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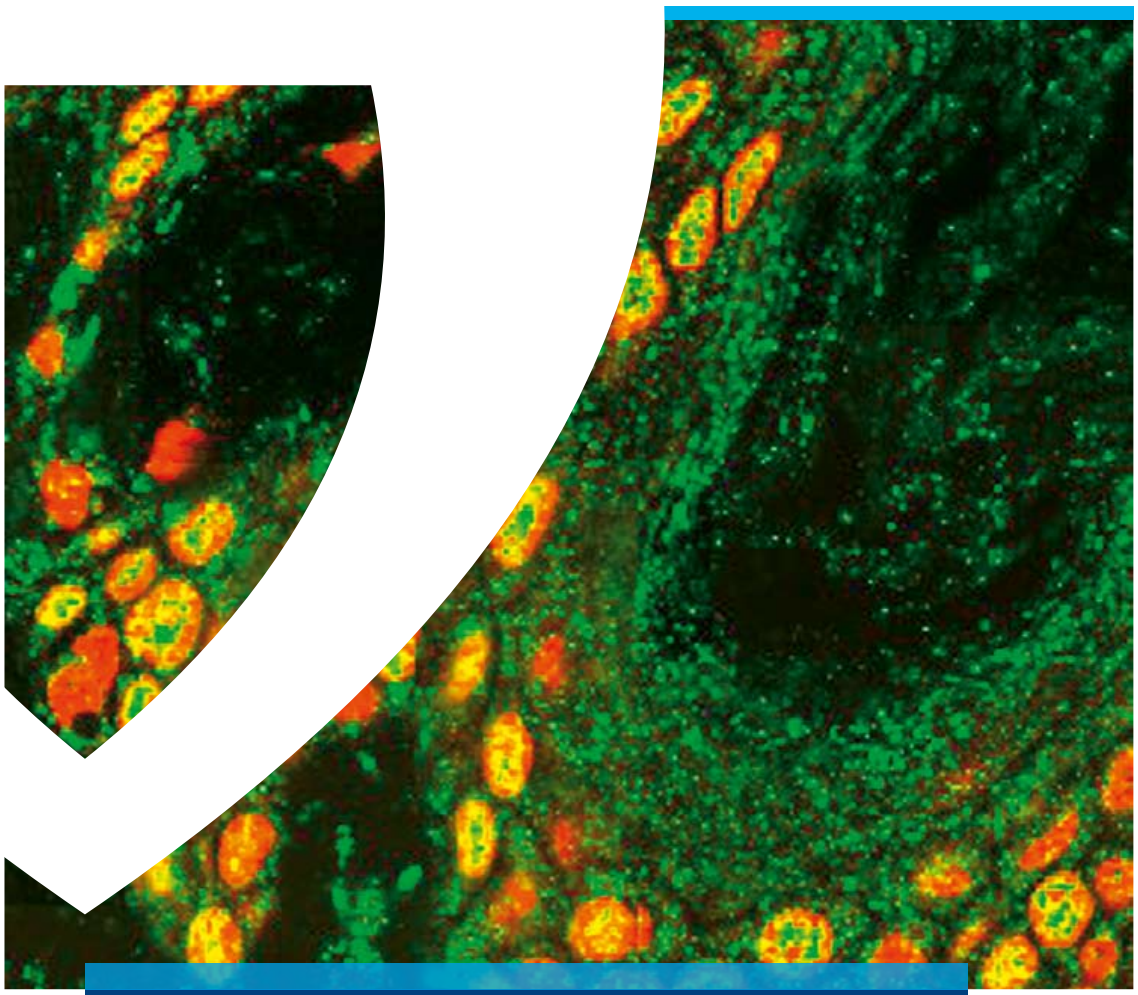

School of Engineering and Science

Biochemistry and Cell Biology (BSc)

Bachelor's Degree Program

Contents

1 Biochemistry and Cell Biology at Jacobs University

1.1 Concept

Biochemistry and Cell Biology explore the molecular mechanisms of cellular functions. The Major program at Jacobs University prepares students for graduate studies in these fields or in biophysics, analytical biochemistry, immunology, microbiology, neurobiology, genetics, molecular biology and molecular medicine. The course starts, in the first year, with a unique biochemistry and cell biology lecture series that gives a comprehensive overview of the two fields and their foundations in chemistry and biology. There are two corresponding laboratory courses. Students also become familiar, to the same depth, with two other natural science subjects of their choice. In the second year, cell biology and biochemistry are taught as separate in-depth lecture courses accompanied by integrated lab courses. The third year is for specialization within the branches of molecular life science such as biochemistry, biomedicine, cell biology, molecular biology, molecular genetics, and microbiology. Laboratory work at that stage takes place in research groups.

1.1.1 Design and specific advantages of the BCCB Major program

Classically, the fields of biochemistry and cell biology were separated and still are in most universities. Recently, however, both fields have merged in research practice. Thus, the BCCB Major at Jacobs University combines two fields of education that are naturally connected but have been formally separated due to their heritage in classical biology and chemistry. It aims to give a deeply integrated view of these and the auxiliary disciplines, and it provides a strong interdisciplinary foundation for a career in the molecular life sciences.

During the detailed planning of the course structure of the BCCB Major program, advice from advisory board members and from various experts from academia, industry, and research foundations was incorporated. A Major program has thus been developed that is fundamentally different from traditional German Diploma programs but also more modern, vigorous, and practice-oriented than most Biochemistry or Cell Biology programs at American or British institutions.

The BCCB Major follows the Jacobs University-specific Shell Model; thus, an overview of the entire field of biochemistry and cell biology in a general manner is already given in the first year, in a unique lecture ”General Biochemistry and Cell Biology” with the accompanying laboratory course. As a result, students are motivated very early to place contents from Biochemistry, Cell Biology, and the other natural sciences such as chemistry and physics into a broad interdisciplinary context. They also learn and work together with students from these disciplines, and exchange of knowledge and experiences is strongly encouraged. This leads to the outstanding motivation that we observe in our students. The first year is followed by the second - year advanced courses in Cell Biology, Biochemistry and Molecular Biology, Genetics, and Microbiology. After two years of intense topical instruction, our students qualify already in their third year for research- and application-oriented experimental work in the laboratory in the ’Guided Research and BSc Thesis’ courses which exemplify our integrated approach to teaching and research. Here, the students experience bench-work in full-day lab rotations in the research laboratories of principal investigators of the disciplines biochemistry, cell bi-

ology, molecular biology, genetics, molecular medicine, biology, microbiology, neurobiology, and bioinformatics. The strength of this scheme lies in the opportunity to choose a specific field of interest and cover it in depth to gain experimental experience in various interconnected disciplines. This communicative approach also brings about scientific cross-talk between the research laboratories. In addition, third-year students take in-depth specialization courses.

