JACOBS UNIVERSITY

Study Program Handbook

Medicinal Chemistry and Chemical Biology

Bachelor of Science

Contents

1 The Medicinal Chemistry and Chemical Biology (MCCB) Study Program

1.1 Concept

The Medicinal Chemistry and Chemical Biology (MCCB) program places the student at the forefront of the revolutionary efforts now underway to understand and treat disease. The program provides a fundamental understanding of the drug-body interaction, from the molecular to the macromolecular level, and this sets the conceptual framework for drug template exploration and lead candidate identification. Your studies in MCCB will also comprise early research involvement. This flagship program is based on an innovative, multidisciplinary approach encompassing life scientists, chemists, biophysicists, and biotechnologist, who are addressing the major health challenges of mankind.

1.2 Specific Advantages of the MCCB Program at Jacobs University

- The Medicinal Chemistry and Chemical Biology (MCCB) Program provides an early academic opportunity for students who know they want a career focused on curing disease, and who wish to acquire a solid foundation for this career from the first day of their studies. Jacobs University offers this forward looking program because the field Chemical Biology (CB) has expanded tremendously in the last years, and the resulting molecular understanding of diseases will strongly accelerate drug discovery. To take advantageous of this, the understanding and tools of Medicinal Chemistry (MC) must be integrated with those of Chemical Biology.

- The Medicinal Chemistry modules of the program cater to the identification, synthesis, and development of new chemical compounds that are suitable 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 revolutions occurring in 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 now without question, and the synergistic understanding that comes from their integration cannot be underestimated.

- During the detailed planning of the course structure of the MCCB major, advice from advisory board members and from various experts from academia, industry, and research foundations was incorporated. A new program was thus developed that is unique because of its early integration of medicinal chemistry and chemical biology.

- The MCCB program provides very strong practical experience, with laboratory courses starting in the first semester. Third-year students take an internship and in-depth specialization courses that allow them to choose a field of interest within MCCB or from adjacent areas such as biotechnology or organic chemistry. The Bachelor thesis consists of a research project with faculty.

- The MCCB degree, with its highly relevant theoretical content and profound laboratory training, allows you to enter graduate programs in Medicinal Chemistry, Biochemistry, or Organic Chemistry before embarking on a career in (for example) the pharmaceutical industry, regulatory authorities, or patent law offices. Additional career paths are possible and detailed later in this handbook, they can begin directly after receiving your B.Sc. degree in MCCB.

1.3 Program-Specific Qualification Aims

Transferable Skills

- Perform literature searches as structured approaches, and extract peer-reviewed information from the primary literature at large.
- Analyze scientific and technical questions, put them into relationship to what is known, and suggest avenues to solve them.
- Demonstrate a general skill set of scientific methods used in pharmaceutical chemistry and biotechnology.
- Present their own results, and those of others, concisely and professionally in front of an audience.

Theory

- Explain the concepts of chemical bonding, conformation and stereochemistry, the major functional groups and their manipulations, chemical synthesis, and naturally occurring chemical compounds (natural products).
- Design some simple chemical syntheses themselves.
- Draw and explain the structure and biochemical properties of proteins, DNA, lipids, and carbohydrates.
- Delineate, with examples from all chemical groups of natural compounds, how chemical structure defines cellular function. ?
- Put into context the chemistry, thermodynamics, and kinetics of biomolecular interaction, ligand binding, and enzymatic catalysis.
- Explain the molecular principles underlying gene expression. ?
- Detail some representative important targets for small molecules in the cell.
- Explain the chemical and biological principles behind some representative important analytical methods used for drug identification and quantification, including bioassays and high-throughput screening, and recount how they are used in industry.
- Classify the bioactivity potential, the drug-target interactions, the structure-activity relationships, and the pharmacokinetics of small molecules and of biologicals, and explain how these parameters are determined.
- Describe the basics of drug production, including pharmaproteins, by chemical and biotechnological means.

Practical Work

- Perform selected chemical syntheses.
- Perform simple computational molecular modeling tasks.
- Demonstrate practical insight into the experimental analysis of biological molecules.
- Practically handle cells and proteins, perform binding and catalysis assays, and analyze the action of small molecules.
- Use state-of-the-art equipment in selected areas of biotechnology and analytical pharmaceutical chemistry.

1.4 The Jacobs University Employability and Personal Development Concept

Jacobs University's educational concept aims at fostering employability which refers to skills, capacities, and competencies which transcend disciplinary knowledge and allow graduates to quickly adapt to professional contexts. Jacobs University defines employability as encompassing not just technical skills and understanding but also personal attributes, competencies and qualities enabling students to become responsible members of their professional and academic fields as well as of the societies they live in. Graduates of JU will be equipped with the ability to find employment and to pursue a successful professional career, which means that graduates will be able to:

- acquire knowledge rapidly, gather, evaluate and interpret relevant information and evaluate new concepts critically to derive scientifically funded judgements;
- apply their knowledge, understanding and methodological competences to their activity or profession to solve problems;
- present themselves and their ideas effectively and to negotiate successfully;
- demonstrate understanding and knowledge of business principles and processes and to manage projects efficiently and independently;
- take responsibility for their and their team's learning and development.

Graduates of JU will also be equipped with a foundation to become globally responsible citizens, which includes the following attributes and qualities:

- graduates have gained intercultural competence; they are aware of intercultural differences and possess skills to deal with intercultural challenges; they are familiar with the concept of tolerance;
- graduates can apply problem-solving skills to negotiate and mediate between different points of view and to manage conflicts;
- graduates can rely on basic civic knowledge; they are able to analyse global issues of economic, political, scientific, social or technological nature; they are able to evaluate situations and take decisions based on ethical considerations;
- graduates are able and prepared to take on responsibility for their professional community and society.

1.5 Career Options

Students who have completed the MCCB program will have acquired a deep understanding of how the life of cells, organisms, and humans is organized at the chemical molecular level. This opens the door to a wide variety of career choices ranging from scientific careers in academia, the pharmaceutical, chemical and biotechnology industries, start-up companies, positions in analytical food testing laboratories, quality management, regulatory affairs or even as a patent attorney; but by far the most natural connectivity will be with the high job growth areas offered by the world-wide pharmaceutical companies.
The critical and goal-oriented skills acquired from in-depth analysis of chemical-biological challenges are now even recognized as valued by headhunters from the seemingly unrelated areas of banking and insurance. An integral part of fulfilling the MCCB curriculum is a half year internship during the third year, which guarantees a state-of-the-art training for future leadership positions.

1.6 More Information and Contact

For more information please contact the study program coordinator:

Prof. Sebastian Springer DPhil
Professor of Biochemistry and Cell Biology
Email: s.springer@jacobs-university.de
Telephone: +49 421 200-3243

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

2 The Curricular Structure

2.1 General

The undergraduate education at Jacobs University equips students with the key qualifications necessary for a successful academic, as well as professional career. By combining disciplinary depth and transdisciplinary breadth, supplemented by skills education and extracurricular elements, students are prepared to be responsible and successful citizens within the societies they work and live in.

The curricular structure provides multiple elements enhancing employability, transdisciplinarity, and internationality. The unique Jacobs Track, offered across all study programs, provides a broad range of tailor-made courses designed to foster career competencies. These include courses which promote communication, technology, business, (German) language, and management skills. The World Track, included in the third year of study, provides extended company internships or study abroad options. Thus students gain training on the job and intercultural experiences. All undergraduate programs at Jacobs University are based on a coherently modularized structure, which provides students with a broad and flexible choice of study plans to meet their major as well as minor study interests.

The policies and procedures regulating undergraduate study programs at Jacobs University in general can be found on the website.

2.2 The Jacobs University 3C-Model

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

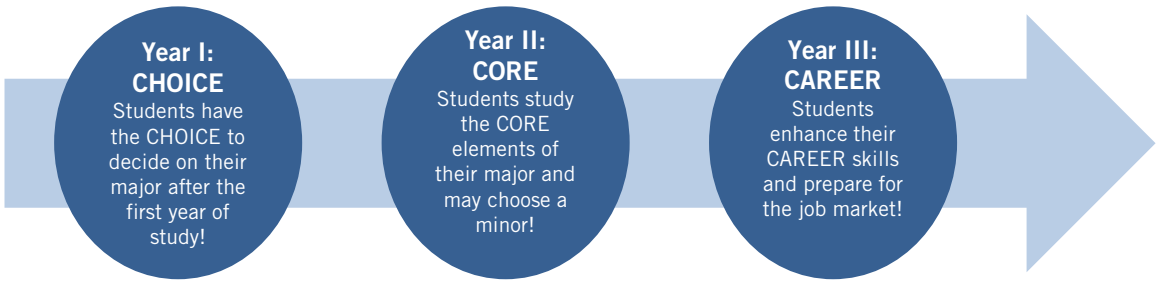


Figure 1: The Jacobs University 3C-Model

2.2.1 YEAR 1 - CHOICE

The first study year is characterized by a broad offer in disciplinary and interdisciplinary education. Students select three CHOICE modules from a variety of study programs. As a unique asset, our curricula allow students to select their study program freely from among the three selected CHOICE modules during their first year of study.

