion and academic writing.

Indicative Literature

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

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

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 major students.

Examination Type: Module Examination

Assessment Type: Term Paper

Length: approx. 3000 words
Weight: 100%

Scope: All intended learning outcomes of the module.

7.16 RNA Biochemistry

<table>
<tr><td colspan="3">Module Name
RNA Biochemistry</td><td>Module Code
CA-S-BCCB-803</td><td>Level (type)
Year 3 (CAREER-Specialization)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components

Number | Name | Type | CP
CA-BCCB-803 | RNA Biochemistry | Lecture and Seminar | 5</td></tr>
<tr><td>Module Coordinator

Christian Hammann</td><td colspan="3">Program Affiliation

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

Mandatory elective for BCCB</td></tr>
<tr><td colspan="3">Entry Requirements

Pre-requisites
☒ Advanced Biochemistry I
☒ Advanced Biochemistry II

Co-requisites
☒ None

Knowledge, Abilities, or Skills
• Advanced knowledge of biochemistry
• Ability to read and understand scientific articles
• Critical discussion skills
• Basic presentation skills</td><td>Frequency

Annually (Fall))

Duration

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

• Lectures (17.5 hours)
• Private study, readings (45 hours)
• Talk preparation (33 hours)
• Poster design (20 hours)
• Presentation (0.5 hours)
• In-class discussions (9 hours)

Workload

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

• Revise the contents of the Mandatory BCCB CORE modules
• Read the reviews that cover the respective topics of this lecture (see syllabus)
• Visit journal clubs or lab meetings of research groups in the field of Molecular Life Science
• Visit the departmental seminar series in which researchers from other institutions give invited talks</td></tr>
<tr><td colspan="6">Content and Educational Aims

RNA molecules, long time thought to be only passive intermediates in the process of gene expression, have taken center stage in the regulation of cellular processes. This specialization module intends to provide a detailed understanding of the Biochemistry of RNA molecules, the most versatile biopolymer. For this, the seminar includes lectures, scheduled in the first half of the term, which will introduce students to the theoretical background. Students will make use of this background in the second half of the term by presenting recent original publications from the field in an oral presentation that is backed by a poster presentation. For this purpose, students will be provided with introductory classes on the design of both good oral and poster presentations. This is important to allow students to actively participate in the assessment process by implementing peer reviewing principles.
Topics include RNA classes, the structural versatility of RNA molecules, the processing of tRNA, rRNA, and mRNA, including splicing, and alternative splicing and underlying RNA-protein interactions. Ribozymes and Aptamers will be introduced and discussed, with respect to biotechnological applications. A main part of the module will be devoted to mechanisms by which endogenous RNA molecules modulate the use of genetic information in eukaryotic and prokaryotic cells, including topics such as RNA interference and riboswitches. High</td></tr>
</table>

throughput techniques of RNA molecules will be introduced with a special emphasis on deep sequencing technologies. The CRISPR/Cas system will be introduced, discussed, and critically compared to non-RNA-based technologies for genome editing. This part will also address issues such as GMO-regulations, biosafety and ethical considerations.

Intended Learning Outcomes

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

- compare the principles of the methods underlying the different deep sequencing techniques;
- analyze deep sequencing data, and compile the varying difficulties are associated with such endeavors;
- discriminate RNA classes;
- evaluate the challenges associated with RNA structure predictions;
- appraise the structural flexibility of RNA molecules and how this manifests in changes of gene expression, in particular in the example of riboswitches;
- formulate the principles of SELEX techniques and design experiments for the generation of novel aptamers;
- discriminate the effects of endogenous RNA molecules in regulating different levels of gene expression in both health and disease;
- rate different methods to edit genomes;
- study and critically interpret scientific articles;
- present other's data while critically discussing their graphical, verbal and oral depiction;
- competently communicate and validate scientific data in the form of both oral and poster presentations;
- evaluate communication and presentation skills of their peers and recommend assessments.

Indicative Literature

Current reviews and original publications (updated yearly).

Usability and Relationship to other Modules

- This module builds on the pre-required BCCB CORE modules Advanced Biochemistry I and Advanced Biochemistry II.
- Mandatory elective specialization module for third year BCCB major students.

Examination Type: Module Examination

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

Scope: All intended learning outcomes of the module.

7.17 Biomedicine

<table>
<tr><td colspan="2">Module Name
Biomedicine</td><td>Module Code
CA-S-BCCB-804</td><td>Level (type)
Year 3 (CAREER-Specialization)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
CA-BCCB-804 | Biomedicine | Lecture and seminar | 5</td></tr>
<tr><td>Module Coordinator

Klaudia Brix</td><td colspan="2">Program Affiliation

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

Mandatory elective for BCCB</td></tr>
<tr><td colspan="3">Entry Requirements

Pre-requisites | Co-requisites | Knowledge, Abilities, or Skills
☒ Advanced Cell Biology I
☒ Advanced Cell Biology II | ☒ None | • Advanced knowledge in cell biology
• Ability to read and understand scientific articles
• Critical discussion skills</td><td>Frequency

Annually (Spring)

Duration

1 semester</td><td>Forms of Learning and Teaching

• Lectures (26 hours)
• Private study, readings (40 hours)
• Poster design (49.5 hours)
• Poster presentation (0.5 hours)
• In-class discussions (9 hours)

