2023

FACULTY OF MATHEMATICS
AND NATURAL SCIENCES
in cooperation with the
MEDICAL FACULTY

UNIVERSITY OF COLOGNE

MODULE COMPENDIUM

BIOCHEMISTRY AND MOLECULAR MEDICINE

MASTER OF SCIENCE

ACCORDING TO THE EXAMINATION REGULATIONS FOR THE MASTER OF SCIENCE IN BIOCHEMISTRY AND MOLECULAR MEDICINE

Universität zu Köln

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Contents

1 The Master's Degree Biochemistry and Molecular Medicine

1.1 Content, Aims of Studies and Requirements

The Master of Science program in Biochemistry and Molecular Medicine is research-oriented and taught in English. The successful completion of the two-year program will lead to a Master of Science (M.Sc.) degree. With the program, students will acquire a strong background in basic biochemistry and in modern life science research practice. This will enable them to take up career paths in both university and company environments. The modules are spread over the main life science areas, including biochemical, biomolecular, and medical research. Students can both extend and specialize their scientific knowledge.

Requirements to participate in the Master's Degree Course Biochemistry and Molecular Medicine are specified in the appendix of the examination regulations.

1.2 Structure and Progression of the Studies

In the first year of the program, students attend an **Advanced Biochemistry and Molecular Medicine Lecture Series** and a **Hot Topics in Biochemistry and Medicine Method Seminar** (both Core Modules/Basismodule) as well as two **Subject Modules** (both Advanced Modules/Aufbaumodule). The latter are 8-week laboratory modules, covering different areas in the life sciences (see Table 3). The second and third term are dedicated to research and comprise two Laboratory Project Modules, Scientific Writing, and the Project Proposal. In the **Laboratory Project Modules** (Specialization Modules/Schwerpunktmodule), students work in a research group of their own choice on a scientific question for 12 weeks, to develop a deeper understanding of experimental methods and techniques. The **Scientific Writing** module (Advanced Module/Aufbaumodul) fosters transferable general writing skills and specific ones for scientific publishing. This prepares students for the **Project Proposal** (Specialization Module/Schwerpunktmodul), where they learn to write an application for funding related to the topic of their future master thesis. The program is completed with a six-month research project that will be written up in a Master's thesis and presented in a colloquium ("**Master Thesis & Defense Module**", (Specialization Module/Schwerpunktmodul).

1.3 General CP-Survey

Professional Studies		**84 CP** (70%)
Master Thesis		**36 CP** (30%)
Total		**120 CP**

1.4 Term Based Schedule

Term#	Core Modules	Advanced Modules	Specialization Modules		Total CP
1	**Advanced Biochemistry and Molecular Medicine** (whole term, 6 CP)	**Subject Module 1*, ****** (12 CP) **Subject Module 2*, ****** (12 CP)			30
2	**Hot Topics in Biochemistry and Medicine** (workshop, 6 CP)	**Scientific Writing** (workshop, 6 CP)	**Laboratory Project Module 1***** (18 CP)		30
3			**Laboratory Project Module 2***** (18 CP) **Project Proposal******** (6 CP)		24
4				**Master Thesis & Defense** (36 CP)	36

* One **Subject Module** has to be completed before the first Laboratory Project Module can be performed
** One **Subject Module** has to have a biochemical focus **(MN-BC-BSM)** the other can have a more general focus **(MN-BC-GSM)**
***Laboratory Project Modules** have to be performed in different research groups.
**** The supervisor of the **Project Proposal** has to be the supervisor of the master thesis.
# As students are admitted in fall and spring, the order in term 1 and 2 can vary.

1.5 Calculation of the Overall Grade

10%	Advanced Biochemistry and Molecular Medicine
5%	Hot Topics in Biochemistry and Medicine
5%	Scientific Writing
10%	Subject Module 1
10%	Subject Module 2
10%	Laboratory Project Module 1
10%	Laboratory Project Module 2
5%	Project Proposal
35%	Master Thesis & Defense
100%	**Total**

2 Module Descriptions

The study program contains **nine modules**.
The study program is initiated with two core modules that define the common knowledge base of Biochemistry and Molecular Medicine students. In the **Advanced Biochemistry and Molecular Medicine** lecture series, researchers from both biochemistry and molecular medicine present core knowledge combined with cutting edge research. The **Hot Topics in Biochemistry and Medicine** reviews core life science methods and techniques and their application in modern research.
Students have to successfully complete two **Subject Modules**, preferably in the 1st and 2nd term (Table 2). The Subject Modules aim to extend the knowledge in the respective research area with 8-week laboratory and theoretical training. Simultaneously, the students extend their skills of presenting scientific results in oral and written form. To better achieve these competencies, the subject modules contain two to three examination elements. The **Scientific Writing** module aims to bolster a necessary transfer skill. It is well placed to support the writing necessary in subsequent modules.
The **Laboratory Projects** in the 2nd and 3rd term of the Master's degree course will help students learn how to actively integrate into a research group and extend their practical skills by means of a laboratory project of 12 weeks. A student may not perform both Project Modules in the same research group to ensure the broadest possible education. In the module **Project Proposal** students will write an application for funding closely related to the topic of their future master thesis. This is both a good test run for later applications and helps with the preparation of the module Master Thesis & Defense.
The Master Thesis is an integrative part of the module **Master Thesis & Defense**. Further information and regulations can be found in the module description as well as in the examination regulations of the Master's degree course.

The following tables give an overview of available modules. Detailed descriptions are listed afterwards.

2.1 **Overview of module types**

The programme consists of nine modules with 12-14 examination elements (+ 2 examination elements for the Master thesis & Defence). For each module all exam elements have to be passed to pass the overall module.

Name	Duration	Examination type* Module type**	Credits
Advanced Biochemistry and Molecular Medicine, MN-BC-ABMM	winter term	1 exam element, P	6
Hot Topics in Biochemistry and Medicine, MN-BC-HT	summer term	1 exam element, P	6
Subject Module 1 & 2 MN-BC-BSM or MN-BC-GSM	8 weeks	2 or 3 exam elements, WP	24 (12+12)
Scientific Writing MN-BC-SW	workshop	1 exam element, P	6
Laboratory Project Module 1 & 2 MN-BC-PM	3 months	2 exam elements, P	36 (18+18)
Project proposal MN-BC-PP	5 weeks	1 exam element, P	6
Master Thesis & Defense MN-BC-MT	6 months	2 exam elements, P	36

* The proportional weighting of the individual examination elements for the total module grade is outlined in the module descriptions (No. 6).

** Module type is either P, obligatory (Pflicht) or WP, facultative obligatory (Wahlpflicht)

2.2 **Available Module Places**

Subject Module Name (ID)	Lecturer	Available Places (subject to change)			
		Winter		Summer	
		1st	2nd	1st	2nd
Medical Biochemistry – Enzymes, Metabolites and Diseases, MN-BC-BSM01	Schwarz (BC)	8			
Molecular concepts of human diseases, MN-BC-BSM02	Brachvogel (Med)	8			
Epigenetics, MN-BC-BSM03	Schweiger (Med)	8			
Peptide Biochemistry, MN-BC-BSM13	Neundorf (BC)		6		
Metabolic Reprogramming in Health and Disease, MN-BC-BSM04	Trifunovic (Med)		10		
3D Cryo Electron Microscopy, MN-BC-BSM07	Behrmann (BC)			7	
Neurobiochemistry, MN-BC-BSM08	Schwarz (BC)			6	
Mitochondria and Neurodegeneration, MN-BC-BSM09	Rugarli (Bio)			2	
Posttranslational Regulation of Proteins, MN-BC-BSM10	Hofmann (Bio)			2	
Molecular Genetics, MN-BC-BSM11	Gehring (Bio)			2	
Advanced Light Microscopy, MN-BC-GSM01	Schauss (Bio)			1	
Introduction to protein crystallography, MN-BC-BSM05	Baumann (BC)				8
Redox Metabolism, MN-BC-BSM12	Riemer (BC)				4
Functional Genomics, MN-BC-GSM03	Deelen (MPI)				2
Cell Death in Inflammation, Immunity and Disease, MN-BC-GSM04	Corona (Bio)				2
Molecular Human Genetics, MN-BC-GSM05	Wirth (Med)				4
Computational Biology II, MN-BC-GSM06	Beyer (Bio)				1

BC - Faculty of Mathematics and Natural Sciences: Institute of Biochemistry, Dep. of Chemistry
Bio - Faculty of Mathematics and Natural Sciences: Dep. of Biology
Med - Medical Faculty: Institute for Biochemistry

2.3 **Core Modules, Basismodule**

<table>
<tr><td colspan="7">Module Name
Advanced Biochemistry and Molecular Medicine (Suckale)</td></tr>
<tr><td colspan="2">Identification Number

MN-BC-ABMM</td><td>Workload

180 h</td><td>Credit Points

6 CP</td><td>Term

1st or 2nd</td><td>Offered Every

winter term</td><td>Duration

15 weeks</td></tr>
<tr><td>1</td><td colspan="2">Type of lessons
Lectures</td><td>Contact Times
49 h</td><td>Self-Study Times
131 h</td><td colspan="2">Group Size*
approx. 50-70</td></tr>
<tr><td>2</td><td colspan="6">Module Objectives and Skills to be Acquired
Students who successfully completed this module …
• have acquired an understanding of advanced concepts and technologies related to the molecular basis of biochemical principles.
• possess the ability to develop hypotheses through problem analysis and will be able to develop experiments to test these hypotheses.
• have acquired a knowledge of important concepts in biochemistry such as reaction mechanisms, molecular basis of diseases, development and use of model systems and key technologies</td></tr>
<tr><td>3</td><td colspan="6">Selected content of the module
The lecture series is organized into 6 blocks (see below) consisting of 4-5 lectures with a review tutorial at the end of each block.
• Structure & proteomics
• Extracellular matrix & transport
• Metabolism & hereditary disease
• Mitochondria & death, immunity, cancer
• Regulation & proteostasis
• Engineering + tools
We bring together a wide range of local researchers to give you a broad overview of advanced biochemistry and molecular medicine topics, spike your curiosity regarding new areas, and lead to research projects for you.</td></tr>
<tr><td>4</td><td colspan="6">Teaching Methods
Research-oriented, interactive lectures (incl. e.g. audience response systems and concept mapping)</td></tr>
<tr><td>5</td><td colspan="6">Prerequisites
Enrolment in the Master´s degree course “Biochemistry and Molecular Medicine” or in the Master´s degree course “Biological Sciences”
Additional academic requirements
The knowledge of basic and specific biochemistry, cell biology and genetics on the level of general biochemistry/biology text books (e.g. Voet-Voet/Stryer/Lehninger, Alberts and Lewin) is required. Lecturers will hand out review articles on the topic that should by read before the lecture.</td></tr>
<tr><td>6</td><td colspan="6">Type of Examination
Two hours written examination (100% of the total mark). All lectures have a first, introductory part relevant for the exam and a second, scientific part not relevant for the exam. The exam will have one question per lecture and you can select a subset.</td></tr>
</table>

7	**Credits Awarded** Written examination at least “sufficient”
8	**Compatibility with other Curricula*** Master's degree course “Biological Sciences”
9	**Proportion of Final Grade** 10%
10	**Module Coordinator** Dr. Jakob Suckale, phone 470-3536, e-mail: jsuckale@uni-koeln.de
11	**Further Information** **Participating faculty**: Prof. Dr. U. Baumann, Prof. Dr. E. Behrmann, Prof. Dr. T. Benzing, Prof. Dr. U. Brandt, Prof. Dr. B. Brachvogel, Prof. Dr. J. Chai, Dr. M. Escobar, Prof. Dr. M. Gather, Prof. Dr. N. Kononenko, Prof. Dr. S. Höning, Prof. Dr. P. Huesgen, Prof. Dr. S. Kath-Schorr, Prof. Dr. M. Krüger, Prof. Dr. T. Langer, Prof. Dr. M Lemberg, Prof. Dr. I. Neundorf, apl. Prof. Dr. K. Niefind, Prof. Dr. M. Pasparakis, Prof. Dr. J. Riemer, Prof. Dr. H.-G. Schmalz, Prof. Dr. G. Schwarz, Dr. Gerhard Sengle, Prof. Dr. H. Walczak, Prof. Dr. B. Wirth **Literature:** • Information material will be given via ILIAS. **General time chedule:** Weeks 1-13: Tue. and Fri. from 8:15 to 9:45AM in seminar room 170 (1st floor, Biochemistry Institute); Week 14-15 (Mon.-Fri) preparation for the written examination.