2.2.2 YEAR 2 - CORE

In the second year, students take three in-depth, discipline-specific CORE modules. One CORE module can also be taken from a second, complementary discipline, which allows students to incorporate a minor study track into their undergraduate education. Students will generally qualify for a minor if they have successfully taken at least one CHOICE module and one CORE module in a second field, and this extra qualification will be highlighted in the transcript.

2.2.3 YEAR 3 - CAREER

During their third year, students must decide on their career after graduation. In order to facilitate this decision, the fifth semester introduces two separate tracks. By default students are registered for the World Track.

1. **The World Track**
   In this track there are two mandatory elective options:

   - **Internship**
     The internship program is a core element of Jacobs Universitys employability approach. It includes a mandatory semester-long internship off-campus (minimum 16 weeks in full-time) which provides insight into the labor market as well as practical work experience related to the respective area of study. Successful internships may initiate career opportunities for students.
     As an alternative to the regular internship, a limited number of students have the opportunity to prepare in a structured manner the formation of their own start-up in the 5th semester, and can attain 20 ECTS for this study-related achievement. Jacobs University cooperates with the City Accelerator Bremen (CAB) to which students can be admitted. There are several requirements which must be fulfilled before the 5th semester in order to be admitted to the CAB, i.e. attendance of specific seminars and workshops and the successful presentation of the business idea within the framework of a competition (pitch). The module is successfully completed, when the student / team of students have submitted the business plan to CAB.

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

   - **Study Abroad**
     Students can take the opportunity to study abroad at one of our partner universities. Courses recognized as study abroad credits need to be pre-approved according to the Jacobs University study abroad procedures and carry minimum of 20 ECTS credits

in total. Several exchange programs allow you to be directly enrolled at prestigious partner institutions worldwide. Jacobs University's participation in Erasmus+, the European Unions exchange program, provides an exchange semester at a number of European universities including Erasmus study abroad funding.

For more information, please contact the International Office (http://intoffice.user.jacobs-university.de/outgoing/).

2. **The Campus Track**
   Alternatively, students may also opt to follow the Campus Track by continuing their undergraduate education at Jacobs, namely by selecting an additional CORE module during their third year and redistributing the remaining courses and modules across the third year. This opportunity can be used by students to more intensively focus on their major or to fulfill the minor requirements for a second field of interest.

In the sixth semester, all students select from a range of specialization courses within their study program and concentrate on their Bachelor thesis in the context of a Project/Thesis Module.

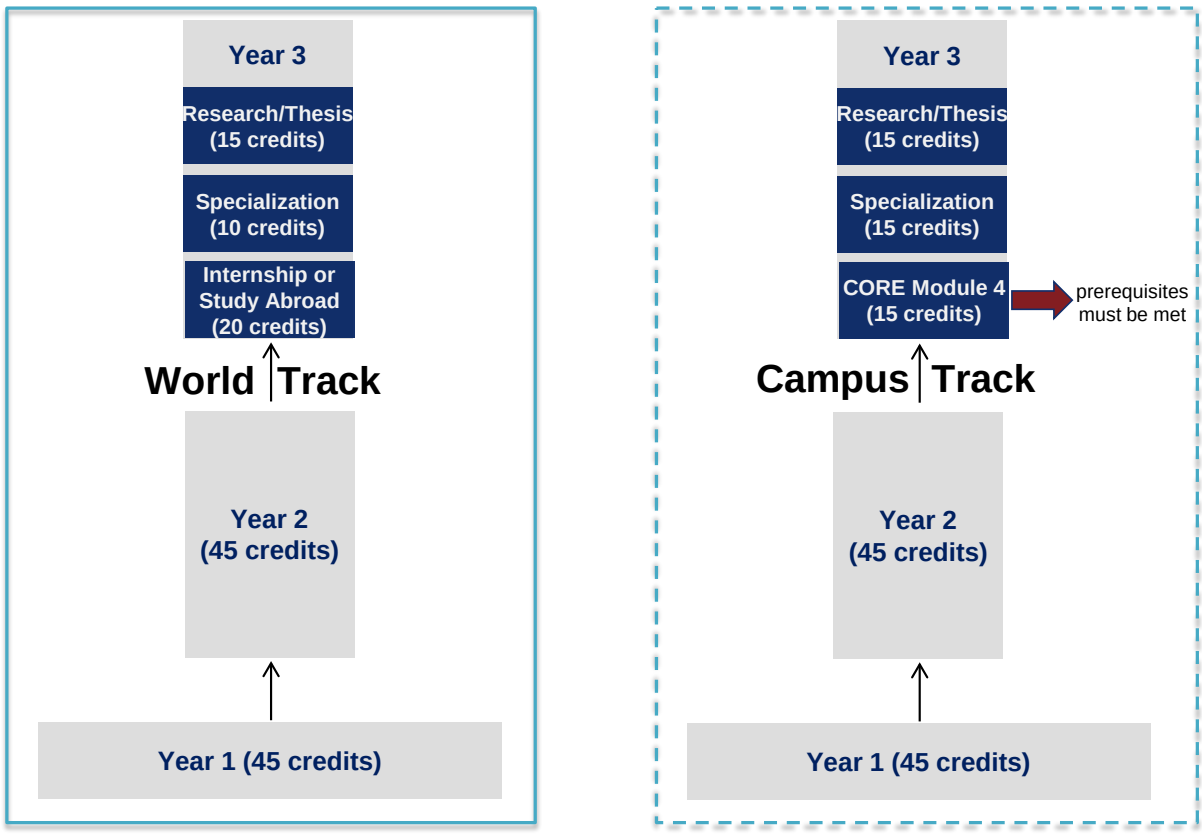


Figure 2: World Track versus Campus Track

Career Advising

Is a mandatory component of the Jacobs University's Advising and Counseling Scheme. Further components are "Academic Advising" and "Psychological Counseling and Intercultural Services". Throughout their studies all students attend a mandatory set of career skills events. The mandatory "Career Skills Advising" prepares all undergraduate students at Jacobs University for the transition from student life to working life as well as for their future career. Skills, knowledge and information which are fundamental for participation in an internship or a semester abroad will be conveyed concurrently. Essential components include information sessions, compulsory workshops on various career-relevant topics as well as participation in the annual Jacobs Career Fair.

All undergraduate students will be automatically registered for "Career Skills Advising". However, every student has to keep track of his/her individual fulfillment of requirements and has to register on CampusNet for all workshops and sessions during the official registration period at the beginning of each semester. An overview of the sequence in which events should be attended is shown in the table below.

CAREER ADVISING For Undergraduate Students matriculated Fall 2017

SEMESTER	1	2	3	4	5	6
MANDATORY BASICS	CSC-INFO Session: "CSC Services" CA01-990000		CSC-INFO Session: "World Track" CA01-990026			CSC-INFO Session "Professional Networking" CA01-990040
MANDATORY SEMINARS	Both seminars have to be attended in your first or second semester: CSC-APPLICATION TRAINING CA01-990001 CSC-SUCCESS IN STUDIES, CAREER AND LIFE CA01-990031					
MANDATORY ELECTIVE SEMINARS (seminar program subject to availability)			Attend 2 out of several career skills seminars and workshops, i.e. ▪ Research & Contacting Employers ▪ Business Etiquette ▪ Presentation Skills ▪ Communication Skills ▪ Grad School Application Training ▪ Self-Management ▪ Time-Management ▪ Decision Making ▪ Preparing for an Interview ▪ Introduction to Project Management			
OTHER MANDATORY COMPONENTS				CSC-JACOBS CAREER FAIR in February, on campus CA01-990003	INTERNSHIP or STUDY ABROAD or CAMPUS TRACK	INTERNSHIP & STUDY ABROAD EVENT Online CSC-CAREER SURVEY CA01-990002

Figure 3: Career Advising

2.3 The Jacobs Track

The Jacobs Track, another stand-alone feature of Jacobs University, runs parallel to the disciplinary CHOICE, CORE, and CAREER modules across all study years and is an integral part of all study programs. It reflects our commitment to an in-depth methodological education, it fosters our transdisciplinary approach, it enhances employability, and equips students with extra skills desirable in your general field of study. Additionally, it integrates essential language courses.

Mathematics, statistics, and other methods courses are offered to all students within a comprehensive Methods Module. This module provides students with general foundations and transferable techniques which are invaluable to follow the study content not only in the study program itself but also in related fields.