Workload

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

• Read the chapters in the recommended textbooks that cover the respective topics of this lecture (see syllabus)
• Read about the diseases covered during this module in the Medline-Plus database (www.medlineplus.gov)
• Visit journal clubs or lab meetings of research groups in the field of Molecular Life Science
• Visit the Molecular Life Sciences Seminar series in which researchers from other institutions give invited talks</td></tr>
<tr><td colspan="5">Content and Educational Aims

Biomedicine considers knowledge of key cellular processes that are often by affected in diseases, e.g. gene expression, cell proliferation, intracellular trafficking, signal transduction, and general the turnover of cellular compounds. This module will analyze how these processes become altered in different diseases, e.g., cancer and neurodegenerative diseases, and how diagnostic tools and therapies (ranging from chemical to natural compound-to cell-based approaches) can be developed according to a disease's molecular origin. The module will critically deduce the challenges in designing research projects aimed at translation to clinics, taking into consideration the societal context in a world with increasing cultural and socio-economic diversity. Environmental effects on disease onset and progression or decline will be considered in the discussion of e.g. endocrine disorders. The regulatory framework of activities in the bioscience field will be explained by including GMO-regulations, biosafety, and the ethical considerations of cloning, or establishing and using animal model systems of diseases. In addition, the production of recombinant proteins for substitution therapies and transgenic mouse models will be examined in detail.</td></tr>
</table>

Intended Learning Outcomes

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

- explain key regulatory processes in cell biology in detail;
- explain possible mechanisms of disease;
- understand diagnostics and therapy development;
- employ the regulatory framework of activities in the bioscience field;
- critically assess approaches in translational medicine;
- study and critically interpret scientific articles;
- present other's data while critically discussing their graphical, verbal and oral depiction;
- enhance personal competence in communicating and validating scientific data in the form of poster design and presentation.

Indicative Literature

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

Pollard et al., Cell Biology, Elsevier, latest edition.

Weinberg, The Biology of Cancer, Garland Science, latest edition.

McDonald, Biology of Aging, Garland Science, latest edition.

Medline-Plus database and related literature cited therein, at www.medlineplus.gov.

Usability and Relationship to other Modules

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

Examination Type: Module Examination

Assessment Type: Poster presentation — Duration: 30 min, Weight: 100%

Scope: All intended learning outcomes of the module.

7.19 Environmental Microbiology and Biotechnology

<table>
<tr><td colspan="3">Module Name
Environmental Microbiology and Biotechnology</td><td>Module Code
CA-S-CBT-804</td><td>Level (type)
Year 3 (CAREER-Specialization)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components

Number | Name | Type | CP
CA-S-CBT-804 | Environmental Microbiology and Biotechnology | Lecture | 5</td></tr>
<tr><td>Module Coordinator

Boran Kartal</td><td colspan="3">Program Affiliation

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

Pre-requisites

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

or

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

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

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

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

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

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

Taking the CORE Modules Industrial Biotechnology (CBT) and Microbiology (BCCB) is helpful. Recall the contents of General Biochemistry Module.</td></tr>
<tr><td colspan="6">Content and Educational Aims

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

Intended Learning Outcomes

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

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

Indicative Literature

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

Usability and Relationship to other Modules

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

Examination Type: Module Examination

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

Scope: All intended learning outcomes of the module

7.20 Current Topics in the Molecular Life Sciences

<table>
<tr><td colspan="3">Module Name
Current Topics in the Molecular Life Sciences</td><td>Module Code
CA-S-MCCB-803</td><td>Level (type)
Year 3 (CAREER-Specialization)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components

Number | Name | Type | CP
CA-MCCB-803 | Current Topics in the Molecular Life Sciences | Seminar | 5</td></tr>
<tr><td>Module Coordinator

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

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

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

Pre-requisites

☒ Advanced Biochemistry II

☒ Advanced Cell Biology II

Or

☒ Chemical Biology
☒ Medicinal Chemistry

Co-requisites

☒ None

Knowledge, Abilities, or Skills

• Advanced knowledge in cell biology
• Advanced self-directed study skills
• Basic presentation skills</td><td>Frequency

Annually (Fall)

Duration

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

• Lecture (10 hours)
• Preparation of presentation (30 hours)
• Seminar (15 hours)
• Private study (69 hours)
• Presentation (45 minutes)

Workload

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

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.

7.21 Internship / Startup and Career Skills

<table>
<tr><td colspan="2">Module Name
Internship / Startup and Career Skills</td><td>Module Code
CA-INT-900</td><td>Level (type)
Year 3 (CAREER)</td><td>CP
15</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
CA-INT-900-0 | Internship | Internship | 15</td></tr>
<tr><td>Module Coordinator

Predrag Tapavicki & Christin Klähn (CSC Organization); SPC / Faculty Startup Coordinator (Academic responsibility);</td><td colspan="2">Program Affiliation

• CAREER module for undergraduate study programs</td><td colspan="2">Mandatory Status

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

Pre-requisites

☒ at least 15 CP from CORE modules in the major

Co-requisites

☒ None

Knowledge, Abilities, or Skills

• Information provided on CSC pages (see below)
• Major specific knowledge and skills</td><td>Frequency

Annually (Spring/Fall)

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

• Internship/Start-up
• Internship event
• Seminars, info-sessions, workshops and career events
• Self-study, readings, online tutorials

Workload

375 Hours consisting of:
• Internship (308 hours)
• Workshops (33 hours)
• Internship Event (2 hours)
• Self-study (32 hours)</td></tr>
<tr><td colspan="5">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</td></tr>
<tr><td colspan="5">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</td></tr>
</table>

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, Chemistry, CS, EES, GEM, IBA, IRPH, Psychology, Math, MCCB, Physics, IMS, and ISS.
- This module applies skills and knowledge acquired in previous modules to a professional environment and provides an opportunity to reflect on their relevance in employment and society. It may lead to thesis topics.