1.1.2 Specific transferable skills

The aim of the program is to give students a solid foundation for a career that involves molecular life science. The necessary competences are systematically trained in the courses from their first year onwards: essay- and lab report writing, poster preparations, oral presentations of their own or others' research based on primary literature. This allows students to develop concepts and research strategies in BCCB as integrated part of modern life sciences.

1.1.3 Prospects

Since 2001, the founding year of the BCCB major program, the constantly high numbers of students who enrol for BCCB clearly demonstrate that our program is very attractive to prospective students. So far, our students have received excellent internship offers, and they have been very successful in continuing their careers mostly in international academia but also industry. This indicates to us that the Graduates of our BCCB Major program are attractive to potential employers and high-ranking institutions worldwide. Graduating with a B.Sc. in BCCB offers our students a wide area of career opportunities in all disciplines of life science. This applies to their qualification for graduate programmes in the life sciences, as well as to a career in biotechnological, pharmaceutical, and medical companies. Since in the current post-genomic era molecular life sciences are still booming, BCCB is probably the most suited programme to train for a future-oriented career, e.g. in biomedicine/molecular medicine.

1.2 Career Options

The Bachelor of Science (BSc) received after three successful years of study at Jacobs University Bremen is the key to a world of possibilities and forms the basis for graduate studies. A student may choose to continue his education in the same field of study and acquire a Masters degree in Molecular Life Science at Jacobs University or at another university. Yet this is only one of many possibilities. It is also very common for students to pursue a Masters degree in a somewhat unrelated field, thus attending Medical school or Business school, for example. Job opportunities for students with a Masters degree are much better than those of students with a Bachelor, hence it is common to complete the five years of study needed in order to acquire a Masters degree. Depending on the country of residency, students with a Masters degree often find jobs in larger companies, but may also work in a forensics laboratory, for example. For those students wishing to continue their studies even further, the Bachelor of Science and the following Masters degree are the keys to a research career.

For more details see
http://ses.jacobs-university.de/ses/bccb.

2 Modules: Biochemistry and Cell Biology

For transparency of the logics and as guidance for the (prospective) student, we have structured the respective major programs in terms of modules. A module is defined as a combination of courses (lectures, lab units or other types of courses) interconnected by the same learning goals (Lernziel). Before listing the individual courses and describing their contents, these modules are presented and characterized by the skills and abilities that the student is expected to acquire. But irrespective of this overarching modular structure, the learning progress will be documented with credit points and grades attributed to the individual courses or lab units. This facilitates the control of the student's progress through the student as well as the university on a semester basis, while the modules may extend over a year or, in exceptional cases, even over longer periods. Only the core content of a major program is suited for modularisation. The freely choosable Home School electives and transdisciplinary courses fall outside this structure.

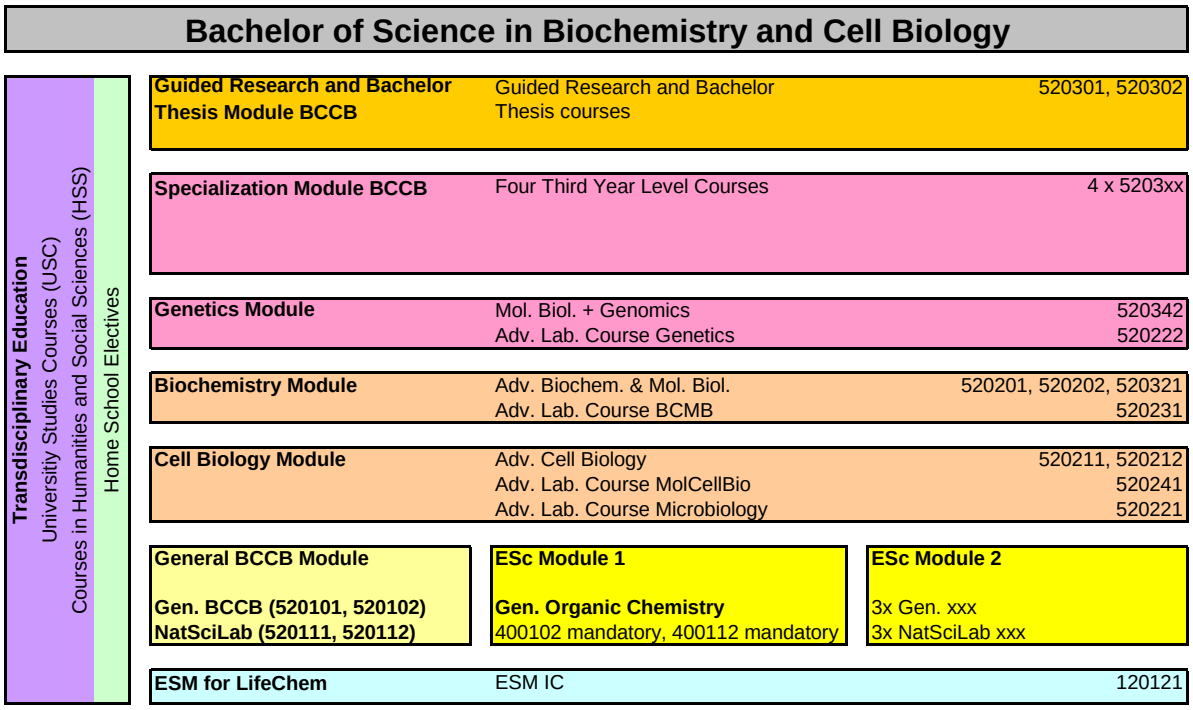

Figure 1: Biochemistry and Cell Biology Module Structure with listings of mandatory requirements only

Subsequently the individual modules are defined with respect to learning goals and acquired competencies. The listed course numbers constitute a reference to the individual courses and the descriptions of their contents.

2.1 General Science

Home School Electives and transdisciplinary courses are not listed as modules.

120110 – MATHEMATICS MODULE

Short Name: ESM for LifeChem
Semester: 1
Credit Points: 5 ECTS

General Information Students of Biochemistry and Cell Biology are required to take one Engineering and Science Mathematics course: See Engineering and Science Mathematics handbook.

Courses
120121 Engineering and Science Mathematics IC or
120101 Engineering and Science Mathematics IA alternatively

xxx – NATURAL SCIENCE MODULES

Short Name: ModGenSES
Semester: 1 – 2
Credit Points: 22.5 ECTS

General Information This includes the additional first year general science modules that consist of the general lectures and associated lab units which are highly recommended for all students majoring in BCCB in the School of Engineering and Science.

Learning goals
- This should offer the student an introduction into other sciences offered within the School of Engineering and Science (SES).

Courses
3 General engineering and science lectures (5 ECTS credits each)
3 Natural Science Lab Units typically associated with the above lectures (2.5 ECTS credits each)

400110 – General Organic Chemistry Module

Short Name: ModGenOrganicChem
Semester: 2
Credit Points: 7.5 ECTS

General Information One lecture and associated lab course.