The Skills Module equips students with general academic skills which are indispensable for their chosen area of study. These could be, for example, programming, data handling, presentation skills, and academic writing, scientific and experimental skills.

The transdisciplinary Triangle Module offers courses with a focus on at least one of the areas of business, technology and innovation, and societal context. The offerings comprise essential knowledge of these fields for students from other majors as well as problem-based courses that tackle global challenges from different disciplinary backgrounds. Working together with students from different disciplines and cultural backgrounds in these courses broadens the students horizon by crossing the boundaries of traditional disciplines.

Foreign languages are integrated within the Language Module. Communicative skills and foreign language competence foster students intercultural awareness and enhance their employability in a globalized and interconnected world. Jacobs University supports its students in acquiring and improving these skills by offering a variety of language courses at all proficiency levels. Emphasis is put on fostering German language skills, as they are an important prerequisite for students to learn about, explore, and eventually integrate into their host country. Hence, acquiring 10 ECTS credits in German is a requirement for all students. Students who meet the requirements of the German proficiency level (e.g. native speakers) are required to select courses in any other language program offered.

2.4 Modularization of the Medicinal Chemistry and Chemical Biology Program

Year 1
Take two mandatory modules listed below and select one further CHOICE module from a different study area.

Biochemistry and Molecular Biology (CH02-BioChem)
Biochemistry and Molecular Biology is a first year module that explains how the structure of biological molecules (proteins, sugars, lipids, nucleic acids) defines their biochemical properties and function. Students will learn the basics of cell structure and metabolism, and how small molecules can influence them, for example in gene expression, symbiosis, infectious diseases and their treatment, and in global element cycles. The discovery of such small molecules in the pharmaceutical industry will be explained. Two lectures are complemented by a 5 ECTS lab course offering practical training in key techniques applied in biochemistry and molecular biology. This module provides the foundation for the CORE modules "Molecular Biology" and "Chemical Biology".

Organic Chemistry (CH03-OrgChem)
We begin by reestablishing atomic structure, and the importance of Lewis dot structures, resonance, valence-shell electron-pair repulsion, and valence-bond theory to give meaning to a covalent bond. Hybridization is then introduced to allow an accurate and predictive accounting of molecular shape. This foundation permits the introduction of: functional groups, conformation, chirality, acidity and basicity, and the basics of equilibria, thermodynamic, and kinetic phenomena. With these concepts in hand, we develop organic reactivity by examining the mechanistic pathways (arrow pushing) and chemical principles behind substitution, elimination, and addition reactions. Common reagents and functional group transformations are then learned in the context of the importance of their order and type (retrosynthetic analysis and strategy) for brevity in synthesis.

Year 2
Take all three modules or replace one with a CORE module from a different study program.

Chemical Biology (CO04-ChemBio)
Chemical Biology asks how small molecules, such as pharmaceutical drugs, act on biological targets, such as proteins or genes, and how they can be used to influence processes in cells and in the entire organism, both for advancing fundamental knowledge and for treating diseases. Work in chemical biology requires a thorough understanding of how these drug targets function and what natural role they play in the cell. Chemical Biology is an essential complement of Medicinal Chemistry enabling the exploration, design, testing and safety assessment of drugs, a key expertise for a career in the pharmaceutical industry.

Drug Action and Production (CO05-DrugProd)
This module introduces students to pharmaceuticals used in current medical practice. Grouped according to therapeutic areas, drugs in current use are discussed in terms of their chemical structure, structural requirement for action, basic pharmacology, synthesis and analysis. The

module summarizes current knowledge on the action and production of drugs in the pharmaceutical industry and the essential set of scientific methods and approaches used in drug production and analysis. This knowledge forms the basis for all future drug development.

Drug Development (CO06-DrugDev)
Pharmaceutical drug development is an interdisciplinary scientific endeavor founded on the discovery of new chemical entities that act at biologically relevant disease targets. The work flow of medicinal chemistry entails target validation, high throughput assay screening of chemical libraries, drug discovery, drug optimization (in silico and laboratory) via structure activity relationships, lead candidate identification, toxicology, preclinical and finally clinical trials. A constant underlying theme is how, why, and when to take advantage of chemical principles to achieve the desired outcome of forming a therapeutic agent (active pharmaceutical ingredient).

Some CORE Modules require students to have taken a specific CHOICE Module. Please see the Module Handbook for details regarding pre-requisites.

Year 3
In the 3rd year students follow the World Track by default:

1. **World Track**
   5th Semester
   - Internship / study abroad

   6th Semester
   - Medicinal Chemistry and Chemical Biology Project / Thesis Module

   - Program-specific Specialization Module
     Exemplary course offering:
     - Project /Thesis Seminar MCCB (WT)
     - Introduction to Biophysical Chemistry
     - Binding and Enzyme Assays
     - Concepts and Applications of Metabolism
     - Pharmaceutical Formulation and Targeting Technology
     - Structure Elucidation of Biomolecules

2. **Campus Track**
   Students who do not enter the World Track follow the Campus Track.

   5th and 6th Semester
   - Program-specific Project / Thesis Module
   - Program-specific Specialization Module
     (please see World Track for exemplary course offering)
   - Additional CORE Module

2.5 The Bachelor Thesis / Project

This module is a mandatory graduation requirement for all undergraduate students. It consists of two components in the major study program guided by a Jacobs Faculty member:

1. **A Research Project** (5 ECTS)
   and
2. **The Bachelor Thesis** (10 ECTS)

The workload for the project component is about 125 hours and for the thesis component about 250 hours.The title of the thesis will be shown on the transcript.

2.5.1 Aims

Within this module, students apply knowledge they have acquired about their major discipline, skills, and methods 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. Research results obtained from the Research Project can be embedded in the Bachelor Thesis.

2.5.2 Intended Learning Outcomes

1. Research Project
   This module component consists of a guided research project in the major study program. The well-defined research task must be completed and documented according to the scientific standards in the respective discipline. It involves a high degree of independence, supported by individualized instructor feedback and guidance.
2. Bachelor Thesis
   With their Bachelor Thesis students should demonstrate mastery of the contents and methods of the major specific research field. Furthermore, students should 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 an original development of their own ideas.

Both, the Research Project and the Bachelor Thesis, can also have an inter- or transdisciplinary nature - with the explicit permission of the supervisor.

2.5.3 Supervision

Both module components can be performed with the same Jacobs faculty member, or different ones, the latter in order to allow a broader research experience. Students are required to choose a supervisor, at the latest, by the end of the drop-add period of the semester in which the module component is taken. **The selected supervisor(s) must approve the Project topic and Bachelor Thesis topic before the student starts to work towards the module component.** The respective study program coordinators will assist in the search for prospective supervisor(s).

2.5.4 Registration

World Track students register for both components, at the earliest, in their 6th semester.
Campus Track students register for the Project component in the 5th and for the Bachelor Thesis component, at the earliest, in their 6th semester.

The registrations must be made before the end of the respective drop/add periods.

Later enrolment is possible for those students pursuing a second major or those who graduate late for other reasons. These students perform their (second) thesis earliest in the 7th semester of their studies. They have to contact the Student Records Office for individual registration.

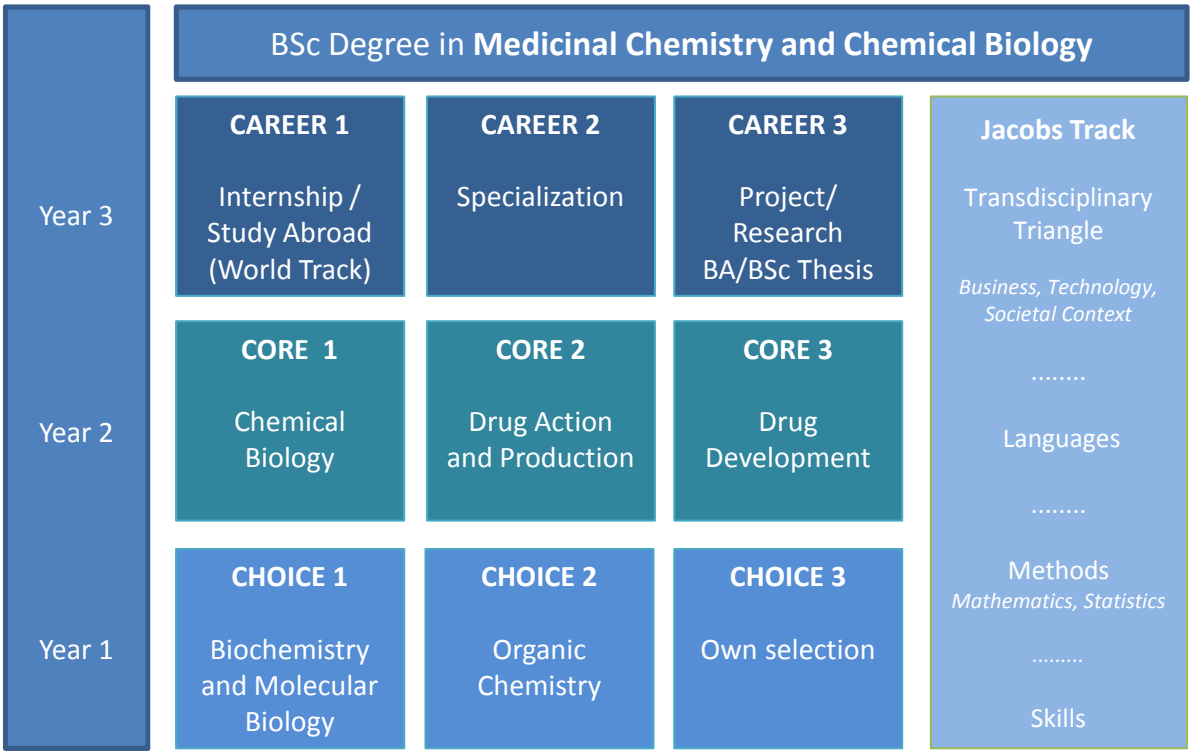
Students are allowed to extend their thesis related work into the intersession or summer break upon approval of the thesis supervisor and Student Records. Students are not allowed to register for different Bachelor Thesis courses in the same semester.