Examination Type: Module Examination

Assessment Type: Internship Report or Business Plan and Reflection	Length: approx. 3.500 words
Scope: All intended learning outcomes	Weight: 100%

7.22 Bachelor Thesis and Seminar BCCB

<table>
<tr><td colspan="2">Module Name
Bachelor Thesis and Seminar BCCB</td><td>Module Code
CA-BCCB-800</td><td>Level (type)
Year 3 (CAREER)</td><td>CP
15</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
CA-BCCB-800-T | Thesis BCCB | Scientific Project | 12
CA-BCCB-800-S | Seminar BCCB | Seminar | 3</td></tr>
<tr><td>Module Coordinator

Sebastian Springer</td><td colspan="2">Program Affiliation

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

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

Pre-requisites

☒Students must be in the third year and have at least 30 CP from CORE modules of their major.

Co-requisites

☒ None

Knowledge, Abilities, or Skills

• Advanced skills in Biochemistry and Cell Biology
• Advanced self-directed study skills
• Basic presentation skills</td><td>Frequency

Annually (Spring)

Duration

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

• Private study (104 hours)
• Scientific project work (200 hours)
• Seminar (21 hours)
• Writing (50 hours)

Workload

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

To begin the Seminar and Thesis BCCB Module, it is essential that students have advanced skills in biochemistry and cell biology. This is achieved by having taken the mandatory CORE modules in Advanced Biochemistry and Advanced Cell Biology. It is also important for students to have self-directed study skills and basic presentation skills.

• Identify an area or a topic of interest and discuss this with your prospective supervisor in good time.
• Create a research proposal including a research plan to ensure timely submission.
• Review the University's Code of Academic Integrity and Guidelines to Ensure Good Academic Practice.</td></tr>
<tr><td colspan="5">Content and Educational Aims

In the Seminar and Thesis BCCB Module, students carry out scientific work in the final semester of the BCCB study program. The scientific work includes both the completion of a scientific project with a host principal investigator as well as the critical and thorough assessment of own and others' scientific work in the frame of a seminar setting with presentations and discussions. With this, the Seminar and Thesis BCCB Module is an essential demonstration of the scientific skills that students have acquired during their study of BCCB. Furthermore, it also serves to prepare students for any further study (Master, PhD degrees) as well as work in a science-related environment. Even for students who aim to follow careers in finance, journalism, law, or consulting (to name but a few), the first-hand knowledge of the scientific process is a crucial educational component and a career-building element.</td></tr>
</table>

Intended Learning Outcomes

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

1. critically evaluate experiments performed by others in terms of scientific consistency, actual process planning, the appropriateness of experimental controls, reproducible execution, interpretation, and embedding in the scientific literature;
2. evaluate the planning of their own project in view of these criteria;
3. integrate any critique to improve their own project;
4. present their work in front of an audience of experts working on similar topics;
5. apply science ethics with respect to their own work and that of others;
6. compose a completed piece of work using scientific methods, i.e., a Bachelor thesis;
7. conduct thorough and cutting-edge literature searches in support of a specific project;
8. plan a scientific project;
9. individually implement a scientific project using acquired time and project management skills;
10. write up a scientific project in a coherent, concise and logical way;
11. evaluate their own performance in projecting, composing, planning, implementing, and concluding a scientific project;
12. summarize the process of scientific knowledge generation.

Indicative Literature

Not indicated.

Usability and Relationship to other Modules

- The Seminar and Thesis BCCB Module takes place in the final semester of the BCCB study program. It is usable for all further study, especially Master and PhD programs.
- Mandatory for BCCB major students.

Examination Type: Module Component Examinations

Module Component 1: Thesis
Assessment Type: Thesis — Length: 20 pages, Weight: 80%

Scope: Intended learning outcomes 6-12

Module Component 2: Seminar
Assessment Type: Presentation — Duration: 45 min, Weight: 20%

Scope: Intended learning outcomes 1-5

7.23 Jacobs Track Modules

7.23.1 Methods and Skills Modules

7.23.1.1 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

Number | Name | Type | CP
JTMS-07 | Mathematical Concepts for the Sciences | Lecture | 5</td></tr>
<tr><td colspan="2">Module Coordinator(s)

Marcel Oliver, Tobias Preußer</td><td colspan="2">Program Affiliation

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

Mandatory for BCCB; Chemistry, EES and MCCB</td></tr>
<tr><td colspan="3">Entry Requirements

Pre-requisites
☒ None

Co-requisites
☒ None

Knowledge, Abilities, or Skills
• none</td><td>Frequency

Annually (Fall)

Duration

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

• Lectures (35 hours)
• Private study (90 hours)

Workload

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

Review basic mathematical concepts and tools.</td></tr>
<tr><td colspan="6">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.</td></tr>
</table>

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, Chemistry, EES, and MCCB
- Elective for all other study programs.

