CONSTRUCTOR
UNIVERSITY

Study Program Handbook

Medicinal Chemistry and Chemical Biology

Bachelor of Science

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

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

Upon graduation, students in this program will receive a Bachelor of Science (BSc) degree with a scope of 180 ECTS (for specifics see Chapter 4 of this handbook).

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1 Program Overview

1.1 Concept

1.1.1 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

Pharmaceutical drug innovation requires well-trained scientists with a deep and broad understanding of current drug development. In that light, Chemical Biology is providing new avenues into Medicinal Chemistry insight, and the combined fields are the inspiration for our B.Sc. degree in Medicinal Chemistry and Chemical Biology (MCCB). The program prepares students to lead tomorrow's advances by learning the core chemical concepts and applying them from the molecular to the physiological level. This more encompassing approach equips students to understand what is required to cure disease while bringing improvement to that process. The program is unique in the German academic landscape in that an interdisciplinary education between Chemistry and the Life Sciences is offered at the Bachelor level. With a degree in MCCB, clear paths to graduate study in Medicinal Chemistry, Chemical Biology, or Biochemistry, as well as Organic Chemistry or Neuroscience are possible. Whether graduate school is in your sites or not, your B.Sc. degree in MCCB will prepare you for a job in the ever-evolving high-growth pharmaceutical sector.

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

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

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

1.2 Specific Advantages of MCCB at Constructor University

- The Medicinal Chemistry and Chemical Biology (MCCB) Program provides an early academic opportunity for students who know they want a career focused on curing disease, and who wish to acquire a solid foundation for this career path starting at the B.Sc. degree level. Constructor University offers this forward-looking program because the field of Chemical Biology (CB) has expanded tremendously in recent years and the resulting molecular understanding of disease will significantly accelerate drug discovery. To take advantage of this, the understanding and tools of Medicinal Chemistry (MC) must be integrated with those of Chemical Biology. This interdisciplinary program is an ideal choice for students who want to combine chemical and life science thematics.
- The Medicinal Chemistry-oriented modules of the program cater to the identification, synthesis, and development of new chemical compounds for therapeutic use. They also comprise the study of existing drugs, structure-activity relationships, the matching of drugs to targets by molecular docking, and the biological properties of drugs. The Chemical Biology modules detail and integrate the advances made within molecular biology, with a focus on how to probe the mechanism and function of living systems via chemical concepts, methods, and tools. This is often achieved by employing the synthetically produced compounds of a medicinal chemist. The connectivity of the two disciplines (MC and CB) is unambiguous and the synergistic understanding that comes from their integration cannot be underestimated.
- During the detailed planning of the course structure for the MCCB major, advice from advisory board members and various experts from academia, industry, and research foundations was incorporated. A program was thus developed that is distinctive within Germany because of its early integration of medicinal chemistry and chemical biology.
- The MCCB program provides strong practical experience and begins in the first semester laboratory courses. Opportunities to participate in graduate level research projects are additionally encouraged, but voluntary, and formalized through independent research courses (Methods in Life Science and Chemical Research I and II). The summer break, between the fourth and fifth semesters, is dedicated to a research-based internship and the sixth semester is used to formalize the Bachelor thesis, which entails a research project and a written thesis with a faculty member. Specialization courses during the third-year of study allow the student to choose specific fields of interest within MCCB or from the adjacent subfields of chemistry, biochemistry, or biotechnology.
- The MCCB degree, with its highly relevant theoretical content and state-of-the-art laboratory training, allows you to enter graduate programs in Medicinal Chemistry, Biochemistry, or Organic Chemistry and related fields. Alternative career paths, directly after obtaining your MCCB B.Sc. degree, are possible within education, the pharmaceutical industry, regulatory authorities, or patent law offices. A more detailed overview of potential career paths is detailed later in this handbook, see section 1.4 Career Options.

1.3 Program-Specific Educational Aims

1.3.1 Qualification Aims

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

1.3.2 Intended Learning Outcomes

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

Theory (T)

1. (T1) recognize and discuss the concepts of bonding, acidity/basicity, conformation, and stereochemistry, as they relate to functional groups;
2. (T2) explain and describe general reactivity patterns (organic or biochemical) and the corresponding reaction categories (chemical or metabolic);
3. (T3) illustrate how chemical tools can be used to probe biological processes;
4. (T4) explain the basic concepts within the fields of biochemistry and cell biology;
5. (T5) describe, with examples from the major categories of biomolecules, how chemical structure defines cellular function;
6. (T6) predict and discriminate the basic principles of drug action;
7. (T7) judge and illustrate how the function of biomolecules can be influenced by small molecules, and how such small molecules are identified, developed, produced, and analyzed to manage disease;
8. (T8) analyze the bioactivity potential, drug-target interactions, structure-activity relationships, or pharmacokinetics of small molecules and biologicals, and explain how these parameters are determined.
9. (T9) test computer-based visualization to correlate protein conformation with drug interaction.
10. (T10) calculate values from data and correlate data using statistical methods as applied to thermodynamics or large data sets;
11. (T11) establish and propose analytical tools for pharmaceutical research;
12. (T12) design scientific hypotheses and suggest experiments to validate them.

Practical Work (PW):

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

Transferable Skills (TS):

21. (TS1) analyze scientific or technical questions, provide perspective with what is known in the literature, suggest avenues to solve the questions at hand, and communicate the solutions;
22. (TS2) concisely and professionally present or defend their own results, and those of others, in front of an audience;
23. (TS3) understand and explain the relationship between experiments, and the data and trends therefrom for scientific hypothesis generation;
24. (TS4) create and write scientific documents with knowledge of their purpose, structure, and conciseness;
25. (TS5) demonstrate or apply a general set of scientific methods and skills used within the pharmaceutical industry;
26. (TS6) engage ethically within the framework of planning, observing, recording, and communicating research within academia, a future work place, and the wider community;
27. (TS7) identify, describe, and evaluate important parameters within the context of drug design;

28. (TS8) understand the value of schematic, graphic, and tabular information for scientific writing;
29. (TS9) take responsibility for their own learning, personal and professional development through the analysis of deficiencies;
30. (TS10) apply numerical skills to solve quantitative problems;
31. (TS11) collaborate with peers in a team and demonstrate intercultural and social competencies.

1.4 Career Options and Support

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

The Career 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:

Thomas Nugent, Ph.D.

Professor of Chemistry

Email: tnugent@constructor.university

Or: visit our program website: https://constructor.university/programs/undergraduate-education/medicinal-chemistry-chemical-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.

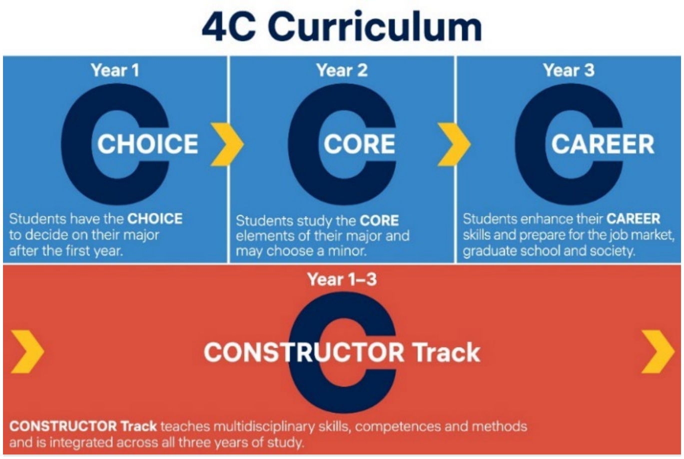

Figure 1: The Constructor University 4C-Model

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

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

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

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

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.

To allow further major changes after the first year the students are strongly recommended to register for the CHOICE modules of one of the following study programs:

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

- Chemistry and Biotechnology (CBT)
  CHOICE module: General and Inorganic Chemistry (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)

- 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)

2.2.2 Year 2 – CORE

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

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

- CORE Module: Medicinal Chemistry (m, 5 CP)
- CORE Module: Chemical Biology (m, 5 CP)
- CORE Module: Advanced Organic Chemistry (m, 5 CP)
- CORE Module: Pharmaceutical Chemistry (m, 5 CP)
- CORE Module: Advanced Organic and Analytical Chemistry Laboratory (m, 5 CP)
- CORE Module: Medicinal Chemistry and Chemical Biology Laboratory (m, 5 CP)

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

- CORE Module: Scientific Software and Databases (me, 5 CP)
- CORE Module: High Throughput Screening (me,5 CP)
- CORE Module: Physical Chemistry and Molecular Modelling (me,5 CP)

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

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

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

As a rule, this requires MCCB students to:

- select CHOICE modules (15 CP in total) from the desired minor program during the first year of study and

- substitute the three mandatory elective CORE MCCB modules (15 CP) in the second year with the default minor CORE modules of the minor study program.

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

2.2.3 Year 3 – CAREER

During their third year, students prepare and make decisions 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 MCCB 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 MCCB 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 MCCB as a major, at least 10 of the 15 CP from the following major-specific Specialization Modules need to be taken:

- MCCB Specialization: Fluorine in Drug Development (me, 2.5 CP)
- MCCB Specialization: Advanced Organic Synthesis (me, 5 CP)
- MCCB Specialization: Drug Discovery (me, 2.5 CP)
- MCCB Specialization: Synthetic Biology (me, 5 CP)

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

- BCCB Specialization: Current Topics in the Molecular Life Sciences (me, 5 CP)
- BCCB Specialization: Biomedicine (me, 5 CP)
- BCCB CORE: Advanced Biochemistry I (me, 5 CP)
- BCCB CORE: Advanced Biochemistry II (me, 5 CP)
- BCCB CORE: Infection and Immunity (me, 7.5 CP)
- CBT CORE: Physical Chemistry (me, 5 CP)
- Specialization (CBT): Organometallic Chemistry (me, 5 CP)
- Specialization (CBT): Biotechnology in Action (me, 5 CP)

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

Specialization courses are designed to allow an MCCB student to become more focused on a particular subject of their choice within the MCCB program or an affiliated program. The intention is to simultaneously support their personal development and career choices.

2.2.3.3 Study Abroad

Students have the opportunity to study abroad for a semester to extend their knowledge and abilities, broaden their horizons and reflect on their values and behavior in a different context as well as on their role in a global society. For a semester abroad (usually the 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)

MCCB 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.