2.5.5 Formal Regulations for the Bachelor Thesis

- Timing
  The Thesis work has to be generated within the semester of registration. The semester period has 14 weeks.
- Extent
  The document must be between 15-25 pages in length, including references, but excluding appendices or supporting information. Deviations in length and format can be determined within individual study programs and should be communicated to all registered students by the study program coordinator.
- Cover page
  The cover page must show the title of the Bachelor Thesis, the university's name, the month and year of submission, the name of the student and the name of the supervisor.
- Statutory Declaration
  Each Bachelor Thesis must include a statutory declaration signed by the student confirming it is their own independent work and that it has not been submitted elsewhere. The respective form can be found on the Student Records Office website.
- Submission
  The Bachelor Thesis must be submitted as a hard copy (pdf-file) to the supervisor and additionally to the Student Records Office via online form on the Student Records Office website.

  Deadline for submission of the Bachelor Thesis is May 15 (unless specified otherwise by the Student Records Office).

2.6 Structure



YEAR 1 *Take three CHOICE modules, one free selection*
YEAR 2 *Take three CORE modules, one CORE module can be substituted by a CORE module from a second study program to pursue a minor*
YEAR 3 *Alternatively Campus Track with a 4th CORE module instead of internship/study abroad module*

Figure 4: Medicinal Chemistry and Chemical Biology Module Structure

3 Appendix 1a/1b: Mandatory Module and Examination Plans for World Track and Campus Track

Jacobs University Bremen reserves the right to substitute courses by replacements and/or reduce the number of mandatory/mandatory elective courses offered.

4 Appendix 2: Course Data for Program-Specific CHOICE and CORE Courses

All course data stated in the appendix is based on the previous study year and subject to change.

Version	Valid as of	Decision	Details
Fall 2017 - V1	01.09.17	AB July 17	Masterversion
Fall 2017 - V2	01.09.17	AB August 17	2.2 revised

Appendix 1a - Mandatory Module and Examination Plan for World Track

Medicinal Chemistry and Chemical Biology – World Track

Matriculation Fall 2017

	Program-Specific Modules	Type	Status[1]	Semester	Credits		Jacobs Track Modules (General Education)	Type	Status[1]	Semester	Credits
Year 1 - CHOICE					**45**						**20**
Take the two mandatory CHOICE modules listed below, these are a requirement for the MCCB program.											
CH02-BioChem	**Module: Biochemistry and Molecular Biology**		**m**		**15**		**JT-ME-MethodsMath**	**Module: Methods / Mathematics**		**m**		**7,5**
CH02-520101	General Biochemistry and Molecular Biology I	Lecture	m	1	5		JT-ME-120106	Applied Calculus I	Lecture	m	1	2,5
CH02-520111	General Biochemistry and Molecular Biology I Lab	Lab	m	1	2,5		JT-ME-120107	Applied Calculus II	Lecture	m	1	2,5
CH02-520201	General Biochemistry and Molecular Biology II	Lecture	m	2	5		JT-ME-120101	Mathematical Concepts in the Sciences	Lecture	m	2	2,5
CH02-520121	General Biochemistry and Molecular Biology II Lab	Lab	m	2	2,5		**JT-SK-Skills**	**Module: Skills**		**m**		**2,5**
CH03-OrgChem	**Module: Organic Chemistry**		**m**		**15**		JT-SK-990103	Scientific and Experimental Skills	Lecture	m	1	2,5
CH03-400102	Organic Chemistry I	Lecture	m	1	5		**JT-TA-TriArea**	**Module: Triangle Area**		**m**		**5**
CH03-400112	Organic Chemistry I Lab	Lab	m	1	2,5			Take two courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	1/2	5
CH03-400103	Organic Chemistry II	Lecture	m	2	5							
CH03-400113	Organic Chemistry II Lab	Lab	m	2	2,5		**JT-LA-Language**	**Module: Language**		**m**		**5**
	Module: CHOICE (own selection)		**e**	**1/2**	**15**			Take two German courses (2,5 ECTS each). Native German speakers take courses in another offered language	Seminar	me	1/2	5
Students take one further CHOICE module from those offered for all other study programs. [2]							**CA01-CarAdv**	**Career Advising**[4]				
Year 2 - CORE					**45**							**20**
Take all three modules or replace one with a CORE module from a different study program. [2]												
CO04-ChemBio	**Module: Chemical Biology**		**me**		**15**		**JT-ME-MethodsMath**	**Module: Methods / Mathematics**		**m**		**7,5**
CO04-520203	Introduction to Chemical Biology	Lecture	m	3	5			Take three Methods (mandatory) elective courses (2,5 ECTS each). [2]	Lecture	me	3/4	7,5
CO04-520213	Advanced Biochemistry Lab	Lab	m	4	5							
CO04-520223	Biological Activity	Lecture	m	4	5							
CO05-DrugProd	**Module: Drug Action and Production**		**me**		**15**		**JT-TA-TriArea**	**Module: Triangle Area**		**m**		**7,5**
CO05-400241	Pharmaceutical Analytical Chemistry	Lecture	m	3	2,5			Take three courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	3/4	7,5
CO05-400243	Pharmaceutical Analytical Chemistry Lab	Lab	m	3	2,5							
CO05-400234	Biopharmaceutical Production Lab	Lab	m	3	2,5							
CO05-400233	Biopharmaceuticals	Lecture	m	4	2,5							
CO05-400244	Pharmaceutical Chemistry	Lecture	m	4	5							
CO06-DrugDev	**Module: Drug Development**		**me**		**15**		**JT-LA-Language**	**Module: Language**		**m**		**5**
CO06-400272	Medicinal Chemistry	Lecture	m	3	5			Take two German courses (2,5 ECTS each). Native German speakers take courses in another offered language	Seminar	me	3/4	5
CO06-400271	Medicinal Chemistry Lab (Intersession)	Lab	m	3	5							
CO06-400275	Medicinal Chemistry of Fluorine and Phosphorus	Lecture	m	4	2,5		**CA01-CarAdv**	**Career Advising**[4]				
CO06-400274	Introduction to Molecular Simulations	Lecture	m	4	2,5							
Year 3 - CAREER					**45**							**5**
CA02 / CA03	**Module: Internship / Study Abroad**		**m**	**5**	**20**		**JT-SK-Skills**	**Module: Skills**		**m**		**2,5**
							JT-SK-990104	Advanced Scientific and Experimental Skills	Lecture	m	6	2,5
CA04-MCCB	**Module: Project/Thesis MCCB**		**m**		**15**		**JT-TA-TriArea**	**Module: Triangle Area**		**m**		**2,5**
CA04-520303	Project MCCB		m	6	5			Take one course from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	6	2,5
CA04-520304	Thesis MCCB		m	6	10							
CAS-WT-MCCB	**Module: Specialization Area MCCB**		**m**		**10**		**CA01-CarAdv**	**Career Advising**[4]				
	Take four specialization courses (2.5 ECTS each) [2]		me	5/6	10							
Total ECTS												**180**

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

[2] For a full listing of all CHOICE / CORE / CAREER / Jacobs Track modules please consult the CampusNet online catalogue and / or the module handbook (on our website).

[3] You are required to take six Triangle Area courses in total. Select two from each of the three triangle areas (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT).

[4] Mandatory component of the Jacobs University's Counseling and Advising Scheme.