Examination Type: Module Examination

Assessment type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of this module.

7.23.1.2 Physics for the Natural Sciences

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

Number | Name | Type | CP
JTMS-17 | Physics for the Natural Sciences | Lecture | 5.0</td></tr>
<tr><td colspan="2">Module Coordinator

Jürgen Fritz</td><td colspan="2">Program Affiliation

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

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

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

Annually (Spring)

Duration

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

• Lecture (35 hours)
• Private study including homework (90 hours)

Workload

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

Indicative Literature

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

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

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

Usability and Relationship to other Modules

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

Examination Type: Module Examination

Assessment type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module.

7.23.1.3 Programming in Python

<table>
<tr><td colspan="3">Module Name
Programming in Python</td><td>Module Code
JTMS-SKI-14</td><td>Level (type)
Year 1 (Methods)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components

Number | Name | Type | CP
JTMS-14 | Programming in Python | Lecture | 5</td></tr>
<tr><td colspan="2">Module Coordinator

Kinga Lipskoch</td><td colspan="2">Program Affiliation

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

Mandatory for IEM
Mandatory elective for BCCB, EES and Physics</td></tr>
<tr><td colspan="3">Entry Requirements

Pre-requisites
☒ None

Co-requisites
☒ None

Knowledge, Abilities, or Skills
• none</td><td>Frequency

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

• Class attendance (35 hours)
• Private study (85 hours)
• Exam preparation (5 hours)</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

It is recommended that students install a suitable programming environment (simple editor or Integrated Development Environment) and a new stable version of Python on their notebooks.</td></tr>
<tr><td colspan="6">Content and Educational Aims

This module offers an introduction to programming using the programming language Python. The module presents the basics of Python programming and provides a short overview of the program development cycle. It covers fundamental programming components and constructs in a hands-on manner. The beginning of the module covers the concepts of data types, variables, operators, strings and basic data structures. Next, other programming constructs such as branching, iterations, and data structures such as strings, lists, tuples, and dictionaries are introduced. The module also gives an introduction to functions, as well as simple file handling by introducing reading data from files, processing the data and writing the results to files. Later, object-oriented programming concepts such as constructors, methods, overloaded operators and inheritance are presented. Retrieving data from URLs and processing of larger amounts of data and their queries and storage in files are addressed. Simple interactive graphics and operations are also presented with the help of an object-oriented graphics library.</td></tr>
</table>

Intended Learning Outcomes

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

- explain basic concepts of imperative programming languages such as variables, assignments, loops, function calls, data structures;
- work with user input from the keyboard, and write interactive Python programs;
- write, test, and debug programs;
- illustrate basic object-oriented programming concepts such as objects, classes, information hiding, and inheritance;
- give original examples of function and operator overloading;
- retrieve data and process and generate data from/to files;
- use some available Python modules and libraries such as those related to data or graphics.

Indicative Literature

Kenneth A. Lambert (2014). Fundamentals of Python Data Structures. Boston: Cengage Learning PTR.

Mark Summerfield (2010). Programming in Python: A complete introduction to the Python language, second edition. London: Pearson Education.

John Zelle (2009). Python Programming: An introduction to Computer Science, second edition. Portland: Franklin, Beedle & Associates.

Igor Milovanovic (2013). Python Data Visualization Cookbook. Birmingham: Packt Publishing.

Cay Horsmann, Rance D. Necaise (2014). Python for Everyone. Hoboken: Wiley.

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 IEM.
- Mandatory elective for a major in BCCB, EES and Physics.
- 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
Module achievements: 50% of the assignments passed

7.23.1.4 Analytical Methods

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

Number | Name | Type | CP
JTMS-16 | Analytical Methods | Lecture | 5</td></tr>
<tr><td>Module Coordinator

Nikolai Kuhnert</td><td colspan="2">Program Affiliation

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

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

Pre-requisites
☒ None

Co-requisites
☒ None

Knowledge, Abilities, or Skills
• Basic knowledge in Life Sciences</td><td>Frequency

Annually (Fall)

Duration

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

• Lecture (35 hours)
• Tutorial (10 hours)
• Private study (80 hours)

Workload

125 hours</td></tr>
<tr><td colspan="5">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.</td></tr>
<tr><td colspan="5">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.</td></tr>
<tr><td colspan="5">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;</td></tr>
</table>

- 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 Chemistry and MCCB.
- Mandatory elective for a major in BCCB and EES.

Examination Type: Module Examination

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

Scope: All intended learning outcomes of the module

7.23.1.5 Plant Metabolism and Natural Products

<table>
<tr><td colspan="2">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="5">Module Components

Number | Name | Type | CP
JTMS-18 | Plant Metabolism and Natural Products | Lecture | 5</td></tr>
<tr><td>Module Coordinator

Matthias Ullrich</td><td colspan="2">Program Affiliation

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

Mandatory for BCCB, MCCB and Chemistry
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>Forms of Learning and Teaching

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

1 semester</td><td>Workload

125 hours</td></tr>
<tr><td colspan="5">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="5">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 Chemistry 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 Chemistry major students: the module can be replaced with a CORE module from another study program to pursue a minor.
- It is elective for all other study programs.