Learning goals

- Besides providing the students with the necessary background knowledge in organic chemistry on the theoretical as well as practical level, students learn how to efficiently take notes in the lab and to write reports - that focus on the methodology - while performing the experiment.
- This differs from the approaches in the Natural Science Lab Course BCCB and others.

Courses
400102 General Chemistry II (Organic Chemistry)
400112 Natural Science Lab Unit Organic Chemistry

2.2 BCCB Major

520100 – General BCCB Module

Short Name: ModGenBCCB
Semester: 1 – 2
Credit Points: 15 ECTS

General Information In this module, the general BCCB lecture is attended in parallel to the BCCB lab course over a period of 2 semesters.

Learning goals

- The course contents of each lecture and lab combination are complementary. Therefore, the students get the chance to directly transfer theoretical knowledge from the lecture to the lab experiments, where they learn how to use basic techniques that are essential in all molecular life science laboratories.
- Furthermore, the students learn how to summarize, graphically depict, and statistically analyze their results in a form resembling the organization of scientific publication.
- Besides learning to use basic computer programs such as Excel and Word while preparing these, the students also learn how to cite and to deal with copyright issues.
- As a crucial basis to safe lab work, the students also learn where and how to access information about hazardous chemicals as they have to prepare Material Safety Data Sheets by using internet databases and catalogues.

Courses
520101 General Biochemistry and Cell Biology I
520102 General Biochemistry and Cell Biology II
520111 Natural Science Lab Unit BCCB I
520112 Natural Science Lab Unit BCCB II

520200 – Cell Biology Module

Short Name: ModCellBio
Semester: 3 – 4
Credit Points: 22.5 ECTS (mandatory and recommended elective courses)

General Information In this module, three lectures (one as recommended elective) and two lab courses are combined.

Learning goals

- In the Advanced Cell Biology lectures, which embed the Advanced Lab Course Molecular Cell Biology, the theoretical aspects of the complex machinery of the eukaryotic cell are taught. The interactive lecture asks as to how an experiment should be constructed to give a conclusive answer to a hypothesis or theory. By this, the students gain knowledge in classical and modern experimental approaches of cell biology.
- In a problem-oriented approach during the practical part students follow the pathway of a given protein and interfere with its route and fate by introducing various addressing codes.
- Poster summaries: Students have to summarize textbook knowledge in posters. The inclusion of illustrations prepared by the students is strongly encouraged to train the ability to condense complex data and extract the essentials. The graphical depiction of data trains them to generate comprehensive research presentation posters. The poster sessions train presentation and discussion skills
- The Advanced Lab Course Microbiology aims at the identification of microorganisms using classical, physiological and molecular techniques. It may be complemented by the Microbiology lecture course as recommended home school elective in which students learn about structure, organization and physiology of the prokaryotic cell.

Courses
520211 Advanced Cell Biology I
520212 Advanced Cell Biology II
520241 Advanced Lab Course Molecular Cell Biology
520221 Advanced Lab Course Microbiology
520251 Microbiology (recommended home school elective)

520210 – Biochemistry Module

Short Name: ModBC
Semester: 3 – 5
Credit Points: 23.75 ECTS (mandatory and recommended elective courses)

General Information Four lectures are combined with one lab course.

Learning goals

- The students should obtain a detailed knowledge of basic and advanced theoretical concepts of biochemistry that can serve as a solid and reliable basis for future work and education.
- In addition, they should become familiar with basic and advanced biochemical experimental methods that provide an entry point into independent experimental work.
- They learn to apply knowledge to novel problems and to find, understand, and interpret additional specific information from the literature and web resources.
- Students learn to interpret experimental results with respect to accuracy and reliability.
- Besides this, their quantitative analytical skills are trained. They are taught in design of simple experiments, and learn about the meaning and importance of positive and negative controls.
- Furthermore, the students communicate experimental results to others in verbal and written form.

Courses
520201 Advanced Biochemistry and Molecular Biology I
520202 Advanced Biochemistry and Molecular Biology II
520321 Advanced Biochemistry and Molecular Biology III
520231 Advanced Lab Course Biochemistry and Molecular Biology
520252 Plant Biochemistry and Biotechnology (recommended home school elective)

520300 – Guided Research and Bachelor Thesis Module

Short Name: ModGRBCCB
Semester: 5 – 6
Credit Points: 20 ECTS

General Information Lab rotations. Within these courses the students start to work in the research laboratories. One to two different research labs may be visited during the two semesters. The Bachelor of Science Thesis is written in this module.

Learning goals

- During each guided research rotation, they learn to work independently on one project related to the hosting research group's topic.
- Students get an overview of the state-of-the-art techniques used and learn how to approach experimental problems beyond the limitations of the previous lab course settings.

- Students learn to take over responsibility for themselves as well as for group-tasks and to organize their time in an efficient way.
- At the end of each lab rotation, the students have to write a report that becomes the B.Sc. thesis containing experimental results from all guided research rotations.
- The BSc thesis is structured like a scientific paper. Thus, students learn how to write a manuscript draft ready for submission to peer-reviewed journals in their field.

Courses
520301 Guided Research and Bachelor Thesis BCCB I
520302 Guided Research and Bachelor Thesis BCCB II

520310 – Molecular Genetics Module

Short Name: MolGenMod
Semester: 4 + 6
Credit Points: 8.75 ECTS

General Information One lecture is combined with one lab course.

Learning goals
- This module introduces the student to the nature of the genetic code, organization of genetic material in chromosomes, molecular mechanisms of genetic variation and stability, transcriptional regulation and assembly of genetic programs underlying development, growth and morphogenesis, human genetic diseases and genome analysis, transcriptomics and functional genomics.
- The students will acquire knowledge on and understanding of the relationships between the genes and traits in cellular growth, differentiation, evolution and disease and become familiar with applications of genome analysis.

Courses
520342 Molecular Biology and Genomics
520222 Advanced Lab Course Genetics

5203xx – Specialization Module BCCB

Short Name: ModSpecBCCB
Semester: 5 – 6
Credit Points: 20 ECTS

General Information The Specialization Module BCCB consists of four advanced 3rd Year or higher level lectures offered in BCCB or related SES undergraduate programs. Students are allowed to freely choose topics according to their scientific background and preferences

Learning goals

- The major goal of this module is to allow more individualized theoretical specialization. Depending on their course selections, students may specialize in different fields of modern life sciences including biochemistry, molecular cell biology, molecular genetics, biomedical research, biotechnology, neuroscience.
- Furthermore, this module offers comprehensive courses on state-of-the-art methodology, research strategies and scientific literature. With these courses the Specialization Module BCCB ideally complements Module 520300 (Guided Research and Bachelor Thesis Module) in that the practical work is corroborated by solid theoretical background information on modern life science research.
- This module thus uniquely combines the empirical, heuristic and epistemological aspects of science, giving the students the possibility to develop their own seeing of the world.

