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

- **Knowledge**
  is any information, including information that we gather with our abilities. Knowledge in MCCB will be taught to the students in lecture courses and through self-learning including basic knowledge in organic chemistry, analytical chemistry, biochemistry, cell biology , chemical biology and medicinal chemistry among others. Knowledge includes facts, structures, chemical and biological concepts, theories and methods. The knowledge will be assessed via knowledge based questions in examinations within the individual subject specific courses. Skills will be furthermore acquired in the areas of transferable skills (communication, presentation, language, IT skills) within modules of the Jacobs Track. Project specific skills include experimental skills and use of scientific equipment taught in the laboratory courses in chemistry and biology. Assessment of skills takes place through report writing and experimental descriptions within the experiment based laboratory courses.

- **Understanding**
  includes the ability to learn, judge, make decisions. Training for improving understanding will be taught in problem solving based elements of modules and courses. Based on basic understanding of chemical and biological facts and theories problems will be set for students to solve. Understanding will be assessed in course specific examination questions, essays homework, essays and related activities as well as in oral discussions between faculty and students in the classroom.

- **Abilities**
  are innate capacities that facilitate the acquisition of knowledge. This includes planning, attention, simultaneous and successive processing skills. Abilities will be trained in research related activities including ”early research involvement” in years 1 and 2 and the Bachelor thesis in year 3. Students are asked to perform complex tasks requiring all elements of abilities. Abilities will be assessed via marking of BSc thesis and research projects provided by the students in form of reports or thesis and by day to day face to face discussions with academic supervisors on progress and planning of the projects.

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 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 possess the ability to acquire knowledge rapidly, to assess information and to evaluate new concepts critically;
- graduates have communicative competences which allow them to present themselves and their ideas and to negotiate successfully;
- graduates are familiar with business-related processes and management skills and are able to manage projects efficiently and independently.

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 in negotiating and mediating between different points of view;
- graduates can rely on basic civic knowledge and have an understanding for ethical reasoning; students are familiar with the requirements for taking on responsibility.

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:

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Email: t.nugent@jacobs-university.de
Telephone: +49 421 200-3202

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:

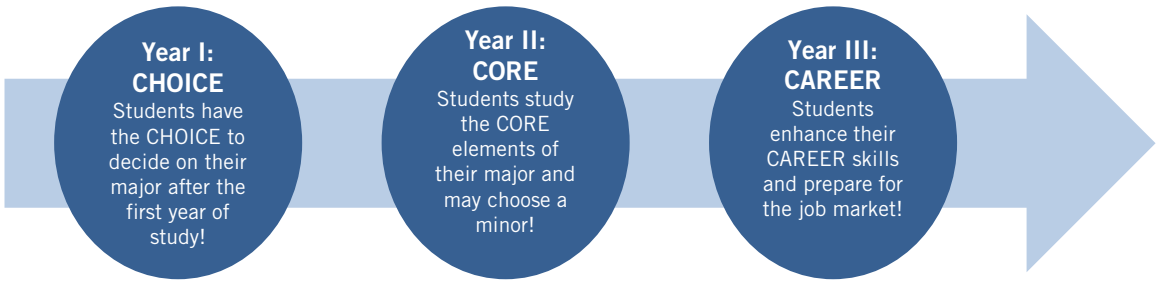


Figure 1: The Jacobs University 3C-Model

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. For more 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.