Examination Type: Module Examination

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

Scope: All intended learning outcomes of the module.

7.23.1 Big Questions Modules

7.23.1.1 Water: The Most Precious Substance on Earth

Module Name	***Module Code***	***Level (type)***	***CP***
Big Questions: Water: The Most Precious Substance on Earth	JTBQ-02	Year 3 (Jacobs Track)	5

Module Components

Number	*Name*	*Type*	*CP*
JTBQ-02	Water: The Most Precious Substance on Earth	Lecture/Tutorial	5

Module Coordinator	***Program Affiliation***	***Mandatory Status***
M. Bau and D. Mosbach	• 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 (part I: Fall; part II: Spring)	• Lectures (17.5 hours) • Project work (90 hours) • Private study (17.5 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*** 2 semesters	***Workload*** 125 hours

Recommendations for Preparation

Critically following media coverage on the module's topics in question.

Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal, and environmental contexts of the global issues and challenges of the coming decades. BQ modules intend to raise awareness of those challenges and broaden students' horizons with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become informed and responsible citizens in a global society.
Water is the basic prerequisite for life on our planet, but it has become a scarce resource and a valuable commodity. Water is of fundamental importance to the world's economy and global food supply, in addition to being a driving force behind geopolitical conflict. In this module, the profound impact of water on all aspects of human life will be addressed from very different perspectives: from the natural and environmental sciences and engineering, and from the social and cultural sciences.
Following topical lectures in the Fall semester, students will work on projects on the occasion of the World Water Day (March 22) in small teams comprised of students from various disciplines and with different cultural backgrounds. This teamwork will be accompanied by related tutorials.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

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

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

Indicative Literature

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

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

United Nation (January 2016): Sustainable Development Goals. Retrieved from https://www.un.org/sustainabledevelopment/sustainable-development-goals

Usability and Relationship to other Modules

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

Examination Type: Module Examination

Assessment Component 1: Written examination	Duration: 60 min Weight: 50%
Assessment Component 2: Team project	Weight: 50%

Scope: All intended learning outcomes of the module

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

7.23.1.2 Ethics in Science and Technology

<table>
<tr><td colspan="2">Module Name
Big Questions: Ethics in Science and Technology</td><td>Module Code
JTBQ-03</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
5.0</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
JTBQ-03 | Ethics in Science and Technology | Lecture /Projects | 5.0</td></tr>
<tr><td>Module Coordinator

A. Lerchl</td><td colspan="2">Program Affiliation

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

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

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

Each semester (Fall & Spring)

Duration

1 semester</td><td>Forms of Learning and Teaching

• Lectures (35 hours)
• Project work (55 hours)
• Private study (35 hours)

Workload

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

Critically following media coverage of the scientific topics in question.</td></tr>
<tr><td colspan="5">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 Chemistry
- 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.

7.23.1.3 Global Health – Historical context and future challenges

<table>
<tr><td colspan="2">Module Name
Big Questions: Global Health – Historical context and future challenges</td><td>Module Code
JTBQ-04</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
JTBQ-04 | Global Health – Historical context and future challenges | Lecture | 5</td></tr>
<tr><td>Module Coordinator

A. M. Lisewski</td><td colspan="2">Program Affiliation

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

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

Pre-requisites
☒ None

Co-requisites
☒ None

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

Annually (Spring)

Duration

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

• Lectures (35 hours)
• Private study (90 hours)

Workload

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

Critically following media coverage on the module's topics in question.</td></tr>
<tr><td colspan="5">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.</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;
- 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%

7.23.1.4 Global Existential Risks

Module Name	**Module Code**	**Level (type)**	**CP**
Big Questions: Global Existential Risks	JTBQ-05	Year 3 (Jacobs Track)	2.5

Module Components

Number	*Name*	*Type*	*CP*
JTBQ-05	Global Existential Risks	Lecture	2.5

Module Coordinator	**Program Affiliation**	**Mandatory Status**
M. A. Lisewski	• Big Questions Area: All undergraduate study programs except IEM	• Mandatory elective for students of all undergraduate study programs except IEM

Entry Requirements

Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*
☒ 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

Frequency	**Forms of Learning and Teaching**
Annually (Spring)	• Lectures (17.5 hours) • Private study (45 hours)
Duration	**Workload**
1 semester	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%

7.23.1.5 Future - From Predictions and Visions to Preparations and Actions

<table>
<tr><td colspan="2">Module Name
Big Questions: Future: From Predictions and Visions to Preparations and Actions</td><td>Module Code
JTBQ-06</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
2.5</td></tr>
<tr><td colspan="5">Module Components
Number | Name | Type | CP
JTBQ-06 | Future: From Predictions and Visions to Preparations and Actions | Lecture | 2.5</td></tr>
<tr><td>Module Coordinator

Joachim Vogt</td><td colspan="2">Program Affiliation

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

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

Pre-requisites

☒ None</td><td>Co-requisites

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

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

Annually (Fall)

Duration

1 semester</td><td>Forms of Learning and Teaching

• Lecture (17.5 hours)
• Private study (45 hours)

Workload

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

Critically following media coverage of the module's topics in question.</td></tr>
<tr><td colspan="5">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 https://www.un.org/sustainabledevelopment/sustainable-development-goals
United Nations University. https://unu.edu.
US National Intelligence Council (2017). Global Trends. Retrieved from https://www.dni.gov/index.php/global-trends-home.
International Panel on Climate Change. Retrieved from https://www.ipcc.ch.
World Inequality Lab (2017, December). World Inequality Report 2018. Retrieved from https://wir2018.wid.world.
World Health Organization. Retrieved from http://www.who.int.
World Trade Organization. Retrieved from *https://www.wto.org*
Gapminder. Retrieved from https://www.gapminder.org.
World Bank. Retrieved from http://www.worldbank.org.