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.

With their Bachelor Thesis, students demonstrate mastery of the contents and methods of the major-specific research field. Furthermore, students show the ability to analyze and solve a well-defined problem with scientific approaches, a critical reflection of the status quo in scientific literature, and the original development of their own ideas. With the permission of a 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 comprehensibly in front of an audience and to explain their methods, solutions and results with 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 programs equip students with transferable academic skills. They convey and practice specific methods that are indispensable for each students' chosen study program. Students are required to take 20 CP in the Methods area. The size of all Methods modules is 5 CP.

To pursue MCCB as a major, the following Methods modules (20 CP) must be taken as mandatory modules:

- Methods Module: Mathematical Concepts for the Sciences (m, 5 CP)
- Methods Module: Physics for the Natural Sciences (m, 5 CP)
- Methods Module: Analytical Methods (m, 5 CP)
- Methods Module: Plant Metabolism and Natural Products (m, 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 MCCB as a Minor

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

3.1 Qualification Aims

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

3.1.1 Intended Learning Outcomes

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

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

3.2 Module Requirements

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

15 CP of the following mandatory CHOICE modules:

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

15 CP of the following mandatory CORE modules:

- CORE Module: Medicinal Chemistry (m, 5 CP)
- CORE Module: Chemical Biology (m, 5 CP)
- CORE Module: Pharmaceutical Chemistry (m, 5 CP)

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

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

3.3 Degree

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

4 MCCB Undergraduate Program Regulations

4.1 Scope of these Regulations

The regulations in this handbook are valid for all students who entered Medicinal Chemistry and Chemical Biology undergraduate program at Constructor University in Fall 2023. In case of a conflict between the regulations in this handbook and the 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 the study program, students are awarded a Bachelor of Science degree in MCCB.

4.3 Graduation Requirements

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

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

5 Schematic Study Plan for MCCB

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

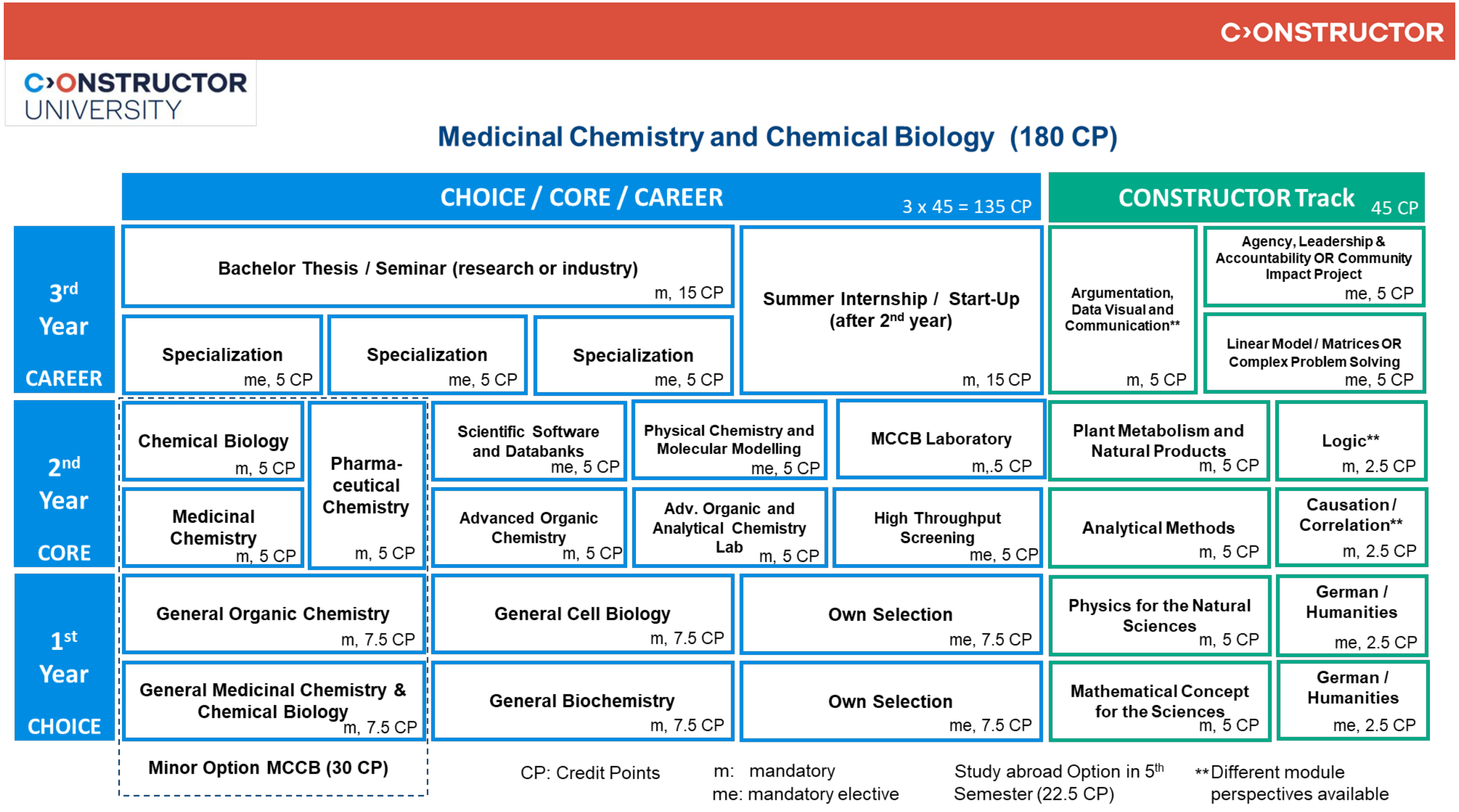

Figure 2: Schematic Study Plan for MCCB

6 Study and Examination Plan

Medicinal Chemistry and Chemical Biology (MCCB)

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 MCCB program.							
	Unit 1: Foundations of Medicinal Chemistry & Chemical Biology *(default minor)*						**15**
CH-110	**Module: General Medicinal Chemistry & Chemical Biology** *(default minor)*				**m**	**1**	**7.5**
CH-110-A	General Medicinal Chemistry & Chemical Biology	Lecture	Written examination	Examination period			5
CH-110-B	General Medicinal Chemistry & Chemical Biology Tutorial	Tutorial					2.5
CH-111	**Module: General Organic Chemistry** *(default minor)*				**m**	**2**	**7.5**
CH-111-A	General Organic Chemistry	Lecture	Written examination	Examination period			5
CH-111-B	General Organic Chemistry Laboratory	Lab	Lab Reports	During the semester			2.5
	Unit 2: General Biochemistry and Cell Biology						**15**
CH-100	**Module: General Biochemistry**				**m**	**1**	**7.5**
CH-100-A	General Biochemistry	Lecture	Written examination	Examination period			5
CH-100-B	General Biochemistry Laboratory	Lab	Lab reports	During the semester			2.5
CH-101	**Module: General Cell Biology**				**m**	**2**	**7.5**
CH-101-A	General Cell Biology	Lecture	Written examination	Examination period			5
CH-101-B	General Cell Biology Laboratory	Lecture	Lab Reports	During the semester			2.5
	Unit 3: CHOICE (own selection)				**me**		**15**
Take two further CHOICE modules from those offered for all other study programs[2]							
Year 2 - CORE							**45**
Take all CORE modules listed below or replace the mandatory elective (me) modules (15 CP) with suitable CORE modules from other study programs[2]							
	Unit 1: Medicinal Chemistry & Chemical Biology *(default minor)*						**15**
CO-420	**Module: Medicinal Chemistry** *(default minor)*				**m**	**3**	**5**
CO-420-A	Medicinal Chemistry	Lecture	Written examination	Examination period			
			Presentation	During the semester			
CO-421	**Module: Chemical Biology** *(default minor)*				**m**	**4**	**5**
CO-421-A	Chemical Biology	Lecture	Written examination	Examination period			
CO-422	**Module: Pharmaceutical Chemistry (default minor)**				**m**	**3+4**	**5**
CO-422-A	Pharmaceutical Chemistry I	Lecture	Oral examination	Examination period		3	2.5
CO-422-B	Pharmaceutical Chemistry II	Lecture				4	2.5
	Unit 2: Organic and Analytical Chemistry						**15**
CO-423	**Module: Advanced Organic Chemistry**				**m**	**3**	**5**
CO-423-A	Advanced Organic Chemistry	Lecture	Written examination	Examination period			
CO-443	**Module: Scientific Software and Databanks**				**me**	**4**	**5**
CO-443-A	Scientific Software and Databanks	Seminar	Report	During the semester			
CO-424	**Module: Advanced Organic and Analytical Chemistry Lab**				**m**	**3**	**5**
CO-424-A	Advanced Organic Chemistry Laboratory	Lab	Lab Reports	During the semester			2.5
CO-424-B	Analytical Chemistry Laboratory	Lab	Lab Reports				2.5
	Unit 3: Drug Screening and Docking						**15**
CO-425	**Module: High Throughput Screening**				**me**	**3**	**5**
CO-425-A	High Throughput Screening	Lecture	Written examination	Examination period			
CO-426	**Module: Physical Chemistry and Molecular Modelling**				**me**	**4**	**5**
CO-426-A	Physical Chemistry and Molecular Modelling	Lecture	Written examination	Examination period			
CO-427	**Module: MCCB Laboratory**				**m**	**4**	**5**
CO-427-A	Medicinal Chemistry & Chemical Biology Laboratory	Lab	Lab Reports	During the semester			5