Module Name Hot Topics in Biochemistry and Molecular Medicine (Suckale)						
ID Number MN-BC-HT	**Workload** 180 h	**Credit Points** 6 CP	**Term** 1st or 2nd term	**Offered Every** summer term	**Start** summer only	**Duration** 14 weeks

1	**Course Types**	**Contact Time**	**Private Study**	**Planned Group Size***
	a) Seminar b) Exercise (mini-conference)	30 h 30 h	60 h 60 h	max. 30 max. 30

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module …

- critically dissect scientific data and literature
- better understand new life science methods and where they can be applied
- improve the understanding of recent discoveries in biochemistry and molecular medicine

3 Module Content

- Students determine the contents of the course to a large extent
- Primers on disease mechanisms, bacterial / viral / degenerative disease
- Practical recap of commonly applied statistical tools
- Novel discoveries in the basic life sciences
- Novel therapies in molecular medicine

4 Teaching Methods

- Research- and method-oriented seminars
- Problem-solving workshops
- Peer review & audience interaction via LiveVoting and similar

5 Prerequisites (for the Module) Enrolment in the Master of Biochemistry and Molecular Medicine

6 Type of Examination: Submitted material and its presentation by the participants (100% of the total)

7 Credits Awarded: Submission of project and its presentation

8 Compatibility with other Curricula

Will be considered on an individual basis depending on availability; master and predoctoral students

9 Proportion of Final Grade: 5%

10 Module Coordinator: Dr. Jakob Suckale, phone 470-3536, e-mail: jsuckale@uni-koeln.de

11 Further Information

Material and details regarding the course will be provided via an accompanying ILIAS course site online.

2.4 **Advanced Modules, Aufbaumodule**

Module Name Scientific Writing (Suckale)						
Identification Number	**Workload**	**Credit Points**	**Term**	**Offered Every**	**Start**	**Duration**
MN-BC-SW	180 h	6 CP	1st-3rd term	Winter term	27.02.2023	5 weeks

1	**Course Types**	**Contact Time**	**Private Study**	**Planned Group Size***
	a) Lectures	10 h	50 h	max. 30
	b) Seminar	30 h	50 h	max. 30
	c) Exercise	10 h	30 h	max. 30

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module …

- Develop a strategic approach to writing
- Hone a succinct, clear, and interesting writing style
- Understand and employ scientific standards
- Craft clear figures and graphics
- Employ advanced features of text and graphics software

3 Module Content

- Features of the English language and style
- Principles of text planning, organization, and composition
- Scientific publication types
- Text software from editors to layout including referencing databases
- Graphics software for bitmaps, vector graphics, and scientific image data
- Analysis of pieces of excellent scientific writing

4 Teaching Methods

- Software demonstrations and tutorials
- Language exercises online and in self-study
- Writing exercises, Sample graphic design
- Peer review

5 Prerequisites (for the Module)

Good written English, good text software skills, basic knowledge of graphics software

6 Type of Examination

Written project with self-made figures (100 % of the total module mark)

7 Credits Awarded

Essay at least sufficient.

8 Compatibility with other Curricula

Will be considered on an individual basis depending on availability; master and predoctoral students.

9 Proportion of Final Grade

5%

10	**Module Coordinator** Dr. Jakob Suckale, phone 470-3536, e-mail: jsuckale@uni-koeln.de
11	**Further Information** Material and details regarding the course will be provided via an accompanying ILIAS course online.

Subject Modules

Module Name Medical Biochemistry – Enzymes, Metabolites and Diseases (Schwarz)					
Identification Number	**Workload**	**Credit Points**	**Term**	**Offered Every**	**Duration**
MN-BC-BSM01	360 h	12 CP	1st or 2nd term	Winter, 1st half	7 weeks

1	**Type of lessons**	**Contact Times**	**Self-Study Times**	**Group Size***
	a) Lectures	24 h	48 h	max. 20
	b) Practical/Lab	154 h	102 h	max. 2
	c) Seminar	8 h	24 h	max. 5

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module …

- have acquired detailed knowledge on biosynthesis of cofactors and coenzymes, their relation to basic metabolism of nucleotides and amino acids and are enabled to recognize common themes in enzymatic catalysis and metabolic networks. In particular, disorders and treatments of inborn errors in metabolism are understood and can be connected to basic biochemical problems.
- can independently develop strategies for protein purification and characterization and are able to analyze enzymes on different levels, such as primary sequence, domain structure, oligomerization and three-dimensional structure.
- can determine enzyme activities, describe their reaction mechanism and uncover the action of different types of inhibitors.
- can independently carry out small scientific projects related to the topic of the module.
- have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module on a professional level.
- are able to transfer skills acquired in this module to other fields of biochemistry

3 Module Content

- Protein purification using column chromatography
- Biophysical, biochemical and structural analysis of proteins (spectroscopy, mass spectrometry, size exclusion, electrophoresis, determination of domain structure)
- Recombinant protein expression (His-tagged, intein-tagged, untagged)
- Enzyme kinetics incl. inhibition, regulation, electron transfer (spectroscopy, HPLC, stopped-flow)
- Assembly of protein complexes and determination of protein-interaction (isothermal titration calorimetry, differential scanning calorimetry, surface plasmon resonance, co-sedimentation)
- HPLC analysis of metabolites in urine and blood
- Maturation of enzymes, cellular localization, enrichment of organelles
- Screening for inhibitors
- Viability of cells (neurons, fibroblast)
- Biogenesis of cofactors and coenzymes
- Nucleotide and amino acid metabolism
- Inborn errors in metabolism
- Drug development

4 Teaching Methods

Lectures; Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form

5 Prerequisites

Enrolment in the Master's degree course “Biochemistry and Molecular Medicine”, in the Master’s degree course “Biological Sciences” or in the Master's degree course “Chemistry”

6	**Type of Examination** The final examination consists of three parts: Two hours written examination about topics of the lectures and the practical/lab part (50% of the total module mark), oral presentation (25% of the total module mark) and seminar paper (25% of the total module mark)
7	**Credits Awarded** Regular and active participation; Each examination part at least “sufficient” (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula** Subject module in the Master’s degree course “Biological Sciences”; combined advanced and experimental module in the Master's degree course “Chemistry”
9	**Proportion of Final Grade** 10%
10	**Module Coordinator** Prof. Dr. Günter Schwarz, phone 470-6440, e-mail: gschwarz@uni-koeln.de
11	**Further Information** Biochemical Subject Module of the Master's degree course “Biochemistry and Molecular Medicine” Literature: • Berg, J.M., Tymoczko, J.L., Stryer, L. (2012) Biochemistry. 7th edition, Springer Spektrum • Voet, D., Voet, J.G. (2011) Biochemistry. 4th edition, Wiley & Sons • Frey, P.A., Hegemann, A.D. (2007) Enzymatic Reaction Mechanisms. Oxford University Press • Additional subject-specific literature will be provided at the beginning of the module Note: The module contains hand-on laboratory work conducted by small groups of students and is taught in course rooms and research laboratories. The module does not contain computer-based research as a main component. General time schedule: Weeks 1-5 (Mon.-Fri.): Lectures, practical/lab, preparation for the seminar talk (topic and date will be arranged individually); Week 6 (Mon.-Fri.): Writing seminar paper; Week 7 (Mon.-Fri.): Preparation for the written examination

Module Name

Molecular concepts of human diseases (Brachvogel)

Identification Number	Workload	Credit Points	Term	Offered Every	Duration
MN-BC-BSM02	360 h	12 CP	1st or 2nd term	Winter, 1st half	7 weeks

1	Type of lessons	Contact Times	Self-Study Times	Group Size*
	a) Lectures	8 h	40 h	max. 10
	b) Practical/Lab	140 h	120 h	max. 2
	c) Seminar	8 h	44 h	max. 10

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module …

- have acquired detailed knowledge on the molecular concepts of diseases related to mutated proteins in e.g. intracellular organelles, immune system, mitochondria or extracellular matrix.
- have learned how to use experimental model systems to analyze molecular disease mechanism.
- can apply flow cytometry to quantify protein levels on the cell surface and phenotype immune cell populations.
- are able to use label-free surface plasmon resonance (SPR) based technology for studying dysfunctional biomolecular interactions in real time.
- can analyze altered gene expression profiles by quantitative PCR approaches.
- can define mitochondrial dysfunction using bioenergetic measurements
- have learned how to present research results in oral and written form and to critically discuss scientific content related to the topic of the module on a professional level.
- are able to transfer skills acquired in this module to other fields of biochemistry.

3 Module Content

- Molecular cloning, recombinant protein expression protein purification
- Flow cytometry
- Analysis of protein-protein interactions
- Gene expression analysis (sequencing, array, quantitative PCR)
- Oxygen consumption measurements, mutation and copy number analysis of mtDNA (long-range and qPCR)
- Fluorescent tagged protein expression and imaging (GFP, HIS)
- Experimental gene regulation (siRNA, miRNA)
- Bioinformatics analysis of gene interaction networks
- Immunofluorescence, laser confocal scanning microscopy
- mass spectrometry

Explanatory note: The exact content for each student will depend on the individual research project.