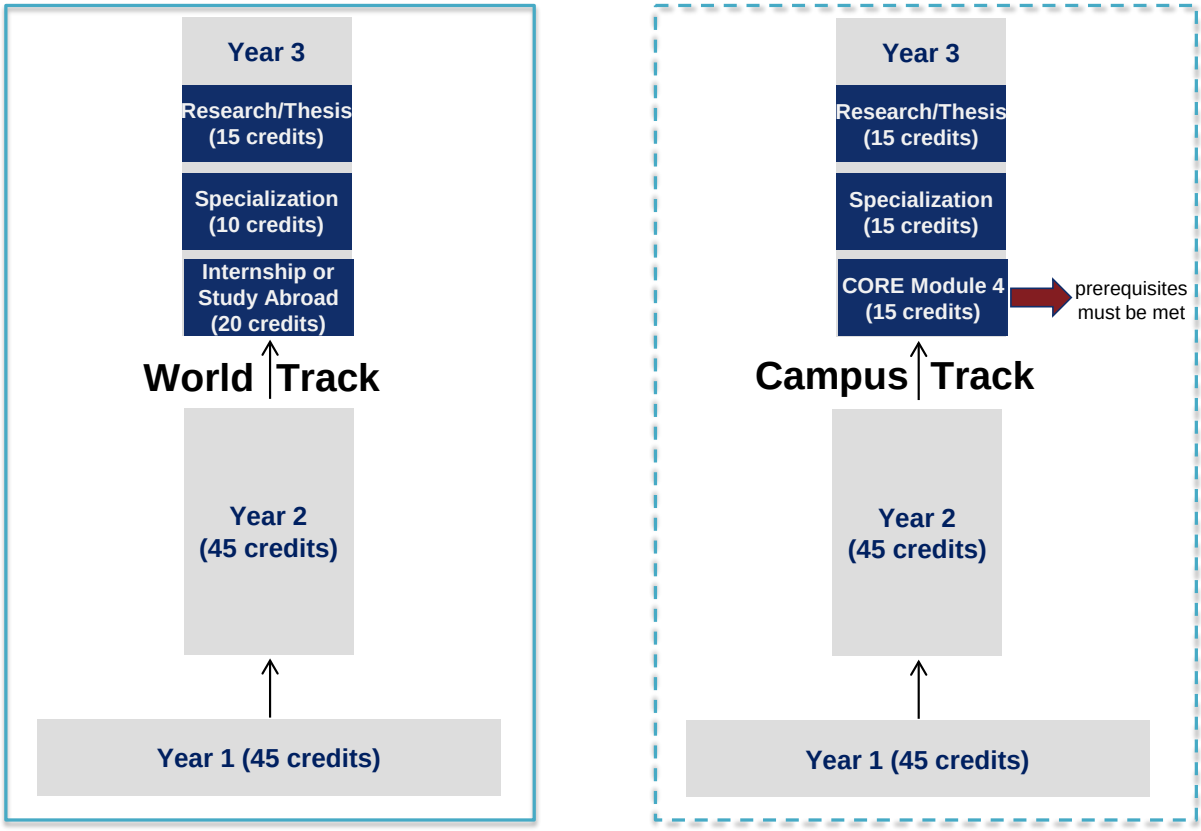


Figure 2: World Track versus Campus Track

Career Skills

Throughout their studies all students attend a mandatory set of career skills courses and events.

The mandatory Career Skills module 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 of the module include information sessions, compulsory seminars on various career-relevant topics as well as participation in the annual Jacobs Career Fair.

The successful completion of the Career Skills Module and the encompassed single seminars are graded with Pass/Fail for all students. ECTS credits are not awarded. All undergraduate students will be automatically registered for the Career Skills Module. However, every student has to keep track of his/her individual fulfillment of requirements and has to register on Campusnet for all seminars and sessions during the official registration period at the beginning of each semester. An overview of the sequence in which components should be completed is shown in the table below:

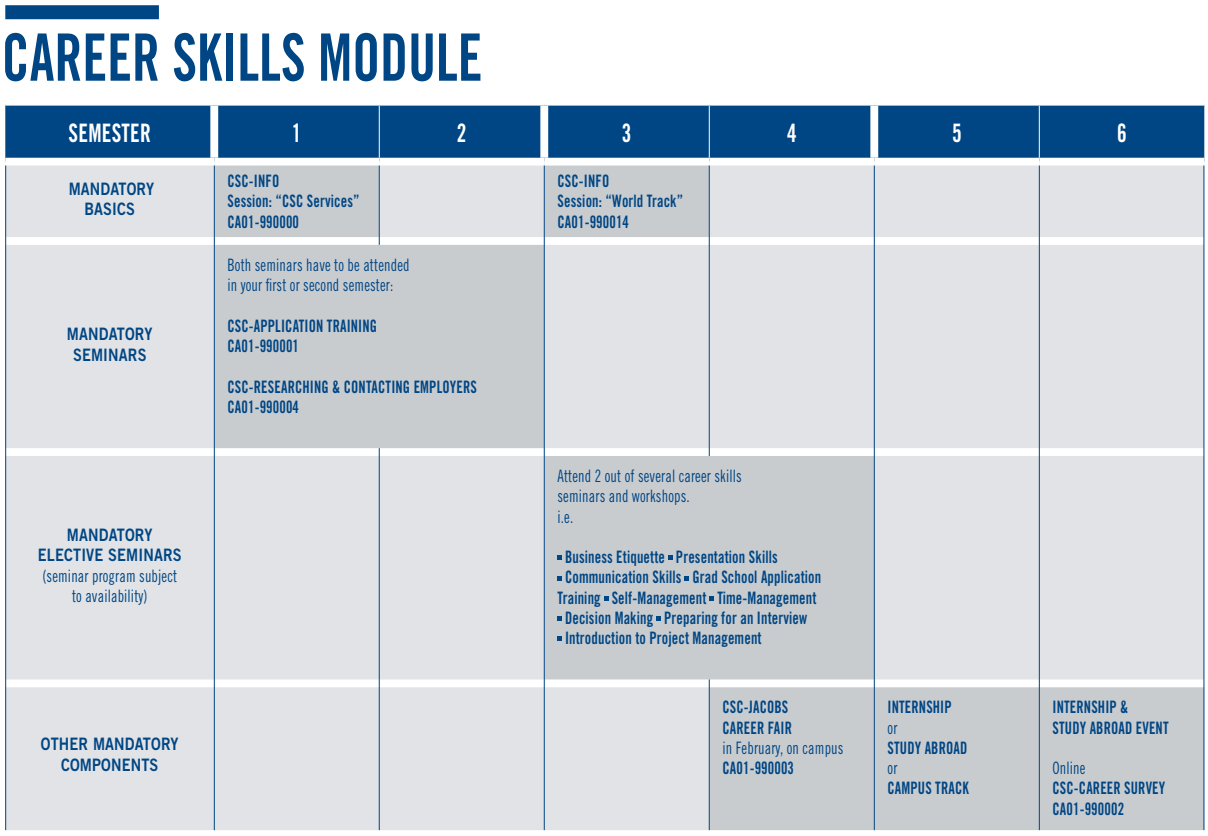


Figure 3: The Career Skills Module

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

2.4.1 Content

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

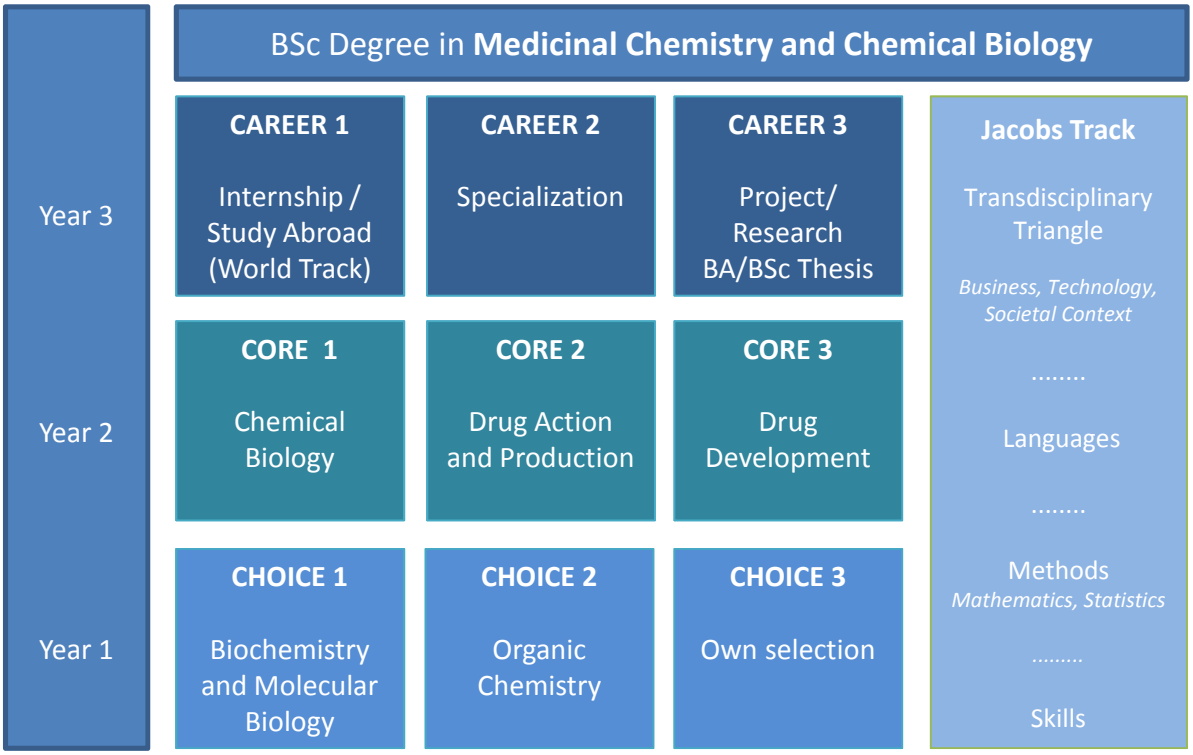
   - Program-specific Specialization Module
     Exemplary course offering:
     - Natural Product Chemistry
     - Structure Determination of Biomolecules
     - Medicinal Chemistry Building Blocks
     - Pharmaceutical Drug Synthesis
     - Drug-Receptor Noncovalent Interactions
     - Bioconjugation Methods
     - Binding and Enzyme Assays
     - Pharmaceutical Manipulation of the Immune System
     - Chemical Biology Approaches in Genomics, Proteomics, and Metabolomics
     - Influencing Transcription, Translation, and other intracellular processes
     - Drug Development as Business
     - Genetic Engineering and Synthetic Biology

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

2.4.2 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 Course 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.

Appendix 1a - Mandatory Course Plan for World Track

Medicinal Chemistry and Chemical Biology – World Track

Matriculation Fall 2016

	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							
CH03-OrgChem	**Module: Organic Chemistry**		**m**		**15**		**JT-SK-Skills**	**Module: Skills**		**m**		**2,5**
CH03-400102	Organic Chemistry I	Lecture	m	1	5		JT-SK-990103	Scientific and Experimental Skills	Lecture	m	1	2,5
CH03-400112	Organic Chemistry I Lab	Lab	m	1	2,5							
CH03-400103	Organic Chemistry II	Lecture	m	2	5		**JT-TA-TriArea**	**Module: Triangle Area**		**m**		**5**
CH03-400113	Organic Chemistry II Lab	Lab	m	2	2,5			Take two courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	1/2	5
	Module: CHOICE (own selection)		**e**	**1/2**	**15**		**JT-LA-Language**	**Module: Language**		**m**		**5**