	Constructor Track Modules (General Education)	Type	Assessment	Period	Status[1]	Sem.	CP
Year 1							**15**
	Unit: Methods						**10**
CTMS-MAT-07	**Module: Mathematical Concepts for the Sciences**		**Final exam**		**m**	**1**	**5**
CTMS-07	Mathematical Concepts for the Sciences	Lecture (online)	Written examination	Examination period			
CTMS-SCI-17	**Module: Physics for the Natural Sciences**		**Final exam**		**m**	**2**	**5**
CTMS-17	Physics for the Natural Sciences	Lecture (online)	Written examination	Examination period			
	Unit: German Language and Humanities (choose one module for each sememster)				**m**		**5**
	German is default language and open to Non-German speakers (on campus and online).[5]						
CTLA-	**Module: German 1**				**me**	**1**	**2,5**
CTLA-	German 1	Seminar	Various	Various	me		
CTLA-	**Module: German 2**				**me**	**2**	**2,5**
CTLA-	German 2	Seminar	Various	Various	me		
CTHU-HUM-001	**Humanities Module: Introduction into Philosophical Ethics**				**me**	**1**	**2,5**
CTHU-001	Introduction into 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		
Year 2							**15**
	Unit: Methods						**10**
CTMS-SCI-16	**Module: Analytical Methods**				**m**	**3**	**5**
CTMS-16	Analytical Methods	Lecture (online)	Written examination	Examination period			
CTMS-SCI-18	**Module: Plant Metabolism and Natural Products**				**m**	**4**	**5**
CTMS-18	Plant Metabolism and Natural Products	Lecture (online)	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 Examinati	Examination period	me		2.5
CTNS-NSK-02	**Module: Logic (perspective II)**						
CTNS-02	Logic (perspective II)	Lecture (online)	Written Examinati	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 Examinati	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 Examinati	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/Business Plan	During the 5th semester			
CA-MCCB-800	**Module: Seminar / Thesis MCCB**				**m**	**6**	**15**
CA-MCCB-800-T	Thesis MCCB	Thesis	Thesis and Presentation	15th of May			12
CA-MCCB-800-S	Seminar MCCB	Seminar		During the semester			3
	Unit: Specialization MCCB [3]				**m**		**15**
Take a total of 15 CP of specialization modules							
CA-S-MCCB-801	Advanced Organic Synthesis	Lecture	Written examination	Examination period	me	5	5
CA-S-MCCB-802	Fluorine in Drug Development	Lecture	Written examination	Examination period	me	6	2.5
CA-S-MCCB-804	Synthetic Biology	Seminar	Oral examination	Examination period	me	6	5
CA-S-MCCB-805	Drug Discovery	Lecture	Written examination	Examination period	me	5	2.5
CA-S-xxx	**Specialization electives (see MCCB study program handbook)**		**Various**	**Various**	**me**	**5/6**	**5**
Total CP							**45**

							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	Lecture (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)	Lecture (online)	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)	Lecture (online)	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	Examination period			5
							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.

[3] 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

[4] German native speakers have alternatives to the language courses (in the field of Humanities).

Figure 3: Schematic Study and Examination Plan

7 Medicinal Chemistry and Chemical Biology Modules

7.1 General Medicinal Chemistry and Chemical Biology

<table>
<tr><td colspan="3">Module Name
General Medicinal Chemistry and Chemical Biology</td><td>Module Code
CH-110</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-110-A</td><td colspan="3">General Medicinal Chemistry and Chemical Biology</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-110-B</td><td colspan="3">General Medicinal Chemistry and Chemical Biology Tutorial</td><td>Tutorial</td><td>2.5</td></tr>
<tr><td>Module Coordinator
Prof. Dr. Nikolai Kuhnert</td><td colspan="3">Program Affiliation
• Medicinal Chemistry and Chemical Biology (MCCB)</td><td colspan="2">Mandatory Status
Mandatory for MCCB</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements
Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• Basic knowledge in Life Sciences and Chemistry</td><td>Frequency
Annually
(Fall)</td><td colspan="2">Forms of Learning and Teaching
• Lecture (52.5 hours)
• Tutorial (15 hours)
• Private study for the Lecture (120 hours)</td></tr>
<tr><td>Duration
1 semester</td><td colspan="2">Workload
187.5 hours (lecture)</td></tr>
<tr><td colspan="6">Recommendations for Preparation
Early reading, extensive note taking and self-testing, work through practice problems, attend the tutorials.</td></tr>
</table>

Content and Educational Aims

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

Intended Learning Outcomes

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

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

Indicative Literature

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

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

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

Usability and Relationship to other Modules

- Strongly recommended for BCCB and CBT students.
- Prerequisite for second year CORE modules "Medicinal Chemistry", "Chemical Biology", "Pharmaceutical Chemistry","Physical Chemistry and Molecular Modelling" and "High Throughput Screening"

.

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 of each module component has to be passed with at least 45%.

7.2 General Organic Chemistry

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

General Organic Chemistry</td><td colspan="2">Module Code

CH-111</td><td>Level (type)

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

7.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CH-111-A</td><td colspan="3">General Organic Chemistry</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-111-B</td><td colspan="3">General Organic Chemistry Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

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

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

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

Pre-requisites

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

Co-requisites

☒ None</td><td rowspan="2">

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

Annually

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

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

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

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

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

This module provides an introduction to Organic Chemistry and begins with general reactivity patterns and the supportive concepts of resonance, conjugation and aromaticity, which come from applying knowledge of orbitals. Carbanion, alcohol, and amine nucleophiles are introduced and this allows carbonyl additions resulting in: alcohol, acetal, imine, enamine, oxime, and 28harmacop 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</td></tr>
</table>

followed by an introduction to conformational analysis and stereochemistry which allow the transition states within the subsequent chapters on substitution, elimination, and addition reactions to be understood.
In a parallel manner, the student will learn that a chemistry laboratory is for exploring chemical reactions. However, before doing so we must demonstrate: safety aspects, common hazards, and the structure and content required for a laboratory report. After this, the essential techniques are shown for: setting up, monitoring (TLC, color change, etc.), and quenching (neutralize active chemicals) reactions. In parallel, the student will purify the products (chromatography, crystallization, separatory funnel extractions, etc.), and use basic methods to identify the products. While doing so, the student is exposed to the common equipment (rotary evaporator, melting point apparatus, etc.) within the laboratory. Reactions based on nucleophilic substitution, elimination, bromination to an alkene, electrophilic aromatic substitution, and the isolation of a natural product, characterize the experimental exposure within this laboratory.

Intended Learning Outcomes

By the end of the module, the students 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%.

7.3 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 in 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. It is a pre-requisite for the General Cell Biology CHOICE Module and the BCCB CORE Modules Microbiology, Infection and Immunity; and Advanced Biochemistry I. It is also a pre-requisite for the Chemistry CHOICE Module
- Introduction to Biotechnology

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%.

7.4 General Cell Biology

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

General Cell Biology</td><td>Module Code

CH-101</td><td>Level (type)

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

7.5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CH-101-A</td><td colspan="3">General Cell Biology</td><td>Lecture</td><td>5</td></tr>
<tr><td>CH-101-B</td><td colspan="3">General Cell Biology Lab</td><td>Lab</td><td>2.5</td></tr>
<tr><td>Module Coordinator

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

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

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

Pre-requisites: ☒ General Biochemistry

Co-requisites: ☒ None

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

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

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

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

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

For this module, students should revise chemistry, mathematics, physics and biology at the high school level and ideally bring basic self-directed study skills at the high school level.
Students need to read the relevant chapters in the recommended textbooks and all course materials provided by the instructors (e.g., manuals for the laboratory course).</td></tr>
</table>

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.

Content and Educational Aims

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

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

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

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

Intended Learning Outcomes

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

1. draw, label and describe cellular structures and processes;
2. recognize cellular structures depicted by different modes of microscopy;
3. use proper terminology and scientific language to explain cellular processes;
4. relate the class examples to more general principles governing cellular physiology;
5. provide examples for methodological approaches to investigate the molecular composition of cells and to monitor cellular processes;
6. predict the outcome of simple experimental approaches in molecular cell biology;
7. apply their knowledge to solve more distantly related problems in molecular cell biology;
8. perform experiments in a Biosafety Level S1 Laboratory, partially under semi-sterile conditions;
9. show practical laboratory skills (use of equipment, carry out methods etc.);
10. follow experimental procedures in the fields of molecular cell biology as outlined in a laboratory manual;
11. use technical equipment and plan basic experiments;
12. relate an experimental setup to the aim of an experiment;
13. formulate expectations and hypotheses to be tested;
14. generally explain the principles of molecular biology and cellular analyses;
15. depict, describe, and interpret experimental data in publication-style 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. It is a pre-requisite for the BCCB CORE Modules Microbiology, Infection and Immunity and Advanced Cell Biology I.
- It is also a pre-requisite for the MCCB CORE Module Chemical Biology and one of two possible pre-requisites for the CBT CORE Module Industrial Biotechnology.

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%.

7.5 Medicinal Chemistry

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

Medicinal Chemistry</td><td>Module Code

CO-420</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-420-A</td><td colspan="3">Medicinal Chemistry</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

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

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

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

Pre-requisites

☒ General Biochemistry
☒ General Organic Chemistry</td><td rowspan="2">Co-requisites

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

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

Annually

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

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

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

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

Early reading, extensive note taking and self-testing, work through practice problems, fully understand the material before entering class, and attend voluntary tutorials</td></tr>
<tr><td colspan="6">Content and Educational Aims
This module provides an insight into the design of drugs, their interactions with targets, and the role of selected targets in selected diseases. It will introduce the concepts of isosteres and bioisosteres. The physical basis of interactions between drugs and targets will be explained. Methods for determining the site and binding strength of drugs to targets will be presented. The optimization of a lead compound to a drug will be detailed. Assay systems for drug optimizations will be presented. The path of drugs from the design to clinical use will be followed. The concept of 37harmacophore will be presented. Stereochemical aspects of drug design will be discussed. Rules for drug design and fragment-based drug design will be explained. The ADME concept will be introduced. LD50 and ED50, as well as dose-response curves, will be presented. Structure-activity relationships will be discussed.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes
By the end of the module, the student will be able to

1. propose a series of isosteres and bioisosteres for common functional groups;
2. understand the principles of testing affinities of drugs to targets;</td></tr>
</table>

3. analyze the interaction potential of drugs with their targets;
4. sketch the path of a drug from lead structure to clinical trial;
5. differentiate between conventional and fragment-based drug design;
6. propose ways to identify targets on which specific molecules act
7. estimate the changes in structure and its effect on ADME;
8. extract information about structure-activity relationships from a given research paper on drug design;
9. explain the testing methods employed in the paper;
10. explain changes in interaction potentials for given modifications of a compound;
11. explain the role of the drug in the disease and identify the role of the target.