4 Teaching Methods

Lectures; Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form

5 Prerequisites

Enrolment in the Master's degree course “Biochemistry and Molecular Medicine” or in the Master’s degree course “Biological Sciences”

6 Type of module examinations

The final examination consists of three parts: 20 min oral examination about the practical/lab part (50 % of the total module mark), 10 min oral presentation (25 % of the total module mark) and written report (25 % of the total module mark)

7	**Credits Awarded** Regular and active participation; Each examination part at least “sufficient” (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula** Subject module in the Master’s degree course “Biological Sciences”
9	**Proportion of Final Grade** 10%
10	**Module Coordinator** Prof. Dr. Bent Brachvogel, phone 478-6996, e-mail: bent.brachvogel@uni-koeln.de
11	**Further Information** Biochemical Subject Module of the Master's degree course “Biochemistry and Molecular Medicine” Literature: • Flow cytometry: principles and clinical applications in hematology. Brown M1, Wittwer C. Clin Chem. 2000 Aug;46(8 Pt 2):1221-9. • https://www.ed.ac.uk/files/atoms/files/igmm_flow-cytometry-basics-guide.pdf • Surface plasmon resonance as a high throughput method to evaluate specific and non-specific binding of nanotherapeutics. Schneider CS, Bhargav AG, Perez JG, Wadajkar AS, Winkles JA, Woodworth GF, Kim AJ. J Control Release. 2015 Dec 10;219:331-44. doi: 10.1016/j.jconrel.2015.09.048. Epub 2015 Sep 28 • The real-time polymerase chain reaction. Kubista M1, Andrade JM, Bengtsson M, Forootan A, Jonák J, Lind K, Sindelka R, Sjöback R, Sjögreen B, Strömbom L, Ståhlberg A, Zoric N .Mol Aspects Med. 2006 Apr-Jun;27(2-3):95-125. Epub 2006 Feb 3. • A beginner’s guide to RT-PCR, qPCR and RT-qPCR, Grace Adams, Biochem (Lond) (2020) 42 (3): 48–53. • Beginner’s guide to next-generation sequencing. Louise Aigrain, Biochem (Lond) (2021) 43 (6): 58–64. • Mitochondrial DNA maintenance: an appraisal. Akhmedov AT, Marín-García J. Mol Cell Biochem. 2015 Nov;409(1-2):283-305. doi: 10.1007/s11010-015-2532-x. Epub 2015 Aug 19. • A beginner’s guide to mass spectrometry–based proteomics. Ankit Sinha; Matthias Mann Biochem (Lond) (2020) 42 (5): 64–69. https://doi.org/10.1042/BIO20200057 General time schedule: Week 1-4 (Mon.-Fri.): Lectures, practical/lab; Week 5-6 (Mon.-Fri.): Preparation of the written report and the oral presentation Week 7 (Mon.-Fri.): Preparation for the oral examination Note: The module contains hand-on laboratory work conducted by small groups of students and individually and is taught in course rooms and research laboratories. The module does not contain computer-based practicals/research as a main component.

Module Name Epigenetics (Schweiger)					
Identification Number MN-BC-BSM03	**Workload** 360 h	**Credit Points** 12 CP	**Term** 1st or 2nd term	**Offered Every** Winter, 1st half	**Duration** 7 weeks

1	**Type of lessons**	**Contact Times**	**Self-Study Times**	**Group Size***
	a) Lectures	24 h	48 h	max. 8
	b) Practical/Lab	154 h	102 h	max. 1
	c) Seminar	8 h	24 h	max. 8

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module…

- have gained broad insight into the field of epigenetics and its implications in development, differentiation and disease
- are familiar with the mechanisms of epigenetic regulation and misregulation in human diseases
- have attended a laboratory with epigenetic projects and have had hands-on experience with technologies used for epigenetic research
- started to acquire bioinformatics skills for high-throughput sequencing data analyses

3 Module Content

- application of different technologies (sequencing, FISH, mass cytometry, biochemistry structural biology) in epigenetics research
- design and performance of experiments and data analyses related to epigenetics
- DNA methylation and demethylation: nucleic acid modifications, transcriptional regulation, mRNA-splicing, conservation of the mechanisms,
- epigenetic DNA methylation clocks and their predictive capacity in ageing and disease
- chromatin remodellers, chromatin modifying enzymes
- hetero- vs euchromatin, higher order chromatin structure and genome architecture
- Cell fate and cellular memory: differentiation, cell fate, polycomb and trithorax group, epigenetic regulation of development
- Analyses of epigenetic high throughput data
- cell culture, protein biochemistry, protein purification, pull-down, qPCR
- immunohistochemistry/immunofluorescence microscopy
- generation of probes to mark epigenetic states (next generation epigenetic mapping, CUT & Tag)

4 Teaching Methods

Lectures; Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form

5 Prerequisites

Enrolment in the Master's degree course “Biochemistry and Molecular Medicine" or a similar master program.

6 Type of Examination

The final examination consists of three parts: Written lab report (50% of the total module mark), oral presentation (25% of the total module mark) and seminar paper (25% of the total module mark)

7 Credits Awarded

Regular and active participation;
Each examination part at least “sufficient” (see appendix of the examination regulations for details)

8	**Compatibility with other Curricula** Related master programs based on availability.
9	**Proportion of Final Grade** 10%
10	**Module Coordinator** Prof. Dr.Dr. Michal-Ruth Schweiger, phone 0221 478-96846, mschweig@uni-koeln.de Dr. R.Hänsel-Hertsch, phone 0221 478 96988, robert.haensel-hertsch@uni-koeln.de Dr. S. Poepsel, phone 0221 478-96987, spoepsel@uni-koeln.de
11	**Further Information** Participating faculty: Andreas Beyer (only lectures), Robert Hänsel-Hertsch, Axel Hillmer, Yulia Kargapolova, Margarete Odenthal, Alicja Pacholewska, Simon Poepsel, Michal R. Schweiger, Peter Tessarz, David Vilchez. Note: The module contains individual hands-on laboratory work and is taught in research laboratories. Location: The lab part will be held at the PI's primary location at 1. Center for Molecular Medicine Cologne, 2. Institute for Pathology, 3. Dep.III of Internal Medicine, 4. Cologne Center for Genomics, 5. Institute for Translational Epigenetics, 5. MPI Literature: • Allis C.D., Caparros M.L., Jenuwein T., Reinberg D., LAchner M. Epigenetics, 2nd edition, Cold Spring Harbor Laboratory Press, U.S.

Nodule Name

Metabolic Reprogramming in Health and Diseases (Trifunovic)

Identification Number	Workload	Credit Point	Term	Offered Every	Duration
MN-BC-BSM04	360 Hours	12 CP	1st or 2nd term	Winter, 2nd half	7 weeks

1	Course Types	Contact Times	Self-Study Times	Group Size
	a) Lecture	20 h	80 h	max. 10
	b) Practical/Lab	150 h	50 h	max 1
	c) Seminar	12 h	48 h	max 10

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module …

- have acquired detailed knowledge on important metabolic concepts in a variety of health and diseases states.
- have acquired experimental skills in state-of-the art methodologies in cell biology, biochemistry and molecular biology and can independently carry out small scientific projects related to the topic of the module.
- have the ability to process, quantify and evaluate their experimental results.
- have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module on a professional level.
- are able to transfer skills acquired in this module to other fields of biochemistry

3 Module Content

In this course we will gain insight into the fundamental principles of metabolic concepts in different health and diseases states and especially emphasize how these processes can be studied using biochemical and molecular biological techniques.

The specific areas that will be covered are:

- Compartmentalization of mitochondrial metabolism in the brain
- Metabolic plasticity of T cell immunity
- Reprogramming of mitochondrial metabolism in macrophages to drive the wound healing response
- Immuno-metabolic pathways involved in human diseases
- Mitochondria and cancer
- Metabolic control of cancer
- Metabolic (re)programming of the heart: during development and disease
- Inflammatory cell death in metabolic diseases linked to obesity
- Mitochondrial metabolism in the defense against microbes
- Metabolic Homeostasis during stress conditions
- Mitochondrial control of metabolism

4 Teaching Methods

Lectures; Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form

5 Prerequisites (for the Module)

Enrolment in the Master´s degree course “Biochemistry and Molecular Medicine”

6 Type of Examination

	The final examination consists of three parts: Two hours written examination about topics of the lectures (50% of the total module mark), oral presentation (25% of the total module mark) and seminar paper (25% of the total module mark)
7	**Credits Awarded** Regular and active participation; Each examination part at least "sufficient" (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula** -
9	**Proportion of Final Grade** 10%
10	**Module Coordinator** Prof. Dr. Aleksandra Trifunovic, phone 478-84291, e-mail: aleksandra.trifunovic@uk-koeln.de Dr. Alexandra Kukat, phone 478-84296, e-mail: akukat@uni-koeln.de
11	**Further Information** Subject module of the Master´s degree course "Biological Sciences", Focus of research: (M) Molecular Biology: Molecular mechanisms of metabolic reprograming. Participating faculty: Prof. Dr. M. Bergami,/Dr. E. Motori, Dr. M. Corrado, Prof. Dr. S. Eming/Dr. S. Willenborg, Prof. Dr. M Fabri, Prof. Dr. C. Frezza, Prof. Dr. H. Kashkar/Dr. L Schiffmann, Dr. L. Kurian, Dr. M. Peltzer, Dr. L. Pernas, Dr. G. Storelli, Prof. Dr. A. Trifunovic Literature: A list of literature that should be used for preparation to the module can be obtained from http://www.genetik.uni-koeln.de/Teaching.html under "Advanced undergraduate courses". General time schedule: Week 1-6 (Mon.-Fri.): Lectures, practical/lab, writing seminar paper and preparation for the oral presentation (held at the end of week 6); Week 7 (Mon.-Fri): Preparation for the written examination Note: The module contains hand-on laboratory work conducted individually and is taught in research laboratories. The module does not contain computer-based practicals/research as a main component.