Usability and Relationship to other Modules

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

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 60 min
Weight: 100%

Scope: All intended learning outcomes of the module

7.23.1.6 Climate Change

<table>
<tr><td colspan="3">Module Name
Big Questions: Climate Change</td><td>Module Code
JTBQ-07</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
2.5</td></tr>
<tr><td colspan="6">Module Components
Number | Name | Type | CP
JTBQ-07 | Climate Change | Lecture | 2.5</td></tr>
<tr><td>Module Coordinator
L. Thomsen/
V. Unnithan</td><td colspan="3">Program Affiliation
• Big Questions Area: All undergraduate study programs, except IEM</td><td colspan="2">Mandatory Status
• Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="3">Entry Requirements
Pre-requisites
☒ None

Co-requisites
☒ None

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

Duration
1 semester</td><td colspan="2">Forms of Learning and Teaching
• Lecture (17.5 hours)
• Private study (45 hours)

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.
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.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes
Students acquire transferable and key skills in this module.

By the end of this module, students should be able to</td></tr>
</table>

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

Indicative Literature

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

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

Usability and Relationship to other Modules

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

Examination Type: Module Examination

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

7.23.1.7 Extreme Natural Hazards, Disaster Risks, and Societal Impact

<table>
<tr><td colspan="2">Module Name
Big Questions: Extreme Natural Hazards, Disaster Risks, and Societal Impact</td><td>Module Code
JTBQ-08</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
2.5</td></tr>
<tr><td colspan="5">Module Components
Number | Name | Type | CP
JTBQ-08 | Extreme Natural Hazards: Disaster Risks, and Societal Impact | Lecture | 2.5</td></tr>
<tr><td>Module Coordinator
L. Thomsen</td><td colspan="2">Program Affiliation
• Big Questions Area: All undergraduate study programs, except IEM</td><td colspan="2">Mandatory Status
• Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="3">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)

Duration
1 semester</td><td>Forms of Learning and Teaching
• Lecture (17.5 hours)
• Private study (45 hours)

Workload
62.5 hours</td></tr>
<tr><td colspan="5">Recommendations for Preparation
Critically following media coverage of the module's topics in question.</td></tr>
<tr><td colspan="5">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="5">Intended Learning Outcomes
Students acquire transferable and key skills in this module.

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

• use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
• advance a knowledge-based opinion on the complex module topics, including how natural processes affect and interact with our civilization, especially those that create hazards and disasters;
• distinguish the methods scientists use to predict and assess the risk of natural disasters;</td></tr>
</table>

- discuss the social implications and policy framework in which decisions are made to manage natural disasters;
- work effectively in a team environment.

Indicative Literature

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

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

Usability and Relationship to other Modules

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

Examination Type: Module Examination

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

7.23.1.8 International Development Policy

<table>
<tr><td colspan="3">Module Name
Big Questions: International Development Policy</td><td>Module Code
JTBQ-09</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
2.5</td></tr>
<tr><td colspan="6">Module Components
Number | Name | Type | CP
JTBQ-09 | Big Questions: International Development Policy | Lecture | 2.5</td></tr>
<tr><td colspan="2">Module Coordinator
C. Knoop</td><td colspan="2">Program Affiliation
• Big Questions Area: All undergraduate study programs, except IEM</td><td colspan="2">Mandatory Status
• Mandatory elective for students of all undergraduate study programs, except IEM</td></tr>
<tr><td colspan="3">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)

Duration
1 semester</td><td colspan="2">Forms of Learning and Teaching
• Lecture (17.5 hours)
• Presentations
• Private study (45 hours)

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 — Duration: 10 minutes per student
Scope: All intended learning outcomes of the module — Weight: 100%

7.23.1.9 Sustainable Value Creation with Biotechnology. From Science to Business

<table>
<tr><td colspan="2">Module Name
Sustainable Value Creation with Biotechnology. From Science to Business.</td><td>Module Code
JTBQ-BQ-011</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
2.5</td></tr>
<tr><td colspan="5">Module Components
Number | Name | Type | CP</td></tr>
<tr><td>JTBQ-011</td><td colspan="2">Sustainable Value Creation with Biotechnology. From Science to Business</td><td>Lecture - Tutorial</td><td>2.5</td></tr>
<tr><td>Module Coordinator
Marcelo Fernandez Lahore</td><td colspan="2">Program Affiliation
• Jacobs Track - Big Questions</td><td colspan="2">Mandatory Status
• Mandatory elective for students of all undergraduate study except IEM</td></tr>
<tr><td colspan="2">Entry Requirements
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</td><td>Frequency
Annually (Spring)
Duration
1 semester</td><td colspan="2">Forms of Learning and Teaching
• Lecture and Tutorial (17.5 hours)
• Private study (45 hours)
Workload
62.5 hours</td></tr>
<tr><td colspan="5">Recommendations for Preparation
https://www.ctsi.ucla.edu/researcher-resources/files/view/docs/EGBS4_Kolchinsky.pdf
https://link.springer.com/article/10.1057/jcb.2008.27
https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf</td></tr>
</table>