Indicative Literature

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

Usability and Relationship to other Modules

- This module is of central importance because it provides the first medicinal chemistry foundation that is then expanded on by other second year (CORE) modules, e.g., Phsyical Chemistry and Molecular Modelling, Chemical Biology, Pharmaceutical Chemistry, and High Throughput Screening.
- Pre-requisite for second year CORE module **“**Medicinal Chemistry and Chemical Biology Laboratory”

Examination Type: Module Examination

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

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

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

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

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

7.6 Chemical Biology

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

Chemical Biology</td><td colspan="2">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 colspan="3" rowspan="2">Entry Requirements

Pre-requisites

☒ General Medicinal Chemistry and Chemical Biology
☒ General Organic Chemistry</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>
</table>

Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills
☒ General Medicinal Chemistry and Chemical Biology ☒ General Organic Chemistry	☒ None	• Basic knowledge in biochemistry, cell biology, and organic chemistry • Understanding of structure-function relationships at the molecular and cellular levels

Recommendations for Preparation

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

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 will 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.

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%.

7.7 Pharmaceutical Chemistry

<table>
<tr><td colspan="3">Module Name
Pharmaceutical Chemistry</td><td>Module Code
CO-422</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-422-A</td><td colspan="3">Pharmaceutical Chemistry I</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>CO-422-B</td><td colspan="3">Pharmaceutical Chemistry II</td><td>Lecture</td><td>2.5</td></tr>
<tr><td>Module Coordinator

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

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

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

Pre-requisites: ☒ General Medicinal Chemistry and Chemical Biology; ☒ General Organic Chemistry
Co-requisites: ☒ None
Knowledge, Abilities, or Skills: • Basic knowledge in Life Sciences</td><td>Frequency

Annually
(Fall & 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

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

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

Recommendations for Preparation

Students should have a basic background knowledge of chemistry, organic chemistry and biochemistry acquired during the first year CHOICE modules, in particular in general MCCB and Organic Chemistry. Students should have a fundamental understanding of organic structure, knowledge of functional groups (naming and properties), chemical bonding and aspects of stereochemistry and conformational changes. A sound knowledge of chemical equilibria and non-covalent interactions is expected. A basic knowledge of human physiology from high school biology and biochemical pathways and metabolism is advantageous.
Early reading, extensive note taking and self-testing, work through practice problems, fully understand the material before entering class, and attend voluntary tutorials.

Content and Educational Aims

Pharmaceutical chemistry deals with all aspects of drugs used in pharmaceutical and medical practice. Grouped according to therapeutic areas, the chemical structures, structural requirements for drug action, mode of action, basic pharmacology and synthesis will be introduced. Therapeutic areas include selected drugs acting on the: peripheral nervous, central nervous, endocrine, cardiovascular, renal, and digestive systems, and will be discussed along with anti-infective drugs (antibiotics and antivirals).

Furthermore, general topics overarching all pharmaceutical applications such as drug analysis, identification, separation, formulation, bioavailability, pharmacokinetics, pharmacodynamics, receptor theory, basic physiology and legal standards will be introduced. The module provides an overview of current knowledge on drugs in daily medicinal use and creates the basic foundation of knowledge required in all future drug development.

Intended Learning Outcomes

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

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

Indicative Literature

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

British National Formulary (BNF, latest edition).

Usability and Relationship to other Modules

- This module forms the co-foundation (with Medicinal Chemistry) for future modules in, for example, Phsyical Chemistry and Molecular Modelling and Chemical Biology.

Examination Type: Module Examination

Assessment Type Oral examination — Duration: 40 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%.

7.8 Advanced Organic Chemistry

Module Name	Module Code	Level (type)	ECTS
Advanced Organic Chemistry	CO-423	Year 2 (CORE)	5

Module Components

Number	Name	Type	ECTS
CO-423-A	Advanced Organic Chemistry	Lecture	5

Module Coordinator	Program Affiliation	Mandatory Status
Prof. Dr. Thomas Nugent	• Medicinal Chemistry and Chemical Biology (MCCB)	Mandatory for CBT and MCCB

Entry Requirements

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

Recommendations for Preparation

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

Content and Educational Aims

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

Intended Learning Outcomes

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

1. understand the value of the order of reactions within multi-step synthesis.
2. design three step reaction sequences.

3. appreciate retrosynthetic approaches to synthesize selected molecules.
4. discern chemoselective and regioselective challenges.
5. recognize the stereochemical outcomes of selected reactions.
6. evaluate and apply transition state analysis to selected reactions.
7. complete some reaction mechanisms.
8. will know common carbonyl group reaction transformations.
9. identify and recall specific structures and reactions discussed during class

Indicative Literature

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

Usability and Relationship to other Modules

- Completion of this module allows the student to understand the common concepts, reactions, and reactivity patterns of organic chemistry. It enhances the learning outcomes for CORE modules Medicinal Chemistry, Chemical Biology, and Pharmaceutical Chemistry, but is not a pre-requisite for those modules.

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%.

7.9 Scientific Software and Databases

<table>
<tr><td colspan="3">Module Name
Scientific Software and Databases</td><td>Module Code
CO-443</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-443-A</td><td colspan="3">Scientific Software and Databases</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator
Prof. Dr. Detlef Gabel</td><td colspan="3">Program Affiliation
• Chemistry and Biotechnology (CBT)</td><td colspan="2">Mandatory Status
Mandatory elective for CBT and MCCB</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements
Pre-requisites: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills</td><td>Frequency
Annually
(Spring)</td><td colspan="2">Forms of Learning and Teaching
• Lecture (20 hours)
• Seminar (15 hours)
• Homework and self-study (50 hours)
• Preparation of term paper (45 hours)</td></tr>
<tr><td>Duration
1 semester</td><td colspan="2">Workload
125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation
First-year modules in General Chemistry, Organic Chemistry, Biochemistry, and Biotechnology</td></tr>
<tr><td colspan="6">Content and Educational Aims
The students will be familiarized with software to visualize scientific information in chemistry and life sciences. They will be familiarized with the sources used to draw the relevant scientific information, and the retrieval of primary sources of data. They will be familiarized with software to present results, and with software to numerically evaluate data.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes
By the end of this module, students will 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;</td></tr>
</table>

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.

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%.

7.10 Advanced Organic and Analytical Chemistry Lab

Module Name	**Module Code**	**Level (type)**	**CP**
Advanced Organic and Analytical Chemistry Laboratory	CO-424	Year 2 (CORE)	5

Module Components

Number	Name	Type	CP
CO-424-A	Advanced Organic Chemistry Lab	Lab	2.5
CO-424-B	Analytical Chemistry Lab	Lab	2.5

Module Coordinator	**Program Affiliation**	**Mandatory Status**
Prof. Dr.Thomas Nugent Prof. Dr. Nikolai Kuhnert	• Medicinal Chemistry and Chemical Biology (MCCB)	Mandatory for CBT and MCCB

Entry Requirements			**Frequency**	**Forms of Learning and Teaching**
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Fall)	• Lab (51 hours) • Private study lab (74 hours)
☒ None	☒ Analytical Methods ☒ Advanced Organic Chemistry	Laboratory safety	**Duration** 1 semester	**Workload** 125 hours

Recommendations for Preparation

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

Content and Educational Aims

A chemical laboratory is a place for exploration, and the second semester of organic laboratory places you squarely in that environment. Here you will set up your own reactions and be taught why an atmosphere of nitrogen, free of moisture, is required when using more reactive reagents. You will also expand your techniques, e.g., employing distillation, and be exposed to important instrumentation, e.g., nuclear magnetic resonance, for product identification. Importantly, you will begin to appreciate the entire process of designing and then performing a reaction. Starting from your reaction table displaying the required stoichiometry and weight or volume of the starting materials, to the order and timing of compound additions, to the isolation of your pure product whose structure you can support via chromatographic and/or spectroscopic evidence. On completing this laboratory you will have an appreciation for the manipulation of common organic functional groups and by extension, some of the challenges of synthesizing a pharmaceutical drug.
Analytical chemistry is an important applied area of chemistry. This part of the laboratory module will introduce students an introduction to experimental analytical chemistry. The use of spectrometers and chromatographic

equipment will be demonstrated to students followed by set experiments to be performed independently by the students. A set of six dedicated experiments on UV/Vis-, NMR-, and IR spectroscopy, mass spectrometry, gas chromatography and HPLC will be performed by the students in small groups (2-3 students) under supervision. Subsequently students are asked to record their data, interpret their experimental findings, estimate errors, and report them.

Intended Learning Outcomes

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

1. independently set-up, monitor, and quench organic reactions;
2. inform yourself about chemical hazards;
3. dispose of chemicals properly;
4. identify and use standard organic laboratory equipment;
5. suggest purification methods for organic compounds;
6. familiar with more advanced organic laboratory techniques;
7. obtain a ^{1}H NMR spectrum with assistance;
8. illustrate knowledge on instrumental methods including spectroscopic and separation techniques;
9. explain and understand the physical principles behind spectroscopic and separation techniques;
10. measure and analyze real samples;
11. apply knowledge on instrumental techniques to solve qualitative and quantitative experimental analytical problems;
12. interpret spectroscopic data and deduce chemical structures from that data;
13. compare spectroscopic data and predict spectral properties from chemical structures;
14. calculate quantitative values from analytical results;
15. prepare scientific reports and critical analysis on the experimental findings of analytical results.

Indicative Literature

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

Usability and Relationship to other Modules

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

Examination Type: Module Examination

Assessment Type Laboratory Reports — Length: 3-15 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%.

7.11 High Throughput Screening (HTS)

Module Name			**Module Code**	**Level (type)**	**CP**
High Throughput Screening (HTS)			CO-425	Year 2 (CORE)	5
Module Components					
Number	Name			Type	CP
CO-425-A	High Throughput Screening			Lecture	5
Module Coordinator Prof. Dr. Mathias Winterhalter	**Program Affiliation** • Medicinal Chemistry and Chemical Biology (MCCB)			**Mandatory Status** Mandatory elective for MCCB	
Entry Requirements			**Frequency**	**Forms of Learning and Teaching**	
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Fall)	• Lecture (35 hours) • Tutorial of the lecture (10 hours) • Private study for the lecture (80 hours)	
☒ General Medicinal Chemistry and Chemical Biology	☒ None	None beyond formal prerequisites	**Duration** 1 semester	**Workload** 125 hours	
Recommendations for Preparation					
There are a number of specialized books that describe parts of this rapidly growing area of research and the corresponding technical know-how, but no standard textbook condenses all of the material needed for this module. Please see the syllabus for specific content guidance. A willingness to learn some physical chemistry concepts will be required.					
Content and Educational Aims					
This module uses analytical and physical chemistry concepts. The students will be introduced to the recent innovation of High Throughput Screening (HTS), which is possible due to the latest advancements in: robotics, data processing/control software, high-speed computer technology, liquid handling devices, and detector sensing. Using HTS researchers can conduct millions of chemical, genetic, or pharmacological tests in a short period of time, and this can allow rapid identification of: active compounds, antibodies, or genes that modulate a particular biomolecular pathway. Our entry point will be the miniaturization of the analytical tools and the advantages and limits therefrom for the respective techniques. This is followed by examples of the current state of the art (primary literature examples). The discussed material bridges the gap between basis science at the typical lab scale and					

the rapid development of the new screening platform technologies. By the end of this module, students will know the basic principles of HTS and how to get access to this technology.