Courses Students may choose from the following BCCB courses or third year courses offered by related programs:

520311 Biomedicine (5 ECTS)
520322 Immunology (5 ECTS)
520332 Current Topics in Life Sciences (5 ECTS)
520341 Methods and Research Stragegies in BCCB (5 ECTS)
520352 Surgery meets Science (2.5 ECTS)
520362 Ribogenetics (5 ECTS)
xx03xx Home School 3rd year courses

3 Requirements for a B.Sc. in Biochemistry and Cell Biology

3.1 General Requirements

To obtain a B.Sc. degree at Jacobs University a minimum of 180 ECTS credit points must be earned over a period of 6 semesters.

- A minimum of 140 ECTS credits must be earned in the School of Engineering and Science.
- 30 ECTS credits must be earned through transdisciplinary courses, comprised of courses in the School of Humanities and Social Sciences (**HSS**) and University Study Courses (**USC**). Students can choose how many USCs or SHSS courses they take.
- 10 ECTS credits are accredited either for language courses (4 courses maximum) or Home School Electives (see also recommendations). Students can decide whether they take language courses or not.

3.2 Mandatory Courses for the Major

Requirements of the Major

Students choose 140 ECTS credits in Engineering and Science out of the following courses:

- **Year 1 level courses**:
  - Engineering and Science Mathematics (ESM IC) (120121, 5 ECTS credits) or (ESM IA) (120101 5 ECTS credits),
  - General Biochemistry and Cell Biology I/II (520101 plus 520102, 10 ECTS credits),
  - associated Natural Science Lab Units (NatSciLabs) (520111, 520112, 5 ECTS credits),
  - General Organic Chemistry (400102, 5 ECTS credits) plus
  - associated NatSciLab (400112, 2.5 ECTS credits)
  - 2 ESc General Lectures, (10 ECTS credits)
  - 2 Natural Science Lab Courses, (5 ECTS credits).
- **Year 2 level courses**:
  - Advanced Biochemistry and Molecular Biology I/II (520201, 520202, 10 ECTS credits),
  - Advanced Cell Biology I/II (520211, 520212, 10 ECTS credits),
  - Advanced Lab Course Biochemistry and Molecular Biology (520231, 3.75 ECTS credits), Advanced Lab Course Molecular Cell Biology (520241, 3.75 ECTS credits), Advanced Lab Course Microbiology (520221, 3.75 ECTS credits), Advanced Lab Course Genetics (520222, 3.75 ECTS credits). Four Advanced Lab Courses are required in total, 15 ECTS credits.
  - 2 Second Year ESc Subject Courses (10 ECTS)

- **Year 3 level courses:**
  - 30 ECTS credits out of year 3 level lectures. Mandatory course requirements are:
    - Advanced Biochemistry and Molecular Biology III (520321, 5 ECTS credits)
    - Molecular Biology and Genomics (520342, 5 ECTS credits).
    - 20 ECTS credits out of Third Year ESc Subject Courses in the Specialization Module BCCB.
  - Practical Work: Guided Research and Bachelor Thesis in Biochemistry and Cell Biology (520301, 520302, 10 ECTS credits each) consists of two research lab rotations out of which one research lab rotation has to be chosen within BCCB

3.3 Additional courses:

The mandatory electives comprise two second Year ESc subjects (10 ECTS credits) and the four third Year ESc subjects (20 ECTS credits) of the Specialization Module. Students cannot choose to take language courses instead. However, higher level courses can substitute lower level courses, e.g. second year ESc courses can be replaced by third year ESc courses. Courses of the MoLife graduate program can substitute for both, second or third year ESc courses, including mandatory electives.
Only recommended Home School Electives in the first and second year may be substituted by up to four language courses (see 3.4 below).

3.4 Recommendations

Students are strongly recommended to take an additional First Year General Lecture and NatSciLab during their first year of studies. Following this recommendation, BCCB students will obtain 30 ECTS credits from the General Lectures, including those prescribed by the major, plus 15 ECTS credits from the associated NatSciLab units.
An additional second year ESc subject (or higher level course) is also recommended for the second year of studies.

4 Recommended Course Plan

Year 1 Courses	**Fall**	**C**	**T**	**Spring**	**C**	**T**
Engineering and Science Mathematics (ESM IA or ESM IC) [1]	120101 or 120121	*5*	s			
General Biochemistry & Cell Biology I/II	520101	*5*	m	520102	*5*	m
NatSciLab BCCB I/II	520111	*2.5*	m	520112	*2.5*	m
General Organic Chemistry				400102	*5*	m
NatSciLab Chemistry II				400112	*2.5*	m
First year courses in first ESc subject		*5*	e		*5*	e
Associated NatSciLabs		*2.5*	e		*2.5*	e
First year courses in second ESc subject		*5*	e			
Associated NatSciLabs		*2.5*	e			
Transdisciplinary Courses		*5*	u		*10*	u
Running Total / *Semester Total*	32.5	*32.5*		65.0	*32.5*	

Year 2 Courses	**Fall**	**C**	**T**	**Spring**	**C**	**T**
Adv. Biochemistry & Mol. Biol. A I/II	520201	*5*	m	520202	*5*	m
Advanced Cell Biology I/II	520211	*5*	m	520212	*5*	m
Adv. Lab Course Biochemistry & Mol. Biol.	520231	*3.75*	m			
Adv. Lab. Course Microbiology	520221	*3.75*	m			
Adv. Lab Course Genetics [2]				520222	*3.75*	m
Adv. Lab. Course Mol. Cell Biology [2]	520241	*3.75*	m			
Second ESc Subject Course recommended: Microbiology 520251 and Plant Biochemistry and Biotechnology 520252		*5*	me		*5*	me
Second ESc Subject Course		*5*	e			
Transdisciplinary Courses		*5*	u		*5*	u
Running Total / *Semester Total*	101.25	*36.25*		125	*23.75*	

Year 3 Courses	**Fall**	**C**	**T**	**Spring**	**C**	**T**
Adv. Biochemistry and Molecular Biology III	520321	*5*	m			
Molecular Biology and Genomics				520342	*5*	m
Year 3 Life Science lectures (see below: Specialization Module BCCB [3])		*10*	me		*10*	me
Guided Research and BSc Thesis BCCB	520301	*10*	m	520302	*10*	m
Transdisciplinary Courses		*5*	u			
Running Total / *Semester Total*	155	*30*		180	*25*	

Year 3 Specialization Module BCCB Courses	Fall	C	T	Spring	C	T
Biomedicine				520311	*5*	me
Immunology	520322	*5*	me			
Current Topics in the Life Sciences II				520332	*5*	me
Meth. and Research Strategies in BCCB	520341	*5*	me			
Surgery meets Science				520352	*2.5*	me
Ribogenetics				520362	*5*	me