Appendix 1b - Mandatory Module and Examination Plan for Campus Track

Medicinal Chemistry and Chemical Biology – Campus Track

Matriculation Fall 2017

	Program-Specific Modules	Type	Status[1]	Semester	Credits		Jacobs Track Modules (General Education)	Type	Status[1]	Semester	Credits
Year 1 - CHOICE					**45**						**20**
Take the two mandatory CHOICE modules listed below, these are a requirement for the MCCB program.											
CH02-BioChem	**Module: Biochemistry and Molecular Biology**		**m**		**15**		**JT-ME-MethodsMath**	**Module: Methods / Mathematics**		**m**		**7,5**
CH02-520101	General Biochemistry and Molecular Biology I	Lecture	m	1	5		JT-ME-120106	Applied Calculus I	Lecture	m	1	2,5
CH02-520111	General Biochemistry and Molecular Biology I Lab	Lab	m	1	2,5		JT-ME-120107	Applied Calculus II	Lecture	m	1	2,5
CH02-520201	General Biochemistry and Molecular Biology II	Lecture	m	2	5		JT-ME-120101	Mathematical Concepts in the Sciences	Lecture	m	2	2,5
CH02-520121	General Biochemistry and Molecular Biology II Lab	Lab	m	2	2,5		**JT-SK-Skills**	**Module: Skills**		**m**		**2,5**
CH03-OrgChem	**Module: Organic Chemistry**		**m**		**15**		JT-SK-990103	Scientific and Experimental Skills	Lecture	m	1	2,5
CH03-400102	Organic Chemistry I	Lecture	m	1	5		**JT-TA-TriArea**	**Module: Triangle Area**		**m**		**5**
CH03-400112	Organic Chemistry I Lab	Lab	m	1	2,5			Take two courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	1/2	5
CH03-400103	Organic Chemistry II	Lecture	m	2	5							
CH03-400113	Organic Chemistry II Lab	Lab	m	2	2,5		**JT-LA-Language**	**Module: Language**		**m**		**5**
	Module: CHOICE (own selection)		**e**	**1/2**	**15**			Take two German courses (2,5 ECTS each). Native German speakers take courses in another offered language	Seminar	me	1/2	5
Students take one further CHOICE module from those offered for all other study programs. [2]							**CA01-CarAdv**	**Career Advising**[4]				
Year 2 - CORE					**45**							**20**
Take all three modules or replace one with a CORE module from a different study program. [2]												
CO04-ChemBio	**Module: Chemical Biology**		**me**		**15**		**JT-ME-MethodsMath**	**Module: Methods / Mathematics**		**m**		**7,5**
CO04-520203	Introduction to Chemical Biology	Lecture	m	3	5			Take three Methods (mandatory) elective courses (2,5 ECTS each). [2]	Lecture	me	3/4	7,5
CO04-520213	Advanced Biochemistry Lab	Lab	m	4	5							
CO04-520223	Biological Activity	Lecture	m	4	5							
CO05-DrugProd	**Module: Drug Action and Production**		**me**		**15**		**JT-TA-TriArea**	**Module: Triangle Area**		**m**		**7,5**
CO05-400241	Pharmaceutical Analytical Chemistry	Lecture	m	3	2,5			Take three courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	3/4	7,5
CO05-400243	Pharmaceutical Analytical Chemistry Lab	Lab	m	3	2,5							
CO05-400234	Biopharmaceutical Production Lab	Lab	m	3	2,5							
CO05-400233	Biopharmaceuticals	Lecture	m	4	2,5							
CO05-400244	Pharmaceutical Chemistry	Lecture	m	4	5							
CO06-DrugDev	**Module: Drug Development**		**me**		**15**		**JT-LA-Language**	**Module: Language**		**m**		**5**
CO06-400272	Medicinal Chemistry	Lecture	m	3	5			Take two German courses (2,5 ECTS each). Native German speakers take courses in another offered language	Seminar	me	3/4	5
CO06-400271	Medicinal Chemistry Lab (Intersession)	Lab	m	3	5							
CO06-400275	Medicinal Chemistry of Fluorine and Phosphorus	Lecture	m	4	2,5		**CA01-CarAdv**	**Career Advising**[4]				
CO06-400274	Introduction to Molecular Simulations	Lecture	m	4	2,5							
Year 3 - CAREER					**45**							**5**
COXX	**Module: Additional (4th) CORE module**		**m**	**5/6**	**15**		**JT-SK-Skills**	**Module: Skills**		**m**		**2,5**
							JT-SK-990104	Advanced Scientific and Experimental Skills	Lecture	m	6	2,5
CA04-MCCB	**Module: Project/Thesis MCCB**		**m**		**15**		**JT-TA-TriArea**	**Module: Triangle Area**		**m**		**2,5**
CA04-520303	Project MCCB		m	5	5			Take one course from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	5	2,5
CA04-520304	Thesis MCCB		m	6	10							
CAS-CT-MCCB	**Module: Specialization Area MCCB**		**m**		**15**		**CA01-CarAdv**	**Career Advising**[4]				
	Take four specialization courses (2.5 ECTS each) [2]		me	5/6	15							
Total ECTS												**180**

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

[2] For a full listing of all CHOICE / CORE / CAREER / Jacobs Track modules please consult the **CampusNet online catalogue** and / or the module handbook (on our website).

[3] You are required to take six Triangle Area courses in total. Select two from each of the three triangle areas (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT).

[4] Mandatory component of the Jacobs University's Counseling and Advising Scheme.

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
General Biochemistry and Molecular Biology I	CH02-520101	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH02-BioChem Biochemistry and Molecular Biology	Contact Time: 35,00 Private Study: 90,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

This is a unique course that gives, over the first year of your studies at Jacobs University, a comprehensive introduction to biochemistry and molecular biology. At the end of the course, you will have gained knowledge of the foundations and the scope of the subject and of the specific scientific reasoning that underlies research in this field. Topics covered will be the chemical basics of the life sciences; the major classes of biological molecules (such as amino acids, proteins, carbohydrates, and lipids); the structure and function of proteins; the nature and regulation of metabolism; and the acquisition, conversion, and use of energy by cells. Information about the techniques and strategies to obtain knowledge and to ask questions in molecular life science, as well as historical outlines, will accompany each topic. This course requires solid High School knowledge of both biology and chemistry, or the willingness to acquire it at Jacobs University.

Methods of Assessment

Name	Weighting
Final Exam	40%
Quizz(es)	60%

Course Name	***Course No***	***ECTS***
General Biochemistry and Molecular Biology I	CH02-520101	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH02-BioChem Biochemistry and Molecular Biology	Contact Time: 35,00 Private Study: 90,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

This is a unique course that gives, over the first year of your studies at Jacobs University, a comprehensive introduction to biochemistry and molecular biology. At the end of the course, you will have gained knowledge of the foundations and the scope of the subject and of the specific scientific reasoning that underlies research in this field. Topics covered will be the chemical basics of the life sciences; the major classes of biological molecules (such as amino acids, proteins, carbohydrates, and lipids); the structure and function of proteins; the nature and regulation of metabolism; and the acquisition, conversion, and use of energy by cells. Information about the techniques and strategies to obtain knowledge and to ask questions in molecular life science, as well as historical outlines, will accompany each topic. This course requires solid High School knowledge of both biology and chemistry, or the willingness to acquire it at Jacobs University.

Methods of Assessment

Name	Weighting
Final Exam	40%
Quizz(es)	60%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
General Biochemistry and Molecular Biology I Lab	CH02-520111	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH02-BioChem Biochemistry and Molecular Biology	Contact Time: 25,50 Private Study: 37,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

This laboratory course accompanies the lecture "General Biochemistry and Molecular Biology I". It aims at introducing students to the experimental analysis of three major classes of biomolecules: carbohydrates, proteins and lipids. Students will apply basic techniques (e.g., pipetting, dilution series, buffer preparation, spectro-photometry, acid-base-titration, thin layer chromatography) and learn how different biomolecules can be characterized by their specific biochemical properties. In-lab seminars will discuss the theory behind the experiments and the expected outcomes. The students will document and discuss their experimental data in publication-style reports. Theoretical preparation will be tested for by quizzes and the preparation of material safety data sheets (MSDS).

Methods of Assessment

Name	Weighting
5 Lab Reports	70%
6 Quizz(es) in Lab	20%
MSDS Preparation	10%

Course Name	***Course No***	***ECTS***
General Biochemistry and Molecular Biology I Lab	CH02-520111	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH02-BioChem Biochemistry and Molecular Biology	Contact Time: 25,50 Private Study: 37,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

This laboratory course accompanies the lecture "General Biochemistry and Molecular Biology I". It aims at introducing students to the experimental analysis of three major classes of biomolecules: carbohydrates, proteins and lipids. Students will apply basic techniques (e.g., pipetting, dilution series, buffer preparation, spectro-photometry, acid-base-titration, thin layer chromatography) and learn how different biomolecules can be characterized by their specific biochemical properties. In-lab seminars will discuss the theory behind the experiments and the expected outcomes. The students will document and discuss their experimental data in publication-style reports. Theoretical preparation will be tested for by quizzes and the preparation of material safety data sheets (MSDS).

