CONSTRUCTOR UNIVERSITY

Study Program Handbook

Biochemistry and Cell Biology

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 4 of this handbook).

Current version	**Valid as of**	**Decision**	**Details**
Fall 2023 – V1.1	Sep 01, 2023	Aug 16, 2023	Editorial changes assessment types in ILO matrix by PSD
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1. Program Overview

1.1 Concept

1.1.1 The Constructor University Educational Concept

Constructor University aims to educate students for both an academic and a professional career by emphasizing three core objectives: academic excellence, personal development, and employability to succeed in the working world. Constructor University offers an excellent research driven education experience across disciplines 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. Through a multi-disciplinary, holistic approach and exposure to cutting-edge technologies and challenges, Constructor University develops and enables the academic excellence, intellectual competences, societal engagement, professional and scientific skills of tomorrows leaders for a sustainable and peaceful future.

In this context, it is Constructor 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 can take responsible roles for 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 Constructor University, both in terms of actual disciplinary subject matter and 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, optional German language and Humanities modules, 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, Constructor University offers professional advising and counseling.

Constructor University's educational concept is highly regarded both nationally and internationally. While the university has consistently achieved top marks over the last decade in Germany's most comprehensive and detailed university ranking by the Center for Higher Education (CHE), it has also been listed by the renowned Times Higher Education (THE) magazine as one of the top 300 universities worldwide (ranking group 251-300) in 2019 as well as in 2021. Since 2022 Constructor University is considered to be among the top 30 percent out of more than 1600 universities worldwide and is ranked the most international university in Germany. 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 Constructor 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 School of Science at Constructor University, regularly reaches top evaluations in rankings of study programs, such as the CHE or U-Multirank.

1.2 Specific Advantages of BCCB at Constructor University

The BCCB program at Constructor 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 Constructor 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 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 different research approaches enabling them to develop their own research strategies.

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 Laboratory 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 Constructor 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 and Support

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, Autodesk, Catenion, Roche, Leroy Merlin, Boston Consulting Group, the non-profit partnership Medicines for Malaria Venture and many others.

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

1.5 Admission Requirements

Admission to Constructor University is selective and based on a candidate's school and/or university achievements, recommendations, self-presentation, and performance on standardized tests. Students admitted to Constructor 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 (optional)
- Official or certified copies of high school/university transcripts
- Educational History Form
- Standardized test results (SAT/ACT) if applicable
- Motivation statement
- ZeeMee electronic resume (optional)
- Language proficiency test results (TOEFL Score: 90, IELTS: Level 6.5 or equivalent)

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

For more detailed information about the admission visit:
https://constructor.university/admission-aid/application-information-undergraduate

1.6 More information and contacts

For more information on the study program please contact the Study Program Coordinator:

Prof. Dr. Klaudia Brix

Professor of Cell Biology

Email: kbrix@constructor.university

or visit our program website: https://constructor.university/programs/undergraduate-education/biochemistry-cell-biology

For more information on Student Services please visit:

https://constructor.university/student-life/student-services

2. The Curricular Structure

2.1 General

The curricular structure provides multiple elements for enhancing employability, interdisciplinarity, and internationality. The unique CONSTRUCTOR 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 Constructor 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 Constructor University can be found on the website (https://constructor.university/student-life/student-services/university-policies)

2.2 The Constructor University 4C Model

Constructor 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 undergraduate programs involve 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 4C Model. It groups the disciplinary content of the study program in three overarching themes, CHOICE-CORE-CAREER according to the year of study, while the university-wide CONSTRUCTOR Track is dedicated to multidisciplinary content dedicated to methods as well as intellectual skills and is integrated across all three years of study. The default module size is 5 CP, with smaller 2.5 CP modules being possible as justified exceptions, e.g., if the learning goals are more suitable for 2.5 CP and the overall student workload is balanced.

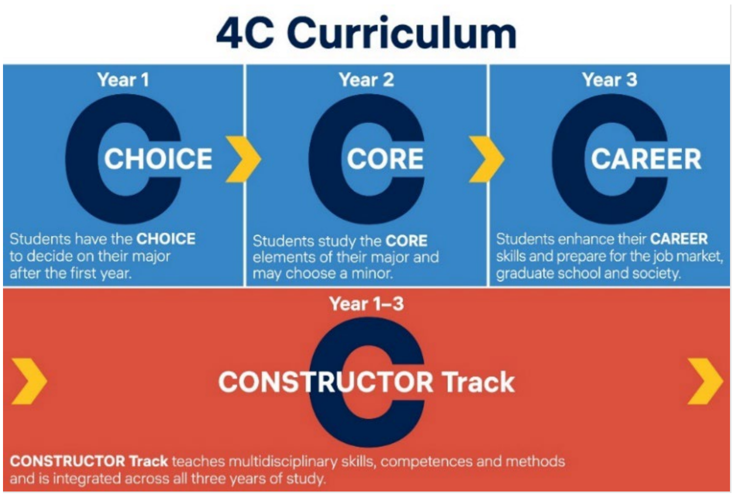

Figure 1: The Constructor University 4C-Model

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 15-45 CP will belong to their intended major. A unique feature of our curriculum structure allows students to select their major freely upon entering Constructor University. The team of Academic Advising Services 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 (m) modules:

- CHOICE Module: General Biochemistry (m, 7.5 CP)
- CHOICE Module: General and Inorganic Chemistry (m, 7.5 CP)
- CHOICE Module: General Cell Biology (m, 7.5 CP)
- CHOICE Module: General Organic Chemistry (m, 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/or with the aim of allowing a change of major until the beginning of the second year, when the major choice becomes fixed.

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 an entry advising session with their Academic Advisors to learn about their major change options and consult their Academic Advisor prior to changing their major.

Students that would like to retain a further option are strongly recommended to additionally register for the CHOICE modules of one of the following study programs in their first year:

- Chemistry and Biotechnology (CBT)
  CHOICE Module: Introduction to Biotechnology (m, 7.5 CP)
  CHOICE Module: Introduction to Biotechnology (m, 7.5 CP)
  CHOICE Module: General Biochemistry: Microbiology and Genetics (m, 7.5 CP)
  CHOICE Module: Introduction to Biotechnology (m, 7.5 CP)

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

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

- International Relations: Politics and History (IRPH)
  CHOICE Module: Introduction to International Relations Theory (m, 7.5 CP)
  CHOICE Module: Introduction to Modern European History (m, 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" (CBT) and “Medicinal Chemistry and Chemical Biology” (MCCB) are recommended as fitting complementation (see above). In the past, students have also declared interest in "Integrated Social and Cognitive Psychology" (ISCP). These students would thus be advised to choose the respective CHOICE Modules during their first year of study.

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 CORE modules need to be acquired:

- CORE Module: Advanced Biochemistry I (m, 5 CP)
- CORE Module: Advanced Biochemistry II (m, 5 CP)
- CORE Module: Advanced Biochemistry Lab (m, 5 CP)
- CORE Module: Advanced Cell Biology I (m, 5 CP)
- CORE Module: Advanced Cell Biology II (m, 5 CP)
- CORE Module: Advanced Cell Biology Lab (m, 5 CP)
- CORE Module: Microbiology (m, 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 replicated, 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 (me) CORE modules (10 CP)

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

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.

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 CONSTRUCTOR 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 a Bachelor thesis project.

2.2.3.1 Internship / Start-up and Career Skills Module

As a core element of Constructor 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 an external professional research environment, apply their knowledge and understanding in the context of an external institution, reflect on the relevance of their major to employment and society, reflect on their own personal role, and further develop their professional orientation. The internship can establish valuable contacts for the students' bachelor's thesis project, for the selection of a master program or graduate school, or for 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 Service Center (CSC) (https://constructor.university/student-life/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 default Specialization Module size is 5 CP, with smaller 2.5 CP modules being possible as justified exceptions.

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

- BCCB Specialization: Experimental Strategy Design (me, 5 CP)
- BCCB Specialization: Biomedicine (me, 5 CP)
- BCCB Specialization: Current Topics in the Molecular Life Sciences (me, 5 CP)

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

- CBT Specialization: Environmental Microbiology and Biotechnology (me, 5 CP)
- CBT CORE Module: Industrial Biotechnology (me, 5 CP)
- CBT CORE Module: Scientific Software and Databases (me, 5 CP)
- MCCB Specialization: Synthetic Biology (me, 5 CP)
- MCCB Specialization: Drug Discovery (me, 2.5 CP)
- MCCB CORE Module: Chemical Biology (me, 5 CP)
- ISCP CORE Module: Neurobiology of Behavior (me, 5 CP)
- ISCP CORE Module: Neuroscience Methods (me, 5 CP)

Students may also select 15 CP entirely from their major-specific Specialization Modules.

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 "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.

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 Constructor University's study abroad procedures. Several exchange programs allow students to directly enroll at prestigious partner institutions worldwide. Constructor 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://constructor.university/student-life/study-abroad/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 New Skills modules (see CONSTRUCTOR 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 New Skills modules to reach the required 15 CP in this area.

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 Constructor University 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. The data will be analyzed and interpreted according to good scientific practice and ethical standards. Hence, the results of students' work will be set into context with the regulatory frameworks governing activities in the bioscience field.

With their Bachelor Thesis students demonstrate mastery of selected 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 Constructor University 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 CONSTRUCTOR Track

The CONSTRUCTOR Track is another important feature of Constructor University's educational model. The Constructor Track runs orthogonal to the disciplinary CHOICE, CORE, and CAREER modules across all study years and is an integral part of all undergraduate study programs. It provides an intellectual tool kit for lifelong learning and encourages the use of diverse methodologies to approach cross-disciplinary problems. The CONSTRUCTOR track contains Methods, New Skills and German Language and Humanities modules.

2.3.1 Methods Modules

Methods 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 area in their curriculum. The modules that are specifically assigned to each study program to 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 area. The size of all Methods 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 (m, 5 CP)
- Methods Module: Physics for the Natural Sciences (m, 5 CP)
- Methods Module: Plant Metabolism and Natural Products (m, 5 CP)

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

- Methods Module: Introduction to Bioinformatics (me, 5 CP)
- Methods Module: Analytical Methods (me, 5 CP)

2.3.2 New Skills Modules

This part of the curriculum constitutes an intellectual and conceptual tool kit that cultivates the capacity for a particular set of intellectual dispositions including curiosity, imagination, critical thought, and transferability. It nurtures a range of individual and societal capacities, such as self-reflection, argumentation and communication. Finally, it introduces students to the normative aspects of inquiry and research, including the norms governing sourcing, sharing, withholding materials and research results as well as others governing the responsibilities of expertise as well as the professional point of view.

All students are required to take the following modules in their second year:

- New Skills Module: Logic (m, 2.5 CP)
- New Skills Module: Causation and Correlation (m, 2.5 CP)

These modules will be offered with two different perspectives of which the students can choose. The module perspectives are independent modules which examine the topic from different point of views. Please see the module description for more details.

In the third year, students take three 5 CP modules that build upon previous modules in the track and are partially constituted by modules that are more closely linked to each student's disciplinary field of study. The following module is mandatory for all students:

- New Skills Module: Argumentation, Data Visualization and Communication (m, 5 CP)

This module will also be offered with two different perspectives of which the students can choose.

In their fifth semester, students may choose between:

- New Skills Module: Linear Model/Matrices (me, 5 CP) and
- New Skills Module: Complex Problem Solving (me, 5 CP).

The sixth semester also contains the choice between two modules, namely:

- New Skills Module: Agency, Leadership and Accountability (me, 5 CP) and
- New Skills Module: Community Impact Project (me, 5 CP).

Students who study abroad during the fifth semester and are not substituting the mandatory Argumentation, Data Visualization and Communication module, are required to take this module during their sixth semester. Students who remain on campus are free to take the Argumentation, Data Visualization and Communication module in person in either the fifth or sixth semester as they prefer.

2.3.3 German Language and Humanities Modules

German language abilities foster students' intercultural awareness and enhance their employability in their host country. They are also beneficial for securing mandatory internships (between the 2nd and 3rd year) in German companies and academic institutions. Constructor University supports its students in acquiring basic as well as advanced German skills in the first year of the CONSTRUCTOR Track. Non-native speakers of German are encouraged to take two German modules (me, 2.5 CP each), but are not obliged to do so. Native speakers and other students not taking advantage of this offering take alternative modules in Humanities in each of the first two semesters:

- Humanities Module: Introduction to Philosophical Ethics (me, 2.5 CP)
- Humanities Module: Introduction to the Philosophy of Science (me, 2.5 CP)
- Humanities Module: Introduction to Visual Culture (me, 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:

- Explain the basic concepts within the fields of biochemistry and cell biology;
- Explain how the structure and biochemical properties of biomolecules define their cellular function;
- Explain general processes governing cellular and early developmental biology in health and diseased condition;
- Describe the molecular principles underlying gene expression and regulation;
- Apply state-of-the-art techniques to experimentally analyze biomolecules and cells;
- Generate, analyze, and interpret data according to good scientific practice and ethical standards;
- Rapidly acquire knowledge, and gather, evaluate, and interpret relevant information, and critically evaluate new concepts to derive scientifically founded judgements;
- Evaluate situations and make decisions based on scientific knowledge and ethical considerations, and adhere to and defend ethical, scientific, and professional standards;
- Take responsibility in diverse and interdisciplinary teams, exhibiting tolerance and intercultural awareness;
- 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 mandatory CHOICE and CORE modules:

- CHOICE Module: General Biochemistry (m, 7.5 CP)
- CHOICE Module: General Cell Biology (m, 7.5 CP)
- CORE Module: Microbiology (m, 5 CP)
- CORE Module: Microbiology Seminar (m, 2.5 CP)
- CORE Module: Infection and Immunity (m, 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 Constructor University in Fall 2023. In case of a conflict between the regulations in this handbook and the general Policies for Bachelor Studies, the latter apply (see https://constructor.university/student-life/student-services/university-policies)

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

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

4.2 Degree

Upon successful completion of this study program, students are awarded a 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.

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.