C = ECTS credit points, T=type (m=mandatory, me=mandatory elective, u=university, e=elective, s=school), Transdisciplinary Courses are School of Humanities and Social Sciences and University Studies Courses

Notes:

1. Biochemistry and Cell Biology students are recommended to take Engineering and Science Mathematics (ESM IC), 120121. In case of specially qualified students, ESM 1A, (120101), may be taken after consultation with the Instructors of the respective Mathematics courses.
2. The Advanced Lab Course Genetics and the Advanced Lab Course Molecular Cell Biology take place during Intersession. Courses during Intersession belong to the fall semester. Therefore the credits do not seem to be equally distributed.
3. In the Specialization Module 20 ECTS credits have to be earned from third year level courses. Students may choose from the above mentioned BCCB courses or any other third year level course offered by undergraduate programs in the natural and life sciences.
4. Course substitutions: For all elective courses and the mandatory electives in the 2^{nd} year and 3^{rd} year the following rules apply: Higher level courses can substitute lower level courses, e.g., second year ESc courses can be replaced by third year ESc courses. Courses of the MoLife graduate program can subsitute any of the undergraduate elective courses and the mandatory electives.
5. Language Courses: Languages courses can account for Home School Electives in the first or second year. In the first year this includes the recommended third general lecture (and lab); in the second year, two language courses (2.5 ECTS credits each) may replace the recommended third second year ESc lecture.
6. Although this course plan is not binding, it is highly recommended since it ensures an even workload, optimum efficiency and maximum congruence with the objectives of the curriculum. Note that language courses (not listed) can be counted as ESc subject courses.

4.1 Recommendation Professional Skills

The SES highly recommends attending the Professional Skills seminars offered by the Career Services Center. Those seminars include soft skills development seminars and application training which will help you to cope with your studies and master your internship and job search.

All undergraduate students are required to complete an internship, normally to be accomplished between the second and third year of study. Information about the internship will be listed on the transcript. The internship must typically last at least two consecutive months. No credits are connected to the internship requirement. For more information on internships see http://www.jacobs-university.de/career-services/internship .

5 Courses: Biochemistry and Cell Biology

5.1 First Year of Study

520101 – General Biochemistry and Cell Biology I

Short Name: GenBCCB I
Type: Lecture
Semester: 1
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: No

Course contents This is a unique course that gives, over the first year of studies at Jacobs University, a comprehensive introduction to biochemistry and cell biology. At the end of the course, students 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 biochemistry and biophysics of DNA, proteins (especially enzymes), carbohydrates, and lipids; the buildup and the breakdown of these substances; the (animal, plant, and bacterial) cell, its substructure, and its organelles; an introduction to the most common chemical reactions in living cells and the underlying thermodynamic, chemical, and kinetic principles, including metabolism and its regulation; and introductory overviews of specialized fields such as biophysics, structural biology, molecular machines, molecular neurobiology, immunology, molecular genetics, developmental biology, and cancer. 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. Depending on their previous training, prospective Biochemistry and Cell Biology major students are advised to take General Chemistry or General Biology or both in addition to this course. General Biochemical Engineering is also a very useful complement.

520111 – Natural Science Lab Unit Biochemistry and Cell Biology I

Short Name: NatSciLabBCCB I
Type: Lab
Semester: 1
Credit Points: 2.5 ECTS
Prerequisites: None
Corequisites: 520101
Tutorial: No

Course contents This course trains basic laboratory skills and gives an introduction to biochemical and cell biological work in the laboratory. The course parallels the general biochemistry and cell biology lecture. An introduction is given to substance classes on one hand and methods on the other. Course days include e.g., the handling of glass and micropipettes, balances, spectrophotometers and light microscopes. Experiments include gel filtration, thin layer

chromatography of plant pigments, titration, pH-dependence of enzymes, identification of carbohydrates, microscopy of sperms and muscle etc. For each course day, a lab report is handed in.

520102 – General Biochemistry and Cell Biology II

Short Name: GenBCCB II
Type: Lecture
Semester: 2
Credit Points: 5 ECTS
Prerequisites: 520101
Corequisites: None
Tutorial: No

Course contents This is the second part of the comprehensive introduction to biochemistry and cell biology with special emphasis on the connections to the related fields chemistry and biology. In the spring semester, the emphasis of the course will be on more complex cell biological topics, such as the synthesis, topogenesis and breakdown of cellular components in the context of the cellular environment, and introductory overviews of specialized fields such as biophysics, structural biology, cell cycle, molecular neurobiology, immunology, DNA technology, developmental biology, and cancer. 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. Good High School knowledge of both biology and chemistry, or the willingness to acquire it in self-study, is assumed. Prospective Biochemistry and Cell Biology major students are advised to take General Chemistry or General Biology or both in addition to this course.

520112 – Natural Science Lab Unit Biochemistry and Cell Biology II

Short Name: NatSciLabBCCB II
Type: Lab
Semester: 2
Credit Points: 2.5 ECTS
Prerequisites: None
Corequisites: 520102
Tutorial: No

Course contents This course trains basic laboratory skills and gives an introduction to biochemical and cell biological work in the laboratory. The course parallels the general biochemistry and cell biology lecture. An introduction is given to substance classes on one hand and methods on the other.
As a continuation of the fall course, this time the focus lies on DNA and RNA. Course days include e.g., the handling of glass and micropipettes, balances, spectrophotometers and light microscopes. Experiments include isolation of DNA and RNA from pea seedlings, isolation of DNA from stressed C6 glioma cells and detection of an apoptotic DNA ladder by means

of agarose gel electrophoresis, sterile cultivation of yeast cells, determination of cytotoxicity, fixation, staining and microscopic investigation of M phase cells.

5.2 Second Year of Study

520201 – Advanced Biochemistry and Molecular Biology I

Short Name: AdvBCMB I
Type: Lecture
Semester: 3
Credit Points: 5 ECTS
Prerequisites: 520101, 520102
Corequisites: None
Tutorial: No

Course contents The course intends to give a detailed understanding of the chemical reactions that underlie life. In the first part the structures, dynamics and chemistry of important biomolecules will be described. The thermodynamics and kinetics of ligand binding to proteins and enzyme catalysis will be explained and enzymatic catalysis explored at the molecular and atomic level. The second part focuses on metabolism and describes how energy is produced by living organisms and how the molecules of life are synthesised and degraded. A special focus will be set on common principles and the integration of the metabolism. The third part of the course explains how the genetic information stored in the DNA sequence is maintained and expressed. In addition the mechanism of DNA binding and modification by proteins and enzymes will be presented. The techniques of modern molecular biology will be described and the results of the human genome project discussed.