Methods of Assessment

Name	Weighting
5 Lab Reports	70%
5 Quizz(es) in Lab	20%
MSDS Preparation	10%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
General Biochemistry and Molecular Biology II Lab	CH02-520121	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH02-BioChem Biochemistry and Molecular Biology	Contact Time: 25,50 Private Study: 37,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

This laboratory course accompanies the lecture "General Biochemistry and Molecular Biology". It aims at introducing students to the experimental analysis of the four major classes of biomolecules: carbohydrates, proteins, lipids and nucleic acids. Students will apply basic techniques (e.g., pipetting, dilution series preparation, spectrophotometry, thin layer chromatography) and learn how different biomolecules can be characterized by their specific biochemical properties. In-lab seminars will discuss the theory behind the experiments and the expected outcomes. The students will document and discuss their experimental data in publication-style reports. Theoretical preparation will be tested for by quizzes and the preparation of material safety data sheets (MSDS).

Methods of Assessment

Name	Weighting
Lab Reports	50%
MSDSs	10%
Quizz(es)	40%

Course Name	***Course No***	***ECTS***
General Biochemistry and Molecular Biology II	CH02-520201	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH02-BioChem Biochemistry and Molecular Biology	Contact Time: 35,00 Private Study: 90,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

This is a unique course that gives, over the first year of your studies at Jacobs University, a comprehensive introduction to biochemistry and molecular biology. At the end of the course, you will have gained knowledge of the foundations and the scope of the subject and of the specific scientific reasoning that underlies research in this field. Topics covered will be the chemical basics of the life sciences; the major classes of biological molecules (such as amino acids, proteins, carbohydrates, and lipids); the structure and function of proteins; the nature and regulation of metabolism; and the acquisition, conversion, and use of energy by cells. Information about the techniques and strategies to obtain knowledge and to ask questions in molecular life science, as well as historical outlines, will accompany each topic. This course requires solid High School knowledge of both biology and chemistry, or the willingness to acquire it at Jacobs University.

Methods of Assessment

Name	Weighting
Final Exam	40%
Midterm Exam	30%
Quizz(es)	30%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Organic Chemistry I	CH03-400102	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH03-OrgChem Organic Chemistry	Contact Time: 35,00 Private Study: 90,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

The course begins by establishing a strong working knowledge of atomic, hybridized, and molecular orbitals. This is vital for our understanding of the next material: Lewis dot structures, octet rule, electron ownership, resonance, bond angles, bond strength, bond order, molecular shape, conformation, transition states, and pKa (acidity/basicity). Functional groups (halides, alcohols, ethers, amines, aldehydes, ketones, carboxylic acids, esters, amides, anhydrides, acetals, etc.), nonmenclature, and chirality (stereogenic centers) are then addressed. This conceptual framework allows reactivity (electrophiles and nucleophiles) to then be discussed in the context of mechanistic pathways (SN1, E1, SN2, and E2) and the law of mass action. Specific functional group interconversions are then addressed beginning with an early discussion of carbonyl reactivity (enolates, imines, enamines, aldol reactions, etc.) to better facilitate our understanding of biochemical reaction pathways.

Methods of Assessment

Name	Weighting
Final Grade	100%

Course Name	***Course No***	***ECTS***
Organic Chemistry I	CH03-400102	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH03-OrgChem Organic Chemistry	Contact Time: 35,00 Private Study: 90,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

The course begins by establishing a strong working knowledge of atomic, hybridized, and molecular orbitals. This is vital for our understanding of the next material: Lewis dot structures, octet rule, electron ownership, resonance, bond angles, bond strength, bond order, molecular shape, conformation, transition states, and pKa (acidity/basicity). Functional groups (halides, alcohols, ethers, amines, aldehydes, ketones, carboxylic acids, esters, amides, anhydrides, acetals, etc.), nonmenclature, and chirality (stereogenic centers) are then addressed. This conceptual framework allows reactivity (electrophiles and nucleophiles) to then be discussed in the context of mechanistic pathways (SN1, E1, SN2, and E2) and the law of mass action. Specific functional group interconversions are then addressed beginning with an early discussion of carbonyl reactivity (enolates, imines, enamines, aldol reactions, etc.) to better facilitate our understanding of biochemical reaction pathways.

Methods of Assessment

Name	Weighting
Final Grade	100%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Organic Chemistry II	CH03-400103	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH03-OrgChem Organic Chemistry	Contact Time: 35,00 Private Study: 90,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

The second semester of Organic Chemistry strongly builds on the concepts and principles introduced during the first semester. During this course a much broader exposure to reagents and reactions (functional group interconversion) is focused on, and this material is learned within the framework of stereocontrol, mechanisms (arrow pushing), and the importance of reaction step order to achieve step efficient synthesis. Exposure to the tactics and strategies of synthesis will provide the context for retrosynthetic analysis, and an appreciation synthesizing challenging drug molecules. Major topics of discussion will be: alkene formation (Wittig reaction) and transformations thereof (bromination, epoxidation, dihydroxylation, Diels-Alder reactions, etc.), aromaticity, Friedel-Crafts alkylation and acylation, benzyne elimination-addition reactions, derivatization and formation of phenols (Meisenheimer complexes - SNAr mechanism), a continued investigation of carbonyl chemistry (aldehyde, ketone, ester, amides, carboxylic acid): formation, reduction, nucleophilic addition to, etc. Amines play a vital role in drug development and their formation and manipulation are discussed. Special topics will be introduced, e.g. amide hydroysis (peptide cleavage) at an oxyanion hole, to show how a living system can accomplish important chemical reactions.

Methods of Assessment

Name	Weighting
Exams	100%

Course Name	***Course No***	***ECTS***
Organic Chemistry I Lab	CH03-400112	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH03-OrgChem Organic Chemistry	Contact Time: 25,50 Private Study: 37,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

A chemical laboratory is a place for exploration, but before that happens we must reinforce important safety aspects, common hazards, and the structure & content requirements of a useful laboratory report. After this, we introduce the essential techniques to: monitor and quench reactions (TLC, color change, neutralizing active chemicals, etc.), purify products (chromatography, crystallization, separatory funnel extractions, etc.), and spectroscopically identify compounds. In parallel, we introduce the equipment (rotary evaporator, melting point apparatus, etc.) and instrumentation (nuclear magnetic resonance (1H and 13C NMR)) to achieve those goals. After mastering these techniques, the next semester (Org Chem II lab) is devoted to the higher level goal of setting up reactions under diverse reaction conditions to produce pure compounds.

Methods of Assessment

Name	Weighting
Compound Synthesis	30%
General Laboratory Performance	40%
Lab Reports	30%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Organic Chemistry I Lab	CH03-400112	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH03-OrgChem Organic Chemistry	Contact Time: 25,50 Private Study: 37,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

A chemical laboratory is a place for exploration, but before that happens we must reinforce important safety aspects, common hazards, and the structure & content requirements of a useful laboratory report. After this, we introduce the essential techniques to: monitor and quench reactions (TLC, color change, neutralizing active chemicals, etc.), purify products (chromatography, crystallization, separatory funnel extractions, etc.), and spectroscopically identify compounds. In parallel, we introduce the equipment (rotary evaporator, melting point apparatus, etc.) and instrumentation (nuclear magnetic resonance (1H and 13C NMR)) to achieve those goals. After mastering these techniques, the next semester (Org Chem II lab) is devoted to the higher level goal of setting up reactions under diverse reaction conditions to produce pure compounds.

Methods of Assessment

Name	Weighting
Final Grade	100%

Course Name	***Course No***	***ECTS***
Organic Chemistry II Lab	CH03-400113	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH03-OrgChem Organic Chemistry	Contact Time: 25,50 Private Study: 37,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

A chemical laboratory is a place for exploration, and the second semester organic laboratory places you squarely in that environment. Here you will set up your own reactions, sometimes at low temperature (e.g. -78 oC) and at other times under an inert atmosphere of nitrogen gas to protect your reactions from the negative effects of the moisture present in the air that we breathe. You will also expand your techniques, e.g., employing vacuum distillation, and exposure to instrumentation, e.g., gas and liquid chromatography, infrared spectroscopy (IR), etc. Most importantly, you will begin to appreciate the whole process of designing and then performing a reaction. From the starting reaction table you have built using reaction stoichiometry to determine the weight or volume of the reagents, to the order and timing of reagent additions, all the way to providing a pure chemical in the end whose structure you can rigorously support via multiple pieces of chromatographic and spectroscopic evidence. You will leave this lab having obtained the essence of the art of organic synthesis.