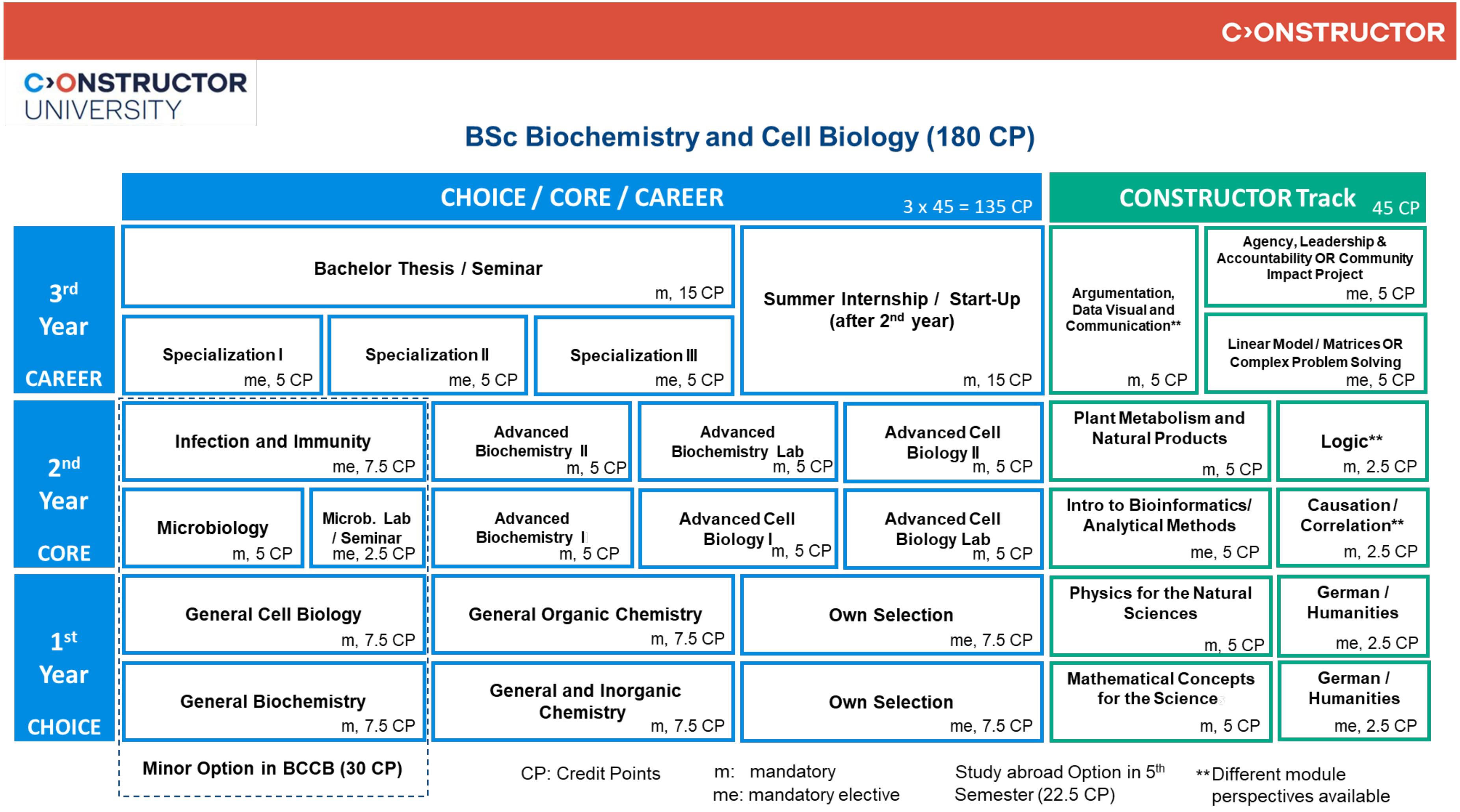

Figure 2: Schematic Study Scheme for BCCB

6. Study and Examination Plan

Biochemistry and Cell Biology

Matriculation Fall 2023

	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**				**me[3]**	**3**	**7.5**
CO-401-A	Immunology	Lecture	Written examination	Examination period			5
CO-401-B	Microbial Pathogenicity	Lecture	Written examination	Examination period			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

	Constructor Track Modules (General Education)	Type	Assessment	Period	Status[1]	Sem.	CP
							15
	Unit: Methods						**10**
CTMS-MAT-07	**Module: Mathematical Concepts for the Sciences**				**m**	**1**	**5**
CTMS-07	Mathematical Concepts for the Sciences	Lecture	Written examination	Examination period			
CTMS-SCI-17	**Module: Physics for the Natural Sciences**				**m**	**2**	**5**
CTMS-17	Physics for the Natural Sciences	Lecture	Written examination	Examination period			
	Unit: German Language and Humanities (choose one module for each sememster)						**5**
	German is default language and open to Non-German speakers (on campus and online).[5]						
CTLA-	**Module: Language 1**				**me**	**1**	**2,5**
CTLA-	Language 1	Seminar	Various	Various	me		
CTLA-	**Module: Language 2**				**me**	**2**	**2,5**
CTLA-	Language 2	Seminar	Various	Various	me		
CTHU-HUM-001	**Humanities Module: Introduction to Philosophical Ethics**				**me**	**1**	**2,5**
CTHU-001	Introduction to Philosophical Ethics	Lecture (online)	Written examination	Examination period	me		
CTHU-HUM-002	**Humanities Module: Introduction to the Philosophy of Science**				**me**	**2**	**2,5**
CTHU-002	Introduction to the Philosophy of Science	Lecture (online)	Written examination	Examination period	me		
CTHU-HUM-003	**Humanities Module: Introduction to Visual Culture**				**me**	**2**	**2,5**
CTHU-003	Introduction to Visual Culture	Lecture (online)	Written examination	Examination period	me		
	Unit: Methods						**10**
Module: Select from the following Methods modules offered in the Fall term or replace the mandatory elective (me) module (5 CP) with suitable CORE modules from other study programs.							
CTMS-SCI-19	**Module: Introduction to Bioinformatics**				**me[3]**	**3**	**5**
CTMS-19	Bioinformatics	Lecture	Written examination	Examination period			
CTMS-SCI-16	**Module: Analytical Methods**				**me[3]**	**3**	**5**
CTMS-16	Analytical Methods	Lecture	Written examination	Examination period			
CTMS-SCI-18	**Module: Plant Metabolism and Natural Products**				**m**	**4**	**5**
CTMS-18	Plant Metabolism and Natural Products	Lecture	Written examination	Examination period			
	Unit: New Skills						**5**
Choose one of the two modules							
CTNS-NSK- 01	**Module: Logic (perspective I)**				**me**	**3**	**2.5**
CTNS-01	Logic (perspective I)	Lecture (online)	Written examination	Examination period	me		2.5
CTNS-NSK-02	**Module: Logic (perspective II)**						
CTNS-02	Logic (perspective II)	Lecture (online)	Written examination	Examination period	me		2.5
Choose one of the two modules							
CTNS-NSK-03	**Module: Correlation and Causation (perspective I)**				**me**	**4**	**2.5**
CTNS-03	Correlation and Causation (perspective I)	Lecture (online)	Written examination	Examination period	me		2.5
CTNS-NSK-04	**Module: Correlation and Causation (perspective II)**				**me**	**4**	**2.5**
CTNS-04	Correlation and Causation (perspective II)	Lecture (online)	Written examination	Examination period	me		2.5

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 [4]						
CA-S-BCCB-801	**Specialization Module: Current Topics in Molecular Life Sciences**				**me**	**5**	**5**
CA-BCCB-801	Current Topics in Molecular Life Sciences	Seminar	Presentation	During the semester			
CA-S-BCCB-802	**Specialization Module: Experimental Strategy Design**				**me**	**5**	**5**
CA-BCCB-802	Experimental Strategy Design	Seminar	Project	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 (see BCCB study program handbook)**				**me**	**5/6**	**5**

							15
	Unit: New Skills						**10**
Choose one of the two modules							
CTNS-NSK-05	**Module: Linear Model / Matrices**				**me**	**5**	**5**
CTNS-05	Linear Model/ Matrices	Seminar (online)	Written examination	Examination period			5
CTNS-NSK-06	**Module: Complex Problem Solving**				**me**	**5**	**5**
CTNS-06	Complex Problem Solving	Lecture (online)	Written examination	Examination period			5
Choose one of the two modules							5
CTNS-NSK-07	**Module: Argumentation, Data Visualization and Communication**				**me**	**5/6**	**5**
CTNS-07	Argumentation, Data Visualization and Communication (perspective I)	Online Lecture	Written examination	Examination period	me	**5**	5
CTNS-NSK-08	**Module: Argumentation, Data Visualization and Communication**				**me**	**5/6**	**5**
CTNS-08	Argumentation, Data Visualization and Communication (perspective II)	Online Lecture	Written examination	Examination period	me	**6**	5
Choose one of the two modules							
CTNS-NSK	**Module: Agency, Accountability & Leadership**				**me**	**6**	**5**
CTNS-09	Agency, Accountability & Leadership	Lecture (online)	Written examination	Examination period			5
CTNC-CIP-10	**Module: Community Impact Project**				**me**	**5/6**	**5**
CTNC-10	Community Impact Project	Project	Project	During the Sememster			5
Total CP							**180**

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

[2] For a full listing of all CHOICE / CORE / CAREER / CONSTRUCTOR 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)

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

[4] Note that 15 CP specialization modules need to be taken, of which a minimum of 10 CP must be major-specific and max. 5 CP can be major-related

[5] German native speakers will have alternatives to the language modules (in the field of Humanities).

Figure 3: Study and Examination Plan

7. Biochemistry and Cell Biology Modules

7.1 General Biochemistry

<table>
<tr><td colspan="3">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="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CH-100-A</td><td colspan="3">General Biochemistry</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-100-B</td><td colspan="3">General Biochemistry Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

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

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

Mandatory for BCCB, CBT and minor BCCB</td></tr>
<tr><td colspan="3" rowspan="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)</td><td colspan="2">Forms of Learning and Teaching

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

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

187.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation
For this module, students should revise chemistry, mathematics, physics and biology at the high school level and ideally bring basic self-directed study skills at the high school level.
Students need to read the relevant chapters in the recommended textbooks and all course materials provided by the instructors (e.g., manuals for the laboratory course).
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 Biochemistry Module aims at students with a good High School knowledge of chemistry, mathematics, physics, and biology as well as basic self-directed study skills at high school level. The module consists of two module components, one lecture and one laboratory course.
In the lecture, students gain solid first-year level understanding of biochemistry and learn how to apply and analyze basic concepts of biochemistry.
In the laboratory course, students develop their practical skills and acquire basic proficiency in the use of laboratory equipment. The experiments parallel the lecture content and allow students to apply methods testing for the chemical properties of biomolecules. Furthermore, students learn how to document, describe, and discuss experimental data.
In both module components, students also acquire meta-skills such as self-organization and teamwork.

Intended Learning Outcomes

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

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

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: Laboratory Reports
Duration: Approx. 10 pages per report
Weight: 33%

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

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

7.2 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</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CH-101-A</td><td colspan="2">General Cell Biology</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-101-B</td><td colspan="2">General Cell Biology Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

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

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

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

Pre-requisites: ☒ General Biochemistry

Co-requisites: ☒ None

Knowledge, Abilities, or Skills:
• General understanding of biomolecules from the General Biochemistry lecture</td><td>Frequency

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

• Lecture (35 hours)
• Tutorials (15 hours)
• Private study (75 hours)
• Safety instructions (1 hours)
• Reading lab manuals (6 hours)
• MSDS preparation (4 hours)
• Experimental work in the laboratory, including seminars (27.5 hours)
• Lab report writing (24 hours)</td></tr>
<tr><td>Duration

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

187.5 hours</td></tr>
<tr><td colspan="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 permanent specimen.

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 Laboratory 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.

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: Laboratory Reports Length: Approx. 10 pages per report
Weight: 33%

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

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

7.3 General and Inorganic Chemistry

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

Recommendations for Preparation

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

Content and Educational Aims

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

Intended Learning Outcomes

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

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
13. perform qualitative and quantitative determination of unknowns and know how to handle and analyze chemical compounds
14. write proper Laboratory 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 CBT, BCCB, and MCCB

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: Laboratory Reports, lab performance

Length: 4-6 pages per report
Weight: 33%

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

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

7.4 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</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CH-111-A</td><td colspan="2">General Organic Chemistry</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-111-B</td><td colspan="2">General Organic Chemistry Lab</td><td>Laboratory</td><td>2.5</td></tr>
<tr><td>Module Coordinator

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

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

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

Pre-requisites

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

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

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

Annually

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

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

1 semester</td><td>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 34harmacop 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</td></tr>
</table>

laboratory report. After this, the essential techniques are shown for: setting up, monitoring (TLC, color change, etc.), and quenching (neutralize active chemicals) reactions. In parallel, the student will purify the products (chromatography, crystallization, separatory funnel extractions, etc.), and use basic methods to identify the products. While doing so, the student is exposed to the common equipment (rotary evaporator, melting point apparatus, etc.) within the laboratory. Reactions based on nucleophilic substitution, elimination, bromination to an alkene, electrophilic aromatic substitution, and the isolation of a natural product, characterize the experimental exposure within this laboratory.

Intended Learning Outcomes

By the end of the module, the student will 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;
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

This module provides the foundation knowledge required for your 2nd year CORE modules

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 Laboratory 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%.

<table>
<tr><td colspan="3">Module Name
Microbiology</td><td>Module Code
CO-400</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-400-A</td><td colspan="3">Microbiology</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator
Prof. Dr. Matthias Ullrich</td><td colspan="3">Program Affiliation
• Biochemistry and Cell Biology (BCCB)</td><td colspan="2">Mandatory Status
Mandatory for BCCB and minor BCCB</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements
Pre-requisites: ☒ General Biochemistry and General Cell Biology
Co-requisites: ☒ Microbiology Lab or Seminar
Knowledge, Abilities, or Skills: • Basic knowledge of biochemistry and cell biology</td><td>Frequency
Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching
• Lecture (35 hours)
• Tutorials (15 hours)
• Private study (75 hours)</td></tr>
<tr><td>Duration
1 semester</td><td colspan="2">Workload
125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation
Students should have a sound background 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 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.</td></tr>
</table>

7.5 Microbiology

Intended Learning Outcomes By the end of this module, students will be able to 1. explain the principles governing the world of microorganisms; 2. apply knowledge of biochemical and cellular processes to microbial metabolism; 3. illustrate the cellular interactions of microbes with their environment; 4. analyze how pathogens cause diseases to infer the establishment of therapeutic strategies; 5. categorize the diversity of microorganisms, their biochemical life styles, and microbial fitness; 6. examine the characteristics of microbial habitats and establish differences between oxygenic and anoxygenic life processes; 7. determine cellular and environmental factors contributing to the evolutionary adaptions of microbes; 8. 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.
Examination Type: Module Examination Assessment Type: Written examination Duration: 120 min Weight: 100% Scope: All intended learning outcomes Completion: To pass this module, the examination has to be passed with at least 45%.

7.6 Microbiology Lab

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

Microbiology Lab</td><td>Module Code

CO-408</td><td>Level (type)

Year 2 (CORE)</td><td>CP

2.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-408-A</td><td colspan="3">Microbiology Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Matthias Ullrich</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" rowspan="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)</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)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">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. Students should have acquired basic skills in experimental molecular biology techniques from the respective CHOICE laboratory courses.</td></tr>
<tr><td colspan="6">Content and Educational Aims
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</td></tr>
</table>

its taxonomic marker genes with genomic databases. The individual experimental results will be summarized in a manuscript-style lab report.

Intended Learning Outcomes

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

1. apply their theoretical knowledge to the skilled use of methods in microbiology and microbial biochemistry;
2. apply methods in microbiology and microbial biochemistry;
3. handle microorganisms in a sterile and safe manner;
4. record and transfer experimental data;
5. identify microorganisms;
6. master classical and molecular tools to characterize microbes;
7. 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.

Examination Type: Module Examination

Assessment Type: Laboratory Reports Length: Approx. 10 pages per report

Weight: 100%

Scope: All intended learning outcomes of the laboratory course

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

7.7 Microbiology Seminar

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

Microbiology Seminar</td><td>Module Code

CO-409</td><td>Level (type)

Year 2 (CORE)</td><td>CP

2.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-409-A</td><td colspan="3">Microbiology Seminar</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

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

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

Mandatory for minor in BCCB</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements</td><td>Frequency

Annually

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

• Tutorials (6 hours)
• Private study (25 hours)
• Preparation and conducting an oral presentation (31.5 hours)</td></tr>
<tr><td>Duration

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

62.5 hours</td></tr>
<tr><td>Pre-requisites

☒ General Biochemistry and General Cell Biology</td><td>Co-requisites

☒ Microbiology</td><td>Knowledge, Abilities, or Skills

• Basic knowledge of biochemistry and cell biology
• Basic laboratory skills in biochemistry and cell biology
• S1 safety instructions</td><td colspan="3"></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</td></tr>
</table>

1. apply their theoretical knowledge to understand the use of microbiological methods in state-of-the-art research publications;
2. examine alternative ways for application of basic methods in microbiology and microbial biochemistry;
3. interpret the level of sterility and sterile research work from published data
4. interpret experimental data in microbiology;
5. 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.