1. The Molecular Logic of Life
2. Carbohydrates and Glycoconjugates
3. Lipids and Biomembranes
4. Amino acids and Proteins
5. Protein Structure and Folding
6. Protein Function: Ligand Interactions
7. Enyzmes and Coenzymes
8. Catalytic Strategies
9. Enzyme Kinetics and Enzyme Inhibition
10. Nucleotides and Nucleic Acids

520211 – Advanced Cell Biology I

Short Name: AdvCB I
Type: Lecture
Semester: 3
Credit Points: 5 ECTS
Prerequisites: 520101, 520102
Corequisites: None
Tutorial: No

Course contents This course intends to give a detailed understanding on the biology of pro- and eukaryotic cells on the basis of the biochemical features of cellular macromolecules. Cells are limited by a plasma membrane bearing important functions like communication of cells with their surroundings. Within eukaryotic cells, biological membranes form cellular compartments to optimize biochemical reactions necessary for all cells to perform their biological functions. The biogenesis of cellular compartments will be a central part on the way of understanding the evolution of multicellular organisms. The complexity of cellular systems and of their macromolecular constituents becomes most obvious in certain disorders that have been characterized on the molecular level. Therefore, biomedical implications will be included whereever possible.

- Definition and evolution of cells
- Cell proliferation, cell differentiation, and cell death
- Nucleus
- From RNA to protein
- Protein folding
- Protein sorting
- ER and Golgi
- Secretory pathway
- Quality control
- Plasma membrane & glycocalyx
- Molecular mechanisms of vesicular traffic

520251 – Microbiology

Short Name: Microbio
Type: Lecture
Semester: 3
Credit Points: 5 ECTS
Prerequisites: 500102 or 520102
Corequisites: None
Tutorial: No

Course contents This course is designed to build up on the content of the General BCCB II or General Biology II courses (500102, 520102) and to deepen the knowledge of physiological phenomena at the molecular level. Besides a detailed view into general microbiology and microbial ecology, the course deals with molecular aspects of evolution, microbiology, and plant cell biology and physiology. Therefore, special emphasis will be given to environmental, microbial, and ”green” biology. This includes exciting insights into molecular aspects of the interactions between living organisms, such as symbiosis, infectious diseases, and global element cycles. While three units within the fall semester will cover the fields of Molecular Evolution, General Microbiology (incl. bacteria, protists, and fungi), and Microbial Ecology (incl. element cycles, symbiosis, and pathology), the three units of the spring semester will bring insights into Molecular Biology of Plant Cells, Plant Eco-physiology, and Plant and Microbial Genetics. Additionally, all units will highlight how we can explore our knowledge of microbial and plant molecular biology at the level of biotechnology.

520231 – Advanced Lab Course Biochemistry and Molecular Biology

Short Name: AdvBCMBLab
Type: Lab
Semester: 3
Credit Points: 3.75 ECTS
Prerequisites: 520111 and 520112
Corequisites: None
Tutorial: No

Course contents Methods in this lab include the isolation and purification of proteins, DNA, carbohydrates, and lipids, enzyme activity assays, enzyme kinetics and restriction analysis of DNA. The methods cover the range from spectrophotometric analysis, fluorescence, chromatography, gel electrophoresis and Western blotting.

520241 – Advanced Lab Course Molecular Cell Biology

Short Name: AdvMCB
Type: Lab
Semester: 3
Credit Points: 3.75 ECTS
Prerequisites: 520111, 520112
Corequisites: 520211
Tutorial: None

Course contents This lab course focuses on the cellular architecture and targeting of proteins. The lab course has three major parts. CHO cells are transfected with plasmids coding for targeted and non-targeted GFP. Then, the localization of these proteins is investigated by microscopy and subcellular fractionation followed by SDS-PAGE and Western Blot. In the third part, normal CHO cells are vital-stained and immuno-labelled. Tissue sections prepared from diverse mouse tissues are also prepared to complement histological aspects. Conventional and confocal fluorescence microscopy is performed on the microscopic specimen.

520221 – Advanced Lab Course Microbiology

Short Name: Adv Lab Microbiology
Type: Lab
Semester: 3
Credit Points: 3.75 ECTS
Prerequisites: 520111 and 520112
Corequisites: None
Tutorial: No

Course contents Participants will learn how and where microbes live, how they utilize nutrients, and how we can identify them based on their phenotypes and genotypes. Students will isolate bacteria from different natural and man-made sources,respectively, and will use pure

cultures of these micro-organisms to conduct physiological experiments and to classify them phylogenetically.

520222 – Advanced Lab Course Genetics

Short Name: Adv Lab Genetics
Type: Lab
Semester: 4
Credit Points: 3.75 ECTS
Prerequisites: 520111 and 520112
Corequisites: None
Tutorial: No

Course contents In this lab course the students have to carry out a small research project concerning the role of the Escherichia coli chromosomal protein IHF (integration host factor) in the global gene regulation, especially regarding the effect of IHF on bacterial drug resistance. The research project combines a series of classical and modern approaches including: gene cloning for genetic complementation studies, drug resistance assays, fermentation, 2D gel electrophoresis and peptide mass fingerprint (PMF) MALDI mass spectrometry.

520202 – Advanced Biochemistry and Molecular Biology II

Short Name: AdvBCMB II
Type: Lecture
Semester: 4
Credit Points: 5 ECTS
Prerequisites: 520201
Corequisites: None
Tutorial: No

Course contents The course intends to give a detailed understanding of the chemical reactions that underlie life. In the first part the structures, dynamics and chemistry of important biomolecules will be described. The thermodynamics and kinetics of ligand binding to proteins and enzyme catalysis will be explained and enzymatic catalysis explored at the molecular and atomic level. The second part focuses on metabolism and describes how energy is produced by living organisms and how the molecules of life are synthesised and degraded. A special focus will be set on common principles and the integration of the metabolism. The third part of the course explains how the genetic information stored in the DNA sequence is maintained and expressed. In addition the mechanism of DNA binding and modification by proteins and enzymes will be presented. The techniques of modern molecular biology will be described and the results of the human genome project discussed.