Module Name

Introduction to protein crystallography (Baumann)

Identification Number	Workload	Credit Points	Term	Offered Every	Duration
MN-BC-BSM05	360 h	12 CP	1st or 2nd term	Summer Term, 2nd half	7 weeks

1	Course Type	Contact Times	Self-Study Times	Group Size*
	a) Lectures	24 h	48 h	max. 16
	b) Practical/Lab	154 h	108 h	max. 16
	c) Seminar	8 h	24 h	max. 16

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module …

- are able to set up crystallization screens, analyse crystals by X-ray diffraction, and determine crystal structures by the application of the relevant computer programs
- have acquired a thorough knowledge of the principles of macromolecular crystallography and can use it to judge crystal structures generated by other scientists regarding their quality
- are familiar with different methods for 3D structure determination and can compare them with respect to their results and limits
- are able to set up crystallization screens, analyse crystals by X-ray diffraction, and determine crystal structures by the application of the relevant computer programs.
- can predict protein structure using state-of-the-art algorithms and judge their quality and usefulness
- are able to recognize different protein folds, analyze and visualize biological macromolecular 3D structures using molecular viewers and other programs
- can independently carry out small scientific projects related to the topic of the module
- have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module on a professional level
- are able to transfer the acquired skills of this module to other fields of biochemistry and biology

3 Module Content

- Visualisation and analysis of protein structures
- Crystallographic foundations: crystal geometry, symmetries, theory and practice of X-ray diffraction
- Crystallization experiments on biological macromolecules
- Crystallographic data collection and analysis
- Approaches for solving the phase problem
- Structure building and refinement
- Validation and quality assessment
- Protein modelling
- Critical reading of publications in the field of Structural Biology
- Software used: ChimeraX, AlphaFold, Phenix, CCP4, Coot and other

4 Teaching Methods

- Lectures; 4 week practical work [wet lab (30%), computer lab (60%) and guided excercises (10%)], 1 week project work ("Solve your *own* structure"); Seminar "Journal Club"; Guidance to independent research; Training on presentation techniques in oral and written form

5 Prerequisites

Enrolment in the Master´s degree course "Biological Sciences", in the Master´s degree course "Biochemistry and Molecular Medicine" or in the Master´s degree course "Chemistry"

6 Type of Examinations

	The final examination consists of two parts: A written examination about topics of the lectures and the practical/lab part (70 % of the total module mark) and an oral presentation of a self-chosen structural biology paper (30 % of the total module mark)
7	**Credits Awarded** Regular and active participation; Each examination part at least "sufficient" (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula** Elective module in the Master´s degree course "Chemistry", Subject module of the Master´s degree course "Biological Sciences"
9	**Proportion of Final Grade** 10%
10	**Module Coordinator** Prof. Dr. Ulrich Baumann, phone 470-3208, e-mail: ubaumann@uni-koeln.de
11	**Additional Information** Focus of research: (B) Biochemistry, Biotechnology and Biophysics Participating faculty: Prof. Dr. U. Baumann, Dr. J. Gebauer Further information: https://px.uni-koeln.de/teaching/proteincrystallography Literature: • Rupp, B. (2010) Biomolecular Crystallography. Garland Science • Blow, D. (2002) Outline of Protein Crystallography for Biologists. Oxford University Press • Branden, C.I., Tooze, J. (1998) Introduction to Protein Structure. 2nd edition, Taylor and Francis • Liljas, A., Liljas, L., Piskur, J., Lindblom, G., Nissen, P., Kjeldgaard, M. (2009) Textbook on Structural Biology. World Scientific • ChimeraX (https://www.rbvi.ucsf.edu/chimerax/) • Additional material and subject specific literature will be provided *ad hoc* **General time schedule:** *WEEK 1-4*: (Mo-Fr) Lectures at approx. 9:00-10:30 a.m. (three times a week), following experimental/computational work till 5 p.m. (including lunch break, the exact times of lectures and practical work may vary according to the laboratory needs). *WEEK 5:* self-organised project work (best performed in the computer lab of the institute). *WEEK 6:* Preparation and presentation of seminar talk; *WEEK 7*: Preparation for the written examination **Note:** The module contains hand-on laboratory work conducted by small groups of students and is taught in course rooms and research laboratories. The module contains computer-based practicals/research as a main component. Further information can be found online: https://px.uni-koeln.de/teaching/proteincrystallography

Module Name

3D Cryo Electron Microscopy (Behrmann)

Identification Number	Workload	Credit Points	Term	Offered Every	Start	Duration
MN-BC-BSM07	360h	12 CP	1st or 2nd term of studying	Summer term	Summer term only	7 weeks

1	Course Types	Contact Time	Private Study	Group Size*
	a) Lecture	24 h	48 h	max. 12
	b) Practical/lab	150 h	106 h	max. 12
	c) Seminar	8 h	24 h	max. 12

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module...

- have acquired fundamental knowledge about the principles of electron microscopy (EM) as a tool in structural biology, including the physical background of electron optics, and about the computational methods required to reconstruct 3D objects from 2D images.
- are able to prepare sample grids for negative-stain EM, operate a transmission electron microscope, assess protein quality by EM, and use computational tools to process EM datasets to determine the 3D structures of proteins.
- are familiar with the use of high-performance computing resources for advanced computational tasks, and are able to write simple computer scripts to automate repetitive tasks.
- have learned how to present research results in oral and written form, and to critically discuss scientific publications related to the topic of the module on a professional level.
- are able to transfer skills acquired in this module to other fields of biochemistry.

3 Module Content

- Imaging with electrons: theory and practical aspects
- Sample preparation for EM: negative-staining and vitrification of biological macromolecules
- Data collection using electron microscopes, routine operations on electron microscopes, and strategies for automated data collection and quality assessment
- Basic introduction into using high-performance computing resources in structural biology
- Reconstruction of 3D structures from 2D EM images using single-particle refinement strategies

4 Teaching Methods

Lectures; Practical/Lab; Seminar; Computer exercises; Guidance to independent research; Training on presentation techniques in oral and written form

5 Prerequisites

Enrollment in the Master's degree course "Biological Sciences", in the Master's degree course "Biochemistry and Molecular Medicine" or in the Master's degree course "Chemistry".

For students from the Master's degree course "Chemistry" prior participation in an advanced Biochemistry module, including its practical lab part, during the Bachelor's degree course is required.

6 Type of Examination

M.Sc. Biochemistry and Molecular Medicine: Type 4: The final examination consists of three parts: 30 min oral examination about topics of the lectures and seminar presentations (50% of the total module mark), and 30 min oral presentation in the framework of a seminar (25% of the total module mark), and poster presentation of the experimental results (25% of the total module mark)

	M.Sc. Biology: Type 2: The final examination consists of two parts: 20-30 min oral examination about topics of the lectures and seminar presentations (50% of the total module mark), and written report on the experimental results (50% of the total module mark).
7	**Credits Awarded** Regular and active participation; completed homework Each examination part at least "sufficient" (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula** Biochemical subject module in the master's degree course "Biological Sciences" and in the master´s degree course "Chemistry"
9	**Proportion of Final Grade** 10%
10	**Module Coordinator** Prof. Dr. Elmar Behrmann, phone 470 76300, e-mail: elmar.behrmann@uni-koeln.de
11	**Further Information** **Participating faculty:** Prof. Dr. E. Behrmann, Dr. M. Gunkel, Dr. S. Pöpsel **Literature** • Frank, J. (2006) Three-Dimensional Electron Microscopy of Macromolecular Assemblies: Visualization of Biological Molecules in Their Native State. Oxford University Press • Jensen, G. Getting Started in Cryo-EM. Online course [https://em-learning.com/] • Additional material and subject specific literature will be provided *ad hoc* via Ilias **Note:** the module contains hand-on laboratory work conducted by small groups of students and is taught in course rooms and research laboratories. The module also contains computer-based research/practicals as an important component. **Location:** The course will take place at the Institute of Biochemistry, Zülpicher Str. 47, 50674 Cologne. **General time schedule:** Week 1-5 (Mon.-Fri.): Lectures from 9:00 to 10:30 three times a week, Experimental/computational work 10:30 to 16:00 including a short lunch break five times a week. Exact times can vary according to the laboratory needs; Week 6 (Mon.-Fri.): Preparation and presentation of the seminar talk and the poster, respective of the written report; Week 7 (Mon.-Fri.): Preparation for the oral examination

Module Name						
Neurobiochemistry (Schwarz)						
Identification Number	**Workload**	**Credit Points**	**Term**	**Offered Every**	**Start**	**Duration**
MN-BC-BSM08	360 h	12 CP	1st or 2nd term of studying	Summer term	summer term only	7 weeks

1	**Course Types**	**Contact Time**	**Private Study**	**Planned Group Size***
	a) Lectures	16 h	80 h	max. 8
	b) Practical/Lab	96 h	72 h	max. 8
	c) Seminar	16 h	80 h	max. 8

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module

- have acquired detailed knowledge about the structure-function relations of ligand-gated ion channels as well as post synaptic proteins and their function within neuronal cells.
- are able to isolate synaptic proteins from recombinant sources.
- can characterize protein interactions between membrane receptors and synaptic proteins on a biochemical level using isothermal titration calorimetry and size exclusion chromatography.
- are able to apply the principle of immunodetection to microscopic samples as well as Western blot-based detection techniques.
- have acquired sterile working practice, are able to express synaptic proteins in cultured mammalian cells and analyze their subcellular distribution using fluorescence microscopy.
- are able to express Adeno-associated viruses (AAV) in a cultured mammalian cell line and enrich AAVs suitable for *in vitro* experiments.
- have prepared hippocampal neuron cultures and quantified synaptic structures using semi-automated image processing.
- can independently carry out small scientific projects related to the topic of the module.
- have the ability to process, quantify and evaluate their experimental results.
- have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module on a professional level.
- are able to transfer skills acquired in this module to other fields of biochemistry.

3 Module Content

- Structure and function of neurons
- Ligand-gated ion channels, post-synaptic proteins, their structures and molecular interaction
- Neuronal receptors in health and disease
- Methods to visualize cellular structures and protein interactions (*in vitro* and *in vivo*)
- Expression of synaptic proteins in cultured mammalian cells and immunostaining analysis
- Preparation of hippocampal neurons from mouse brain
- Fluorescence microscopy and image analysis
- Model organisms: vertebrates – *Mus musculus*, prokaryotes – *E. coli*

4	**Teaching Methods** Lectures (including discussions); Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form
5	**Prerequisites (for the Module)** Enrollment in the Master´s degree course "Biological Sciences" or in the Master's degree course "Biochemistry and Molecular Medicine" **Additional academic requirements** For students of Master "Biological Sciences": Previous attendance of the lecture module "Neurobiology: Genes, Circuits, and Behavior (N)". Experimental expertise in biochemical techniques (protein biochemistry, cell biology) is mandatory. If basic knowledge is missing, the attendance of the module cannot be continued. Please contact the module coordinator for more information.
6	**Type of Examination** The final examination consists of two parts: Written examination on topics of lectures, seminars and the practical/lab part (1 hour; 50 % of the total module mark), oral poster presentation of (20-30 min; 50 % of the total module mark).
7	**Credits Awarded** Regular and active participation Each examination part at least "sufficient" (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula** Biochemical subject module in the Master´s degree course "Biological Sciences"
9	**Proportion of Final Grade** In the Master´s degree course "Biochemistry and Molecular Medicine": 10 % of the overall grade (see also appendix of the examination regulations)
10	**Module Coordinator** Prof. Dr. Günter Schwarz, phone 470-6440, e-mail: gschwarz@uni-koeln.de
11	**Further Information** **Participating faculty**: Prof. Dr. M. Bergami, Dr. Patricia Brown, Prof. Dr. G. Schwarz, Prof. Dr. N. Kononenko, Dr. F. Liebsch, Dr. Elisa Motori, Dr. F. Neuser **Literature:** • Kandel, E.R., Schwartz, J.H., Jessell, T. (2014) Principles of Neural Science. 5th edition, McGraw-Hill. Chapters 21, 22, 32. • Further original publications will be handed out at the introduction to the module **General time schedule:** Week 1-5 (Mon.-Fri.): Lectures, practical/lab, preparation for the seminar talk (topic and date will be arranged individually); Week 6 (Mon.-Fri.): Preparing the poster for presentation; Week 7 (Mon.-Fri.): Preparation for the written examination **Note:** The module contains hand-on laboratory work conducted by small groups of students and individually and is taught in course rooms and research laboratories. The module does not contain computer-based practicals/research as a main component.