Intended Learning Outcomes

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

1. explain how and when common analytical tools can be used for HTS
2. understand the physical and technical limitations required for miniaturization and parallelization
3. choose suitable analytical tool to obtain thermodynamic parameters needed for optimization
4. design simple assays
5. realize the fundamental value of statistical analysis for large data sets
6. appreciate the value of quality control

Indicative Literature

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

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

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

Usability and Relationship to other Modules

- This module extends and complements the learning outcomes for the second year modules.
- This module is mandatory elective for MCCB but is highly recommended.
- This module extends and complements some of the learning outcomes from the parallel taught CORE modules in Medicinal Chemistry and Pharmaceutical Chemistry.

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%.

7.12 Physical Chemistry and Molecular Modelling

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

Physical Chemistry and Molecular Modelling</td><td>Module Code

CO-426</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-426-A</td><td colspan="3">Physical Chemistry and Molecular Modelling</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

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

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

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

Pre-requisites: ☒ Medicinal Chemistry

Co-requisites: ☒ None

Knowledge, Abilities, or Skills
• Basics of protein structure
• Newton’s equation including applications</td><td>Frequency

Annually

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

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

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

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

Reviewing the basics of and principles of biochemistry and Newtonian physics.</td></tr>
<tr><td colspan="6">Content and Educational Aims

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

Intended Learning Outcomes

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

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

Indicative Literature

Not specified

Usability and Relationship to other Modules

- This module builds on the CORE module Medicinal Chemistry and does so by providing an introductory understanding for the statistical thermodynamics required for computational modelling.

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%.

7.14 Medicinal Chemistry and Chemical Biology Laboratory

Module Name		**Module Code**	**Level (type)**	**CP**
Medicinal Chemistry and Chemical Biology Laboratory		CO-427	Year 2 (CORE)	5
Module Components				
Number	Name		Type	CP
CO-427-A	Medicinal Chemistry and Chemical Biology Laboratory		Laboratory	5
Module Coordinator Prof. Dr. Nikolai Kuhnert / Prof. Dr. Thomas Nugent	**Program Affiliation** • Medicinal Chemistry and Chemical Biology (MCCB)		**Mandatory Status** Mandatory for MCCB	
Entry Requirements Pre-requisites: ☒ Medicinal Chemistry; ☒ Organic and Analytical Chemistry Lab Co-requisites: ☒ Chemical Biology Knowledge, Abilities, or Skills: • Laboratory safety		**Frequency** Annually (Spring)	**Forms of Learning and Teaching** • Lab (51 hours) • Private study lab (74 hours)	
		Duration 1 semester	**Workload** 125 hours	

Recommendations for Preparation

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

Content and Educational Aims

This laboratory module offers a series of experiments encompassing the fields of medicinal chemistry, pharmaceutical chemistry, and chemical biology. It follows that an array of experiments from the drug development pathway are examined, starting from chemical synthesis and isolation, and natural sources of a drug molecule, to enzyme inhibition assays and aspects of ADME, including permeation experiments and the identification of metabolites in vitro and from body fluids. Drug quality control as carried out in pharmaceutical practice is additionally included. On the chemical biology side, experiments include the use of labelled biomolecules as probes and the quantification of small molecule target interactions. The module uses a multitude of experimental techniques already introduced in other mandatory laboratory courses such as synthesis, UV/VIS spectroscopy, HPLC, MS, and fluorimetry, in addition to specialized techniques using plate readers, PAMPA plates, and calorimetry.

Intended Learning Outcomes

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

1. plan an experiment studying interactions between small molecules and biomolecules;
2. describe and identify a series of selected experimental instrumental techniques;
3. record and critically evaluate numerical experimental data;
4. read and engage in unfamiliar experimental approaches;
5. explain the broader scientific approach to drug development and the probing of cellular function.

Indicative Literature

Not specified

Usability and Relationship to other Modules

- These laboratories provide the skills and techniques required to perform the most often chosen thesis research topics. The introduced techniques and instruments provide the hands-on knowledge that complement the theoretical content learned in the CORE year modules.
- Mandatory for a major in MCCB

Examination Type: Module Examination

Assessment Type: Laboratory Reports — Length: 3-15 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 Advanced Organic Synthesis

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

Advanced Organic Synthesis</td><td>Module Code

CA-S-MCCB-801</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-MCCB-801</td><td colspan="2">Advanced Organic Synthesis</td><td>Lecture</td><td>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 elective for CBT and MCCB</td></tr>
<tr><td colspan="2" rowspan="2">Entry Requirements

Pre-requisites: ☒ Advanced Organic Chemistry
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• Broad organic chemistry concepts</td><td>Frequency

Annually

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

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

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

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

Review the concepts within Advanced Organic Chemistry</td></tr>
<tr><td colspan="5">Content and Educational Aims
Building on your basic knowledge of functional group transformations and stereochemistry, strategies for the synthesis of complex building blocks, natural products, or pharmaceutical drugs will be discussed from the primary literature. In this context, you will learn the importance of the order and type of transformation (retrosynthetic analysis) required for brevity in synthesis. Critical reaction steps, examples of which could be, enantioselective hydrogenation, biaryl coupling, aldol reactions, etc., will be discussed at length to define current transition state knowledge and substrate limitations. In doing so, you will learn the how and why of organic reaction product selectivity. In a parallel manner, functional group compatibility, pKa, the use of modern reagents, radical clock chemistry, the nuances of chemo-, regio-, diastereo-, and enantiocontrol through the use of proximal functional groups vs enantioselective catalysis, etc. will be discussed when and where appropriate.</td></tr>
</table>

Intended Learning Outcomes

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

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

Indicative Literature

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

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

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

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

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

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

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

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

Usability and Relationship to other Modules

- This module is for students who continue to be curious and want to extends their studies in organic synthesis and may be considering graduate level education in Medicinal Chemistry or Organic Chemistry.

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%.

7.16 Fluorine in Drug Development

Module Name			Module Code	Level (type)	CP
Fluorine in Drug Development			CA-S-MCCB-802	Year 3 (Specialization)	2.5
Module Components					
Number	Name			Type	CP
CA-MCCB-802	Fluorine in Drug Development			Lecture	2.5
Module Coordinator	**Program Affiliation**			**Mandatory Status**	
Prof. Dr. Gerd-Volker Röschenthaler	• Medicinal Chemistry and Chemical Biology (MCCB)			Mandatory elective for MCCB and CBT	
Entry Requirements			**Frequency**	**Forms of Learning and Teaching**	
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Spring)	• Lecture (17.5 hours) • Tutorial lecture (5 hours) • Private study lecture (40 hours)	
☒ Advanced Organic Chemistry	☒ None	• recognize organic functional groups • familiar with organic mechanisms • exposed to the concept of dynamic processes	**Duration**	**Workload**	
			1 semester	67.5 hours	
Recommendations for Preparation					
None.					

Content and Educational Aims

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

Intended Learning Outcomes

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

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

Indicative Literature

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

Usability and Relationship to other Modules

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

Examination Type: Module Examination

Assessment Type: Written examination — Duration: 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%.

7.17 Drug Discovery

Module Name Drug Discovery			Module Code CA-S-MCCB-805	Level (type) Year 3 (Specialization)	CP 2.5
Module Components					
Number	Name			Type	CP
CA-S-MCCB-805	Drug Discovery			Lecture	2.5
Module Coordinator Prof. Dr. Björn Windshügel	**Program Affiliation** • Medicinal Chemistry and Chemical Biology (MCCB)			**Mandatory Status** Mandatory elective for MCCB and BCCB	
Entry Requirements			**Frequency** Annually (Fall)	**Forms of Learning and Teaching** • Lecture (17.5 hours) • Private study lecture (45 hours)	
Pre-requisites ☒ None	Co-requisites ☒ None	Knowledge, Abilities, or Skills	**Duration** 1 semester	**Workload** 67.5 hours	
Recommendations for Preparation None.					

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.

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

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: (weighted according CP)

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 Synthetic Biology

Module Name Synthetic Biology	Module Code CA-S-MCCB-804	Level (type) Year 3 (Specialization)	CP 5
Module Components			
Number	Name	Type	CP
CA-S-MCCB-804	Synthetic Biology	Seminar	5
Module Coordinator Dr. Andreas M. Lisewski	**Program Affiliation** • Medicinal Chemistry and Chemical Biology (MCCB)	**Mandatory Status** Mandatory elective for MCCB and BCCB	
Entry Requirements Pre-requisites: ☒ General Cell Biology Co-requisites: ☒ None Knowledge, Abilities, or Skills: • Molecular and cell biology main concepts	**Frequency** Annually (Spring)	**Forms of Learning and Teaching** • Lecture (35 hours) • Tutorial of the lecture (10 hours) • Private study for the lecture (80 hours)	
	Duration 1 semester	**Workload** 125 hours	
Recommendations for Preparation Review the elementary concepts of Molecular and Cell Biology.			

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.

Intended Learning Outcomes

Upon completion of this module, students will be able to

1. identify and explain basic concepts in synthetic biology by collecting and assessing appropriate items from the primary literature
2. schematize, differentiate and discuss parts, modules, and devices in synthetic biology systems
3. conclude that parts, modules, and devices predispose synthetic biological systems to rational (re-)design and engineering
4. identify information codes, redundancy and errors (noise) in synthetic biology systems

5. break down today’s main directions in synthetic biology, present their landmark experiments, and formulate specific technical challenges in their experimental realizations
6. assess, compare, and rank inherent risks (e.g., from individual to public health, to entire human society) associated with synthetic biology

Indicative Literature

1. Synthetic Biology - A Primer (Revised Edition), Geoff Baldwin, Published 2016; ISBN 978-1783268795
2. 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
3. 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%.