Methods of Assessment

Name	Weighting
General Performance	50%
Lab Reports	25%
Results	25%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Introduction to Chemical Biology	CO04-520203	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO04-ChemBio Chemical Biology	Contact Time: 35,00 Private Study: 90,00	Bachelor 2nd Year CORE

Course Description / Content / Aims

Understanding the underlying principles of Chemical Biology requires a rigorous and robust knowledge about Nature's ways and capacities to form and use bio-active molecules. This course will guide you through the breath-taking diversity of plant-borne biochemical and cellular processes including their purposes and functions. An array of compounds produced by plants and relevant to human health and nutrition will be introduced. This will be done by demonstrating the natural function of the biomolecule(s) in plant cell biology, developmental processes, or during regulation of biochemical processes. The phytohormone-based language of plants and the fascinating types of interactions with other organisms will be explained. Plant genetics and plant genetic engineering will be introduced and the methodology explained in detail. Ultimately, modern aspects of agriculture, food production, and the employment of plant compounds in medicine will complete this basic survey of plant-focused chemical biology.

Methods of Assessment

Name	Weighting
2 Quizz(es)	10%
Active Participation	20%
Exam 1	30%
Exam 2	40%

Course Name	***Course No***	***ECTS***
Introduction to Chemical Biology	CO04-520203	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO04-ChemBio Chemical Biology	Contact Time: 35,00 Private Study: 90,00	Bachelor 2nd Year CORE

Course Description / Content / Aims

Understanding the underlying principles of Chemical Biology requires a rigorous and robust knowledge about Nature's ways and capacities to form and use bio-active molecules. This course will guide you through the breath-taking diversity of plant-borne biochemical and cellular processes including their purposes and functions. An array of compounds produced by plants and relevant to human health and nutrition will be introduced. This will be done by demonstrating the natural function of the biomolecule(s) in plant cell biology, developmental processes, or during regulation of biochemical processes. The phytohormone-based language of plants and the fascinating types of interactions with other organisms will be explained. Plant genetics and plant genetic engineering will be introduced and the methodology explained in detail. Ultimately, modern aspects of agriculture, food production, and the employment of plant compounds in medicine will complete this basic survey of plant-focused chemical biology.

Methods of Assessment

Name	Weighting
2 Quizz(es)	10%
Active Participation	20%
Exam 1	30%
Exam 2	40%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Advanced Biochemistry Lab	CO04-520213	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO04-ChemBio Chemical Biology	Contact Time: 51,00 Private Study: 74,00	Bachelor 2nd Year CORE

Course Description / Content / Aims

Understanding the relationships between structure, biochemical properties, and activity of biomolecules is at the core of the discipline of Chemical Biology. This lab course focuses on the activity and the biologial roles of biomolecules such as enzymes. We will investigate the isolation and purification of proteins, enzyme activity assays, enzyme kinetics, and the action of small molecules on proteins. Methods include spectrophotometry, fluorimetry, chromatography, and gel electrophoresis. Students will document their results in publication-style reports.

Methods of Assessment

Name	Weighting
Active Participation	20%
Exam	20%
Tests/Reports	60%

Course Name	***Course No***	***ECTS***
Biological Activity	CO04-520223	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO04-ChemBio Chemical Biology	Contact Time: 35,00 Private Study: 90,00	Bachelor 2nd Year CORE

Course Description / Content / Aims

This lecture course 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 activation and inactivation of cellular programs through maturation, activation, inactivation, or destruction of the key molecules involved. Proteases are critical from the beginning of life until its end, they regulate the cell cycle, they involve in developmental processes, and they bring about catabolism. 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 drug. Students will learn how diseases are treated with pharmaceutical reagents that inhibit proteolytic enzymes, thereby gaining a deeper understanding about the challenges and the chances that arise when choosing a drug target to be exploited for clinical application. From bench to bedside will be the over-arching theme of this course.

Methods of Assessment

Name	Weighting
4 Quizz(es)	40%
Essay on a drug	20%
Final Exam	40%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Biopharmaceuticals	CO05-400233	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO05-DrugProd Drug Action and Production	Contact Time: 17,50 Private Study: 45,00	Bachelor 2nd Year CHOICE

Course Description / Content / Aims

Biological systems such as enzymes and cells are increasingly used for the production of drugs and drug precursors. Typical drugs that cannot be synthesized by chemical means and that are commonly produced with the help of living cells are pharmaceutical proteins (including the well-known example of insulin), antibiotics, and other bioactive compounds that result from secondary cellular metabolism. Enzymes are increasingly used in order to introduce chiral centers into small molecules, facilitating the synthesis of chiral drugs. Many cells and enzymes used in these approaches are genetically engineered for better performance. Therefore, a brief introduction into the concepts of genetic and cellular engineering is also given.

Methods of Assessment

Name	Weighting
Quizz(es)	100%

Course Name	***Course No***	***ECTS***
Biopharmaceutical Production Lab	CO05-400234	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO05-DrugProd Drug Action and Production	Contact Time: 25,50 Private Study: 37,00	Bachelor 2nd Year CHOICE

Course Description / Content / Aims

Recombinant cells have been used for the production of pharmaproteins and pharmaceutically relevant small molecule drugs or their precursors. Recombinant enzymes become increasingly important for biotransformations particularly during the production of chiral molecules. The lab course will provide the students with fundamental practical skills for generating, optimizing, and using recombinant cells and enzymes for the production of biopharmaceuticals.

Methods of Assessment

Name	Weighting
Final Grade	100%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Biopharmaceutical Production Lab	CO05-400234	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO05-DrugProd Drug Action and Production	Contact Time: 25,50 Private Study: 37,00	Bachelor 2nd Year CHOICE

Course Description / Content / Aims

Recombinant cells have been used for the production of pharmaproteins and pharmaceutically relevant small molecule drugs or their precursors. Recombinant enzymes become increasingly important for biotransformations particularly during the production of chiral molecules. The lab course will provide the students with fundamental practical skills for generating, optimizing, and using recombinant cells and enzymes for the production of biopharmaceuticals.

Methods of Assessment

Name	Weighting
Final Grade	100%

Course Name	***Course No***	***ECTS***
Pharmaceutical Analytical Chemistry	CO05-400241	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO05-DrugProd Drug Action and Production	Contact Time: 17,50 Private Study: 45,00	Bachelor 2nd Year CHOICE

Course Description / Content / Aims

Compound identification and quantification play a crucial role at every step of the drug development and drug production process. Structure elucidaton is carried out for every compound in lead identification and lead optimization, for degradation products and drug metabolites in pharmacokinetic studies and finally for all intermediates and final products in the drug production process. Purity of compounds must be established at every stage of the process.
To enable this, a sound knowledge of instrumental analytical techniques is introduced to the students in this course. An introduction to the most important spectroscopic techniques including NMR, IR- UV/VIS spectroscopy, and mass spectrometry is given, along with an introduction to separation science including chromatographic techniques.
The course also introduces the concept of Quality by Design (QbD) as a vision that promotes a harmonized system applicable across the lifecycle of the pharmaceutical product or biological, emphasizing an integrated approach to quality risk management and science. The field of Process Analytical Technology (PAT) is also explored. This includes timely measurements of critical quality and performance attributes of raw and in-process so as to assure final product quality. The principles of analytical chemistry that form the basis for QbD and PAT are discussed from the fundamentals into the application in industrial practice.

Methods of Assessment

Name	Weighting
Final Grade	100%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Pharmaceutical Analytical Chemistry	CO05-400241	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO05-DrugProd Drug Action and Production	Contact Time: 17,50 Private Study: 45,00	Bachelor 2nd Year CHOICE

Course Description / Content / Aims

Compound identification and quantification play a crucial role at every step of the drug development and drug production process. Structure elucidaton is carried out for every compound in lead identification and lead optimization, for degradation products and drug metabolites in pharmacokinetic studies and finally for all intermediates and final products in the drug production process. Purity of compounds must be established at every stage of the process.
To enable this, a sound knowledge of instrumental analytical techniques is introduced to the students in this course. An introduction to the most important spectroscopic techniques including NMR, IR- UV/VIS spectroscopy, and mass spectrometry is given, along with an introduction to separation science including chromatographic techniques.
The course also introduces the concept of Quality by Design (QbD) as a vision that promotes a harmonized system applicable across the lifecycle of the pharmaceutical product or biological, emphasizing an integrated approach to quality risk management and science. The field of Process Analytical Technology (PAT) is also explored. This includes timely measurements of critical quality and performance attributes of raw and in-process so as to assure final product quality.
The principles of analytical chemistry that form the basis for QbD and PAT are discussed from the fundamentals into the application in industrial practice.