Students take one further CHOICE module from those offered for all other study programs. [2]								Take two German courses (2,5 ECTS each). Native German speakers take courses in another offered language	Seminar	me	1/2	5
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 I (Intersession)	Lab	m	3	2,5							
CO06-400251	Drug Design (Intersession)	Lecture	m	3	5							
CO06-400273	Medicinal Chemistry Lab II	Lab	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**
CA01-CarSkills	**Module: Career Skills**		**m**				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							
CA-S-MCCB	**Module: Specialization Area MCCB**		**m**		**10**							
	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).

Appendix 1b - Mandatory Course Plan for Campus Track

Medicinal Chemistry and Chemical Biology – Campus Track

Matriculation Fall 2016

	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**
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CH03-400113	Organic Chemistry II Lab	Lab	m	2	2,5			Take two courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	1/2	5
	Module: CHOICE (own selection)		**e**	**1/2**	**15**		**JT-LA-Language**	**Module: Language**		**m**		**5**
Students take one further CHOICE module from those offered for all other study programs. [2]								Take two German courses (2,5 ECTS each). Native German speakers take courses in another offered language	Seminar	me	1/2	5
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**
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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 I (Intersession)	Lab	m	3	2,5							
CO06-400251	Drug Design (Intersession)	Lecture	m	3	5							
CO06-400273	Medicinal Chemistry Lab II	Lab	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**
CA01-CarSkills	**Module: Career Skills**		**m**				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							
CA-S-MCCB	**Module: Specialization Area MCCB**		**m**		**15**							
	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).