7.19 Current Topics in the Molecular Life Sciences

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

Current Topics in the Molecular Life Sciences</td><td>Module Code

CA-S-BCCB-801</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-801</td><td colspan="3">Current Topics in the Molecular Life Sciences</td><td>Seminar</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 elective for BCCB and MCCB</td></tr>
<tr><td rowspan="2">Entry Requirements

Pre-requisites

☒ Advanced Biochemistry II

☒ Advanced Cell Biology II

Or

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

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

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

Annually

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

• Lecture (10 hours)
• Preparation of presentation (30 hours)
• Seminar (15 hours)
• Private study (69 hours)
• Presentation (45 minutes)</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 and cell biology at the second-year level. They also need to be able to analyze (and partially, create) logical connections between scientific contents.</td></tr>
</table>

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 Biomedicine

Module Name			Module Code	Level (type)	CP
Biomedicine			CA-S-BCCB-804	Year 3 (Specialization)	5
Module Components					
Number	Name			Type	CP
CA-BCCB-804	Biomedicine			Lecture and seminar	5
Module Coordinator	**Program Affiliation**			**Mandatory Status**	
Prof. Dr. Klaudia Brix	• 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 (Spring)	• Lectures (26 hours) • Private study, readings (40 hours) • Poster design (49.5 hours) • Poster presentation (0.5 hours) • In-class discussions (9 hours)	
☒ Advanced Cell Biology I ☒ Advanced Cell Biology II	☒ None	• Advanced knowledge in cell biology • Ability to read and understand scientific articles • Critical discussion skills	**Duration**	**Workload**	
			1 semester	125 hours	

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

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

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

Examination Type: Module Examination

Assessment Type: Poster presentation — Duration: 30 min

Weight: 100%

Scope: All intended learning outcomes of the module.

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

7.21 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 and MCCB</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ General Biochemistry and General Cell Biology

Co-requisites: ☒ None

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

Annually

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

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

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

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

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

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

The human immune system is central to fighting disease. Immunology is thus one of the central sciences underlying medicine and at the same time a fascinating application of the principles of molecular life sciences to a complex organismic phenomenon. The Immunology lecture provides a second-year undergraduate-level introduction to the entire field of immunology that is based on knowledge in general biochemistry and cell biology. Students will get to know the molecular agents of the system (receptors and metabolic processes), with intracellular processes (antigen presentation and innate intracellular defense), cell-specific phenomena (cell differentiation, maturation, and trafficking), the function of the organs of the immune system, and organismic phenomena such as the acute phase response. The lecture then turns towards the mechanisms of disease and</td></tr>
</table>

disease-specific immunity, focusing on autoimmunity, HIV infection, and cancer as three major examples. In addition, pathogen evasion of the immune response is discussed as an important feature. Finally, immunotherapy approaches are thoroughly discussed. Altogether, the lecture enables students to understand the functioning of the immune system, its role in preventing, fighting, and (sometimes) causing diseases, as well as the possibilities that arise from the manipulation of the immune system through vaccination and adoptive transfer.

The Microbial Pathogenicity lecture will familiarize students with basic principles of microbial pathogenicity, methods used to investigate pathogens, and a selection of infectious diseases caused by microbes and viruses. The lecture is meant to explore potential ways to treat and heal infected individuals and how to utilize our knowledge of pathogens for the successful treatment of diseases. Aside of state-of-the-art methods on how to identify virulence and pathogenicity factors, the lecture will introduce specific examples of diseases and the pathogens that cause them. For each disease, the lecture will address the pathogen's discovery, how it employs virulence factors, how it infects and transmits, and how the respective infection can be treated. Students will learn how to distinguish between different types of microbial infections and will understand how the immune system copes with various types of infection both qualitatively and quantitatively. The Emerging problems of 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: Oral examination	 Duration: 20 min Weight: 33%
Scope: All intended learning outcomes	
Completion: To pass this module, the examination has to be passed with at least 45%.	

7.22 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

Number Name Type 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 rowspan="2" colspan="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

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

Annually

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

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

1 semester</td><td>Workload

125 hours</td></tr>
<tr><td colspan="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 and enzymatic catalysis is explored at the molecular and atomic level. The module will further introduce advanced methods to study the molecules involved in enzymatic catalysis. These concepts are applied to explain the principles of metabolism. In this context, the module describes how energy is produced by living organisms, and how key types of biomolecules are synthesized and degraded. Thus, all important classes of biomolecules are covered (with exception of nucleic acids that are covered in Advanced Biochemistry II). A special focus will be placed on common schemes and the adjustment of metabolism under different cellular conditions. <u>Note:</u> 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. qualitatively and quantitatively analyze kinetic data of enzymatic reactions;
7. apply their knowledge to novel problems;
8. find, understand, and interpret additional specific information from the literature and web resources.

Indicative Literature

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

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

Usability and Relationship to other Modules

- This module builds on the pre-required BCCB CHOICE Modules General Biochemistry and General Cell Biology.
- It is a pre-requisite for the BCCB CORE modules Advanced Biochemistry Laboratory and Advanced Biochemistry II.

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%.

7.23 Advanced Biochemistry II

Module Name			**Module Code**	**Level (type)**	**CP**
Advanced Biochemistry II			CO-403	Year 2 (CORE)	5
Module Components					
Number	Name			Type	CP
CO-403-A	Molecular Genetics			Lecture	5
Module Coordinator Prof. Dr. Felix Jonas	**Program Affiliation** • Biochemistry and Cell Biology (BCCB)			**Mandatory Status** Mandatory for BCCB Mandatory elective for MCCB	
Entry Requirements Pre-requisites ☒ General Biochemistry ☒ General Cell Biology	Co-requisites ☒ None	Knowledge, Abilities, or Skills • Knowledge of biochemical compounds • Ability to write chemical equations • Knowledge about metabolic principles • Ability to determine kinetic and thermodynamic parameters	**Frequency** Annually (Spring) **Duration** 1 semester	**Forms of Learning and Teaching** • Lecture (35 hours) • Private study (90 hours) **Workload** 125 hours	
Recommendations for Preparation Revision of the module content of the pre-required CORE module					
Content and Educational Aims The module intends to propvide a detailed understanding of the biochemical mechanisms that underlie the realization of genetic information in living systems. Initially, the focus lies on the structure, biosynthesis, and degradation of nucleotides and nucleic acids. Molecular mechanisms are elucidated, by which genetic information is regulated, controlled, and expressed in bacterial and eukaryotic cells, with an emphasis on replication, transcription, and translation. Furthermore, this module gives an insight in DNA damage and repair mechanisms and it introduces advanced concepts such as epigenetic regulation and control. Molecular mechanisms contributing to an altered use of genetic information in living systems are exemplified (e.g., homologous recombination, (alternative) splicing or chemical modifications, and processing of both, RNAs and proteins). Advanced methods to study these processes are introduced and examples of experimental results obtained by these methods are discussed. A special focus is placed on common principles and the cellular integration of					

regulatory processes governing these pathways.

Intended Learning Outcomes

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

1. illustrate the biosynthesis and degradation of nucleotides and discriminate different types of nucleic acid structures;
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

- This module builds on the pre-required BCCB CORE module Advanced Biochemistry I. It is a co-requisite for the BCCB CORE module Advanced Biochemistry Laboratory.
- Further, it is the pre-requisite for BCCB CAREER Specialization modules Current Topics in the Molecular Life Sciences and Experimental Strategy Design.

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 Organometallic Chemistry

Module Name		**Module Code**	**Level (type)**	**CP**
Organometallic Chemistry		CA-S-CBT-802	Year 3 (Specialization)	5
Module Components				
Number	Name		Type	CP
CA-CBT-802	Organometallic Chemistry		Lecture	5
Module Coordinator Prof. Dr. Detlef Gabel	**Program Affiliation** • Chemistry and Biotechnology (CBT)		**Mandatory Status** Mandatory elective for CBT and MCCB	

Entry Requirements			**Frequency**	**Forms of Learning and Teaching**
Pre-requisites ☒ General and Inorganic Chemistry ☒ General Organic Chemistry	Co-requisites ☒ None	Knowledge, Abilities, or Skills • None beyond formal prerequisites	Annually (Fall)	• Lecture (35 hours) • Private study (75 hours) • Exam preparation (15 hours)
			Duration 1 semester	**Workload** 125 hours

Recommendations for Preparation

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

Content and Educational Aims

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

Intended Learning Outcomes

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

1. classification and electronegativity considerations;
2. fundamentals of structure and bonding;
3. energy, polarity, and reactivity of the M-C bond;
4. NMR characterization of organometallics;
5. Main-Group organometallics (lithium, magnesium, aluminium, and tin);
6. transition metal organyls: concept of s-donor, s-donor/p-acceptor, s, and p -donor/p-acceptor ligands;
7. transition metal organyls: concept of metal-carbene and carbyne complexes;
8. isolobal concept;
9. metathesis and polymerization reactions and industrial processes;
10. concept of C-C bond formation (coupling reactions);
11. use of organometallics in medicine (enzyme inhibitors);
12. concept of metalloproteins;
13. concept of organometallic bioprobes for cellular imaging;

Indicative Literature

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

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

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

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Oral examination — Duration: 40 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%.

7.25 Biotechnology in Action

Module Name		Module Code	Level (type)	CP
Biotechnology in Action		CA-CBT-805	Year 3 (Specialization)	5
Module Components				
Number	Name		Type	CP
CA-CBT-805	Biotechnology in Action		Excursion	5
Module Coordinator Prof. Dr. Detlef Gabel	**Program Affiliation** • Chemistry and Biotechnology (CBT)		**Mandatory Status** Mandatory elective CBT and MCCB	
Entry Requirements Pre-requisites ☒ Industrial Biotechnology	Co-requisites ☒ none	Knowledge, Abilities, or Skills	**Frequency** Annually (Spring)	**Forms of Learning and Teaching** • Excursion (30 hours) • Lecture (17.5 hours) • Private Study including preparation of a presentation (77.5 hours)
			Duration 1 Semester	**Workload** 125 hours

Recommendations for Preparation

Content and Educational Aims

The module communicates basic knowledge in the use of biotechnology for industry and other purposes. Real processes in the pharmaceutical industry, the chemical industry and the food industry, among others, are subject to study and are presented either through a field trip or through lectures by industry representatives. The students will understand the sources of microorganisms and enzymes used in such processes, understand the disposal of side products and waste, and estimate the energetic balances of such large-scale processes.
The industry lectures and field trips are complemented by lectures in which advanced aspects of process design are discussed, such as the principles of conceptual design, block, process or P&I flow diagrams, technical-economic and ecological assessments of bioprocesses.