Module Name
Mitochondria and Neurodegeneration (Rugarli)

Identification Number	Workload	Credit Points	Term	Offered Every	Start	Duration
MN-BC-BSM09	360 h	12 CP	1st or 2nd term of studying	Summer term	summer term only	7 weeks

1	Course Types	Contact Time	Private Study	Planned Group Size*
	a) Lectures	20 h	30 h	max. 10
	b) Practical/Lab	154 h	126 h	max. 1
	c) Seminars	6 h	24 h	max. 2

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module

- have gained in-depth knowledge in mitochondrial research and the role of mitochondrial dysfunction in neurodegeneration and aging.
- have acquired experimental skills in state-of-the art methods in cell biology and molecular biology (see contents of the module) and are able to independently design and perform small scientific projects related to topics of the module.
- have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module on a professional level.
- are able to transfer skills acquired in this module to other fields of biology.

3 Module Content

- Principles of mitochondrial biology including protein and membrane biogenesis, mitochondrial dynamics and inheritance, and mitochondrial genetics
- The role of mitochondrial dysfunction for aging and disease
- Mechanisms of mitochondrial quality control including autophagy and apoptosis
- The role of mitochondria for neuronal activities and survival
- Mitochondrial DNA mutations and human disease
- Mitochondria and neurodegenerative diseases including Parkinson disease, amyotrophic lateral sclerosis, hereditary spastic paraplegia, spinocerebellar ataxia, and peripheral neuropathies
- Analysis of subcellular localization of proteins using fluorescence microscopy and cellular fractionation
- Molecular cloning (cloning of PCR fragments into plasmids, transfections, etc.)
- Cell culture technology (working with human and murine cell lines)
- Immunohistochemistry
- Protein analysis and protein-interaction methods (Western blotting, co-immunoprecipitation of proteins, pull-down, etc.)
- Analysis of knock-out and transgenic mice

Explanatory note: The list above comprises techniques that are commonly used in the participating groups. Thus every student will be confronted with a large subset of it. The exact content, however, will depend on the tutor and the research project the student will work on.

4	**Teaching Methods** Lectures; Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form
5	**Prerequisites (for the Module)** Enrollment in the Master´s degree course “Biological Sciences” or in the Master´s degree course “Biochemistry and Molecular Medicine”. **Additional academic requirements** For Students of Master “Biological Sciences”: Previous attendance of the lecture module “Principles of Molecular Genetics, Development and Aging (A/D/G)”.
6	**Type of Examination** The final examination consists of two parts Type 1: written examination on topics of lectures and seminars (1 hour; 50 % of the total module mark), oral presentation of the research performed in the lab in a poster session with questions (20-30 min; 50 % of the total module mark)
7	**Credits Awarded** Regular and active participation; Each examination part at least “sufficient” (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula*** Biological subject module in the Master´s degree course “Biological Sciences”
9	**Proportion of Final Grade** In the Master´s degree course “Biochemistry and Molecular Medicine”: 10 % of the overall grade (see also appendix of the examination regulations)
10	**Module Coordinator** Prof. Dr. Elena Rugarli, phone 478-84244, e-mail: elena.rugarli@uni-koeln.de
11	**Further Information** **Participating faculty**: Prof. Dr. M. Bergami, Dr. M. Corrado, Dr. M. Escobar, Prof. Dr. A. Garcia, Prof. Dr. T. Langer, Dr. D. Pla-Martin, Prof. Dr. J. Riemer, Prof. Dr. E. Rugarli, Prof. Dr. A. Trifunovic. **Literature:** Information about textbooks and other reading material will be given on the ILIAS representation of the course (https://www.ilias.uni-koeln.de/ilias/goto_uk_cat_2815610.html) **General time schedule:** Week 1-5 (Mon.-Fri.): Lectures, practical/lab and preparation for the poster presentation (topic and date will be arranged individually); Week 6 (Mon.-Fri.): Scientific poster presentation of individual research results; Week 7 (Mon.-Fri): Preparation for the written examination **Note:** The module contains hand-on laboratory work conducted individually and is taught in research laboratories. The module does not contain computer-based practicals/research as a main component.

Module Name
Posttranslational Regulation of Proteins (Hofmann)

Identification Number	Workload	Credit Points	Term	Offered Every	Start	Duration
MN-BC-BSM10	360 h	12 CP	1st or 2nd term of studying	Summer term	summer term only	7 weeks

1	Course Types	Contact Time	Private Study	Planned Group Size*
	a) Lectures	20 h	30 h	max. 14
	b) Practical/Lab	150 h	126 h	max. 2
	c) Seminar	10 h	24 h	max. 2

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module

- have gained in-depth knowledge in protein research and the role of posttranslational regulation of protein activity, localization, stability and interaction properties.
- have acquired experimental skills in state-of-the art methods in cell biology and molecular biology (see contents of the module) and are able to independently design and perform small scientific projects related to topics of the module.
- have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module on a professional level.
- are able to transfer skills acquired in this module to other fields of biology.

3 Module Content

- Principles of posttranslational regulation, and how they impact protein activity, localization, stability and interaction pattern
- Enzymes involved in protein modification (‘writers’), and de-modification (‘erasers’)
- Recognition factors for posttranslational modifications (‘readers’)
- Structural biology of protein modifications
- Role of protein modifications in the regulation of the cell cycle, DNA integrity, vesicular trafficking, and other processes in cell biology
- Protein modification pathways as drug targets
- Major protein modification systems: phosphorylation, ubiquitination, SUMOylation, acetylation, lipidation, glycosylation and others
- Experimental techniques for studying protein modification (in vitro modification/de-modification assay, identification/isolation of modification and de-modification enzymes, identification of modification substrates, modification-dependent protein binding)
- Bioinformatical methods for predicting and understanding modification sites and components of the modification system.

  Understanding and working with databases of protein modification sites and patterns
- The role of Mass Spectroscopy in the large-scale identification of protein modifications
- Protein analysis and protein-interaction methods (Western blotting, co-immunoprecipitation of proteins, pull-down, etc.)

	Explanatory note: The list above comprises techniques that are commonly used in the participating group. Thus, every student will be confronted with a large subset of it. The exact content, however, will depend on the tutor and the research project the student will work on.
4	**Teaching Methods** Lectures; Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form
5	**Prerequisites (for the Module)** Enrollment in the Master´s degree course "Biological Sciences" or in the Master´s degree course "Biochemistry and Molecular Medicine". **Additional academic requirements** For Students of Master "Biological Sciences": Previous attendance of the lecture module "Principles of Molecular Genetics, Development and Aging (A/D/G)". Solid skills concerning laboratory work are indispensable for participation in this module.
6	**Type of Examination** The final examination consists of two parts Written examination on topics of lectures, seminars and the practical/lab part (1 hour; 50 % of the total module mark), oral presentation (20-30 min; 50 % of the total module mark)
7	**Credits Awarded** Regular and active participation; Each examination part at least "sufficient" (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula*** Biological subject module in the Master´s degree course "Biological Sciences"
9	**Proportion of Final Grade** In the Master´s degree course "Biochemistry and Molecular Medicine": 10 % of the overall grade (see also appendix of the examination regulations)
10	**Module Coordinator** Prof. Dr. Kay Hofmann, phone 470-1701, e-mail: kay.hofmann@uni-koeln.de
11	**Further Information** **Participating faculty**: Prof. Dr. J. Dohmen, Prof. Dr. K. Hofmann, Dr. K. Klopffleisch, Prof. Dr. M. Krüger **Literature:** Information about textbooks and other reading material will be given on the ILIAS representation of the course (https://www.ilias.uni-koeln.de/ilias/goto_uk_cat_2815610.html) **General time schedule:** Week 1-5 (Mon.-Fri.): Lectures, practical/lab and preparation for the seminar talk (topic and date will be arranged individually); Week 6 (Mon.-Fri.): Seminar talks; Week 7 (Mon.-Fri.): Preparation for the written examination **Note:** The module contains hand-on laboratory work conducted individually and is taught in research laboratories. The module contains computer-based practicals/research as a main component.

Module Name
Molecular Genetics (Gehring)

Identification Number	Workload	Credit Points	Term	Offered Every	Start	Duration
MN-BC-BSM11	360 h	12 CP	1st or 2nd term of studying	Summer term	summer term only	7 weeks

1	Course Types	Contact Time	Private Study	Planned Group Size*
	a) Lectures	20 h	40 h	max. 8
	b) Practical/Lab	150 h	118 h	max. 2
	c) Seminar	8 h	24 h	max. 8

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module

- have acquired detailed knowledge of molecular genetics, the function of RNA-binding proteins and the different steps of eukaryotic gene expression, including pre-mRNA processing, RNA export, translation and RNA degradation.
- have acquired experimental skills in state-of-the art methods in molecular biology and can independently design and perform small scientific projects related to the topics of the module.
- have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module on a professional level.
- are able to transfer skills acquired in this module to other fields of biology.

3 Module Content

- Project planning
- Analysis of co- and post-transcriptional steps of human gene expression, with focus on regulation conferred by RNA-binding proteins
- Evaluation of potential protein-protein interactions involving the analysis of published structural information or the prediction via computational approaches such as AlphaFold.
- Applying recombinant DNA technologies, e.g. cloning, DNA preparation, etc.
- Cell culture using immortalized human cell lines, transfection of plasmid DNA, expression of gene products (RNA/protein) and stable cell line generation
- Functional characterization of RNA-binding proteins by knockdown, knockout or degron-induced protein depletion
- Extraction of nucleic acid and protein samples from cultured cells
- Analysis of abundance and sub-cellular localization of proteins using immunofluorescence and/or western blotting
- Techniques for monitoring alternative splicing and RNA degradation (RT-PCR, etc.)
- Basic workflows for producing, analyzing and interpreting high-throughput RNA-sequencing data
- Addressing and solving scientific problems

Explanatory note: The list above comprises state-of-the art molecular methods with emphasis on RNA biology that are commonly used in the field of molecular cell biology. Every student participating in this module will apply a subset of it. The exact content will depend on the research project the student will work on.

4 Teaching Methods

Lectures; Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form

5	**Prerequisites (for the Module)** Enrollment in the Master´s degree course “Biological Sciences” or in the Master´s degree course “Biochemistry and Molecular Medicine”. **Additional academic requirements** The RNA-related lessons of the lecture “Principles of Molecular Genetics, Development and Aging (A/D/G)” are a prerequisite for the theoretical and practical work in the module and the exam. These are provided via Ilias for self-study. For Students of Master “Biological Sciences”: Previous attendance of the lecture module “Principles of Molecular Genetics, Development and Aging (A/D/G)”.
6	**Type of Examination** The final examination consists of two parts Written examination on topics of lectures, seminars and the practical/lab part (1 hour; 50 % of the total module mark), oral presentation (20-30 min; 50 % of the total module mark)
7	**Credits Awarded** Regular and active participation; Each examination part at least “sufficient” (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula*** Biological subject module in the Master´s degree course “Biological Sciences”
9	**Proportion of Final Grade** In the Master´s degree course “Biochemistry and Molecular Medicine”: 10 % of the overall grade (see also appendix of the examination regulations)
10	**Module Coordinator** Prof. Dr. Niels Gehring, phone 470-3873, e-mail: ngehring@uni-koeln.de
11	**Further Information** **Participating faculty**: Prof. Dr. N. Gehring, Dr. V. Boehm, Prof. Dr. D. Mörsdorf **Literature:** Information about textbooks and other reading material will be given on the ILIAS representation of the course (https://www.ilias.uni-koeln.de/ilias/goto_uk_cat_2815610.html) **General time schedule:** Week 1-6 (Mon.-Fri.): Lectures, Practical/Lab (Project work); (daily from approximately 9 a.m. to 5 p.m. including lunch break, times may vary depending on project’s tasks) as well as preparation for the seminar talk (held at the end of week 6); Week 7 (Mon.-Thu.): Preparation for the written examination **Note:** The module contains hand-on laboratory work conducted individually or by small groups of students and is taught mainly in course rooms. The module does contain computer-based practicals/research.