Examination Type: Module Examination

Assessment Type: Presentation

Duration: 30 min
Weight: 100%

Scope: All intended learning outcomes of the seminar

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

7.8 Infection and Immunity

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

Infection and Immunity</td><td>Module Code

CO-401</td><td>Level (type)

Year 2 (CORE)</td><td>CP

7.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>CO-401-A</td><td colspan="3">Immunology</td><td>Lecture</td><td>5</td></tr>
<tr><td>CO-401-B</td><td colspan="3">Microbial Pathogenicity</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

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

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

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

Pre-requisites

☒ General Biochemistry and General Cell Biology</td><td rowspan="2">Co-requisites

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

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

Annually

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

• Lectures (52.5 hours)
• Private study (135 hours)</td></tr>
<tr><td>Duration

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

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

Students should have a sound background in biochemistry and cell biology that they acquired by attending the respective CHOICE modules. They should understand the basic structure and function of biomolecules, and the general principles by which cells multiply and interact with each other. Furthermore, students should have acquired basic skills in experimental molecular biology techniques from the respective CHOICE laboratory courses.</td></tr>
<tr><td colspan="6">Content and Educational Aims

Infectious diseases of all types have always been and still are a major threat to our civilization. Our immune system defends us against pathogens such as viruses, bacteria, worms, and fungi, and it also contributes to protection against cancer and other diseases. The module brings pathogenicity and immunity and their relationship into close context and enables a thorough understanding of the underlying complexities.

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

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 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

1. explain the topics of the lecture at the level presented;
2. apply this understanding to relate the basic knowledge to current problems in research and medicine;
3. analyze and discriminate immunological challenges posed by specific pathogens;
4. correlate pathogen exposure with the characteristic answer of the immune system;
5. judge the success rates, likelihoods, and time lines of different immunological treatments currently available, in development, or being envisioned;
6. apply knowledge of biochemical and cellular processes to understand principles in infection biology;
7. analyze infectious diseases, their principles and mechanisms;
8. evaluate the applicability of molecular methods to assess microbial pathogenicity;
9. distinguish between how bacteria, fungi, viruses or parasitic pathogen infect a host;
10. identify and investigate microbial pathogens and their role in symptom development;
11. prioritize measures on how to cope with a microbial infection;
12. correlate basic principles of immunology and pathogenicity;
13. deduce the impact of a virulence or pathogenicity factor on the functioning of the immune system;
14. 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.

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: Written examination — Duration: 60 min, Weight: 33%

Scope: All intended learning outcomes

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

7.9 Advanced Biochemistry I

<table>
<tr><td colspan="2">Module Name
Advanced Biochemistry I</td><td colspan="2">Module Code
CO-402</td><td>Level (type)
Year 2
(CORE)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-402-A</td><td colspan="3">Metabolic Pathways</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator
Prof. Dr. Susanne Illenberger</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" rowspan="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)</td><td colspan="2">Forms of Learning and Teaching
• Lecture (35 hours)
• Private study (90 hours)</td></tr>
<tr><td>Duration
1 semester</td><td colspan="2">Workload
125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation
Revision of the module content of the pre-required CHOICE modules</td></tr>
<tr><td colspan="6">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. 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 DNA and RNA 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>
</table>

Intended Learning Outcomes By the end of this module, students will be able to 1. explain advanced theoretical concepts of metabolism; 2. outline advanced biochemical experimental methods that provide an entry point into independent experimental work; 3. outline key biochemical pathways and selected reaction mechanisms; 4. predict the outcome of metabolic pathways under variable conditions; 5. qualitatively and quantitatively solve thermodynamic equations; 6. apply their knowledge to novel problems; 7. 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
Examination Type: Module Examination Assessment Type: Written examination Duration: 120 min Weight: 100% Scope: All intended learning outcomes of the module. Completion: To pass this module, the examination has to be passed with at least 45%.

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</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-403-A</td><td colspan="3">Molecular Genetics</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Felix Jonas</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</td><td>Frequency

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

• Lecture (35 hours)
• Private study (90 hours)</td></tr>
<tr><td>Pre-requisites

☒ General Biochemistry

☒ General Cell Biology</td><td>Co-requisites

☒ None</td><td>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>Duration

1 semester</td><td colspan="2">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 provide a detailed understanding of the biochemical mechanisms that underlie the realization of genetic information in living systems. Initially, the focus lies on the organization of genetic information in eukaryotic and prokaryotic cells. Molecular mechanisms are elucidated, by which genetic information is replicated/inherited, 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</td></tr>
</table>

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

1. discriminate different types of nucleic acid structures and understand the spatial organization of genetic information in cells;
2. outline the flow and control of genetic information in living systems;
3. explain the mechanisms of replication, transcription and translation;
4. discriminate regulatory processes on the different levels of the flow of information;
5. outline advanced biochemical experimental methods that provide an entry point into independent experimental work;
6. interpret experimental data obtained by these methods;
7. predict the outcome of information pathways under variable conditions;
8. summarize epigenetic control mechanisms;
9. assess which repair mechanisms act on which type of DNA damage;
10. rate the impact of the different mechanisms acting in the altered use of genetic information;
11. apply their knowledge to novel problems;
12. 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

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module.

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

7.11 Advanced Biochemistry Lab

<table>
<tr><td colspan="3">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="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-404-A</td><td colspan="3">Advanced Biochemistry Lab</td><td>Lab</td><td>5</td></tr>
<tr><td>Module Coordinator
Prof. Sebastian Springer DPhil</td><td colspan="3">Program Affiliation
• Biochemistry and Cell Biology (BCCB)</td><td colspan="2">Mandatory Status
Mandatory for BCCB</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

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

Pre-requisites: ☒ General Biochemistry
☒ General Cell Biology

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)</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)</td></tr>
<tr><td>Duration
1 semester</td><td colspan="2">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 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>
</table>

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.
Intended Learning Outcomes By the end of this module, students will be able to 1. explain and practically apply various techniques in the biochemistry laboratory; 2. perform all calculations required to prepare the experiments; 3. organize the laboratory workflow to be safe, equitable, and reproducible; 4. act safely in the laboratory; 5. assess the method most suitable for a given scientific problem; 6. exchange results, discuss them with their peers, and defend them in front of an audience; 7. write up their results in a coherent laboratory report.
Indicative Literature Laboratory Manuals (updated yearly)
Usability and Relationship to other Modules
Examination Type: Module Examination Assessment Type: Laboratory Reports — Duration: 5 x 10 pages; Weight: 100% Scope: All intended learning outcomes of the module. Completion: To pass this module, the examination has to be passed with at least 45%.

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</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-405-A</td><td colspan="2">From Cells to Tissues</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. 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" rowspan="2">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)</td><td colspan="2">Forms of Learning and Teaching

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

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

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

Intended Learning Outcomes

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

1. explain key molecular mechanisms and regulatory processes in cell biology in detail;
2. identify specific cell types common or unique to specific tissues;
3. explain cellular interactions in tissues and organs;
4. examine tissue morphogenesis and organ functions for an advanced understanding of physiological bodily functions;
5. evaluate experimental designs used to answer key cell biological questions;
6. critically compare model systems used in cell biological research approaches;
7. enhance personal competence in abstracting complex data and devising scientific hypotheses.

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.

Usability and Relationship to other Modules

Examination Type: Module Examination

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

Scope: All intended learning outcomes of the module.

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

7.13 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</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-406-A</td><td colspan="2">From Genes to Organism</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. 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" rowspan="2">Entry Requirements

Pre-requisites: ☒ General Cell Biology ☒ General Biochemistry ☒ 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)</td><td colspan="2">Forms of Learning and Teaching

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

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

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

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.

Intended Learning Outcomes

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

1. explain key molecular mechanisms and regulatory cellular processes in detail;
2. relate individual cellular processes to one another in early organismal development;
3. critically compare model systems used in developmental biology;
4. correlate alterations in molecular functions to consequences in organismal development;
5. explain the general principles underlying natural selection and evolution;
6. apply simple calculations to predict changes in allele frequency;
7. deduce common principles in cell communication and regulation;
8. enhance personal competence in abstracting complex cellular processes.

Indicative Literature

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

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

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module.

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

7.14 Advanced Cell Biology Lab

Module Name			**Module Code**	**Level (type)**	**CP**
Advanced Cell Biology Lab			CO-407	Year 2 (CORE)	5
Module Components					
Number	Name			Type	CP
CO-407-A	Cellular Compartments			Lab	5
Module Coordinator Prof. Dr. Klaudia Brix	**Program Affiliation** • Biochemistry and Cell Biology (BCCB)			**Mandatory Status** Mandatory for BCCB	
Entry Requirements			**Frequency**	**Forms of Learning and Teaching**	
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	Annually (Fall)	• 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)	
			Duration Blocked course, Intersession	**Workload** 125 hours	
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)					

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 including quantitative cell biological approaches. 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

1. explain key regulatory processes in cell biology;
2. discover the structure-function relationship of biomolecules at the cellular level;
3. gain detailed insight into the experimental analysis of cells on the practical level;
4. employ the regulatory framework of genetic engineering in the bioscience field;
5. test research questions of protein targeting and trafficking experimentally;
6. consider the basic principles of image analysis and quantitative cell biology;
7. enhance personal competence in experimental skills in a research-oriented manner;
8. 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

Examination Type: Module Examination

Assessment Type: Lab report

Length: 20 pages
Weight: 100%

Scope: All intended learning outcomes of the module.

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

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 (Specialization)</td><td>CP

5</td></tr>
<tr><td colspan="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CA-BCCB-802</td><td colspan="2">Experimental Strategy Design</td><td>Lecture and Seminar</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. 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="2" rowspan="2">Entry Requirements

Pre-requisites: ☒ Advanced Cell Biology I; ☒ 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)</td><td colspan="2">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)
• Project (25 hours)</td></tr>
<tr><td>Duration

1 semester</td><td colspan="2">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</td></tr>
</table>

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.

Intended Learning Outcomes

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

1. explain routine and advanced methodology;
2. evaluate the advantages and limitations of different methods;
3. formulate and test hypotheses for experimental research based on current knowledge and literature;
4. predict the experimental outcomes of experiments;
5. study and critically analyze scientific literature;
6. design a coherent experimental strategy in Molecular Life Science;
7. present experimental data in both, oral and written form;
8. 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

Examination Type: Module Examination

Assessment Type: Project Weight: 100%

Scope: All intended learning outcomes of the module.

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

7.16 Biomedicine

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

Biomedicine</td><td>Module Code

CA-S-BCCB-804</td><td>Level (type)

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

5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CA-BCCB-804</td><td colspan="3">Biomedicine</td><td>Lecture and seminar</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Klaudia Brix</td><td colspan="3">Program Affiliation

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

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

Annually

(Spring)</td><td colspan="2">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)</td></tr>
<tr><td>Duration

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

125 hours</td></tr>
<tr><td>Pre-requisites

☒ Advanced Cell Biology I

☒ Advanced Cell Biology II</td><td>Co-requisites

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

• Advanced knowledge in cell biology
• Ability to read and understand scientific articles
• Critical discussion skills</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="6">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>
</table>

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.

Intended Learning Outcomes

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

1. explain key regulatory processes in cell biology in detail;
2. explain possible mechanisms of disease;
3. understand diagnostics and therapy development;
4. employ the regulatory framework of activities in the bioscience field;
5. critically assess approaches in translational medicine;
6. study and critically interpret scientific articles;
7. present other's data while critically discussing their graphical, verbal and oral depiction;
8. 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

Examination Type: Module Examination

Assessment Type: Poster presentation

Duration: 30 min
Weight: 100%

Scope: All intended learning outcomes of the module.

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

7.18 Environmental Microbiology and Biotechnology

Module Name	Module Code	Level (type)	CP
Environmental Microbiology and Biotechnology	CA-S-CBT-804	Year 3 (Specialization)	5

Module Components

Number	Name	Type	CP
CA-S-CBT-804	Environmental Microbiology and Biotechnology	Lecture	5

Module Coordinator	Program Affiliation	Mandatory Status
Dr. Boran Kartal	• Chemistry and Biotechnology (CBT)	Mandatory elective for BCCB and CBT

Entry Requirements			Frequency	Forms of Learning and Teaching
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Spring)	• Lecture and presentations (45 hours) • Private study (45 hours) • Exam preparation (35 hours)
☒ General and Inorganic Chemistry ☒ General Biochemistry ☒ Introduction to Biotechnology or ☒ Microbiology (for BCCB students)	☒ none	• Basic knowledge of Microbiology, Molecular Biology, Biotechnology	**Duration** 1 semester	**Workload** 125 Hours

Recommendations for Preparation

Taking the CORE Modules Industrial Biotechnology (CBT) and Microbiology (BCCB) is helpful. Recall the contents of General Biochemistry Module.

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.

Intended Learning Outcomes

Upon completion of this module, students will be able to

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

Indicative Literature

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

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min.
Weight: 100%

Scope: All intended learning outcomes of the module

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

7.19 Current Topics in the Molecular Life Sciences

Module Name	Module Code	Level (type)	CP
Current Topics in the Molecular Life Sciences	CA-S-BCCB-801	Year 3 (Specialization)	5

Module Components

Number	Name	Type	CP
CA-BCCB-801	Current Topics in the Molecular Life Sciences	Seminar	5

Module Coordinator	Program Affiliation	Mandatory Status
Prof. Sebastian Springer DPhil	• Biochemistry and Cell Biology (BCCB)	Mandatory elective for BCCB and MCCB

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

Recommendations for Preparation

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

Content and Educational Aims

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

Intended Learning Outcomes

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

1. explain how publications in the Molecular Life Sciences are structured;
2. explain how publications in the Molecular Life Sciences are put together and written by the authors;
3. explain how publications in the Molecular Life Sciences are pre-reviewed and how they undergo changes during the review process;
4. analyze a scientific paper of their own choice in detail and how to evaluate its logical reasoning;
5. professionally and coherently explain scientific experiments to a professional audience;
6. test scientific conclusions for their logical rigor and discuss this with peers;
7. report on some of the latest and most modern developments in the molecular life sciences;
8. present scientific results (own or others') in front of an audience;
9. 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;
10. plan an oral presentation for diverse audiences;
11. design slides to explain a specific set of scientific contents;
12. 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;
13. 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

Examination Type: Module Examination

Assessment Type Presentation — Duration: 45 minutes, Weight: 100%

Scope: All intended learning outcomes of the module.

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

7.20 Neurobiology of Behavior

<table>
<tr><td colspan="3">Module Name
Neurobiology of Behavior</td><td>Module Code
CO-683</td><td>Level (type)
Year 3 (Specialization)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-683-A</td><td colspan="3">Neurobiology of Behavior I</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>CO-683-B</td><td colspan="3">Neurobiology of Behavior II</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Ben Godde</td><td colspan="3">Program Affiliation
Integrated Social and Cognitive Psychology (ISCP)</td><td colspan="2">Mandatory Status

Mandatory for a minor in Cognitive Psychology
Mandatory elective for BCCB and ISCP</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ Essentials of Cognitive Psychology
Co-requisites: ☒ None
Knowledge, Abilities, or Skills</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching
Lectures (35 hours)
Private study (90 hours)</td></tr>
<tr><td>Duration

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

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

None.</td></tr>
<tr><td colspan="6">Content and Educational Aims
This module introduces state-of-the-art knowledge of structure-function relationships in the mammalian nervous system, particularly at the large-scale systems level. Starting from the organization of neural systems and the neuroanatomy of the brain, this module focuses on the neurobiological basis of cognitive processing in the areas of perception, motor control, attention, emotion, memory, learning, and language, etc. How do neurons communicate? What do drugs do to the brain and how do they alter behavior? How is the brain involved in making decisions? How does the brain change? These and other questions as well as critical perspectives are addressed in this module.