Intended Learning Outcomes

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

1. identify sources for microorganisms in large-scale processes
2. understand the problems caused by waste and side products of large-scale processes
3. understand how recycling or upcycling can be used for waste and side products
4. identify the energy needed for such processes, and how the off-heat can be used for the processes
5. understand the supply chains in such processes

Literature / Reading List

Usability and Relationship to other Modules

Examination Type: Module Examination

Assessment Type: Written examination Duration: 120 min

Weight: 100 %

Module achievement: An oral presentation is a module achievement and a prerequisite for participation in the exam.

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 Physical Chemistry

<table>
<tr><td colspan="3">Module Name
Physical Chemistry</td><td>Module Code
CO-440</td><td>Level (type)
Year 2 (CORE)</td><td>CP
5</td></tr>
<tr><td colspan="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CO-440-A</td><td colspan="3">Physical Chemistry</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

Prof. Dr. Detlef Gabel</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 MCCB and PHDS</td></tr>
<tr><td colspan="3" rowspan="2">Entry Requirements

Pre-requisites: ☒ General and Inorganic Chemistry or ☒Modern Physics
Co-requisites: ☒ None
Knowledge, Abilities, or Skills: • None beyond formal prerequisites</td><td>Frequency

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

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

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

125 hours</td></tr>
<tr><td colspan="6">Recommendations for Preparation
None</td></tr>
<tr><td colspan="6">Content and Educational Aims
The module provides an introduction to Physical Chemistry and focusses on thermodynamics, kinetics, intermolecular forces, surfaces, and electrochemistry. It also provides an introduction to quantum chemistry. This knowledge is essential to understand when chemical reactions can take place and how fast they can occur, and how molecules interact with each other and the solvent.</td></tr>
<tr><td colspan="6">Intended Learning Outcomes
By the end of the module, the student will be able to
1. use the gas laws to predict the behavior of perfect and real gases;
2. differentiate between enthalpy, entropy, and Gibbs energy;
3. correlate Gibbs energy with equilibrium constants;
4. derive the velocities of reactions of zero, first, and the second order;
5. derive the velocities of enzyme reactions and coupled reactions;
6. explain and apply the concept of activation energy;
7. calculate the velocity of reactions as a function of temperature;
8. recognize phase transitions from measurable properties;
9. explain and apply fundamentals in electrochemistry;
10. explain how given molecules and their functional groups can interact with each other and their surroundings;
11. recognize the different approaches to quantum chemical calculations;
12. use an electronic lab book and share their own results with others through it;
13. derive the fundamental equations of importance in physical chemistry;
14. demonstrate presentation skills;</td></tr>
</table>

Indicative Literature Atkins and de Paula, Elements of Physical Chemistry, 7th edition. Oxford: Oxford University Press, 2017.
Usability and Relationship to other Modules • Pre/corequisite for the Inorganic and Physical Chemistry lab • Mandatory for a Major and a Minor in CBT • Mandatory elective specialization module for third year Physics and MCCB major students;
Examination Type: Module Examination Assessment Component 1: Written examination — Duration: 120 min. Weight: 75% Scope: Intended learning outcomes of the module (1-12) Assessment Component 2: Presentation — Duration 15 min Weight 25% Scope: Intended learning outcomes of the module (13-14) Completion: This module is passed with an assessment-component weighted average grade of 45% or higher.

7.27 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>
<tr><td colspan="6">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</td></tr>
<tr><td colspan="6">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</td></tr>
</table>

times, such as before teaching starts in the 3rd semester or after teaching finishes in the 6th semester. The Study Program Coordinator or their faculty delegate approves the intended internship a priori by reviewing the tasks in either the Internship Contract or Internship Confirmation from the respective internship institution or company. Further regulations as set out in the Policies for Bachelor Studies apply.

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

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

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

Intended Learning Outcomes

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

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

Indicative Literature

Not specified

Usability and Relationship to other Modules

- 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

Module Name			Module Code	Level (type)	CP
Bachelor Thesis and Seminar MCCB			CA-MCCB-800	Year 3 (CAREER)	15
Module Components					
Number	Name			Type	CP
CA-MCCB-800-T	Thesis MCCB			Thesis	12
CA-MCCB-800-S	Thesis Seminar MCCB			Seminar	3
Module Coordinator	**Program Affiliation**			**Mandatory Status**	
Study Program Chair	• All undergraduate programs			Mandatory for all undergraduate programs	
Entry Requirements			**Frequency**	**Forms of Learning and Teaching**	
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Spring)	• Self-study/lab work (350 hours) • Seminars (25 hours)	
☒ 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	• comprehensive knowledge of the subject and deeper insight into the chosen topic; • ability to plan and undertake work independently; • skills to identify and critically review literature.	**Duration** 14-week lecture period	**Workload** 375 hours	
Recommendations for Preparation					

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

Content and Educational Aims

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

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

Intended Learning Outcomes

On completion of this module, students will be able to

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

Usability and Relationship to other Modules

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

Examination Type: Module Component Examinations

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

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

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

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

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

8. Constructor Track Modules

8.1 Methods

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(s)	Program Affiliation	Mandatory Status
Prof. Dr. Joachim Vogt	• 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

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

Examination Type: Module Examination

Assessment type: Written examination

Duration: 120 min
Weight: 100%

Scope: All intended learning outcomes of this module.
Completion: To pass this module, the examination has to 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: ☒ None
Co-requisites: ☒ None
Knowledge, Abilities, or Skills:
• High school math
• Basic high school physics</td><td>Frequency

Annually

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

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

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

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

Content and Educational Aims

Physics is the most fundamental of all natural sciences and serves as a basis for other sciences and engineering disciplines. This module introduces non-physics majors to the basic principles, facts, and experimental evidence from physics, as it is needed especially for the life sciences, geosciences, and chemistry.

Emphasis is placed on general principles and general mathematical concepts for a basic understanding of physical phenomena. Basic mathematics (geometry, calculus, vector analysis) is used to develop a quantitative and scientific description of physical phenomena. A voluntary tutorial is offered to discuss homework or topics of interest in more detail.

The lecture provides an overview of the basic fields of physics such as mechanics (motion, force, energy, momentum, oscillations, fluid mechanics), thermodynamics (temperature, heat, 1st law, ideal gas and kinetic gas theory, thermodynamic processes, entropy), electromagnetism (charge, electric field, potential, current, magnetic field, induction), optics (oscillations, waves, sound, reflection and refraction, lenses and optical instruments, interference and diffraction), and modern physics (particle-wave duality, atoms and electrons, absorption and emission, spin, NMR, ionizing radiation, radioactivity).

Intended Learning Outcomes

1. By the end of the module, students will be able to
2. recall the basic facts and experimental evidence in mechanics, thermodynamics, electromagnetism, optics and modern physics;
3. use the basic concepts of motion, force, energy, oscillations, heat, and light to describe natural and technical phenomena;
4. 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;
5. 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 has to be passed with at least 45%.

8.1.3 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	**Program Affiliation**			**Mandatory Status**	
Prof. Dr. Nikolai Kuhnert	• CONSTRUCTOR Track Area			Mandatory for MCCB and CBT 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**	**Workload**	
			1 semester	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%.

8.1.4 Plant Metabolism and Natural Products

<table>
<tr><td colspan="2">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="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTMS-18</td><td colspan="2">Plant Metabolism and Natural Products</td><td>Lecture</td><td>5</td></tr>
<tr><td>Module Coordinator

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

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

Mandatory for BCCB, MCCB
Mandatory elective for CBT</td></tr>
<tr><td colspan="2" 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="5">Recommendations for Preparation

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

Read the chapter “Plant Form and Function” (Joanne Chory) in the recommended textbook of Neil A. Campbell and Jane B. Reece, BIOLOGY, Benjamin Cummings, Pearson Education, current edition.</td></tr>
<tr><td colspan="5">Content and Educational Aims

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

Intended Learning Outcomes

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

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.

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 New Skills

8.2.1 Logic (perspective I)

<table>
<tr><td colspan="2">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="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTNS-01</td><td colspan="2">Logic (perspective I)</td><td>Lecture (online)</td><td>2.5</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 elective for all UG students (one perspective must be chosen)</td></tr>
<tr><td colspan="2" 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 lecture (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="5">Recommendations for Preparation</td></tr>
<tr><td colspan="5">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: 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)

<table>
<tr><td colspan="3">Module Name
Logic (perspective II)</td><td>Module Code
CTNS-NSK-02</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-02</td><td colspan="3">Logic (perspective II)</td><td>Lecture (online)</td><td>2.5</td></tr>
<tr><td>Module Coordinator

NN</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
Online lecture (17.5h)
Private study (45h)</td></tr>
<tr><td>Duration

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

62.5 hours</td></tr>
</table>

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: 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%

8.2.3 Causation and Correlation (perspective I)

<table>
<tr><td colspan="2">Module Name
Causation and Correlation (perspective I)</td><td>Module Code
CTNS-NSK-03</td><td>Level (type)
Year 2
(New Skills)</td><td>CP
2.5</td></tr>
<tr><td colspan="5">Module Components</td></tr>
<tr><td>Number</td><td colspan="2">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTNS-03</td><td colspan="2">Causation and Correlation</td><td>Lecture (online)</td><td>2.5</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 elective for all UG students (one perspective must be chosen)</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 lecture (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="5">Recommendations for Preparation</td></tr>
<tr><td colspan="5">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 <u>a causal</u> 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 <u>a correlation</u> 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 <u>counterfactual.</u></td></tr>
</table>

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%

2.2.4 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 (perspective II)			Lecture (online)	2.5
Module Coordinator Dr. Keivan Mallahi-Karai Dr. Eoin Ryan Dr. Irina Chiaburu	**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 • Basic probability theory	**Frequency** Annually (Spring)	**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					