Module Name

Redox Metabolism (Riemer)

Identification Number	Workload	Credit Points	Term	Offered Every	Start	Duration
MN-BC-BSM12	360 h	12 CP	2nd term of studying	Summer term	Second half of summer term	7 weeks

1	Course Types	Contact Time	Private Study	Planned Group Size*
	a) Lectures	24 h	90 h	max. 8
	b) Practical/Lab	154 h	60 h	max. 2
	c) Seminar	6 h	26 h	max. 2

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module

- have acquired detailed knowledge on cellular redox processes (e.g. redox reactions, oxidative protein folding, redox metabolism, sources of reactive oxygen species, antioxidative defence systems).
- have acquired detailed knowledge on and can employ techniques to investigate cellular redox processes (e.g. tools to assess small redox molecules in intact cells [genetically encoded fluorescent protein sensors], tools for characterizing redox pathways in vitro [protein purification and enzymatic characterization], tools to assess the redox state of proteins [thiol modification and subsequent analysis]).
- can independently design experiments for characterization of redox processes including planning of suitable controls, definition of expected outcomes and pitfalls.
- can independently carry out small scientific projects (i.e. a series of experiments) related to the topic of the module.
- have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module.
- are able to transfer skills acquired in this module to other fields of biochemistry.

3 Module Content

- Theory: e.g. redox processes, evolution of redox signalling, origins of reactive oxygen species, cellular antioxidative systems, cellular machineries for oxidative protein folding, redox reactions in metabolism, the central role of NADPH, redox modifications on biomolecules, consequences of cellular redox perturbations
- Practical methods: e.g. genetically encoded fluorescent proteins as tools to measure small redox molecules, experiments to determine protein redox states in intact cells and in vitro, in vitro characterization of redox proteins and pathways, isolation of mitochondria and experiments to assess mitochondrial reactive oxygen species production, assessment of cellular behaviour upon redox stress (proliferation, cell death), redox stress response pathway analysis in cells and in silico

4 Teaching Methods

Lectures; Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form

5 Prerequisites (for the Module)

Enrollment in the Master´s degree course “Biological Sciences” or in the Master’s degree course “Biochemistry and Molecular Medicine”

Additional academic requirements

	For Students of Master “Biological Sciences”: Previous attendance of the lecture module “Principles of Molecular Genetics, Development and Aging (A/D/G)”.
6	**Type of Examination** The final examination consists of two parts written examination on topics of lectures, seminars and the practical/lab part (60 min; 50 % of the total module mark), presentation (20-30 min, 50 % of the total module mark).
7	**Credits Awarded** Regular and active participation; Each examination part at least “sufficient” (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula*** Biochemical subject module in the Master´s degree course “Biochemistry and Molecular Medicine”
9	**Proportion of Final Grade** In the Master´s degree course “Biological Sciences”: 15 % of the overall grade (see also appendix of the examination regulations)
10	**Module Coordinator** Prof. Dr. Jan Riemer, phone 470-7306, e-mail: jan.riemer@uni-koeln.de
11	**Further Information** **Subject module** of the Master´s degree course “Biological Sciences”, **Specialization:** (G) Molecular and Developmental Genetics **Participating faculty**: Prof. Dr. J. Riemer **Literature:** Information about textbooks and other reading material will be given on the ILIAS representation of the course **General time schedule:** Week 1-5 (Mon.-Fri.): Lectures, preparations for practical work, practical work, and analysis and documentation of practical work; Week 6 (Mon.-Fri.): Preparing posters, and poster presentation about the content of the practical course and conceptual development of a research project delineating from the practical; Week 7 (Mon.-Fri.): Preparation for the written examination

Module Name
Peptide Biochemistry (Neundorf)

Identification Number	Workload	Credit Points	Term	Offered Every	Start	Duration
MN-BC-BSM13	360 h	12 CP	1st or 2nd term of studying	Summer term	summer term only	7 weeks

1	Course Types	Contact Time	Private Study	Planned Group Size*
	a) Lectures	25 h	50 h	max. 10
	b) Practical/Lab	154 h	103 h	max. 2
	c) Seminar	4 h	24 h	max. 4

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module

- have a general understanding about the recent developments in the field of peptides including synthetic methodologies, biology of peptides and the application of peptides and peptide conjugates in medicinal or analytical context.
- have acquired working skills to tackle the synthesis of peptides and peptide libraries, to apply deconvolution techniques, and to investigate peptide structure by biophysical methods.
- can independently carry out small scientific projects related to the topic of the module.
- have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module on a professional level.
- are able to transfer the skills acquired in this module to other fields of biochemistry.

3 Module Content

- Synthesis of peptides and proteins (i.e. solid phase peptide synthesis, native chemical ligation, Staudinger ligation, etc.)
- Peptide modifications (i.e. mimetics, labeling strategies, cyclic peptides)
- Peptide libraries and arrays, deconvolution
- Analytical methods (mass spectrometry, Edman degradation, fluorescence techniques, CD spectroscopy)
- Antimicrobial peptides, peptide hormones, cell-penetrating peptides, peptide targeting sequences
- Peptides in diagnostics and therapy

4 Teaching Methods

Lectures; Practical/Lab (Project work); Seminar; Computer exercises, Guidance to independent research; Training on presentation techniques in oral and written form

5 Prerequisites (for the Module)

Enrollment in the Master´s degree course “Biological Sciences”, in the Master’s degree course “Biochemistry and Molecular Medicine” or in the Master´s degree course “Chemistry”

6	**Type of Examination** The final examination consists of two parts written examination on topics of lectures, seminars and the practical/lab part (60 min; 50 % of the total module mark) oral report (50 % of the total module mark)
7	**Credits Awarded** Regular and active participation Each examination part at least “sufficient” (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula*** Subject module in the Master´s degree course “Biochemical Sciences”, combined advanced and experimental module in the Master’s degree course “Chemistry”
9	**Proportion of Final Grade** In the Master´s degree course “Biochemistry and Molecular Medicine”: 10 % of the overall grade (see also appendix of the examination regulations)
10	**Module Coordinator** Prof. Dr. Ines Neundorf, phone 470-8847, e-mail: ines.neundorf@uni-koeln.de
11	**Further Information** **Participating faculty:** Prof. Dr. I. Neundorf **Literature:** • Information about textbooks and other reading material will be given on the ILIAS representation of the course (https://www.ilias.uni-koeln.de/ilias/goto_uk_cat_2815610.html) **General time schedule:** Week 1-6 (Mon.-Fri.): Lectures, practical/lab, preparation for the seminar talk (topic and date will be arranged individually); Week 7 (Mon.-Fri.): Preparation for the written examination **Note:** The module contains hand-on laboratory work conducted by small groups of students and individually and is taught in course rooms and research laboratories. The module does not contain computer-based practicals/ research as a main component.

Module Name
Advanced Light and Electron Microscopy (Schauss)

Identification Number	Workload	Credit Points	Term	Offered Every	Start	Duration
MN-BC-GSM01	360 h	12 CP	1st or 2nd term of studying	Summer term	summer term only	7 weeks

1	Course Types	Contact Time	Private Study	Planned Group Size*
	a) Lectures	40 h	80 h	max. 6
	b) Practical/Lab	80 h	133 h	max. 2-3
	c) Seminar	3 h	24 h	max. 2

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module

- have acquired theoretical and experimental skills in state-of-the art light and electron microscopy methodologies.
- are able to plan, carry out and evaluate a project using advanced light and electron microscopy.
- are able to perform quantitative image analysis independently.
- have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module on a professional level.
- are able to transfer skills acquired in this module to other fields of biology.

3 Module Content

Advanced Light microscopy:

- Optical principles of light microscopy
- Different kinds of fluorescent microscope types and their strength
- Advanced fluorescence techniques (including FCS, FRET and FLIM)
- Multi Photon microscopy including other non-linear techniques (SHG, CARS)
- Superresolution microscopy (STED, SIM, dSTORM and Minflux)

Electron microscopy (EM):

- Principles of transmission and scanning electron microscopy
- Basic EM preparation techniques (embedding, cutting, contrasting)
- Advanced EM preparation techniques (Tokuyaso with Immunogold, negative staining)
- Electron Tomography
- Correlative light and electron microscopy
- *Explanatory note:* To gain insight into state-of-the art methodologies the course will start with a combination of a lecture series and hands-on experience introducing different techniques (two weeks LM, two weeks EM). Three days are dedicated to Image Analysis and Data handling. An oral presentation will be given on dedicated techniques.

4 Teaching Methods

Lectures; Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form

5 Prerequisites (for the Module)

Enrollment in the Master´s degree course “Biological Sciences”, in the Master’s degree course “Biochemistry and Molecular Medicine” or in the Master´s degree course “Chemistry”

6	**Type of Examination** The final examination consists of two parts Written examination on topics of lectures, seminars and the practical/lab part (2 hours; 50 % of the total module mark), oral presentation (20-30 min; 25 % of the total module mark), seminar paper (25% of the total module mark)
7	**Credits Awarded** Regular and active participation Each examination part at least “sufficient” (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula*** Biological subject module in the Master´s degree course “Biological Sciences”
9	**Proportion of Final Grade** In the Master´s degree course “Biochemistry and Molecular Medicine”: 10 % of the overall grade (see also appendix of the examination regulations)
10	**Module Coordinator** Dr. Astrid Schauss, phone 478-84027, e-mail: aschauss@uni-koeln.de
11	**Further Information** **Subject module** of the Master´s degree course “Biological Sciences”, **Participating faculty:** Dr. A. Schauss, Math.-Nat. faculty, CECAD **Literature:** • Information about textbooks and other reading material will be given on the ILIAS representation of the course (https://www.ilias.uni-koeln.de/ilias/goto_uk_cat_2815610.html) **General time schedule:** Week 1-6 (Mon.-Fri.): Lectures and practical/lab and preparation for the seminar talk (topic and date will be arranged individually); Week 7 (Mon.-Fri): Preparation for the written examination **Note:** The module contains hand-on laboratory work conducted by small groups of students and is taught in research laboratories. Only if the Corona situation permits it, the module will be held in an online format.