Content and Educational Aims

All "Big Questions" (BQ) modules deal with the economic, technological, societal and environmental contexts of the global issues and challenges of the coming decades. The BQ modules intend to raise awareness of those challenges and broaden the students' horizon with applied problem solving beyond the borders of their own disciplines. Knowledge and skills offered in the interdisciplinary BQ modules support students in their development to become an informed and responsible citizen in a global society.
This module has a particular focus on the role that Biotechnology and Biorefining is expected to play in social, economic and environmental contexts.

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

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

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

1. design and develop a Business Case based on the tools provided by modern Biotechnology;
2. explain the interplay between Science, Technology and Economics / Finance;
3. use their disciplinary factual and methodological knowledge to reflect on interdisciplinary questions by comparing approaches from various disciplines;
4. work effectively in a team environment and undertake data interpretation and analysis;
5. discuss approaches to value creation in the context of Biotechnology and Sustainable Development;
6. explain the ethical implications of technological advance and implementation;
7. 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)	

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

7.23.1.10 Gender and Multiculturalism. Debates and Trends in Contemporary Societies

<table>
<tr><td colspan="2">Module Name
Big Questions: Gender and Multiculturalism. Debates and Trends in Contemporary Societies</td><td>Module Code
JT-BQ-013</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
5.0</td></tr>
<tr><td colspan="5">Module Components

Number | Name | Type | CP
JT-BQ-013 | Gender and Multiculturalism: Debates and Trends in Contemporary Societies | Lecture | 5.0</td></tr>
<tr><td>Module Coordinator

J. Price</td><td colspan="2">Program Affiliation

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

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

Pre-requisites
☒ None

Co-requisites
☒ None

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

Annually (Spring)

Duration

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

• Lectures (35 hours)
• Private study (90 hours)

Workload

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

Critical following of the media coverage on the module's topics in question.</td></tr>
<tr><td colspan="5">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.</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 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.

Indicative Literature

Moller Okin, S. (1999). Is Multiculturalism Bad for Women? New Jersey: Princeton University Press.

Connell, R. W. (2002). Gender. Cambridge: Polity Press.

Inglehart, Ronald and Pippa Norris (2003). Rising Tide: Gender Equality and Cultural Change Around the World. New York and 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. Weight: 100%

Scope: All intended learning outcomes of the module

7.23.1.11 Big Questions: The Challenge of Sustainable Energy

Module Name	**Module Code**	**Level (type)**	**ECTS**
Big Questions: The Challenge of Sustainable Energy	JTBQ-14	Year 3 (Jacobs Track)	2.5

Module Components

Number		*Type*	*ECTS*
JTBQ-14	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

Entry Requirements			**Frequency**	**Forms of Learning and Teaching**
Pre-requisites	*Co-requisites*	*Knowledge, Abilities, or Skills*	Annually (Fall or 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 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/ISS), "Environmental Science" (EES), "General Earth and Environmental Sciences" (EES), and "Renewable Energies" (Physics).

Examination Type: Module Examination

Assessment Type: Written Examination

Duration: 60 min
Weight: 100%

Scope: All intended learning outcomes of the module

7.23.1.12 Big Questions: State, Religion and Secularism

<table>
<tr><td colspan="2">Module Name
Big Questions: State, Religion and Secularism</td><td>Module Code
JTBQ-15</td><td>Level (type)
Year 3 (Jacobs Track)</td><td>CP
2.5</td></tr>
<tr><td colspan="5">Module Components

Number | Type | CP
JTBQ-15 | State, religion and secularism | Lecture | 2.5</td></tr>
<tr><td>Module Coordinator

Manfred O. Hinz</td><td colspan="2">Program Affiliation

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

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

Pre-requisites
☒ None

Co-requisites
☒ None

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

Annually (Fall or Spring)</td><td>Forms of Learning and Teaching

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

1 semester</td><td>Workload

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

Reflect on the situation and role in respective home-country</td></tr>
<tr><td colspan="5">Content and Educational Aims

The relationship between state and religion has been a matter of concern in most if not all societies. Is religion above the state, or is it to the state to determine the place of religion? What does secularity mean? To what extent will religion accept secularity? Where does the idea of secularity come from? The course State, religion, secularism will search for answers to questions of this nature. After introducing to the topic and looking at some legal attempts to regulate the relationship between state and religion, the focus will be, on the one hand, on Christianity and secularity and, on Islam and secularity, on the other. Depending on the interest of participants, other religions and their relationships to states of relevance can be added.</td></tr>
<tr><td colspan="5">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.</td></tr>
<tr><td colspan="5">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</td></tr>
<tr><td colspan="5">Examination Type: Module Examination

Assessment Type: Term paper
Length:1.500 – 3.000 words
Weight: 100%</td></tr>
</table>

Scope: All intended learning outcomes of the module.