With a clear focus on the human brain, the module provides a basic review of the brain as a biological organ, including its basic structure and operations, and teaches students how the brain gives rise to a wide variety of complex behaviors. You will learn how to integrate knowledge obtained from several levels of analysis – neurons, circuits, systems – into a coherent understanding of the brain’s structure and function. Thus, this module, lays the groundwork for other modules in psychology that relate behavior to underlying neural mechanisms. You will learn to evaluate the challenges and limits of modern, neuro-oriented psychology.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes
By the end of this module, you will be able to
explain the brain’s basic structure and processes;
describe how brain structures and functions relate to psychological processes, phenomena, and behaviors;
critically evaluate the neuroscience approach to psychology.</td></tr>
<tr><td colspan="6">Indicative Literature
Kolb, B. & Wishaw I.Q (2015).Fundamentals of Human Neuropsychology, 7th ed. New York: Worth Publishers.
Breedlove, S.M. & Watson, N.V. (2017). Behavioral Neuroscience, 8th ed. Sunderland: Sinauer.</td></tr>
</table>

Usability and Relationship to other Modules
Examination Type: Module Examination Assessment Type: Written examination — Duration: 120 minutes Scope: All intended learning outcomes of the module. — Weight: 100% Completion: To pass this module, the examination has to be passed with at least 45%.

7.21 Neuroscience Methods

<table>
<tr><td colspan="3">Module Name
Neuroscience Methods</td><td>Module Code
CO-684</td><td>Level (type)
Year 3
(Specialisation)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-684-A</td><td colspan="3">Neuroscience Methods</td><td>Seminar</td><td>2.5</td></tr>
<tr><td>CO-684-B</td><td colspan="3">Neuroscience Methods Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Ben Godde</td><td colspan="3">Program Affiliation

• Integrated Social and Cognitive Psychology (ISCP)</td><td colspan="2">Mandatory Status

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

Pre-requisites

☒ Essentials of Cognitive Psychology

Co-requisites

☒ Neurobiology of Behavior 1

Knowledge, Abilities, or Skills</td><td>Frequency

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

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

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

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

Content and Educational Aims

In neurobiology and cognitive psychology, respectively, a vast array of methods exists for investigating neuropsychological processes from single cells up to complex human behavior. Apart from basic research, these methods are very important in clinical investigations. Both in terms of methods that enable researchers to analyze processes (e.g. structural and functional neuroimaging, magnetoencephalography) and of techniques for manipulating processes (e.g. brain stimulation, optogenetic methods), fundamental new techniques have been developed recently.

Based on this, a thorough overview of available methods and their specific purposes is essential. With a strong focus on human brain imaging and electrophysiology, this module provides you with both practical skills and the conceptual knowledge to responsibly choose modern human brain imaging techniques for specific research or diagnostics purposes and to critically discuss their application potential as revealed by seminal or recent publications in the field.

Intended Learning Outcomes

Upon completion of this module, you will be able to

1. choose and apply appropriate methods to answer specific research questions;
2. interpret empirical results in the context of the chosen methods;
3. draw implications for further research from specific findings;
4. critically assess and compare the advantages and disadvantages of selected techniques.

Indicative Literature

Kolb, B. & Wishaw I.Q (2015).Fundamentals of Human Neuropsychology, 7th ed. Chapter 7: Imaging the brain's activity. New York: Worth Publishers.

Usability and Relationship to other Modules

Examination Type: Module Component Examinations

Module Component 1: Seminar

Assessment Type: Presentation

Length: 15-20 minutes (+ Summary: ~ 500 words)
Weight: 50%

Scope: Intended learning outcomes of the lecture (2-4).

Module Component 2: Lab

Assessment Type: Lab report

Length 1500 Words
Weight: 50%

Scope: Intended learning outcomes of the lab (1).

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

7.22 Scientific Software and Databases

<table>
<tr><td colspan="2">Module Name
Scientific Software and Databases</td><td>Module Code
CO-443</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-443-A</td><td colspan="2">Scientific Software and Databases</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

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

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

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

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

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

• Lecture (20 hours)
• Seminar (15 hours)
• Homework and self-study (50 hours)
• Preparation of term paper (45 hours)</td></tr>
<tr><td>Duration
1 semester</td><td colspan="2">Workload
125 hours</td></tr>
<tr><td colspan="5">Recommendations for Preparation

First-year modules in General Chemistry, Organic Chemistry, Biochemistry, and Biotechnology</td></tr>
<tr><td colspan="5">Content and Educational Aims

The students will be familiarized with software to visualize scientific information in chemistry and life sciences. They will be familiarized with the sources used to draw the relevant scientific information, and the retrieval of primary sources of data. They will be familiarized with software to present results, and with software to numerically evaluate data.</td></tr>
<tr><td colspan="5">Intended Learning Outcomes

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

1. use software to write reports and scientific papers;
2. use software to evaluate and handle numerical data;
3. use software to present data graphically;
4. use Entrez as a source of information on the life sciences;
5. use software to draw chemical structures;
6. use SciFinder to find information on research subjects, chemical structures and substructures, reactions to and from given structures, and patents;
7. use the Cambridge Data System to retrieve data on crystal structures;
8. use software to visualize data for small molecules;
9. use PDB to retrieve and three-dimensionally visualize data on protein structures and interactions;
10. use software to visualize protein structures and the interaction of small molecules with proteins;
11. use GenBank to retrieve information on gene sequences and the similarities between genes;
12. use metabolic data banks to retrieve information on metabolic pathways;
13. use data banks to obtain information about clinical trials;
14. use data banks to obtain data on toxicity and the side effects of drugs;
15. retrieve the primary sources of information of such data.</td></tr>
</table>

Indicative Literature Handout provided by instructor.
Usability and Relationship to other Modules Module can be replaced with a CORE module from another study program in order to pursue a minor, but has to be taken in Year 3, replacing one specialization module
Examination Type: Module Examination Assessment Type: Term paper — Duration: 3000 words; Weight: 100% Scope: All intended learning outcomes of the module. Completion: To pass this module, the examination has to be passed with at least 45%.

7.23 Industrial Biotechnology

<table>
<tr><td colspan="3">Module Name
Industrial Biotechnology</td><td>Module Code
CO-441</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-441-A</td><td colspan="3">Industrial Biotechnology</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Elke Nevoigt</td><td colspan="3">Program Affiliation

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

Mandatory for CBT and minor in CBT

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

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

Lecture (45 hours)
Private study (45 hours)
Exam preparation (35 hours)</td></tr>
<tr><td>Pre-requisites</td><td>Co-requisites</td><td>Knowledge, Abilities, or Skills</td></tr>
<tr><td>☒ Introduction to Biotechnology
or
☒ Cell Biology</td><td>☒ None</td><td>• None beyond formal prerequisites</td><td>Duration

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

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

None.</td></tr>
<tr><td colspan="6">Content and Educational Aims
This module provides insight into how biotechnology impacts chemical production. The replacement of both chemical catalysts by enzymes and cells and of fossil resources by renewable raw materials are two aspects that are increasingly pushed by the chemical industry in order to achieve a more sustainable production of bulk and fine chemicals, building blocks for chemical industry as well as food ingredients, bioplastics, and biofuels. Using a number of commercially successful examples as well as current R&D efforts of chemical industry, students will be introduced to the advantages and practice of implementing cells or enzymes for the production of industrially relevant products. Moreover, the module describes the utilization of biomass and biomass waste streams as feedstock for the production of the above mentioned compounds.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes
By the end of the module, the student will be able to

1. evaluate the use of renewable as opposed to fossil resources as raw materials for chemical production;
2. explain the impact of using enzymes and cells in the chemical and pharmaceutical industry;
3. evaluate the value and applications of industrial enzymes;
4. express the concept of a cell factory;
5. list important commercial products made by microorganisms;
6. assess the limitations of natural organisms for chemical production;
7. evaluate the feasibility of a bio-based process compared to its chemical counterpart;
8. identify possibilities to modify the characteristics of an enzyme
9. sketch the basic concept of metabolic engineering;</td></tr>
</table>

Indicative Literature

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

Usability and Relationship to other Modules

The module Industrial Biotechnology is complementary to the Advanced Biotechnology Lab and synergistic to the Specialization course Environmental Microbiology and Biotechnology;

Examination Type: Module Examination

Assessment Type: Written examination

Duration: 120 min.
Weight: 100%

Scope: All intended learning outcomes of the module

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

7.24 Chemical Biology

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

Chemical Biology</td><td>Module Code

CO-421</td><td>Level (type)

Year 2 (CORE)</td><td>CP

5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-421-A</td><td colspan="3">Chemical Biology</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Klaudia Brix

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

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

Mandatory for a MCCB and minor in MCCB

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

Pre-requisites

☒ General Medicinal Chemistry and Chemical Biology
☒ General Organic Chemistry

Co-requisites

☒ None

Knowledge, Abilities, or Skills

• Basic knowledge in biochemistry, cell biology, and organic chemistry
• Understanding of structure-function relationships at the molecular and cellular levels</td><td>Frequency

Annually

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

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

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

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

• Read the chapters in the recommended textbooks that cover the respective topics of this lecture course (see syllabus)
• attend the lab meetings of research groups in the Life Sciences and Chemistry
• visit the Molecular Life Sciences Seminar series in which researchers from other institutions are invited to give talks</td></tr>
</table>

Content and Educational Aims

Chemical biology combines the fields of chemistry and biology. In particular, chemical techniques such as targeted drug design and small molecule synthesis are applied to study and interfere with biological systems. In such approaches, the aim is to analyze, quantify and modify regulatory mechanisms of cellular and organ systems. Therefore, a general understanding of physiological processes is crucial. This module will focus on cellular decision making by enzymes that mediate biological processes and enable cellular functions as diverse as cell differentiation, proliferation, tissue regeneration, and cell death. The group of enzymes chosen are the hundreds of proteolytic enzymes that enable the most important post-translational modification, proteolysis. Proteases are critical – vital or deadly – from the beginning of life until its end they regulate the cell cycle, they involve in developmental processes, and they bring about catabolism. Proteolytic cleavages allow the activation and inactivation of cellular programs through the maturation, activation, inactivation, or destruction of the key molecules involved. Proteases are involved in as many diseases as molecules exist, and because their action is irreversible, they are prime targets to treat diseases with pharmaceutical drugs. From bench to bedside will be the over-arching theme of this module. In keeping with this notion, G protein-coupled receptors constitute another important group of molecules that have more recently been targeted in pharmacology. The use of biologics is another recent paradigm shift in the treatment of diseases and pharmaceutical exploitation. These topics will be discussed in order to broaden the understanding of the application aspects of medicinal chemistry and chemical biology.

Intended Learning Outcomes

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

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

Indicative Literature

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

Usability and Relationship to other Modules

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

Examination Type: Module Examination

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

Scope: All intended learning outcomes of the module.

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

7.25 Drug Discovery

<table>
<tr><td colspan="3">Module Name
Drug Discovery</td><td>Module Code
CA-S-MCCB-805</td><td>Level (type)
Year 3 (Specialization)</td><td>CP
2.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CA-S-MCCB-805</td><td colspan="3">Drug Discovery</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator
Prof. Dr. Björn Windshügel</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" rowspan="2">Entry Requirements
Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills</td><td>Frequency
Annually (Spring/Fall)</td><td colspan="2">Forms of Learning and Teaching
Lecture (17.5 hours)
Private study lecture (45 hours)</td></tr>
<tr><td>Duration
1 semester</td><td colspan="2">Workload
67.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation</td></tr>
<tr><td colspan="6">Content and Educational Aims
Drug discovery is a multidisciplinary process that historically requires ten or more years to bring a drug to market. The drug discovery value chain can be divided into pre-clinical and clinical phases, and the subdivisions of each will be discussed. Within those discussions, an important theme will be target identification and validation, which will be covered in detail. The most important techniques for identifying bioactive small molecules will also be presented for different types of drug targets using relevant case study examples. Furthermore, pre-clinical processes such as hit-to-lead development and ADME (absorption, distribution, metabolism, excretion) properties assessment are delineated. Finally, the progression and importance of typical clinical trials will be covered (phase I-III) and this is complemented with the critical points required for regulatory approval.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes
Upon completion of this module, students will be able to
1. explain the overall process of drug discovery
2. summarize the challenges of the drug discovery process
3. plan an early stage drug discovery study for a given target
4. assess the validity of a potential drug target
5. interpret the outcome of a screening campaign
6. recommend strategies for characterizing bioactive small molecules
7. select the best candidate compound to be progressed in clinical trials</td></tr>
</table>

Indicative Literature

Benjamin Blass: Basic Principles of Drug Discovery and Development. Academic Press, 2nd edition 2021

Rick Ng: Drugs: From Discovery to Approval. Wiley-Blackwell 3rd edition 2015

Raymond G. Hill, Humphrey P. rang: Drug Discovery and Development: Technology in Transition. Churchill Livingstone 2nd edition 2012

Usability and Relationship to other Modules

- This module is for students who continue to be curious and want to extend their studies within the field of drug discovery and may considering graduate level education in Life Sciences or Medicinal Chemistry.

Examination Type: Module Examination

Assessment Type: Written examination

Duration/length: 90 min
Weight: 100%

Scope: All intended learning outcomes of the module.

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

7.26 Synthetic Biology

<table>
<tr><td colspan="2">Module Name
Synthetic Biology</td><td>Module Code
CA-S-MCCB-804</td><td>Level (type)
Year 3 (Specialization)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CA-S-MCCB-804</td><td colspan="2">Synthetic Biology</td><td>Seminar</td><td>5</td></tr>
<tr><td>Module Coordinator

Dr. Andreas M. Lisewski</td><td colspan="2">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="2" rowspan="2">Entry Requirements

Pre-requisites: ☒ General Cell Biology
Co-requisites: ☒ None
Knowledge, Abilities, or Skills: • Molecular and cell biology main concepts</td><td>Frequency

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

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

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

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

Review the elementary concepts of Molecular and Cell Biology.</td></tr>
<tr><td colspan="5">Content and Educational Aims
Assuming elementary knowledge in molecular and cell biology the students will learn the basic elements of molecular biology (such as DNA replication, transcription, translation) from a modern information engineering perspective that incorporates the transmission of genetic information from a sender to a receiver (communication theory at a molecular biology level). This allows a representation of the basic concepts of synthetic biology using a hierarchy of abstraction through parts, modules, devices, and sender-receiver systems. We then critically discuss several landmark experimental realizations of this hierarchy during the "golden decade" of synthetic biology, from the 2000s to 2010s, including genetic logic gates, engineered genetic and metabolic networks, and synthetic genomes or even entire cells. A subtheme is additionally placed on the technological risks and societal impacts that come from breakthroughs in synthetic biology.</td></tr>
<tr><td colspan="5">Intended Learning Outcomes
Identify and explain basic concepts in synthetic biology by collecting and assessing appropriate items from the primary literature
Schematize, differentiate and discuss parts, modules, and devices in synthetic biology systems
Conclude that parts, modules, and devices predispose synthetic biological systems to rational (re-)design and engineering
Identify information codes, redundancy and errors (noise) in synthetic biology systems
Break down today's main directions in synthetic biology, present their landmark experiments, and formulate specific technical challenges in their experimental realizations
Assess, compare, and rank inherent risks (e.g., from individual to public health, to entire human society) associated with synthetic biology</td></tr>
</table>

Indicative Literature

Synthetic Biology - A Primer (Revised Edition), Geoff Baldwin, Published 2016; ISBN 978-1783268795

Cameron, D., Bashor, C. & Collins, J. A brief history of synthetic biology. Nat Rev Microbiol 12(5):381-390 (2014) https://doi.org/10.1038/nrmicro3239

Meng, F., Ellis, T. The second decade of synthetic biology: 2010–2020. Nat Commun 11(1):5174 (2020). https://doi.org/10.1038/s41467-020-19092-2

Usability and Relationship to other Modules

- Complements and further advances General Cell Biology and Advanced Cell Biology I and II (BCCB)
- Partly complements Bioprocess Engineering and Chemical and Pharmaceutical Technology (CBT)

Examination Type: Module Examination

Assessment Component: Oral examination

Duration/Length: <40 min

Weight: 100%

Scope: All intended learning outcomes of the module

Module achievement: Oral presentation of landmark experiments in synthetic biology

The module achievement ensures sufficient knowledge of key experiments and their underlying technologies.