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	125	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 Lab	CH02-520111	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH02-BioChem Biochemistry and Molecular Biology	62,5	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
5 Lab Reports	70%
6 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	62,5	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
5 Lab Reports	70%
5 Quizz(es)	20%
Active Participation	10%

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	125	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.

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	125	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 Lab	CH03-400112	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH03-OrgChem Organic Chemistry	62,5	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 II	CH03-400103	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH03-OrgChem Organic Chemistry	125	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.

Course Name	***Course No***	***ECTS***
Organic Chemistry II Lab	CH03-400113	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH03-OrgChem Organic Chemistry	62,5	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.

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	125	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***
Advanced Biochemistry Lab	CO04-520213	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO04-ChemBio Chemical Biology	125	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%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Biological Activity	CO04-520223	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO04-ChemBio Chemical Biology	125	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%

Course Name	***Course No***	***ECTS***
Biopharmaceutical Production Lab	CO05-400234	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO05-DrugProd Drug Action and Production	62,5	Bachelor 2nd Year CORE

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***
Pharmaceutical Analytical Chemistry	CO05-400241	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO05-DrugProd Drug Action and Production	62,5	Bachelor 2nd Year CORE

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	62,5	Bachelor 2nd Year CORE

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***
Biopharmaceuticals	CO05-400233	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO05-DrugProd Drug Action and Production	62,5	Bachelor 2nd Year CORE

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.

Course Name	***Course No***	***ECTS***
Pharmaceutical Chemistry	CO05-400244	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO05-DrugProd Drug Action and Production	125	Bachelor 2nd Year CORE

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
Final Exam	70%
Tests/Reports	30%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Drug Design	CO06-400251	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO06-DrugDev Drug Development	125	Bachelor 2nd Year CORE

Course Description / Content / Aims

Drug design could be broadly described as an ever-shifting landscape of design hurdles to optimize drug candidate–to–biological target interaction, while maintaining the latter's ability to reach the former in vivo. By default, we must begin with the biological target: where is the binding site(s) on it, and what binding interactions will trigger a tertiary structural change with a medicinally relevant outcome? Drug programs begin in earnest when those opportunities (a new drug) are found to be greater than the risks (large investment but no drug). This course provides the relevant foundation knowledge and links it all together for a robust understanding of what drug design entails. This necessitates a multidisciplinary discussion encompassing constant structure refinement based on biological data. Topics to be introduced to the students include: drug target identification and validation (receptors, enzymes, carrier proteins, nucleic acids, etc.), assay development, lead compound identification, lead optimization with a view of optimizing activity, selectivity and pharmacokinetic parameters, drug candidate: scaffolds, libraries, and synthesis, pharmacodynamics (structure-activity relationships), pharmacokinetics (ADME: adsorption, distribution, metabolism, and excretion), toxicology, in silico modeling, and finally clinical trials.

Course Name	***Course No***	***ECTS***
Medicinal Chemistry Lab I	CO06-400271	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO06-DrugDev Drug Development	62,5	Bachelor 2nd Year CORE

Course Description / Content / Aims

The Medicinal chemistry laboratory I 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 6x2 hours	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	125	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
Examination(2*30 minutes)	70%
Tests/Reports(3*20 minutes)	30%

Course Name	***Course No***	***ECTS***
Medicinal Chemistry Lab II	CO06-400273	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO06-DrugDev Drug Development	62,5	Bachelor 2nd Year CORE

Course Description / Content / Aims

The Medicinal chemistry laboratory II will give the students practical experience in a range of experimental skills required in medicinal chemistry experimental research. Experiments to be conducted include enzyme assays, receptor binding studies, drug metabolite profiling in biological fluids, drug stability assessement, and in silico modelling of drug target interactions.

Methods of Assessment

Name	Weighting
Tests/Reports 6x 2 hours	100%