7.23.2 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

Number | Name | Type | CP
JTCI-950 | Community Impact Project | Project | 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">Entry Requirements

Pre-requisites

☒ at least 15 CP from CORE modules in the major</td><td>Co-requisites

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

• Basic knowledge of the main concepts and methodological instruments of the respective disciplines</td><td>Frequency

Annually (Spring)</td><td>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 colspan="4"></td><td>Duration

1 semester</td><td>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</td></tr>
</table>

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

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

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

Indicative Literature

Not specified

Usability and Relationship to other Modules

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

Examination Type: Module Examination

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

7.23.3 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

8 Appendix

Intended Learning Outcomes Assessment-Matrix

Biochemistry and Cell Biology BSc					General Biochemistry	General Cell Biology	General and inorganic Chemistry	General Organic Chemistry	Microbiology	Infection and Immunity	Advanced Biochemistry I	Advanced Biochemistry II	Advanced Biochemistry Lab	Advanced Cell Biology I	Advanced Cell Biology Lab	Advanced Cell Biology II	Experimental Strategy Design	RNA Biochemistry	Biomedicine	Internship / Startup and Career Skills	Bachelor Thesis and Seminar BCCB	JT Methods/Skills	JT Language Modules	JT Big Questions	JT Community Impact Project
Semester					1	2	1	2	3	4	3	4	4	3	4	4	5	5	6	4-5	6	1-4	1-4	5-6	5
Mandatory/mandatory elective					m	m	m	m	me	me	m	m	m	m	m	m	me	me	me	m	m	m/me	m	m	m
Credits					7.5	7.5	7.5	7.5	7.5	7.5	5	5	5	5	5	5	5	5	5	15	15	20	10	10	5
	Competencies*																								
Program Learning Outcomes	**A**	**E**	**P**	**S**																					
Apply basic concepts from the natural sciences (general chemistry, organic chemistry, physics) and mathematics, including statistics	x	x					x	x	x													x			
Explain the basic concepts within the fields of biochemistry and cell biology;	x	x			x	x			x																
Recognize general biochemical reactivity patterns and metabolic pathways;	x	x			x		x	x	x		x											x			
Explain how the structure and biochemical properties of biomolecules define their cellular function;	x	x			x	x			x	x	x	x	x	x	x	x						x			
Explain general processes governing cellular and early developmental biology in health and diseased conditions;	x	x		x		x			x	x	x	x		x	x	x			x			x			
Describe the molecular principles underlying gene expression and regulation;	x	x		x		x			x	x		x	x		x	x	x	x							
Apply state-of-the-art techniques to experimentally analyze biomolecules and cells;	x	x			x	x		x	x						x						x	x			
Collect, analyze and evaluate relevant literature within the fields of biochemistry, molecular biology and cell biology;	x	x							x	x		x	x	x	x	x	x	x	x		x	x			
Use their acquired theoretical knowledge and practical skills to design and implement experimental approaches to address scientific questions in the modern Life Sciences;	x	x	x	x					x				x		x		x	x	x		x				
Generate, analyze and interpret data according to good scientific practice and ethical standards;	x	x	x	x	x	x	x	x	x	x			x		x		x				x	x			
Present their own results, and those of others, concisely and professionally both, in writing and in front of an audience;	x	x	x	x	x	x	x	x	x				x		x		x	x	x		x				
Develop and advance solutions to problems in the Life Sciences and defend these in discussions with specialists and non-specialists;	x	x	x	x						x		x		x		x	x	x	x		x	x			
Explore related subjects such as biotechnology, biophysics, bioinformatics, organic chemistry, drug design, marine science, food analytics, and others;	x	x							x	x	x	x		x	x	x	x	x	x		x	x			
Acquire knowledge rapidly, gather, evaluate and interpret relevant information and evaluate new concepts critically to derive scientifically founded judgements;	x	x	x	x						x	x	x	x	x	x	x	x	x	x	x	x				
Evaluate situations and take decisions based on ethical considerations, and adhere to and defend ethical, scientific and professional standards;			x	x								x		x	x	x		x	x	x	x	x			
Negotiate and mediate between different points of view and to manage conflicts;			x	x								x		x		x		x	x	x	x	x			x
Analyze global issues of economic, political, scientific, social or technological nature;		x	x	x					x	x		x		x		x	x	x				x		x	
Take on responsibility in diverse and interdisciplinary teams, exhibiting tolerance and intercultural awareness;		x	x	x	x	x	x	x	x				x		x		x	x	x	x	x		x		x
Take on responsibility for their own and their team's learning, personal and professional development and role in society, evaluating critical feedback and using self-analysis;		x	x	x	x	x	x	x	x				x		x		x	x	x	x	x			x	x
Take on responsibility for their professional community and society.		x	x	x					x	x		x		x	x	x		x	x	x	x	x	x	x	x
Assessment Type																									
Oral examination										x								x							
Written examination					x	x	x	x	x	x	x	x		x		x						x			
Project																				x					x
Term paper																	x								
(Lab) report					x	x	x	x	x				x		x										
Poster presentation																			x						
Presentation																					x				
Thesis																									
Various																					x		x	x	
Module achievements/bonus achievements							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