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

7.27 Internship / Startup and Career Skills

<table>
<tr><td colspan="3">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="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CA-INT-900-0</td><td colspan="3">Internship</td><td>Internship</td><td>15</td></tr>
<tr><td>Module Coordinator

Sinah Vogel & Dr. Tanja Woebs (CSC Organization); SPC / Faculty Startup Coordinator (Academic responsibility)</td><td colspan="3">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="3" rowspan="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)</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</td></tr>
<tr><td>Duration
1 semester</td><td colspan="2">Workload

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

Recommendations for Preparation

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

Content and Educational Aims

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

The full-time internship must be related to the students' major area of study and extends lasts a minimum of two consecutive months, normally scheduled just before the 5th semester, with the internship event and submission of the internship report in the 5th semester. Upon approval by the SPC and CSC, the internship may take place at other times, such as before teaching starts in the 3rd semester or after teaching finishes in the 6th semester. The Study Program

Coordinator or their faculty delegate approves the intended internship a priori by reviewing the tasks in either the Internship Contract or Internship Confirmation from the respective internship institution or company. Further regulations as set out in the Policies for Bachelor Studies apply.

Students will be gradually prepared for the internship in semesters 1 to 4 through a series of mandatory information sessions, seminars, and career events.
The purpose of the Career Services Information Sessions is to provide all students with basic facts about the job market in general, and especially in Germany and the EU, and services provided by the Career Service 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 Service Center (e.g. the annual Constructor 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 4^{th} 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 will be able to

1. describe the scope and the functions of the employment market and personal career development;
2. 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.;
3. 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.);
4. 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;
5. justify professional decisions based on theoretical knowledge and academic methods;
6. reflect on their professional conduct in the context of the expectations of and consequences for employers and their society;
7. reflect on and set their own targets for the further development of their knowledge, skills, interests, and values;
8. 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;
9. discuss observations and reflections in a professional network.

Indicative Literature

Not specified

Usability and Relationship to other Modules

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%

7.28 Bachelor Thesis and Seminar BCCB

Module Name	Module Code	Level (type)	CP
Bachelor Thesis and Seminar BCCB	CA-BCCB-800	Year 3 (CAREER)	15

Module Components

Number	Name	Type	CP
CA-BCCB-800-T	Thesis BCCB	Scientific Project	12
CA-BCCB-800-S	Seminar BCCB	Seminar	3

Module Coordinator	Program Affiliation	Mandatory Status
Prof. Sebastian Springer DPhil	Biochemistry and Cell Biology (BCCB)	Mandatory for BCCB

Entry Requirements

Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills
☒ Students must have taken and successfully passed a total of at least 30 CP from advanced modules, and of those, at least 20 CP from advanced modules in the major.	☒ None	Advanced skills in Biochemistry and Cell Biology Advanced self-directed study skills Basic presentation skills

Frequency	Forms of Learning and Teaching
Annually (Spring)	• Private study (104 hours) • Scientific project work (200 hours) • Seminar (21 hours) • Writing (50 hours)

Duration	Workload
14-week lecture period	375 hours

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.

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. Data analyses and interpretation will be according to good scientific practice and ethical standards. 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.

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. evaluate situations and make decisions based on ethical considerations, and adhere to and defend ethical, scientific, and professional standards
13. 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.

Examination Type: Module Component Examinations

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

Scope: Intended learning outcomes 6-13

Module Component 2: Seminar
Mandatory Achievement: Attendance of online lecture series on ethical topics.
Assessment Type: Presentation — Duration: 45 min
Weight: 20%

Scope: Intended learning outcomes 1-5

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

8. CONSTRUCTOR Track Modules

8.1 Methods Modules

8.1.1 Mathematical Concepts for the Sciences

Module Name	**Module Code**	**Level (type)**	**CP**
Mathematical Concepts for the Sciences	CTMS-MAT-07	Year 1 (Methods)	5

Module Components

Number	Name	Type	CP
CTMS-07	Mathematical Concepts for the Sciences	Lecture	5

Module Coordinator	**Program Affiliation**	**Mandatory Status**
Dr. Keivan Mallahi Karai	• CONSTRUCTOR Track Area	Mandatory for BCCB, CBT, ESSMER and MCCB

Entry Requirements

Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills
☒ None	☒ None	

Frequency	**Forms of Learning and Teaching**
Annually (Fall)	Lectures (35 hours) Private study (90 hours)

Duration	**Workload**
1 semester	125 hours

Recommendations for Preparation

Review basic mathematical concepts and tools.

Content and Educational Aims

In this module, students develop and strengthen quantitative problem-solving skills that are important in the natural sciences. Hands-on exercises and group work are integrated in the lectures to maximize feedback between the students and the instructor. The module starts with a review of elementary mathematical concepts such as functions and their graphs, units and dimensions, and series and convergence. Vectors and matrices are introduced using linear equations, and then motivated further in the context of basic analytical geometry. An extended section on calculus proceeds from basic differentiation and integration to the solution of differential equations, always guided by applications in the natural sciences. The module is concluded by a data-oriented introduction to descriptive statistics and basic statistical modeling applied to laboratory measurements and observations of natural systems.

Intended Learning Outcomes

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

1. identify important types of quantitative problems in the natural sciences;
2. select and use key solution strategies, methods, and tools;
3. explain and apply linear algebra concepts and techniques;
4. analyze models and observations of natural systems using derivatives and integrals;
5. classify differential equations, find equilibria, and apply standard solution methods;
6. 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

Examination Type: Module Examination

Assessment type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of this module.

Completion: To pass this module, the examination must be passed with at least 45%.

8.1.2 Physics for the Natural Sciences

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

Physics for the Natural Sciences</td><td>Module Code

CTMS-SCI-17</td><td>Level (type)

Year 1
(Methods)</td><td>CP

5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTMS-17</td><td colspan="3">Physics for the Natural Sciences</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Jürgen Fritz</td><td colspan="3">Program Affiliation
CONSTRUCTOR Track Area</td><td colspan="2">Mandatory Status

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

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

☒ None | ☒ None | High school math
Basic high school physics</td><td>Frequency

Annually

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

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

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

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

Intended Learning Outcomes

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

1. recall the basic facts and experimental evidence in mechanics, thermodynamics, electromagnetism, optics and modern physics;
2. use the basic concepts of motion, force, energy, oscillations, heat, and light to describe natural and technical phenomena;
3. 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;
4. apply basic calculus, geometry, and vector analysis for a quantitative description of physical systems.

Indicative Literature

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

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

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

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination must be passed with at least 45%.

8.1.3 Introduction to Bioinformatics

Module Name			Module Code	Level (type)	CP
Introduction to Bioinformatics			CTMS-SCI-19	Year 2 (Methods)	5
Module Components					
Number	Name			Type	CP
CTMS-19	Introduction to Bioinformatics			Lecture and exercise	5
Module Coordinator Prof. Dr. Marc-Thorsten Hütt & Prof. Dr. Felix Jonas	**Program Affiliation** • CONSTRUCTOR Track Area			**Mandatory Status** Mandatory elective for BCCB	
Entry Requirements Pre-requisites ☒ none	Co-requisites ☒ none	Knowledge, Abilities, or Skills none	**Frequency** Annually (Fall)	**Forms of Learning and Teaching** Class attendance (35 hrs) Private study (80 hrs) Exam preparation (10 hrs)	
			Duration 1 semester	**Workload** 125 hours	

Recommendations for Preparation

It is recommended that students install a recent stable version of Python on their notebooks and familiarize themselves with Jupyter notebooks as a programming environment.

Content and Educational Aims

Bioinformatics has become an indispensable backbone of modern research in biology and medicine. With this course we want to provide an overview of current bioinformatics approaches, ranging from sequence analysis to biological databases and networks. An emphasis is on describing both, the biological applications of such methods as well as the underlying mathematical and algorithmic concepts. The Python programming language will be used to illustrate these concepts.
The theoretical aspects of the lecture will be complemented by hands-on problem-solving exercises that amount to at least 30% of the in-class time. As such, the final examination will have a corresponding fraction of practical problem-solving components.

Intended Learning Outcomes
Upon completion of this module, students will be able to

1. apply standard and current bioinformatics tools
2. explain the limitations and parameter dependences of these tools
3. access and use the main bioinformatics databases
4. delineate the main principles and the relevance of algorithmic approaches

Indicative Literature

Please see CampusNet entry for further details.

Arthur M. Lesk, Introduction to Bioinformatics, Oxford University Press, 2013
R. Durbin, S. Eddy, A. Krogh, G. Mitchison, Biological sequence analysis - Probabilistic models of proteins and nucleic acids, CU Press, 1998
Hütt M., Dehnert M., Methoden der Bioinformatik. 2nd edition. Springer-Verlag, 2016
S Choudhuri, Bioinformatics for Beginners: Genes, Genomes, Molecular Evolution, Databases and Analytical Tools. Academic Press, 2014, and recent scientific literature.

Usability and Relationship to other Modules	
Examination Type: Module Examination	
Assessment Type: Written examination	Duration: 120 min Weight: 100%
Scope: All intended learning outcomes of the module	
Module achievement: Practical in-class exercises	
Completion: To pass this module, the examination must be passed with at least 45%.	

8.1.4 Analytical Methods

Module Name			**Module Code**	**Level (type)**	**CP**
Analytical Methods			CTMS-SCI-16	Year 2 (Methods)	5
Module Components					
Number	Name			Type	CP
CTMS-16	Analytical Methods			Lecture	5
Module Coordinator Prof. Dr. Nikolai Kuhnert	**Program Affiliation** • CONSTRUCTOR Track Area			**Mandatory Status** Mandatory for CBT and MCCB Mandatory elective for BCCB	
Entry Requirements			**Frequency**	**Forms of Learning and Teaching**	
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Fall)	Lecture (35 hours) Tutorial (10 hours) Private study (80 hours)	
☒ None	☒ None	Basic knowledge in Life Sciences	**Duration** 1 semester	**Workload** 125 hours	

Recommendations for Preparation

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

Content and Educational Aims

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

Intended Learning Outcomes

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

1. illustrate knowledge of instrumental methods including spectroscopic techniques and separation techniques;
2. explain and understand physical principles behind spectroscopic techniques and separation techniques and apply them to practically-orientated issues;
3. apply knowledge of instrumental techniques to solve qualitative and quantitative analytical problems;
4. interpret spectroscopic data and deduce chemical structures from these data;
5. compare spectroscopic data and predict spectral properties from chemical structures;
6. calculate quantitative values from analytical results;
7. plan analytical experiments to solve chemical problems;
8. calculate and estimate errors in analytical procedures by applying statistical methods;
9. test scientific hypotheses;
10. 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.

Examination Type: Module Examination

Assessment type: Written examination

Duration: 180 min
Weight: 100%

Scope: All intended learning outcomes of the module

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

8.1.5 Plant Metabolism and Natural Products

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

Plant Metabolism and Natural Products</td><td>Module Code

CTMS-SCI-18</td><td>Level (type)

Year 2
(Methods)</td><td>CP

5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTMS-18</td><td colspan="3">Plant Metabolism and Natural Products</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

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

• CONSTRUCTOR Track Area</td><td colspan="2">Mandatory Status

Mandatory for BCCB and MCCB

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

Pre-requisites: ☒ None

Co-requisites: ☒ None

Knowledge, Abilities, or Skills: Comprehensive high school knowledge of chemistry, mathematics, physics, biochemistry, and cell biology</td><td>Frequency

Annually

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

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

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

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

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

Read the chapter “Plant Form and Function” (Joanne Chory) in the recommended textbook of Neil A. Campbell and Jane B. Reece, BIOLOGY, Benjamin Cummings, Pearson Education, current edition.</td></tr>
<tr><td colspan="6">Content and Educational Aims

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

Intended Learning Outcomes

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

1. apply knowledge of biochemical and cellular processes to understand principles in the world of plants and algae;
2. illustrate a plant's basic metabolic and biochemical features of plants;
3. describe plant cells and plant tissue characteristics;
4. explain how photosynthesis and the Calvin cycle enable autotrophic life;
5. delineate how plants interact with their biotic and abiotic environment;
6. explain the basic principles of Environmental Biochemistry;
7. classify plant hormones, their roles, and the importance of their homeostasis;
8. interpret the bioactivity potential of natural products;
9. outline processes in plant biochemistry and plant genetics;
10. describe natural product biosynthesis;
11. illustrate how plants use basic building blocks to create complex structures;
12. relate biological activities of natural products with their use for medicinal purposes;
13. transfer the acquired knowledge to novel natural products;
14. 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

- It complements the non-photosynthesis learning components of BCCB's general education. It furthermore provides essential background knowledge for medicinal chemistry, chemical biology, chemistry, and biotechnology.
- For CBT major students: the module can be replaced with a CORE module from another study program to pursue a minor.

Examination Type: Module Examination

Assessment type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination must be passed with at least 45%.

8.2 New Skills

8.2.1 Logic (perspective I)

<table>
<tr><td colspan="3">Module Name
Logic (perspective I)</td><td>Module Code
CTNS-NSK-01</td><td>Level (type)
Year 2
New Skills</td><td>CP
2.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTNS-01</td><td colspan="3">Logic (perspective I)</td><td>Lecture (online)</td><td>2.5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Jules Coleman</td><td colspan="3">Program Affiliation
CONSTRUCTOR Track Area</td><td colspan="2">Mandatory Status

Mandatory elective for all UG students (one perspective must be chosen)</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ none
Co-requisites: ☒ none
Knowledge, Abilities, or Skills</td><td>Frequency

Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching
Lecture (online, 17.5h)
Private study (45h)</td></tr>
<tr><td>Duration

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

62.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation</td></tr>
<tr><td colspan="6">Content and Educational Aims

Suppose a friend asks you to help solve a complicated problem? Where do you begin? Arguably, the first and most difficult task you face is to figure out what the heart of the problem actually is. In doing that you will look for structural similarities between the problem posed and other problems that arise in different fields that others may have addressed successfully. Those similarities may point you to a pathway for resolving the problem you have been asked to solve. But it is not enough to look for structural similarities. Sometimes relying on similarities may even be misleading. Once you've settled tentatively on what you take to be the heart of the matter, you will naturally look for materials, whether evidence or arguments, that you believe is relevant to its potential solution. But the evidence you investigate of course depends on your formulation of the problem, and your formulation of the problem likely depends on the tools you have available – including potential sources of evidence and argumentation. You cannot ignore this interactivity, but you can't allow yourself to be hamstrung entirely by it. But there is more. The problem itself may be too big to be manageable all at once, so you will have to explore whether it can be broken into manageable parts and if the information you have bears on all or only some of those parts. And later you will face the problem of whether the solutions to the particular sub problems can be put together coherently to solve the entire problem taken as a whole.