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%

2.2.5 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
(online)</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>
<tr><td colspan="5">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</td></tr>
</table>

choice of data analysis methods and become mindful of the challenges when going from a linear to a 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%

2.2.6 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

Marco Verweij</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: ☒ Logic
☒ Causation & Correlation

Co-requisites: ☒ none

Knowledge, Abilities, or Skills:
• Being able to read primary academic literature
• Willingness to engage in teamwork</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

Please read: Camillus, J. (2008). Strategy as a wicked problem. Harvard Business Review 86: 99-106; Rogers, P. J. (2008). Using programme theory to evaluate complicated and complex aspects of interventions. Evaluation, 14, 29–48.</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

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%

2.2.7 Argumentation, Data Visualization and Communication (perspective I)

Module Name		**Module Code**	**Level (type)**	**CP**
Argumentation, Data Visualization and Communication (perspective I)		CTNS-NSK-07	Year 3 (New Skills)	5
Module Components				
Number	Name		Type	CP
CTNS-07	Argumentation, Data Visualization and Communication (perspective I)		Lecture (online)	5
Module Coordinator Prof. Dr. Jules Coleman, Prof Dr. Arvid Kappas	**Program Affiliation** • CONSTRUCTOR Track Area		**Mandatory Status** Mandatory elective for all UG students (one perspective must be chosen)	
Entry Requirements Pre-requisites ☒ Logic ☒ Causation & Correlation	Co-requisites ☒ none Knowledge, Abilities, or Skills	**Frequency** Annually (Fall)	**Forms of Learning and Teaching** • Online Lectures (35h) • Private Study (90h)	
		Duration 1 semester	**Workload** 125h	
Recommendations for Preparation				

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 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%

2.2.8 Argumentation, Data Visualization and Communication (perspective II)

Module Name	Module Code	Level (type)	CP
Argumentation, Data Visualization and Communication (perspective II)	CTNS-NSK-08	Year 3 (New Skills)	5

Module Components

Number	Name	Type	CP
CTNS-08	Argumentation, Data Visualization and Communication (perspective II)	Lecture (online)	5

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

Entry Requirements

Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Frequency	Forms of Learning and Teaching
☒ Logic ☒ Causation & Correlation	☒ none	• ability and openness to engage in interactions • media literacy, critical thinking and a proficient handling of data sources • own research in academic literature	Annually (Spring)	• Online Lecture (35 hours) • Tutorial of the lecture (10 hours) • Private study for the lecture (80 hours)
			Duration 1 semester	**Workload** 125 hours

Recommendations for Preparation

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.

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

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

2.2.9 Agency, Leadership, and Accountability

<table>
<tr><td colspan="3">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="6">Module Components</td></tr>
<tr><td>Number</td><td colspan="3">Name</td><td>Type</td><td>CP</td></tr>
<tr><td>CTNS-09</td><td colspan="3">Agency, Leadership, and Accountability</td><td>Lecture</td><td>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 for CSSE
Mandatory elective for all other UG study programs</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)</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</td></tr>
<tr><td colspan="6">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</td></tr>
</table>

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 and 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%

2.2.10 Community Impact Project

Module Name	Module Code	Level (type)	CP
Community Impact Project	CTNC-CIP-10	Year 3 (New Skills)	5

Module Components

Number	Name	Type	CP
CTNC-10	Community Impact Project	Project	5

Module Coordinator	Program Affiliation	Mandatory Status
CIP Faculty Coordinator	• CONSTRUCTOR Track Area	Mandatory elective

Entry Requirements

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

Frequency

Annually (Fall / Spring)

Forms of Learning and Teaching

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

Duration

1 semester

Workload

125 hours

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 Constructor University as socially conscious and responsible graduates (part of the Constructor University's mission) and to convey social and personal abilities to the students, including a practical awareness of the societal context and relevance of their academic discipline.

By the end of this project, students 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

Not specified

Usability and Relationship to other Modules

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

Examination Type: Module Examination

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

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/learning-languages).

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 must 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	**Program Affiliation**	**Mandatory Status**
Dr. Irina Chiaburu	• CONSTRUCTOR Track Area	Mandatory elective

Entry Requirements			**Frequency**	**Forms of Learning and Teaching**
Pre-requisites	Co-requisites	Knowledge, Abilities, or Skills	Annually (Spring/Fall)	• Online Lecture
☒ none	☒ none	•	**Duration**	**Workload**
			1 semester	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

Medicinal Chemistry and Chemical Biology					General MCCB	General Org Chem	General Biochemistry	General Cell Bio	Medicinal Chemistry	Chemical Biology	Pharmaceutical Chem	Adv Org Chem	Sci Software & Databanks	Adv Org & Analytical Lab	High Throughput Screen	Physical Chem & Molecular Mod	MCCB Lab	Plant Metabolites & Nat Prod	Analytical Methods	Summer Internship	Adv Org Synth	Flourine in Drug Dev	Drug Discovery	Synthetic Biology	Specialisation modules	Seminar MCCB/CBT	Thesis MCCB	CT Methods	CT New Skills	CT Language / Humanities
Semester					1	2	1	2	3	4	3/4	3	4	3	3	4	4	4	3	4-5	5	6	5/6	6	5-6	6	6	1-4	3-6	1-2
Mandatory/mandatory elective					m	m	m	m	m	m	m	m	me	m	me	me	m	m	m	m	me	me	me	me	me	m	m	m	m	m
Credits					7.5	7.5	7.5	7.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	15	5.0	2.5	2.5	5.0	5.0-7.5	3.0	12.0	20.0	20.0	10.0
	Competencies*																													
Program Learning Outcomes	**A**	**E**	**P**	**S**																										
(T1) recognize and discuss the concepts of bonding, acidity/basicity, conformation, and stereochemistry, as they relate to functional groups;	x	x			x	x			x			x									x	x	x							
(T2) explain and describe general reactivity patterns (organic or biochemical) and the corresponding reaction categories (chemical or metabolic)	x	x			x	x						x									x			x						
(T3) illustrate how chemical tools can be used to probe biological processes	x	x			x		x	x		x	x						x	x					x	x	x			x		
T4) explain the basic concepts within the fields of biochemistry and cell biology	x	x					x	x																x	x					
(T5) describe, with examples from the major categories of biomolecules, how chemical structure defines cellular function;	x	x			x		x	x		x							x	x						x	x			x		
(T6) predict and discriminate the basic principles of drug action;	x	x							x		x												x							
(T7) judge and illustrate how the function of biomolecules can be influenced by small molecules, and how such small molecules are identified, developed, produced, and analyzed to manage disease;	x	x			x				x	x	x											x	x							
(T8) analyze the bioactivity potential, drug-target interactions, structure-activity relationships, or pharmacokinetics of small molecules and biologicals, and explain how these parameters are determined.	x	x			x				x	x	x												x							
(T9) test computer-based visualization to correlate protein conformation with drug interaction	x	x														x														
(T10) calculate values from data and correlate data using statistical methods as applied to thermodynamics or large data sets	x	x											x		x	x														
(T11) establish and propose analytical tools for pharmaceutical research	x	x												x	x				x			x						x		
(T12) design scientific hypotheses and suggest experiments to validate them	x	x																			x	x	x	x						
(PW1) analyze or propose research challenges and plan experiments and analytical methods that allow for their solution within the fields of: medicinal chemistry, pharmaceutical chemistry, and chemical biology	x	x												x			x								x		x			
(PW2) propose, critically evaluate, and report on experimental data	x	x												x			x										x			
PW3) understand and explain basic experimental techniques within the fields of: organic chemistry, biochemistry, and cell biology	x	x				x	x	x						x											x					
(PW4) demonstrate the ability to perform basic chemical syntheses	x	x				x								x			x													
(PW5) develop or design simple binding or catalysis assays	x	x													x		x													
(PW6) apply basic computational molecular modeling tasks and illustrate their value for drug-target interactions	x	x											x			x														
(PW7)recognize or apply laboratory equipment or instruments routinely used for qualitative measurements, chromatography, and/or spectroscopy collection as they relate to the quality or characterization of small molecules or biomolecules	x	x				x	x	x						x			x													
(PW8) collect and survey material safety data sheets or clinical trial data for research purposes	x	x				x	x	x					x	x			x													
(TS1) analyze scientific or technical questions, p	x	x	x	x					x	x	x	x			x	x			x		x	x	x	x	x	x	x		x	
(TS2) concisely and professionally present or de	x	x	x	x					x	x	x															x				
(TS3) understand and explain the relationship between experiments, and the data and trends therefrom for scientific hypothesis generation	x	x	x	x					x	x	x	x		x	x	x	x		x		x	x	x	x				x	x	
(TS4) create and write scientific documents with knowledge of their purpose, structure, and conciseness	x	x		x				x						x			x			x				x			x			
(TS5) demonstrate or apply a general set of scientific methods and skills used within the pharmaceutical industry	x	x				x	x	x						x			x		x						x			x		
(TS6) engage ethically within the framework of planning, observing, recording, and communicating research within academia, a future work place, and the wider community	x	x	x	x		x	x	x	x	x	x		x	x			x			x						x	x			x
(TS7) identify, describe, and evaluate important parameters within the context of	x	x		x					x		x											x	x							
(TS8)understand the value of schematic, graphic, and tabular information for scientific writing	x	x		x				x					x							x							x			
(TS9) take responsibility for their own learning, personal and professional development through the analysis of	x	x	x	x				x	x	x	x									x					x	x	x		x	x
(TS10) apply numerical skills to solve quantitative problems	x	x			x	x	x	x						x			x		x						x			x		
(TS11) collaborate with peers in a team and demonstrate intercultural and social competencies	x	x	x	x		x	x	x						x		x	x			x					x	x	x		x	x
Assessment Type																														
Oral examination											x													x	x					x
Written examination					x	x	x	x	x	x		x		x	x	x		x	x		x	x	x		x			x	x	x
Project assessment																													x	
Project report																				x										
Essay																										x				x
Term paper													x																	
Laboratory report						x	x	x						x			x													
Poster presentation																									x					
Presentation																									x		x		x	x
Thesis																											x			
Module achievements																									x				x	x

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

Figure 4: Intended Learning Outcomes Assessment-Matrix