1. Basic Concepts in Metabolism
2. Glycolysis
3. Tricarboxylic Acid (TCA) Cycle
4. Fatty Acid Catabolism

5. Protein Turnover: Amino Acid Degradation and the Urea Cycle
6. Oxidative Phosphorylation
7. Pentose Phosphate Pathway
8. Gluconeogenesis and Glycogen Metabolism
9. Biosynthesis of Fatty Acids and Related Molecules
10. Biosynthesis of Amino Acids
11. Biosynthesis of Nucleotides
12. Photosynthesis and the Calvin Cycle

520252 – Plant Biochemistry and Biotechnology

Short Name: Plant BCBiotech
Type: Lecture
Semester: 4
Credit Points: 5 ECTS
Prerequisites: 520251
Corequisites: None
Tutorial: No

Course contents This course is designed to build up on the content of the General BCCB II or General Biology II (500102, 520102) courses and to deepen the knowledge of physiological phenomena at the molecular level. Besides a detailed view into general microbiology and microbial ecology, the course deals with molecular aspects of evolution, microbiology, and plant cell biology and physiology. Therefore, special emphasis will be given to environmental, microbial, and ”green” biology. This includes exciting insights into molecular aspects of the interactions between living organisms, such as symbiosis, infectious diseases, and global element cycles. While three units within the fall semester will cover the fields of Molecular Evolution, General Microbiology (incl. bacteria, protists, and fungi), and Microbial Ecology (incl. element cycles, symbiosis, and pathology), the three units of the spring semester will bring insights into Molecular Biology of Plant Cells, Plant Eco-physiology, and Plant and Microbial Genetics. Additionally, all units will highlight how we can explore our knowledge of microbial and plant molecular biology at the level of biotechnology.

520212 – Advanced Cell Biology II

Short Name: AdvCB II
Type: Lecture
Semester: 4
Credit Points: 5 ECTS
Prerequisites: 520211
Corequisites: None
Tutorial: No

Course contents The course intends to give a detailed understanding on the biology of pro- and eukaryotic cells on the basis of the biochemical features of cellular macromolecules. Cells are limited by a plasma membrane bearing important functions like communication of cells

with their surroundings. Within eukaryotic cells, biological membranes form cellular compartments to optimize biochemical reactions necessary for all cells to perform their biological functions. The biogenesis of cellular compartments will be a central part on the way of understanding the evolution of multicellular organisms. The complexity of cellular systems and of their macromolecular constituents becomes most obvious in certain disorders that have been characterized on the molecular level. Therefore, biomedical implications will be included whereever possible.

- Endocyctic organelles & endocytic route
- Cytoskeleton
- Cell-cell adhesion and communiation
- Interaction between cells and extracellular matrix
- Cell migration
- Signal Transduction
- Mitosis and cytokinesis
- Cell proliferation - cell differentiation - cell death

5.3 Third Year of Study

520301 – Guided Research and BSc Thesis Biochemistry and Cell Biology I

Short Name: GR&BScT BCCB I
Type: Research
Semester: 5
Credit Points: 10 ECTS
Prerequisites: 520231, 520241, 520221, 520222
Corequisites: None
Tutorial: No

Course contents This lab course intends to intensely train students in laboratory practice on a given research project of the Instructor's group. It is an integrated part of the lab rotations each student has to attend during the 3rd year education. One lab rotation per each semester of the 3rd year will give the students the opportunity to visit different research laboratories of the various life sciences disciplines participating in this course structure. All individual lab rotations will finally be written up in a thesis to prove the student's ability of performing independent research. Scheduling has to be decided between the Students and the individual Instructors of the particular lab rotations. The Instructor of Record will have to organize for accommodation of each student within the research laboratories preferably of their first choices. However, this needs to be done in a way to allow equal and appropriate distribution of all students between the various research groups. Students will indicate their preferences, and the Instructor of Record will decide on the order of lab rotations during the 3rd year; this happens at the end of the fourth semester.

520302 – Guided Research and BSc Thesis in Biochemistry and Cell Biology II

Short Name: GR&BScT BCCB II
Type: Research
Semester: 6
Credit Points: 10 ECTS
Prerequisites: 520301
Corequisites: None
Tutorial: No

Course contents This lab course intends to intensely train students in laboratory practice on a given research project of the Instructor's group. It is an integrated part of the lab rotations each student has to attend during the 3rd year education. One lab rotation per each semester of the 3rd year will give the students the opportunity to visit four different research laboratories of the various life sciences disciplines participating in this course structure. All individual lab rotations will finally be written up in a thesis to prove the student's ability of performing independent research. Scheduling has to be decided between the Students and the individual Instructors of the particular lab rotations. The Instructor of Record will have to organize for accommodation of each student within the research laboratories preferably of their first choices. However, this needs to be done in a way to allow equal and appropriate distribution of all students between the various research groups. Students will indicate their preferences, and the Instructors of Record will decide on the order of lab rotations during the 3rd year; this happens at the end of the fourth semester.

Bachelor of Science THESIS
The lab reports of the individual lab rotations conducted in the courses 520301 and 520302 are the basis for preparation of the thesis, i.e. two lab reports of 10 pages each will make up the thesis.

The Bachelor of Science thesis starts with a title page containing the following:

- Jacobs University logo
- name of the student
- matriculation number
- course number/s and course title/s
- thesis title (max. 190 characters including spaces)

The second page should contain information on the individual projects conducted in courses 520301 and 520302:

- title of each lab rotation
- name of supervisor/s
- time periods of project work
- optional: synopsis of both projects
- optional: in cases where publications were achieved, they should be listed here.

Note that only accepted manuscripts in print but not submitted manuscripts under review are to be listed.

Followed by the two individual lab rotation reports of approx. 10 pages each:

- printed in DIN A4 format
- margins of 2.54 cm
- project title in the header, page numbers in the footer
- text single-spaced, font size 10-12 pt, 8-10 pt for figure captions
- reports should follow the style of scientific papers and each report should be sub-divided as detailed below:
  - Project Title, Supervising Laboratory, Supervisor, Author (one-column-style)
  - Abstract (max. 200 words, one-column-style)
  - Introduction, Materials and Methods, Results, Discussion, Conclusion (optional), References (all in two-column-style)

Any additional material that the student wants to submit with the Bachelor of Science Thesis can be added as appendices to the individual lab rotation reports. The appendix has no limitations with respect to page numbers or styles. Appendices are optional.
The Bachelor of Science Thesis has to be submitted as one PDF-file in electronic version and in 3 printed (double-sided) and comb-bound copies to the Instructor of Record of the courses 520301 and 520302. Deadlines for the submission of the individual lab reports for 520301 and 520302 are set by the Instructor of Record. The Bachelor Thesis has to be submitted approximately 1 week before the Final examination week of the respective semester.

520311 – Biomedicine and Infection Biology

Short Name: BiomedInfBio
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 520211, 520212
Corequisites: None
Tutorial: No

Course contents This course aims to introduce students to the various aspects of biomedical research and infection biology. The understanding of the underlying molecular principles and mechanisms that enable our cells, tissues, and bodies to function properly will be of central interest. However, the complexity of biological systems becomes most obvious in challenging or disease situations. Therefore, biomedical research has largely focussed on chronic degenerative diseases of the adult such as atherosclerosis, neurodegenerative diseases and cancer to name a few. In this course, we will discuss model organisms to which molecular medicine refers, experimental approaches taken to challenge cellular or organism function, and we will talk in detail about animal models for human diseases. Evolutionary and ecological aspects will be included in that we intend to compare the biological significance of carcinogenesis and related metabolic changes in the human body with their ecotoxicological role in the very diverse marine organisms for the environmental risk assessment. Understanding the principles of infectious diseases is an integrated part of biomedicine. The course is therefore also designed to elucidate the various virulescence mechanisms of pathogenic microorganisms.