Module Name
Functional Genomics (Deelen)

Identification Number	Workload	Credit Points	Term	Offered Every	Start	Duration
MN-BC-GSM03	360 h	12 CP	1st or 2nd term of studying	Summer term	summer term only	7 weeks

1	Course Types	Contact Time	Private Study	Planned Group Size*
	a) Lectures	22 h	50 h	max. 12
	b) Practical/Lab	150 h	100 h	max. 2
	c) Seminar	8 h	30 h	max. 2

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module

- genome regulation in physiology and disease.
- have acquired experimental skills in state-of-the art methods in genomics, cell biology and molecular biology and can independently carry out small scientific projects related to the topic of the module.
- have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module on a professional level.
- are able to transfer skills acquired in this module to other fields of biology.

3 Module Content

- Regulation of nuclear and chromatin architecture
- Epigenetic regulation of gene expression
- Principles of transcriptional regulation
- Identification of longevity genes
- Next generation sequencing methods for genomic analyses
- Genetic screening
- Genetic reprogramming
- Chromatin immunoprecipitation
- Cloning methods
- Cell biology, immunological staining methods, microscopy
- DNA repair

4 Teaching Methods

Lectures; Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form

5 Prerequisites (for the Module)

Enrollment in the Master´s degree course “Biological Sciences” or in the Master´s degree course “Biochemistry and Molecular Medicine”.

Additional academic requirements
For Students of Master “Biological Sciences”: Previous attendance of the lecture module “Principles of Molecular Genetics, Development and Aging (A/D/G)”.

6	**Type of Examination** The final examination consists of two parts Type 1: written examination on topics of lectures, seminars and the practical/lab part (1 hour; 50 % of the total module mark), oral presentation (20-30 min; 50 % of the total module mark)
7	**Credits Awarded** Regular and active participation; Passed seminar paper; Each examination part at least "sufficient" (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula*** Biological subject module in the Master´s degree course "Biological Sciences"
9	**Proportion of Final Grade** In the Master´s degree course "Biochemistry and Molecular Medicine": 10 % of the overall grade (see also appendix of the examination regulations)
10	**Module Coordinator** Dr. Joris Deelen, phone: +49 (0)221 379 70 480, e-mail: Joris.Deelen@age.mpg.de
11	**Further Information** **Participating faculty**: Dr. J. Deelen, Dr. S. Panier, Dr. H. Bazzi, Dr. L. Kurian, Dr. S. Steculorum, Dr. I. Huppertz **Literature:** Information about textbooks and other reading material will be given on the ILIAS representation of the course (https://www.ilias.uni-koeln.de/ilias/goto_uk_cat_2815610.html) **General time schedule:** Week 1 (Mon.-Fri.): Introduction to Functional Genomics (lectures), safety lecture and lab projects; Week 2-6 (Mon.-Fri.): Lectures, seminars and lab projects; Week 7 (Mon.-Fri): Preparation for the written examination **Note:** The module contains hand-on laboratory work conducted individually and is taught in research laboratories. The module does not contain computer-based practicals/research as a main component.

Module Name
Cell Death in Inflammation, Immunity and Disease (Corona)

Identification Number	Workload	Credit Points	Term	Offered Every	Start	Duration
MN-BC-GSM04	360 h	12 CP	1st or 2nd term of studying	Summer term	summer term only	7 weeks

1	Course Types	Contact Time	Private Study	Planned Group Size*
	a) Lectures	26 h	39 h	max. 12
	b) Practical/Lab	145 h	120 h	max. 4
	c) Seminar	6 h	24 h	max. 2

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module

- have acquired a comprehensive understanding of the mechanisms regulating different pathways of regulated cell death including apoptosis, necroptosis, pyroptosis and ferroptosis
- have acquired detailed knowledge on important concepts concerning the functional implications of different pathways or regulated cell death in inflammation and immunity, as well as in the pathogenesis of inflammatory and degenerative diseases.
- have acquired experimental skills in molecular, biochemical and imaging methodologies used to detect and measure cell death as well as inflammatory responses
- have acquired experimental skills in the use of several important molecular biological methods (see contents of the module) and are able to independently design and perform small scientific projects related to topics of the module.
- have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module on a professional level.
- are able to transfer skills acquired in this module to other fields of biology.

3 Module Content

- Eukaryotic cell culture and transfection
- Protein and DNA purification and analysis
- Gel electrophoresis (agarose and PAGE)
- Western blot
- Immunofluorescence Staining, immunohistochemistry (confocal and fluorescent microscopy)
- FACS

  Assays detecting different forms of cell death (Apoptosis, Necroptosis, Pyroptosis and Ferroptosis)

4 Teaching Methods

Lectures; Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form.

5	**Prerequisites (for the Module)** Enrollment in the Master´s degree course “Biological Sciences” or in the Master´s degree course “Biochemistry and Molecular Medicine”. **Additional academic requirements** For Students of Master “Biological Sciences”: Previous attendance of the lecture module “Principles of Molecular Genetics, Development and Aging (A/D/G)”.
6	**Type of Examination** The final examination consists of two parts Written examination on topics of lectures, seminars and the practical/lab part (1 hour; 50 % of the total module mark), oral presentation (20-30 min; 50 % of the total module mark)
7	**Credits Awarded** Regular and active participation; Each examination part at least “sufficient” (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula*** Biological subject module in the Master´s degree course “Biological Sciences”
9	**Proportion of Final Grade** In the Master´s degree course “Biochemistry and Molecular Medicine”: 10 % of the overall grade (see also appendix of the examination regulations)
10	**Module Coordinator** Dr. Teresa Corona (Pasparakis Lab), phone 0221-478-84362, e-mail: tcorona@uni-koeln.de
11	**Further Information** **Participating faculty**: Dr. T. Corona, Dr. Alina Farid, Dr. M. Fritsch, Dr. M. Hafner, Prof.Dr. H. Kashkar, Prof. Dr. M. Pasparakis, Dr. J. Seeger, Dr. Eric Seidel, Prof. Dr. S. von Karstedt, Dr. L. Wachsmuth. **Literature:** Information about textbooks and other reading material will be given on the ILIAS representation of the course (https://www.ilias.uni-koeln.de/ilias/goto_uk_cat_2815610.html) **General time schedule:** Week 1-6 (Mon.-Fri.): Lectures, practical/lab, writing seminar paper and preparation for the seminar talk (topic and date will be arranged individually); Week 7 (Mon.-Fri): Preparation for the written examination **Note:** The module contains hands-on laboratory work conducted by small groups of students (2 max. 4) and is taught in course rooms. The module does not contain computer-based practicals/research as a main component.

Module Name
Molecular Human Genetics (Wirth)

Identification Number	Workload	Credit Points	Term	Offered Every	Start	Duration
MN-BC-GSM05	360 h	12 CP	1st or 2nd term of studying	Summer term	summer term only	7 weeks

1	Course Types	Contact Time	Private Study	Planned Group Size*
	a) Lectures	10 h	20 h	max. 8
	b) Practical/Lab	155 h	136 h	max. 1
	c) Seminar	15 h	24 h	max. 1

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module

- have gained in-depth knowledge in modern human genetics methods.
- have acquired experimental skills in state-of-the art molecular genetics and molecular biology (see contents of the module) and can independently design and perform small scientific projects related to the topics of the module.
- have learned how to present research results in oral and written form and to critically discuss scientific publications related to the topic of the module on a professional level.
- are able to transfer skills acquired in this module to other fields of biology.

3 Module Content

- Identification and characterization of the molecular basis of human inherited diseases (neuromuscular and neurodegenerative disorders, kidney diseases, skeletal disorders, and hereditary tumor predisposition syndromes) and of rare developmental syndromes. Subtopics: disease gene location (linkage studies), identification of disease genes (targeted (Panel) and whole exome sequencing using next generation sequencing), identification of underlying mutations, functional analysis of disease genes in vitro and in vivo, functional analysis of the disease relevant protein complexes
- Identification of disease modifying/protective factors
- Therapeutic approaches (pharmacotherapy, epigenetic approaches, gene therapy)
- Molecular genetic technologies (PCR, sequencing, real-time PCR, genotyping of polymorphic markers, RT-PCR, pyrosequencing, Southern-blotting, etc.)
- Analysis of sequencing data and mutations, construction of haplotypes, construction of primers, assembling and alignment of sequences, etc.
- Molecular cloning (cloning of PCR fragments into plasmids, isolation of plasmid DNA, transfections); use of CRISPR/Cas-system
- Cell culture technology (working with human and murine cell lines)
- Working with inducible pluripotent stem cells (iPSC) and neuronal differentiation
- Immunohistochemistry, fluorescence microscopy
- Protein analysis and protein-interaction methods (Western blotting, co-immunoprecipitation of proteins, pull-down, chromatin-immunoprecipitations (ChIP) etc.)
- Analysis of knock-out and transgenic mice

Explanatory note: The list above comprises topics and techniques that are commonly used at the Institute of Human Genetics, CECAD, CMMC, CCG, Epigenomics and Experimental Immunology of the Eye. Thus, every student participating in this module will be confronted with a large subset of it. The exact content, however, will depend on the tutor and the research project the student will work on.

4	**Teaching Methods** Lectures; Practical/Lab (Project work); Seminar; Computer exercises; Guidance to independent research; Training on presentation techniques in oral and written form
5	**Prerequisites (for the Module)** Enrollment in the Master´s degree course “Biological Sciences” or in the Master’s degree course “Biochemistry and Molecular Medicine”
6	**Type of Examination** Type 3: oral examination on topics of lectures, seminars and the practical/lab part (20-30 min; 50 % of the total module mark) written report (50 % of the total module mark)
7	**Credits Awarded** Regular and active participation Each examination part at least “sufficient” (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula*** Biochemical subject module in the Master´s degree course “Biological Sciences”
9	**Proportion of Final Grade** In the Master´s degree course “Biochemistry and Molecular Medicine”: 10 % of the overall grade (see also appendix of the examination regulations)
10	**Module Coordinator** Prof. Dr. Brunhilde Wirth, phone 478-86464, e-mail: brunhilde.wirth@uk-koeln.de
11	**Further Information** **Participating faculty:** Prof. Dr. M. Bergami, Dr. R. Hänsel-Hertsch, Prof. Dr. N. Kononenko, Prof. Dr. T. Langmann, Dr. Valentina Piano, Prof. Dr. M. Schweiger, Prof. Dr. B. Wirth, Dr. H. Zempel **Location:** The lab part will be held depending on the PI at 1) Center for Molecular Medicine Cologne, 2) CECAD, 3) Department of Ophthalmology or 4) CCG, 50931 Cologne. Seminars will be held at the Institute of Human Genetics, library (Frauenklinik Building 47, Kerpener Str. 34, ninth floor) **Literature:** • Strachan, T., Read, A.P. (2019) Human Molecular Genetics. 5th edition, Garland Science • Nussbaum, R.L., Willard, H.F., McInnes, R.R. (2015) Thompson and Thompson - Genetics in Medicine. 8th edition, Saunders • For those students, who speak German: Hirsch-Kauffmann, M., Schweiger, M., Schweiger, M.R. (2009) Biologie und Molekulare Medizin.7.Auflage, Thieme **General time schedule:** Week 1-6 (Mon.-Fri.): Lectures, practical/lab and preparation for the seminar talk (topic and date will be arranged individually) as well as writing seminar paper; Week 7 (Mon.-Fri): Preparation for the oral examination **Note:** The module contains hand-on laboratory work conducted individually and is taught in research laboratories. The module does not contain computer-based practicals/ research as a main component.