What you are doing is what we call engaging in computational thinking. There are several elements of computational thinking illustrated above. These include: Decomposition (breaking the larger problem down into smaller ones); Pattern recognition (identifying structural similarities); Abstraction (ignoring irrelevant particulars of the problem): and Creating Algorithms), problem-solving formulas.

But even more basic to what you are doing is the process of drawing inferences from the material you have. After all, how else are you going to create a problem-solving formula, if you draw incorrect inferences about what information has shown and what, if anything follows logically from it. What you must do is apply the rules of logic to the information to draw inferences that are warranted.</td></tr>
</table>

We distinguish between informal and formal systems of logic, both of which are designed to indicate fallacies as well as warranted inferences. If I argue for a conclusion by appealing to my physical ability to coerce you, I prove nothing about the truth of what I claim. If anything, by doing so I display my lack of confidence in my argument. Or if the best I can do is berate you for your skepticism, I have done little more than offer an ad hominem instead of an argument. Our focus will be on formal systems of logic, since they are at the heart of both scientific argumentation and computer developed algorithms. There are in fact many different kinds of logic and all figure to varying degrees in scientific inquiry. There are inductive types of logic, which purport to formalize the relationship between premises that if true offer evidence on behalf of a conclusion and the conclusion and are represented as claims about the extent to which the conclusion is confirmed by the premises. There are deductive types of logic, which introduce a different relationship between premise and conclusion. These variations of logic consist in rules that if followed entail that if the premises are true then the conclusion too must be true.

There are also modal types of logic which are applied specifically to the concepts of necessity and possibility, and thus to the relationship among sentences that include either or both those terms. And there is also what are called deontic logic, a modification of logic that purport to show that there are rules of inference that allow us to infer what we ought to do from facts about the circumstances in which we find ourselves. In the natural and social sciences most of the emphasis has been placed on inductive logic, whereas in math it is placed on deductive logic, and in modern physics there is an increasing interest in the concepts of possibility and necessity and thus in modal logic. The humanities, especially normative discussions in philosophy and literature are the province of deontic logic.

This module will also take students through the central aspects of computational thinking, as it is related to logic; it will introduce the central concepts in each, their relationship to one another and begin to provide the conceptual apparatus and practical skills for scientific inquiry and research.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

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

1. apply the various principles of logic and expand them to computational thinking.
2. understand the way in which logical processes in humans and in computers are similar and different at the same time.
3. apply the basic rules of first-order deductive logic and employ them rules in the context of creating a scientific or social scientific study and argument.
4. employ those rules in the context of creating a scientific or social scientific study and argument

Indicative Literature

Frege, Gottlob (1879), Begriffsschrift, eine der arithmetischen nachgebildete Formelsprache des reinen Denkens [Translation: A Formal Language for Pure Thought Modeled on that of Arithmetic],Halle an der Salle: Verlag von Louis Nebert.

Gödel, Kurt (1986), Russels mathematische Logik. In: Alfred North Whitehead, Bertrand Russell: Principia Mathematica. Vorwort, S. V–XXXIV. Suhrkamp.

Leeds, Stephen. "George Boolos and Richard Jeffrey. Computability and logic. Cambridge University Press, New York and London1974, x+ 262 pp." The Journal of Symbolic Logic 42.4 (1977): 585-586.

Kubica, Jeremy. Computational fairy tales. Jeremy Kubica, 2012.

McCarthy, Timothy. "Richard Jeffrey. Formal logic: Its scope and limits. of XXXVIII 646. McGraw-Hill Book Company, New York etc. 1981, xvi+ 198 pp." The Journal of Symbolic Logic 49.4 (1984): 1408-1409.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written Examination

Duration/Length: 60 min
Weight: 100%

Scope: All intended learning outcomes of the module.

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

8.2.2 Logic (perspective II)

Module Name Logic (perspective II)		**Module Code** CTNS-NSK-02	**Level (type)** Year 2 New Skills	**CP** 2.5
Module Components				
Number	Name		Type	CP
CTNS-02	Logic (perspective II)		Lecture (online)	2.5
Module Coordinator NN	**Program Affiliation** • CONSTRUCTOR Track Area		**Mandatory Status** Mandatory elective for all UG students (one perspective must be chosen)	
Entry Requirements Pre-requisites ☒ none	Co-requisites ☒ none Knowledge, Abilities, or Skills	**Frequency** Annually (/Fall)	**Forms of Learning and Teaching** • Online lecture (17.5h) • Private study (45h)	
		Duration 1 semester	**Workload** 62.5 hours	
Recommendations for Preparation				

Content and Educational Aims

The focus of this module is on formal systems of logic, since they are at the heart of both scientific argumentation and computer developed algorithms. There are in fact many kinds of logic and all figure to varying degrees in scientific inquiry. There are inductive types of logic, which purport to formalize the relationship between premises that if true offer evidence on behalf of a conclusion and the conclusion and are represented as claims about the extent to which the conclusion is confirmed by the premises. There are deductive types of logic, which introduce a different relationship between premise and conclusion. These variations of logic consist in rules that if followed entail that if the premises are true then the conclusion too must be true.

This module introduces logics that go beyond traditional deductive propositional logic and predicate logic and as such it is aimed at students who are already familiar with basics of traditional formal logic. The aim of the module is to provide an overview of alternative logics and to develop a sensitivity that there are many different logics that can provide effective tools for solving problems in specific application domains.
The module first reviews the principles of a traditional logic and then introduces many-valued logics that distinguish more than two truth values, for example true, false, and unknown. Fuzzy logic extends traditional logic by replacing truth values with real numbers in the range 0 to 1 that are expressing how strong the believe into a proposition is. Modal logics introduce modal operators expressing whether a proposition is necessary or possible. Temporal logics deal with propositions that are qualified by time. Once can view temporal logics as a form of modal logics where propositions are qualified by time constraints. Interval temporal logic provides a way to reason about time intervals in which propositions are true.
The module will also investigate the application of logic frameworks to specific classes of problems. For example, a special subset of predicate logic, based on so-called Horn clauses, forms the basis of logic programming languages such as Prolog. Description logics, which are usually decidable logics, are used to model relationships and they have applications in the semantic web, which enables search engines to reason about resources present on the Internet.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

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

1. apply the various principles of logic
2. explain practical relevance of non-standard logic

3. describe how many-valued logic extends basic predicate logic
4. apply basic rules of fuzzy logic to calculate partial truth values
5. sketch basic rules of temporal logic
6. implement predicates in a logic programming language
7. prove some simple non-standard logic theorems

Indicative Literature

Bergmann, Merry. “An Introduction to Many-Valued and Fuzzy Logic: Semantics, Algebras, and Derivation Systems”, Cambridge University Press, April 2008.

Sterling, Leon S., Ehud Y. Shapiro, Ehud Y. "The Art of Prolog", 2nd edition, MIT Press, March 1994.

Fisher, Michael. “An Introduction to Practical Formal Methods Using Temporal Logic”, Wiley, Juli 2011.

Baader, Franz. "The Description Logic Handbook: Theory Implementation and Applications", Cambridge University Press, 2nd edition, May 2010.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written Examination

Duration/Length: 60 min
Weight: 100%

Scope: All intended learning outcomes of the module.

Completion: To pass this module, the examination must be passed with at least 45%.

8.2.3 Causation and Correlation (perspective I)

Module Name	Module Code	Level (type)	CP
Causation and Correlation (perspective I)	CTNS-NSK-03	Year 2 New Skills	2.5

Module Components

Number	Name	Type	CP
CTNS-03	Causation and Correlation	Lecture (online)	2.5

Module Coordinator	Program Affiliation	Mandatory Status
Prof. Dr. Jules Coleman	• CONSTRUCTOR Track Area	Mandatory elective for all UG students (one perspective must be chosen)

Entry Requirements			Frequency	Forms of Learning and Teaching
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Spring)	• Online lecture (17.5h) • Private study (45h)
☒ none	☒ none		**Duration** 1 semester	**Workload** 62.5 hours

Recommendations for Preparation

Content and Educational Aims

In many ways, life is a journey. And also, as in other journeys, our success or failure depends not only on our personal traits and character, our physical and mental health, but also on the accuracy of our map. We need to know what the world we are navigating is actually like, the how, why and the what of what makes it work the way it does. The natural sciences provide the most important tool we have developed to learn how the world works and why it works the way it does. The social sciences provide the most advanced tools we have to learn how we and other human beings, similar in most ways, different in many others, act and react and what makes them do what they do. In order for our maps to be useful, they must be accurate and correctly reflect the way the natural and social worlds work and why they work as they do.

The natural sciences and social sciences are blessed with enormous amounts of data. In this way, history and the present are gifts to us. To understand how and why the world works the way it does requires that we are able to offer an explanation of it. The data supports a number of possible explanations of it. How are we to choose among potential explanations? Explanations, if sound, will enable us to make reliable predictions about what the future will be like, and also to identify many possibilities that may unfold in the future. But there are differences not just in the degree of confidence we have in our predictions, but in whether some of them are necessary future states or whether all of them are merely possibilities? Thus, there are three related activities at the core of scientific inquiry: understanding where we are now and how we got here (historical); knowing what to expect going forward (prediction); and exploring how we can change the paths we are on (creativity).

At the heart of these activities are certain fundamental concepts, all of which are related to the scientific quest to uncover immutable and unchanging laws of nature. Laws of nature are thought to reflect a causal nexus between a previous event and a future one. There are also true statements that reflect universal or nearly universal connections between events past and present that are not laws of nature because the relationship they express is that of a correlation between events. A working thermostat accurately allows us to determine or even to predict the temperature in the room in which it is located, but it does not explain why the room has the temperature it has. What then is the core difference between causal relationships and correlations? At the same time, we all recognize that given where we are now there are many possible futures for each of us, and even had our lives gone just the slightest bit differently than they have, our present state could well have been very different than it is. The relationship between possible pathways between events that have not materialized but could have is expressed through the idea of counterfactual.

Creating accurate roadmaps, forming expectations we can rely on, making the world a more verdant and attractive place requires us to understand the concepts of causation, correlation, counterfactual explanation, prediction, necessity, possibility, law of nature and universal generalization. This course is designed precisely to provide the conceptual tools and intellectual skills to implement those concepts in our future readings and research and ultimately in our experimental investigations, and to employ those tools in various disciplines.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

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

1. formulate testable hypotheses that are designed to reveal causal connections and those designed to reveal interesting, important and useful correlations.
2. distinguish scientifically interesting correlations from unimportant ones.
3. apply critical thinking skills to evaluate information.
4. understand when and why inquiry into unrealized possibility is important and relevant.

Indicative Literature

Thomas S. Kuhn: The Structure of Scientific Revolutions, Nelson, fourth edition 2012;

Goodman, Nelson. Fact, fiction, and forecast. Harvard University Press, 1983;

Quine, Willard Van Orman, and Joseph Silbert Ullian. The web of belief. Vol. 2. New York: Random house, 1978.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written Examination

Duration/Length: 60 min
Weight: 100%

Scope: All intended learning outcomes of the module

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

8.2.4 Causation and Correlation (perspective II)

Module Name	**Module Code**	**Level (type)**	**CP**
Causation and Correlation (perspective II)	CTNS-NSK-04	Year 2 New Skills	2.5

Module Components

Number	Name	Type	CP
CTNS-04	Causation and Correlations	Lecture (online)	2.5

Module Coordinator	**Program Affiliation**	**Mandatory Status**
Dr. Keivan Mallahi-Karai, Dr. Eoin Ryan, Dr. Irina Chiaburu	• CONSTRUCTOR Track Area	Mandatory elective for all UG students (one perspective must be chosen)

Entry Requirements			**Frequency**	**Forms of Learning and Teaching**
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Spring)	• Online lecture (17.5h) • Private study (45h
☒ none	☒ none	• Basic probability theory	**Duration**	**Workload**
			1 semester	62.5 hours

Recommendations for Preparation

Content and Educational Aims

Causality or causation is a surprisingly difficult concept to understand. David Hume famously noted that causality is a concept that our science and philosophy cannot do without, but it is equally a concept that our science and philosophy cannot describe. Since Hume, the problem of cause has not gone away, and sometimes seems to get even worse (e.g., quantum mechanics confusing previous notions of causality). Yet, ways of doing science that lessen our need to explicitly use causality have become very effective (e.g., huge developments in statistics). Nevertheless, it still seems that the concept of causality is at the core of explaining how the world works, across fields as diverse as physics, medicine, logistics, the law, sociology, and history – and ordinary daily life – through all of which, explanations and predictions in terms of cause and effect remain intuitively central.

Causality remains a thorny problem but, in recent decades, significant progress has occurred, particularly in work by or inspired by Judea Pearl. This work incorporates many 20th century developments, including statistical methods – but with a reemphasis on finding the why, or the cause, behind statistical correlations –, progress in understanding the logic, semantics and metaphysics of conditionals and counterfactuals, developments based on insights from the likes of philosopher Hans Reichenbach or biological statistician Sewall Wright into causal precedence and path analysis, and much more. The result is a new toolkit to identify causes and build causal explanations. Yet even as we get better at identifying causes, this raises new (or old) questions about causality, including metaphysical questions about the nature of causes (and effects, events, objects, etc), but also questions about what we really use causality for (understanding the world as it is or just to glean predictive control of specific outcomes), about how causality is used differently in different fields and activities (is cause in physics the same as that in history?), and about how other crucial concepts relate to our concept of cause (space and time seem to be related to causality, but so do concepts of legal and moral responsibility).

This course will introduce students to the mathematical formalism derived from Pearl's work, based on directed acyclic graphs and probability theory. Building upon previous work by Reichenbach and Wright, Pearl defines a "a calculus of interventions" of "do-calculus" for talking about interventions and their relation to causation and counterfactuals. This model has been applied in various areas ranging from econometrics to statistics, where acquiring knowledge about causality is of great importance.

At the same time, the course will not forget some of the metaphysical and epistemological issues around cause, so that students can better critically evaluate putative causal explanations in their full context. Abstractly, such issues involve some of the same philosophical questions Hume already asked, but more practically, it is important to see how metaphysical and epistemological debates surrounding the notion of cause affect scientific practice, and equally if not more importantly, how scientific practice pushes the limits of theory. This course will look at various ways in which empirical data can be transformed into explanations and theories, including the variance approach to causality (characteristic of the positivistic quantitative paradigm), and the process theory of causality (associated with qualitative methodology). Examples and case studies will be relevant for students of the social sciences but also students of the natural/physical world as well.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

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

1. have a clear understanding of the history of causal thinking.
2. form a critical understanding of the key debates and controversies surrounding the idea of causality.
3. recognize and apply probabilistic causal models.
4. explain how understanding of causality differs among different disciplines.
5. demonstrate how theoretical thinking about causality has shaped scientific practices.

Indicative Literature

Paul, L. A. and Ned Hall. Causation: A User's Guide. Oxford University Press 2013.