520321 – Advanced Biochemistry and Molecular Biology III

Short Name: AdvBCMB III
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 520201, 520202
Corequisites: None
Tutorial: No

Course contents The course intends to give a detailed understanding of the chemical reactions that underlie life. In the first part the structures, dynamics and chemistry of important biomolecules will be described. The thermodynamics and kinetics of ligand binding to proteins and enzyme catalysis will be explained and enzymatic catalysis explored at the molecular and atomic level. The second part focuses on metabolism and describes how energy is produced by living organisms and how the molecules of life are synthesized and degraded. A special focus will be set on common principles and the integration of the metabolism. The third part of the course explains how the genetic information stored in the DNA sequence is maintained and expressed. In addition the mechanism of DNA binding and modification by proteins and enzymes will be presented. The techniques of modern molecular biology will be described and the results of the human genome project discussed.

1. Information Pathways
2. Genes and Chromosomes
3. Topology of DNA
4. DNA Replication
5. DNA Repair
6. DNA Recombination
7. RNA directed DNA Synthesis
8. DNA Modification
9. RNA Synthesis
10. RNA Processing
11. Protein Synthesis
12. Protein Targeting and Degradation
13. Protein-DNA Interaction
14. Protein-RNA Interaction
15. Regulation of Gene Expression
16. Recombinant DNA Technology
17. RNA Technology

520341 – Methods and Research Strategies in BCCB

Short Name: Methods BCCB
Type: Lecture
Semester: 5
Credit Points: 5 ECTS
Prerequisites: 520201, 520211 and 520212
Corequisites: None
Tutorial: No

Course contents One of the most challenging tasks in modern science is to design the optimal experimental strategy to unravel the fascinating complexity of biological systems. On one hand, this strategy may involve the isolation and characterization of a single macromolecule, on the other hand it could require the genetic manipulation and functional analysis of a whole organism. This course provides a problem-oriented introduction to important experimental methods employed in modern Molecular Life Sciences. The participants will learn about advantages and limitations of a broad spectrum of different techniques in biochemistry, molecular biology and cell biology. Research strategies will be developed based on both, solving fictitious problems in theory and by analyzing current scientific literature. At the end of the course, students will write their own research proposal to analyze a given scientific problem.

520342 – Molecular Biology and Genomics

Short Name: MolBio&Genomics
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 500201 or 520251
Corequisites: None
Tutorial: No

Course contents This course is thought as an introduction to contemporary genetics starting from chromosomal theory of inheritance to molecular genetics and genomics. The purpose of the course is to gain understanding of the relationships between the genes and traits in growth, differentiation, development, evolution and disease.

520322 – Immunology

Short Name: Immunology
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: No

Course contents An advanced course that gives:

- a thorough basic training in immunology through the weekly review of one chapter from the textbook, "Immunobiology" (Janeway et al.). Students will be asked to read and prepare the chapter, and discuss it in the first class each week based on the instructor's questions (tutorial-style).
- a cutting-edge knowledge of some select new developments in immunology through the weekly presentation and discussion of one paper from an area corresponding to that week' s textbook chapter. Presentations will be of high quality because of comprehensive preparation (see below). Transferable skills that will be taught:
- Presentation of complex scientific contents: Students will learn to understand, and to present in 30 minutes, the contents of a research paper. They will meet with the professor beforehand to prepare their presentations, and they will receive feedback on their presentation style afterwards from professor and class.
- Critical assessment of research papers: students will learn to read research papers and judge whether the conclusions are supported by the data.
- Communication and discussion of scientific data: students will learn to use coherent scientific logic in discussing scientific results and theories. The course will also be useful to beginning graduate students with an interest in immunology, biomedicine, and related fields.

520332 – Current Topics in Molecular Life Sciences

Short Name: CTMLS
Type: Seminar
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 520201, 520202, 520211, 520212
Corequisites: None
Tutorial: No

Course contents This course is meant to introduce students to a range of current research topics in Advanced Biochemistry, Molecular Cell Biology, Molecular Genetics, Biophysics, and Molecular Microbiology through directed reading of the primary literature and actively attending all seminars. Primary literature is meant as original research articles from current issues of the leading scientific journals, such as Nature, Science, Cell, EMBO Journal, Molecular Cell Biology, and others. At each time of class, students will meet with a faculty member to discuss one or more papers authored by scientists/laboratories which lead the respective field of research. Active participation of the students will be in form of detailed scientific presentations of the published experiments and their background and conclusions, respectively, followed by an in-depth discussion with all students and the faculty member(s).
Since state-of-the-art science lives from communication among scientists, the prime purpose of this seminar series is to enable students to communicate advanced scientific topics. Furthermore, this course is devoted to the development of presentation skills and to an in-depth understanding of what is so exciting about current life science research. Topics to be dealt with will be chosen based on comprehensiveness, actuality, and the individual scientific interests of students and faculty alike.

520352 – Surgery meets Science: Problems - Pathophysiology - Therapeutic perspectives

Short Name: Surgery
Type: Lecture
Semester: 6
Credit Points: 2.5 ECTS
Prerequisites: None
Corequisites: None
Tutorial: No

Course contents This lecture is meant to give insight into diseases and disease management using a rollercoaster approach: starting with the macroscopic view of a patient who presents with a problem; we will continue diving down to analyze the underlying biomolecular pathology; and finally, we leave the microscopic field again and come back to the patient by discussing either the current state-of-the-art treatment or putative innovative therapeutic options. The success of translating science into applied medicine bases on mutual understanding of clinicians and researchers. The course shall provide insight into a clinician's daily work and thinking including a quick "haptic" approach: meet the materialized problem, meet the patient!

520362 – Ribogenetics: Molecular Biology and Biotechnology on RNA

Short Name: Ribogenetics
Type: Lecture
Semester: 6
Credit Points: 5 ECTS
Prerequisites: 520321
Corequisites: None
Tutorial: No

Course contents The course intends to give a detailed understanding of the Biochemistry of RNA molecules, the most versatile biopolymer. Topics include RNA classes, structural versatility, processing of tRNA, mRNA and rRNA, splicing and alternative splicing and underlying RNA-protein interactions. Ribozymes and Aptamers will be introduced and discussed with respect to biotechnological applications. A main part of the course will be devoted to mechanisms by which RNA molecules modulate the use of information in eukaryotic and prokaryotic cells, including topics like RNA interference and riboswitches. High throughput techniques of RNA molecules will be introduced with a special emphasis on the recently developed deep sequencing technologies.