Course Name	***Course No***	***ECTS***
Pharmaceutical Analytical Chemistry Lab	CO05-400243	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO05-DrugProd Drug Action and Production	Contact Time: 25,50 Private Study: 37,00	Bachelor 2nd Year CHOICE

Course Description / Content / Aims

This laboratory course gives a practical introduction to the most important spectroscopic techniques including NMR, IR, and UV/VIS spectroscopy and mass spectrometry along with an introduction to separation science including chromatographic techniques. Students are provided with samples of drug molecules and are asked to determine their structure, quantify them, and assess their purity.
The laboratory familiarizes students with the concepts and methods utilized in a Process Analytical Technologies (PAT) framework. The PAT approach in presented as an innovative approach to pharmaceutical development, manufacturing and quality assurance. Aspects such as process understanding, underlying scientific principles, analytical methods, and statistical tools are demonstrated with typical examples from traditional pharma or from the bio-therapeutic area.
Students will gain hands-on experience in common analytical routines that are practically utilized in industry, and they will know how to utilize the information gained in the laboratory with the aim of securing process and product quality.

Methods of Assessment

Name	Weighting
Report	100%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Pharmaceutical Analytical Chemistry Lab	CO05-400243	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO05-DrugProd Drug Action and Production	Contact Time: 25,50 Private Study: 37,00	Bachelor 2nd Year CHOICE

Course Description / Content / Aims

This laboratory course gives a practical introduction to the most important spectroscopic techniques including NMR, IR, and UV/VIS spectroscopy and mass spectrometry along with an introduction to separation science including chromatographic techniques. Students are provided with samples of drug molecules and are asked to determine their structure, quantify them, and assess their purity.
The laboratory familiarizes students with the concepts and methods utilized in a Process Analytical Technologies (PAT) framework. The PAT approach in presented as an innovative approach to pharmaceutical development, manufacturing and quality assurance. Aspects such as process understanding, underlying scientific principles, analytical methods, and statistical tools are demonstrated with typical examples from traditional pharma or from the bio-therapeutic area.
Students will gain hands-on experience in common analytical routines that are practically utilized in industry, and they will know how to utilize the information gained in the laboratory with the aim of securing process and product quality.

Methods of Assessment

Name	Weighting
Report	100%

Course Name	***Course No***	***ECTS***
Pharmaceutical Chemistry	CO05-400244	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO05-DrugProd Drug Action and Production	Contact Time: 35,00 Private Study: 90,00	Bachelor 2nd Year CHOICE

Course Description / Content / 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. For therapeutic areas, selected drugs acting on the peripheral nervous system, central nervous system, endocrine system, cardiovascular system, renal system and digestive systems will be discussed along with antiinfective drugs.
Furthermore, general topics overarching all pharmaceutical applications such as drug analysis, identification, separation, formulation, bioavailibilty, 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.

Methods of Assessment

Name	Weighting
Essay	30%
Final Exam	70%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Medicinal Chemistry Lab (Intersession)	CO06-400271	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO06-DrugDev Drug Development	Contact Time: 51,00 Private Study: 74,00	Bachelor 2nd Year CORE

Course Description / Content / Aims

The Medicinal chemistry laboratory course will give the students practical experience in synthesis of selected bioactive compounds. Synthesis will include one step procedures as well as a multi-step chemical synthesis. Students will learn basic synthetic skills including compound purification and characterization using modern analytical instrumentation.

Methods of Assessment

Name	Weighting
Tests/Reports	100%

Course Name	***Course No***	***ECTS***
Medicinal Chemistry Lab (Intersession)	CO06-400271	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO06-DrugDev Drug Development	Contact Time: 51,00 Private Study: 74,00	Bachelor 2nd Year CORE

Course Description / Content / Aims

The Medicinal chemistry laboratory course will give the students practical experience in synthesis of selected bioactive compounds. Synthesis will include one step procedures as well as a multi-step chemical synthesis. Students will learn basic synthetic skills including compound purification and characterization using modern analytical instrumentation.

Methods of Assessment

Name	Weighting
Tests/Reports	100%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Medicinal Chemistry	CO06-400272	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO06-DrugDev Drug Development	Contact Time: 35,00 Private Study: 90,00	Bachelor 2nd Year CORE

Course Description / Content / Aims

The goals and tools of medicinal chemistry represent a focused pursuit of new chemical entities via synthetic organic chemistry. It is the cornerstone of drug discovery, and it is driven by structure-activity relationships from an evolving array of bioassay data (binding and dissociation constants, EC50, IC50, solubility, metabolites, etc.) that directs drug scaffold functional group diversification and refinement. To excel, the medicinal chemist must be a general practitioner of organic chemistry who understands the demands and nuances of a drug's interaction with its biological target, i.e., constructing pharmacophores and translating them into real chemical entities. This requires a rational understanding of steric and electronic substituent effects (bond polarization, resonance, Hammett substituent effects, etc.) and their consequences for noncovalent interactions at the binding site (Van der Waal forces, ?-? stacking, halogen bonding, hydrogen bonding, salt bridges, etc.). In this context, we will also learn about isosteres, prodrugs, structure deconvolution of lead compounds, drug isotope labeling, Lipinski's rule of five (druglikeness and oral activity), the role of hydrophobicity, efficacy, and potency.

Methods of Assessment

Name	Weighting
Final Grade	100%

Course Name	***Course No***	***ECTS***
Medicinal Chemistry	CO06-400272	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO06-DrugDev Drug Development	Contact Time: 35,00 Private Study: 90,00	Bachelor 2nd Year CORE

Course Description / Content / Aims

The goals and tools of medicinal chemistry represent a focused pursuit of new chemical entities via synthetic organic chemistry. It is the cornerstone of drug discovery, and it is driven by structure-activity relationships from an evolving array of bioassay data (binding and dissociation constants, EC50, IC50, solubility, metabolites, etc.) that directs drug scaffold functional group diversification and refinement. To excel, the medicinal chemist must be a general practitioner of organic chemistry who understands the demands and nuances of a drug's interaction with its biological target, i.e., constructing pharmacophores and translating them into real chemical entities. This requires a rational understanding of steric and electronic substituent effects (bond polarization, resonance, Hammett substituent effects, etc.) and their consequences for noncovalent interactions at the binding site (Van der Waal forces, ?-? stacking, halogen bonding, hydrogen bonding, salt bridges, etc.). In this context, we will also learn about isosteres, prodrugs, structure deconvolution of lead compounds, drug isotope labeling, Lipinski's rule of five (druglikeness and oral activity), the role of hydrophobicity, efficacy, and potency.

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Introduction to Molecular Simulations	CO06-400274	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO06-DrugDev Drug Development	Contact Time: 17,50 Private Study: 45,00	CORE

Course Description / Content / Aims

This combined lecture and hands-on computer tutorial focuses on the basics of molecular simulations in biological systems. After a brief excurse to molecular interactions, the basics of molecular dynamics simulations will be introduced. At the same time, hands-on computer sessions will take place in which the theoretical material can be tested in actual simulations of proteins. Possibilities concerning the visualization of proteins and simulation results will be introduced and trained. In addition to molecular dynamics simulations, the basics of molecular docking will be presented. During the course, examples from drug related fields will be introduced.

Methods of Assessment

Name	Weighting
Final Exam	50%
Tests/Reports	50%

Course Name	***Course No***	***ECTS***
Medicinal Chemistry of Fluorine and Phosphorus	CO06-400275	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO06-DrugDev Drug Development	Contact Time: 17,50 Private Study: 45,00	Bachelor 2nd Year CORE

Course Description / Content / Aims

Fluoroorganic compounds are almost completely foreign to the biosphere. No central biological processes rely on fluorinated metabolites, unlike countless phosphorus containing substances which are essential for life processes.

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 action and optimal pharmacological profile. 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. 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).

Bisphosphonates are currently the most important and effective class of drugs developed for the treatment of metabolic bone disorders associated with increased osteoclast-mediated bone resorption, such as osteoporosis, and Paget's disease. Organophosphorus compounds and their metal complexes are used as anticancer drugs. Phosphorus analogs of amino acids, such as aminophosphinic and aminophosphonic acids, are applied as inhibitors of metalloproteinases. Phosphinic acid derivatives are used in the treatment of Alzheimer's disease. A fluorine-containing phosphonate with antiviral activity (Hepatitis C) has been synthesized and is on the market as sofosbuvir. Synthestic routes and diagnostic tools, like 19F (also for imaging) NMR and 31P NMR as well as 18F PET will be discussed in the course.

Methods of Assessment

Name	Weighting
Active Participation	20%
Final Exam	50%
Midterm Exam	30%