Pearl, Judea. Causality: Models, Reasoning and Inference. Cambridge University Press 2009

Pearl, Judea, Glymour Madelyn and Jewell, Nicolas. Causal Inference in Statistics: A Primer. Wiley 2016

Ilari, Phyllis McKay and Federica Russo. Causality: Philosophical Theory Meets Scientific Practice. Oxford University Press 2014.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment: Written examination

Duration/Length: 60 min

Weight: 100 %

Scope: All intended learning outcomes of the module

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

8.2.5 Linear Model and Matrices

<table>
<tr><td colspan="2">Module Name
Linear Model and Matrices</td><td>Module Code
CTNS-NSK-05</td><td>Level (type)
Year 3
(New Skills)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTNS-05</td><td colspan="2">Linear model and matrices</td><td>Seminar</td><td>5</td></tr>
<tr><td>Module Coordinator
Prof. Dr. Marc-Thorsten Hütt</td><td colspan="2">Program Affiliation
• CONSTRUCTOR Track Area</td><td colspan="2">Mandatory Status
Mandatory elective</td></tr>
<tr><td colspan="2" rowspan="2">Entry Requirements
Pre-requisites: ☒ Logic; ☒ Causation & Correlation
Co-requisites: ☒ none
Knowledge, Abilities, or Skills</td><td>Frequency
Annually
(Fall)</td><td colspan="2">Forms of Learning and Teaching
Online lecture (35h)
Private Study (90h)</td></tr>
<tr><td>Duration
1 Semester</td><td colspan="2">Workload
125 hours</td></tr>
<tr><td colspan="5">Recommendations for Preparation</td></tr>
</table>

Content and Educational Aims

There are no universal 'right skills'. But the notion of linear models and the avenue to matrices and their properties can be useful in diverse disciplines to implement a quantitative, computational approach. Some of the most popular data and systems analysis strategies are built upon this framework. Examples include principal component analysis (PCA), the optimization techniques used in Operations Research (OR), the assessment of stable and unstable states in nonlinear dynamical systems, as well as aspects of machine learning.

Here we introduce the toolbox of linear models and matrix-based methods embedded in a wide range of transdisciplinary applications (part 1). We describe its foundation in linear algebra (part 2) and the range of tools and methods derived from this conceptual framework (part 3). At the end of the course, we outline applications to graph theory and machine learning (part 4). Matrices can be useful representations of networks and of system of linear equations. They are also the core object of linear stability analysis, an approach used in nonlinear dynamics. Throughout the course, examples from neuroscience, social sciences, medicine, biology, physics, chemistry, and other fields are used to illustrate these methods.

A strong emphasis of the course is on the sensible usage of linear approaches in a nonlinear world. We will critically reflect the advantages as well as the disadvantages and limitations of this method. Guiding questions are: How appropriate is a linear approximation of a nonlinear system? What do you really learn from PCA? How reliable are the optimal states obtained via linear programming (LP) techniques?

This debate is embedded in a broader context: How does the choice of a mathematical technique confine your view on the system at hand? How, on the other hand, does it increase your capabilities of analyzing the system (due to software available for this technique, the ability to compare with findings from other fields built upon the same technique and the volume of knowledge about this technique)?

In the end, students will have a clearer understanding of linear models and matrix approaches in their own discipline, but they will also see the full transdisciplinarity of this topic. They will make better decisions in their choice of data analysis methods and become mindful of the challenges when going from linear to nonlinear thinking.

Intended Learning Outcomes

Upon completion of this module, students will be able to

1. apply the concept of linear modeling in their own discipline
2. distinguish between linear and nonlinear interpretation strategies and understand the range of applicability of linear models
3. make use of data analysis / data interpretation strategies from other disciplines, which are derived from linear algebra
4. be aware of the ties that linear models have to machine learning and network theory

Note that these four ILOs can be loosely associated with the four parts of the course indicated above

Indicative Literature

Part 1:

material from Linear Algebra for Everyone, Gilbert Strang, Wellesley-Cambridge Press, 2020

Part 2:

material from Introduction to Linear Algebra (5th Edition), Gilbert Strang, Cambridge University Press, 2021

Part 3:

Mainzer, Klaus. "Introduction: from linear to nonlinear thinking." Thinking in Complexity: The Computational Dynamics of Matter, Mind and Mankind (2007): 1-16.

material from Mathematics of Big Data: Spreadsheets, Databases, Matrices, and Graphs, Jeremy Kepner, Hayden Jananthan, The MIT Press, 2018

material from Introduction to Linear Algebra (5th Edition), Gilbert Strang, Cambridge University Press, 2021

Part 4:

material from Linear Algebra and Learning from Data, Gilbert Strang, Wellesley-Cambridge Press, 2019

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment: Written examination

Duration/Length: 120 min

Weight: 100 %

Scope: All intended learning outcomes of the module

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

8.2.6 Complex Problem Solving

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

Complex Problem Solving</td><td>Module Code

CTNS-NSK-06</td><td>Level (type)

Year 3
(New Skills)</td><td>CP

5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTNS-06</td><td colspan="3">Complex Problem Solving</td><td>Lecture (online)</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Marco Verweij</td><td colspan="3">Program Affiliation

• CONSTRUCTOR Track Area</td><td colspan="2">Mandatory Status

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

Pre-requisites: ☒ Logic; ☒ Causation & Correlation
Co-requisites: ☒ none
Knowledge, Abilities, or Skills:
• Project Management
• Complex Problem Solving</td><td>Frequency

Annually

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

• Online Lectures (35h)
• Private Study (90h)</td></tr>
<tr><td>Duration

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

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

Wherever possible intuition will be emphasized over technical detail. Technical readings will be made available and discussed with students in class.</td></tr>
<tr><td colspan="6">Content and Educational Aims

Complex problems are, by definition, non-linear and/or emergent. Some fifty years ago, scholars such as Herbert Simon began to argue that societies around the world had developed an impressive array of tools with which to solve simple and even complicated problems, but still needed to develop methods with which to address the rapidly increasing number of complex issues. Since then, a variety of such methods has emerged. These include ‘serious games’ developed in computer science, ‘multisector systems analysis’ applied in civil and environmental engineering, ‘robust decision-making’ proposed by the RAND Corporation, ‘design thinking’ developed in engineering and business studies, ‘structured problem solving’ used by McKinsey & Co., ‘real-time technology assessment’ advocated in science and technology studies, and ‘deliberative decision-making’ emanating from political science.

In this course, students first learn to distinguish between simple, complicated and complex problems. They also become familiar with the ways in which a particular issue can sometimes shift from one category into another. In addition, the participants learn to apply several tools for resolving complex problems. Finally, the students are introduced to the various ways in which natural and social scientists can help stakeholders resolve complex problems. Throughout the course examples and applications will be used. When possible, guest lectures will be offered by experts on a particular tool for tackling complex issues. For the written, take-home exam, students will have to select a specific complex problem, analyse it and come up with a recommendation – in addition to answering several questions about the material learned.</td></tr>
</table>

Intended Learning Outcomes

Upon completion of this module, students will be able to

1. identify a complex problem;
2. develop an acceptable recommendation for resolving complex problems.
3. understand the roles that natural and social scientists can play in helping stakeholders resolve complex problems;

Indicative Literature

Camillus, J. (2008). Strategy as a wicked problem. Harvard Business Review 86: 99-106.

Chia, A. (2019). Distilling the essence of the McKinsey way: The problem-solving cycle. Management Teaching Review 4(4): 350-377.

Den Haan, J., van der Voort, M.C., Baart, F., Berends, K.D., van den Berg, M.C., Straatsma, M.W., Geenen, A.J.P., & Hulscher, S.J.M.H. (2020). The virtual river game: Gaming using models to collaboratively explore river management complexity, Environmental Modelling & Software 134, 104855,

Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C.S., & Walker, B. (2002). Resilience and sustainable development: Building adaptive capacity in a world of transformations. AMBIO: A Journal of the Human Environment 31(5): 437-440.

Ostrom, E. (2010). Beyond markets and states: Polycentric governance of complex economic systems. American Economic Review 100(3): 641-72.

Pielke, R. Jr. (2007). The honest broker: Making sense of science in policy and politics. Cambridge: Cambridge University Press.

Project Management Institute (2021). A guide to the project management body of knowledge (PMBOK® guide).

Schon, D. A., & Rein, M. (1994). Frame reflection: Toward the resolution of intractable policy controversies. New York: Basic Books.

Simon, H. A. (1973). The structure of ill structured problems. Artificial Intelligence 4(3-4): 181-201.

Verweij, M. & Thompson, M. (Eds.) (2006). Clumsy solutions for a complex world. London: Palgrave Macmillan.

Usability and Relationship to other Modules

Examination Type: Module Examination

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

Scope: All intended learning outcomes of the module.

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

8.2.7 Argumentation, Data Visualization and Communication (perspective I)

<table>
<tr><td colspan="3">Module Name
Argumentation, Data Visualization and Communication (perspective I)</td><td>Module Code
CTNS-NSK-07</td><td>Level (type)
Year 3
New Skills</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTNS-07</td><td colspan="3">Argumentation, Data Visualization and Communication</td><td>Lecture (online)</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Jules Coleman,
Prof. Dr. Arvid Kappas</td><td colspan="3">Program Affiliation

• CONSTRUCTOR Track Area</td><td colspan="2">Mandatory Status

Mandatory elective for all UG students (one perspective must be chosen)</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ Logic; ☒ Causation & Correlation
Co-requisites: ☒ none
Knowledge, Abilities, or Skills:</td><td>Frequency

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

• Online Lectures (35h)
• Private Study (90h)</td></tr>
<tr><td>Duration

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

125h</td></tr>
<tr><td colspan="6">Recommendations for Preparation</td></tr>
<tr><td colspan="6">One must be careful not to confuse argumentation with being argumentative. The latter is an unattractive personal attribute, whereas the former is a requirement of publicly holding a belief, asserting the truth of a proposition, the plausibility of a hypothesis, or a judgment of the value of a person or an asset. It is an essential component of public discourse. Public discourse is governed by norms and one of those norms is that those who assert the truth of a proposition or the validity of an argument or the responsibility of another for wrongdoing open themselves up to good faith requests to defend their claims. In its most general meaning, argumentation is the requirement that one offer evidence in support of the claims they make, as well as in defense of the judgments and assessments they reach. There are different modalities of argumentation associated with different contexts and disciplines. Legal arguments have a structure of their own as do assessments of medical conditions and moral character. In each case, there are differences in the kind of evidence that is thought relevant and, more importantly, in the standards of assessment for whether a case has been successfully made. Different modalities of argumentation require can call for different modes of reasoning. We not only offer reasons in defense of or in support of beliefs we have, judgments we make and hypotheses we offer, but we reason from evidence we collect to conclusions that are warranted by them.

Reasoning can be informal and sometimes even appear unstructured. When we recognize some reasoning as unstructured yet appropriate what we usually have in mind is that it is not linear. Most reasoning we are familiar with is linear in character. From A we infer B, and from A and B we infer C, which all together support our commitment to D. The same form of reasoning applies whether the evidence for A, B or C is direct or circumstantial. What changes in these cases is perhaps the weight we give to the evidence and thus the confidence we have in drawing inferences from it.

Especially in cases where reasoning can be supported by quantitative data, wherever quantitative data can be obtained either directly or by linear or nonlinear models, the visualization of the corresponding data can become key in both, reasoning and argumentation. A graphical representation can reduce the complexity of argumentation and is</td></tr>
</table>

considered a must in effective scientific communication. Consequently, the course will also focus on smart and compelling ways for data visualization - in ways that go beyond what is typically taught in statistics or mathematics lectures. These tools are constantly developing, as a reflection of new software and changes in state of the presentation art. Which graph or bar chart to use best for which data, the use of colors to underline messages and arguments, but also the pitfalls when presenting data in a poor or even misleading manner. This will also help in readily identifying intentional mis-representation of data by others, the simplest to recognize being truncating the ordinate of a graph in order to exaggerate trends. This frequently leads to false arguments, which can then be readily countered.

There are other modalities of reasoning that are not linear however. Instead they are coherentist. We argue for the plausibility of a claim sometimes by showing that it fits in with a set of other claims for which we have independent support. The fit is itself the reason that is supposed to provide confidence or grounds for believing the contested claim.

Other times, the nature of reasoning involves establishing not just the fit but the mutual support individual items in the evidentiary set provide for one another. This is the familiar idea of a web of interconnected, mutually supportive beliefs. In some cases, the support is in all instances strong; in others it is uniformly weak, but the set is very large; in other cases, the support provided each bit of evidence for the other is mixed: sometimes strong, sometimes weak, and so on.

There are three fundamental ideas that we want to extract from this segment of the course. These are (1) that argumentation is itself a requirement of being a researcher who claims to have made findings of one sort or another; (2) that there are different forms of appropriate argumentation for different domains and circumstances; and (3) that there are different forms of reasoning on behalf of various claims or from various bits of evidence to conclusions: whether those conclusions are value judgments, political beliefs, or scientific conclusions. Our goal is to familiarize you with all three of these deep ideas and to help you gain facility with each.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

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

1. distinguish among different modalities of argument, e.g. legal arguments, vs. scientific ones.
2. construct arguments using tools of data visualization.
3. communicate conclusions and arguments concisely, clearly and convincingly.

Indicative Literature

- Tufte, E.R. (1985). The visual display of quantitative information. The Journal for Healthcare Quality (JHQ), 7(3), 15.
- Cairo, A (2012). The Functional Art: An introduction to information graphics and visualization. New Ridders.
- Knaflic, C.N. (2015). Storytelling with data: A data visualization guide for business professionals. John Wiley & Sons.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written Examination

Duration/Length: 120 (min)
Weight: 100%

Scope: All intended learning outcomes of the module

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

8.2.8 Argumentation, Data Visualization and Communication (perspective II)

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

Argumentation, Data Visualization and Communication (perspective II)</td><td>Module Code
CTNS-NSK-08</td><td>Level (type)
Year 3
New Skills</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTNS-08</td><td colspan="3">Communication, Interaction, and Argumentation</td><td>Lecture (online)</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Jules Coleman,
Prof. Dr. Arvid Kappas</td><td colspan="3">Program Affiliation

• CONSTRUCTOR Track Area</td><td colspan="2">Mandatory Status

Mandatory elective for all UG students (one perspective must be chosen)</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ Logic; ☒ Causation & Correlation

Co-requisites: ☒ none

Knowledge, Abilities, or Skills:
• ability and openness to engage in interactions
• media literacy, critical thinking and a proficient handling of data sources
• own research in academic literature</td><td>Frequency

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

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

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

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation</td></tr>
<tr><td colspan="6">Content and Educational Aims
Humans are a social species and interaction is crucial throughout the entire life span. While much of human communication involves language, there is a complex multichannel system of nonverbal communication that enriches linguistic content, provides context, and is also involved in structuring dynamic interaction. Interactants achieve goals by encoding information that is interpreted in the light of current context in transactions with others. This complexity implies also that there are frequent misunderstandings as a sender’s intention is not fulfilled. Students in this course will learn to understand the structure of communication processes in a variety of formal and informal contexts. They will learn what constitutes challenges to achieving successful communication and to how to communicate effectively, taking the context and specific requirements for a target audience into consideration. These aspects will be discussed also in the scientific context, as well as business, and special cases, such as legal context – particularly with view to argumentation theory.

Communication is a truly transdisciplinary concept that involves knowledge from diverse fields such as biology, psychology, neuroscience, linguistics, sociology, philosophy, communication and information science. Students will learn what these different disciplines contribute to an understanding of communication and how theories from these fields can be applied in the real world. In the context of scientific communication, there will also be a focus on visual communication of data in different disciplines. Good practice examples will be contrasted with typical errors to facilitate successful communication also with view to the bachelor's thesis.</td></tr>
</table>

Intended Learning Outcomes

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

1. Analyze communication processes in formal and informal contexts.
2. Identify challenges and failures in communication.
3. Design communications to achieve specified goals to specific target groups.
4. Understand the principles of argumentation theory.
5. Use data visualization in scientific communications.

Indicative Literature

Joseph A. DeVito: The Interpersonal Communication Book (Global edition, 16th edition), 2022
Steven L. Franconeri, Lace M. Padilla, Priti Shah, Jeffrey M. Zacks, and Jessica Hullman: The Science of Visual Data Communication: What Works Psychological Science in the Public Interest, 22(3), 110–161, 2022
Douglas Walton: Argumentation Theory – A Very Short Introduction. In: Simari, G., Rahwan, I. (eds) Argumentation in Artificial Intelligence. Springer, Boston, MA, 2009

Examination Type: Module Examination

Assessment Type: Digital submission of asynchronous presentation, including reflection

Duration/Length: Asynchronous/Digital submission

Weight: 100%

Scope: All intended learning outcomes of the module

Module achievement: Asynchronous presentation on a topic relating to the major of the student, including a reflection including concept outlining the rationale for how arguments are selected and presented based on a particular target group for a particular purpose. The presentation shall be multimedial and include the presentation of data

The module achievement ensures sufficient knowledge about key concepts of effective communication including a reflection on the presentation itself

8.2.9 Agency, Leadership, and Accountability

<table>
<tr><td colspan="2">Module Name
Agency, Leadership, and Accountability</td><td>Module Code
CTNS-NSK-09</td><td>Level (type)
Year 3
(New Skills)</td><td>CP
5</td></tr>
<tr><td colspan="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTNS-09</td><td colspan="2">Agency, Leadership, and Accountability</td><td>Lecture (online)</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Jules Coleman</td><td colspan="2">Program Affiliation

• CONSTRUCTOR Track Area</td><td colspan="2">Mandatory Status

Mandatory for ACS

Mandatory elective for all other UG study programs</td></tr>
<tr><td colspan="2" rowspan="2">Entry Requirements

Pre-requisites: ☒ none
Co-requisites: ☒ none
Knowledge, Abilities, or Skills</td><td>Frequency

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

• Online Lectures (35h)
• Private Study (90h)</td></tr>
<tr><td>Duration

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

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

Content and Educational Aims

Each of us is judged by the actions we undertake and held to account for the consequences of them. Sometimes we may be lucky and our bad acts don't have harmful effects on others. Other times we may be unlucky and reasonable decisions can lead to unexpected or unforeseen adverse consequences for others. We are therefore held accountable both for choices and for outcomes. In either case, accountability expresses the judgment that we bear responsibility for what we do and what happens as a result. But our responsibility and our accountability in these cases is closely connected to the idea that we have agency.

Agency presumes that we are the source of the choices we make and the actions that result from those choices. For some, this may entail the idea that we have free will. But there is scientific world view that holds that all actions are determined by the causes that explain them, which is the idea that if we knew the causes of your decisions in advance, we would know the decision you would make even before you made it. If that is so, how can your choice be free? And if it is not free, how can you be responsible for it? And if you cannot be responsible, how can we justifiably hold you to account for it?

These questions express the centuries old questions about the relationship between free will and a determinist world view: for some, the conflict between a scientific world view and a moral world view.

But we do not always act as individuals. In society we organize ourselves into groups: e.g. tightly organized social groups, loosely organized market economies, political societies, companies, and more. These groups have structure. Some individuals are given the responsibility of leading the group and of exercising authority. But one can exercise authority over others in a group merely by giving orders and threatening punishment for non-compliance.

Exercising authority is not the same thing as being a leader? For one can lead by example or by encouraging others to exercise personal judgment and authority. What then is the essence of leadership?

The module has several educational goals. The first is for students to understand the difference between actions that we undertake for which we can reasonably held accountable and things that we do but which we are not responsible for. For example, a twitch is an example of the latter, but so too may be a car accident we cause as a result of a heart attack we had no way of anticipating or controlling. This suggests the importance of control to responsibility. At the heart of personal agency is the idea of control. The second goal is for students to understand what having control means. Some think that the scientific view is that the world is deterministic, and if it is then we cannot have any personal control over what happens, including what we do. Others think that the quantum scientific view entails a degree of indeterminacy and that free will and control are possible, but only in the sense of being unpredictable or random. But then random outcomes are not ones we control either. So, we will devote most attention to trying to understand the relationships between control, causation and predictability.

But we do not only exercise agency in isolation. Sometimes we act as part of groups and organizations. The law often recognizes ways in which groups and organizations can have rights, but is there a way in which we can understand how groups have responsibility for outcomes that they should be accountable for. We need to figure out then whether there is a notion of group agency that does not simply boil down to the sum of individual actions. We will explore the ways in which individual actions lead to collective agency.

Finally we will explore the ways in which occupying a leadership role can make one accountable for the actions of others over which one has authority.

Intended Learning Outcomes

Students acquire transferable and key skills in this module.

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

1. understand and reflect how the social and moral world views that rely on agency and responsibility are compatible, if they are, with current scientific world views.
2. understand how science is an economic sector, populated by large powerful organizations that set norms, fund research agendas.
3. identify the difference between being a leader of others or of a group – whether a research group or a lab or a company – and being in charge of the group.
4. learn to be a leader of others and groups. Understand that when one graduates one will enter not just a field of work but a heavily structured set of institutions and that one's agency and responsibility for what happens, what work gets done, its quality and value, will be affected accordingly.

Indicative Literature

Hull, David L. "Science as a Process." Science as a Process. University of Chicago Press, 2010;

Feinberg, Joel. "Doing & deserving; essays in the theory of responsibility." (1970).

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written examination

Duration/Length: 120 min
Weight: 100%

Scope: All intended learning outcomes of the module

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

8.2.10 Community Impact Project

<table>
<tr><td colspan="3">Module Name
Community Impact Project</td><td>Module Code
CTNC-CIP-10</td><td>Level (type)
Year 3
(New Skills)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTNC-10</td><td colspan="3">Community Impact Project</td><td>Project</td><td>5</td></tr>
<tr><td>Module Coordinator

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

CONSTRUCTOR Track Area</td><td colspan="2">Mandatory Status

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

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

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

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

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

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

Recommendations for Preparation

Develop or join a community impact project before the 5th or 6th 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.

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.

Intended Learning Outcomes

The Community Impact Project is designed to convey the required personal and social competencies for enabling students to finish their studies at Jacobs as socially conscious and responsible graduates (part of the Constructor University'smission) 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 will be able to

1. understand the real-life issues of communities, organizations, and industries and relate them to concepts in their own discipline;
2. enhance problem-solving skills and develop critical faculty, create solutions to problems, and communicate these solutions appropriately to their audience;
3. apply media and communication skills in diverse and non-peer social contexts;

4. develop an awareness of the societal relevance of their own scientific actions and a sense of social responsibility for their social surroundings;
5. reflect on their own behavior critically in relation to social expectations and consequences;
6. work in a team and deal with diversity, develop cooperation and conflict skills, and strengthen their empathy and tolerance for ambiguity.

Indicative Literature

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

8.3 Language and Humanities Modules

8.3.1 Languages

The descriptions of the language modules are provided in a separate document, the "Language Module Handbook" that can be accessed from the Constructor University's Language & Community Center internet sites https://constructor.university/student-life/language-community-center.

8.3.2 Humanities

8.3.2.1 Introduction to Philosophical Ethics

<table>
<tr><td colspan="3">Module Name
Introduction to Philosophical Ethics</td><td>Module Code
CTHU-HUM-001</td><td>Level (type)
Year 1</td><td>CP
2.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTHU-001</td><td colspan="3">Introduction to Philosophical Ethics</td><td>Lecture (online)</td><td>2.5</td></tr>
<tr><td>Module Coordinator
Dr. Eoin Ryan</td><td colspan="3">Program Affiliation
• CONSTRUCTOR Track Area</td><td colspan="2">Mandatory Status
Mandatory elective</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements
Pre-requisites: ☒ none
Co-requisites: ☒ none
Knowledge, Abilities, or Skills</td><td>Frequency
Annually (Fall)</td><td colspan="2">Forms of Learning and Teaching
• Online lectures (17.5 h)
• Private Study (45h)</td></tr>
<tr><td>Duration
1 semester</td><td colspan="2">Workload
62.5 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation</td></tr>
<tr><td colspan="6">Content and Educational Aims
The nature of morality – how to lead a life that is good for yourself, and how to be good towards others – has been a central debate in philosophy since the time of Socrates, and it is a topic that continues to be vigorously discussed. This course will introduce students to some of the key aspects of philosophical ethics, including leading normative theories of ethics (e.g. consequentialism or utilitarianism, deontology, virtue ethics, natural law ethics, egoism) as well as some important questions from metaethics (are useful and generalizable ethical claims even possible; what do ethical speech and ethical judgements actually do or explain) and moral psychology (how do abstract ethical principles do when realized by human psychologies). The course will describe ideas that are key factors in ethics (free will, happiness, responsibility, good, evil, religion, rights) and indicate various routes to progress in understanding ethics, as well as some of their difficulties.</td></tr>
</table>

Intended Learning Outcomes

Upon completion of this module, students will be able to

1. describe normative ethical theories such as consequentialism, deontology and virtue ethics.
2. discuss some metaethical concerns.
3. analyze ethical language.
4. highlight complexities and contradictions in typical ethical commitments.
5. indicate common parameters for ethical discussions at individual and social levels.
6. analyze notions such as objectivity, subjectivity, universality, pluralism, value.

Indicative Literature

Simon Blackburn, Being Good (2009)

Russ Shafer-Landay, A Concise Introduction to Ethics (2019)

Mark van Roojen, Metaethicas: A Contemporary Introduction (2015)

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written Examination

Duration/Length: 60 min
Weight: 100%

Scope: All intended learning outcomes of the module.

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

8.3.2.2 Introduction to the Philosophy of Science

Module Name	**Module Code**	**Level (type)**	**CP**
Introduction to the Philosophy of Science	CTHU-HUM-002	Year 1	2.5

Module Components

Number	Name	Type	CP
CTHU-002	Introduction to the Philosophy of Science	Lecture (online)	2.5

Module Coordinator	**Program Affiliation**	**Mandatory Status**
Dr. Eoin Ryan	• CONSTRUCTOR Track Area	Mandatory elective

Entry Requirements

Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills
☒ none	☒ none	

Frequency	**Forms of Learning and Teaching**
Annually (Spring)	• Online lectures (17.5h) • Private Study (45h)

Duration	**Workload**
1 semester	62.5 hours

Recommendations for Preparation

Content and Educational Aims

This humanities module will introduce students to some of the central ideas in philosophy of science. Topics will include distinguishing science from pseudo-science, types of inference and the problem of induction, the pros and cons of realism and anti-realism, the role of explanation, the nature of scientific change, the difference between natural and social sciences, scientism and the values of science, as well as some examples from philosophy of the special sciences (e.g., physics, biology).

The course aims to give students an understanding of how science produces knowledge, and some of the various contexts and issues which mean this process is never entirely transparent, neutral, or unproblematic. Students will gain a critical understanding of science as a human practice and technology; this will enable them both to better understand the importance and success of science, but also how to properly critique science when appropriate.

Intended Learning Outcomes

Upon completion of this module, students will be able to

1. understand key ideas from the philosophy of science.
2. discuss different types of inference and rational processes.
3. describe differences between how the natural sciences, social sciences and humanities discover knowledge.
4. identify ways in which science can be more and less value-laden.
5. illustrate some important conceptual leaps in the history of science.

Indicative Literature

Peter Godfrey-Smith, Theory and Reality (2021)

James Ladyman, Understanding Philosophy of Science (2002)

Paul Song, Philosophy of Science: Perspectives from Scientists (2022)

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written Examination

Duration/Length: 60 min
Weight: 100%

Scope: All intended learning outcomes of the module.

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

8.3.2.3 Introduction to Visual Culture

Module Name			**Module Code**	**Level (type)**	**CP**
Introduction to Visual Culture			CTHU-HUM-003	Year 1	2.5
Module Components					
Number	Name			Type	CP
CTHU-003	Introduction to Visual Culture			Lecture (online)	2.5
Module Coordinator Dr.Irina Chiaburu	**Program Affiliation** • CONSTRUCTOR Track Area			**Mandatory Status** Mandatory elective	
Entry Requirements			**Frequency**	**Forms of Learning and Teaching**	
Pre-requisites ☒ none	Co-requisites ☒ none	Knowledge, Abilities, or Skills	Annually (Spring/Fall)	• Online lectures (17.5h) • Private Study (45h)	
			Duration 1 semester	**Workload** 62.5 h	
Recommendations for Preparation					

Content and Educational Aims

Of the five senses, the sense of sight has for a long time occupied the central position in human cultures. As John Berger has suggested this could be because we can see and recognize the world around us before we learn how to speak. Images have been with us since the earliest days of the human history. In fact, the earliest records of human history are images found on cave walls across the world. We use images to capture abstract ideas, to catalogue and organize the world, to represent the world, to capture specific moments, to trace time and change, to tell stories, to express feelings, to better understand, to provide evidence and more. At the same time, images exert their power on us, seducing us into believing in their ‘innocence’, that is into forgetting that as representations they are also interpretations, i.e., a particular version of the world.

The purpose of this course is to explore multiple ways in which images and the visual in general mediate and structure human experiences and practices from more specialized discourses, e.g., scientific discourses, to more informal and personal day-to-day practices, such as self-fashioning in cyberspace. We will look at how social and historical contexts affect how we see, as well as what is visible and what is not. We will explore the centrality of the visual to the intellectual activity, from early genres of scientific drawing to visualizations of big data. We will examine whether one can speak of visual culture of protest, look at the relationship between looking and subjectivity and, most importantly, ponder the relationship between the visual and the real.

Intended Learning Outcomes

Upon completion of this module, students will be able to

1. understand a range of key concepts pertaining to visual culture, art theory and cultural analysis
2. understand the role visuality plays in development and maintenance of political, social, and intellectual discourses
3. think critically about images and their contexts
4. reflect critically on the connection between seeing and knowing

Indicative Literature

Berger, J., Blomberg, S., Fox, C., Dibb, M., & Hollis, R. (1973). Ways of seeing.

Foucault, M. (2002). The order of things: an archaeology of the human sciences (Ser. Routledge classics). Routledge.

Hunt, L. (2004). Politics, culture, and class in the French revolution: twentieth anniversary edition, with a new preface (Ser. Studies on the history of society and culture, 1). University of California Press.

Miller, V. (2020). Understanding digital culture (Second). SAGE.

Thomas, N. (1994). Colonialism's culture: anthropology, travel and government. Polity Press.

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment: Written examination

Duration/Length: 60 min.
Weight: 100%

Scope: all intended learning outcomes

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

9. Appendix

9.1 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	Current Topics in the Molecular Life Sciences	Experimental Strategy Design	Biomedicine	Internship / Startup and Career Skills	Bachelor Thesis and Seminar BCCB	CT Methods	CT German Language and Humanities Modules	CT New Skills
Semester					1	2	1	2	3	4	3	4	4	3	4	4	5	5	6	4-5	6	1-4	1-2	3-6
Mandatory/mandatory elective					m	m	m	m	me	me	m	m	m	m	m	m	me	me	me	m	m	m/me	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	5	20
	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				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						
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			
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		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			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			(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	(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)	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
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
Assessment Type																								
Oral examination																							x	
Written examination					x	x	x	x	x	x	x	x		x		x						x	x	x
Project assessment																		x		x				x
Essay																							x	
Term paper																								
Laboratory report					x	x	x	x	x				x		x									
Poster presentation																			x					
Presentation																	x				x			x
Thesis																					x			
Module achievements							x															x	x	x

*Competencies: A-scientific/academic proficiency; E-competence for qualified employment; P-development of personality; S-competence for engagement in society

Figure 4: Intended Learning Outcomes Assessment-Matrix