Module Name
Computational Biology II

Identification Number	Workload	Credit Points	Term	Offered Every	Start	Duration
MN-BC-GSM06	360 h	12 CP	2nd or 3rd term of studying	Summer term	summer term only	7 weeks

1	Course Types	Contact Time	Private Study	Planned Group Size*
	a) Lectures	18 h	36 h	max. 12
	b) Practical/Lab	99 h	159 h	max. 12
	c) Seminar	12 h	36 h	max. 12

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module

- have acquired detailed knowledge about the experimental background of advanced methods in Bioinformatics and Computational Biology.
- have gained insight into contemporary topics of bioinformatic and biostatistical research and application to high-throughput data analysis.
- are able to use the above mentioned systems to analyse genome-scale data, conduct downstream analyses, and to interpret and document their research.
- can independently carry out small scientific projects related to the topic of the module.
- have learned how to present research results in oral form and to critically discuss scientific publications related to the topic of the module on a professional level.
- are able to transfer skills acquired in this module to other fields of biology.

3 Module Content

- Modern bioinformatic methods for genome, transcriptome and proteome data analysis
- Multi-variate and high-dimensional data analysis
- Advanced regression methods, such as regularized linear models
- Application of these methods to molecular biology and for understanding disease mechanisms
- Handling of Unix based computer systems
- Scientific programming

4 Teaching Methods

Lectures; Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques.

5 Prerequisites (for the Module)

Enrollment in the Master´s degree course “Biological Sciences” or in the Master´s degree course “Biochemistry and Molecular Medicine”

Additional academic requirements
Previous attendance of the lecture module “Computational Biology (C)”.
Knowledge and understanding of the content of the theory module “Computational Biology (C)“ and basic programming skills in “R“ are absolutely required for participation in the course. In cases of doubt, please contact the module coordinator (see 10).

6	**Type of Examination** The final examination consists of two parts Written examination on topics of lectures, seminars and the practical/lab part (2 hours; 50 % of the total module mark), oral presentation (20-30 min; 50 % of the total module mark).
7	**Credits Awarded** Regular and active participation; Each examination part at least "sufficient" (see appendix of the examination regulations for details)
8	**Compatibility with other Curricula*** Biological subject module in the Master´s degree course "Biological Sciences"
9	**Proportion of Final Grade** 10 % of the overall grade (see also appendix of the examination regulations)
10	**Module Coordinator** Prof. Dr. Andreas Beyer, phone 478-84429, e-mail: andreas.beyer@uni-koeln.de
11	**Further Information** **Participating faculty**: Prof. Dr. Andreas Beyer, phone 478-84429, e-mail: andreas.beyer@uni-koeln.de Prof. Dr. T. Wiehe, Prof. Dr. A. Tresch, Prof. Dr. K. Bozek, Dr. P. Antczak **Literature:** Information about textbooks and other reading material will be given on the ILIAS representation of the course (https://www.ilias.uni-koeln.de/ilias/goto_uk_cat_2815610.html) **General time schedule:** Week 1-6 (Mon.-Fri.): Lectures, practical/lab, preparation for the seminar talk (topic and date will be arranged individually); Week 7 (Mon.-Fri.): Preparation for the written examination **Note:** The module does not contain hands-on laboratory work. The module contains computer-based practicals/research as a main component, using RStudio Server Pro.

Specialization Modules, Schwerpunktmodule

Module Name					
Laboratory Project Module					
Identification Number	**Workload**	**Credit Points**	**Term**	**Offered Every**	**Duration**
MN-BC-LM1/2	540h	18 CP	2nd-3rd term	all year round	12 weeks

1	**Course Types**	**Contact Time**	**Self-Study Times**	**Group Size**
	Interactive Tutorials, Project work and Seminar	360 h	180 h	1

2 **Module Objectives and Skills to be Acquired**

Students who successfully completed this module ...

- have learned to do scientific work in a specific field of a given research group.
- have understood how to plan and conduct a small scientific project.
- have gained experience in following the presentation of scientific material by others in the frame of the seminar program of a research group.
- have learned how to present research results in oral and written form and to critically discuss scientific publications.

3 **Module Content**

The detailed content of the Laboratory Module is proposed by the supervising tutor on an individual basis in agreement with the student. The content requires approval by the M.Sc. Biochemistry and Molecular Medicine Degree Committee. A Laboratory Module may be supervised by any member of staff qualified under the University Regulation § 65 HG.

4 **Teaching Methods**

Interactive tutorials; Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form

5 **Prerequisites**

Enrollment in the Master or Biochemistry and Molecular Medicine
Successful completion of at least one Biochemical Subject Module

6 **Type of Examination**

The final examination consists of two parts: 20 min oral presentation followed by a 10-30 min discussion of the presented work and the scientific background (30 % of the total module mark) and seminar paper (70 % of total module mark).

7 **Credits Awarded**

18 CP

8 **Compatibility with other Curricula**

Specific

9	**Proportion of Final Grade** 10%
10	**Module Coordinator** Head of the M.Sc. Biochemistry and Molecular Medicine Degree Committee
11	**Further Information** Note: A student may not perform both laboratory modules in the same research group. Before taking the first Laboratory Project Module, one Subject Module has to be completed.

Module Name Project Proposal					
Identification Number MN-BC-PP	**Workload** 180 h	**Credit Points** 6 CP	**Term** 3rd term	**Offered Every** all year round	**Duration** 5 weeks

1	**Type of lessons** Interactive Tutorials, Project work, Scientific talks	**Contact times** approx. 30 h	**Self-Study Times** approx. 150 h	**Group Size** max. 1

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module …

- have learned to search the literature, to identify papers with important impact in the field and to extract relevant information in respect to their own research topic
- are able to develop a working hypothesis, theory or model that explains a biochemical mechanism and/or biochemical problem which has been studied in a research project
- are able to propose reasonable experiments and define expected positive and negative outcomes including control experiments
- are able to develop a work plan using different and complementary experimental approaches to prove or disprove their hypothesis
- have learned to describe and to critically discuss a state-of-the-art method

3 Module Content

The Project Proposal Module may be supervised by any member of staff qualified under the University Regulation § 65 HG. The subject of the Project Proposal is developed with the supervising tutor on an individual basis in agreement with the student. It may cover the following areas:

- Listen to 10 scientific presentations (documentation required)
- Review of the results of the passed laboratory module (MN-BC-LM1/2) and definition of the strength and weaknesses of the available results and data
- Description of the state-of -the-art research in a specific field by searching the literature and extracting the most important and influential work in the field (include citations)
- Definition of new research aims and hypothesis for the Master thesis module
- Identification of key methods and technologies that can be applied, including a critical discussion of 1-2 key methods with advantages and disadvantages in a separate essay
- Development of a work plan including in detail description and justification of experimental approaches
- Suggestion of alternative approaches, identification of pit falls and definition of crucial control experiments
- Timed work schedule

4 Teaching Methods

Interactive tutorials; Guidance to independent research project planning and proposal writing; Training on presentation techniques in written form; literature search; Essay writing

5 Prerequisites

	Enrollment in the Master's degree course “Biochemistry and Molecular Medicine”; Successful completion of 2 laboratory project and 2 subject modules
6	**Type of Examination** The final examination consists of a written project proposal.
7	**Credits Awarded** Documented participation in 10 scientific presentations throughout the Master studies Total module mark at least “sufficient” (see appendix of the examination regulations for details).
8	**Compatibility with other Curricula** None
9	**Proportion of Final Grade** 5 %
10	**Module Coordinator** Head of the M.Sc. Biochemistry and Molecular Medicine Degree Committee
11	**Further Information** Compulsory Specialization Module of the Master’s degree course “Biochemistry and Molecular Medicine”. Literature: Will be handed out at the beginning and during the module General time schedule: Throughout the master studies listening to at least 10 scientific presentations, Week 1-3 (Mon.-Fri.): Interactive tutorials, literature search, preparation of the seminar paper; Week 4-5 (Mon.-Fr.): writing seminar paper Introduction to the module/Examination dates: will be arranged in agreement between the student and the supervising tutor.

Module Name Master Thesis and Defense					
Identification Number MN-BC-MT	**Workload** 1080 h	**Credit Points** 36 CP	**Term** 4th term	**Offered Every** all year round	**Duration** 6 months*

1	**Type of lessons** a) Master Thesis b) Defense	**Contact times** According to the individual demand of the student	**Self-Study Times** According to the individual need of the student	**Group Size** max. 1

2 Module Objectives and Skills to be Acquired

Students who successfully completed this module …

- have learned to perform scientific work independently and at a demanding level.
- have gained substantial further training in presenting their results to scientific audiences in written and oral form.
- are able to defend their scientific achievements and to develop their own ideas within their research fields.

3 Module Content

- The detailed content of the Master Thesis (30 CP) is proposed by the supervising tutor on an individual basis in agreement with the student and has to be approved by the M.Sc. Biochemistry and Molecular Medicine Degree Committee. The Master Thesis may be supervised by any member of staff qualified under the University Regulation § 65 HG.
- The Defense (6 CP) consists of a 20 min talk on the results of the thesis and is followed by a 25-40 min discussion on the thesis as well as its scientific background.

4 Teaching Methods

Practical/Lab (Project work); Seminar; Guidance to independent research; Training on presentation techniques in oral and written form

5 Prerequisites

Successful completion of all other modules of the Master´s degree course “Biochemistry and Molecular Medicine”.

Thesis: Formal written permission by the M.Sc. Biochemistry and Molecular Medicine Degree Committee before starting the module (application form can be obtained from http://www.biochemie.uni-koeln.de/).

Defense: Successful completion of the Master Thesis with a grade of at least “sufficient”.

6 Type of Examination

The final examination consists of two parts: Master Thesis (75 % of the total module mark), Defense of the Master Thesis (25% of the total module mark). The written thesis will be graded by two examiners and their grades combined 1:1.

7 Credits Awarded

Each examination part at least “sufficient” (see appendix of the examination regulations for details)

8	**Compatibility with other Curricula** Specific to the Master of Biochemistry and Molecular Medicine
9	**Proportion of Final Grade** 35%
10	**Module Coordinator** Head of the M.Sc. Biochemistry and Molecular Medicine Degree Committee
11	**Further Information** Final Specialization Module of the Master's degree course "Biochemistry and Molecular Medicine". • In case a student cannot find a supervisor for this module, it is the responsibility of the M.Sc. Biochemistry and Molecular Medicine Degree Committee to arrange for one. • The topic of a Master Thesis may be changed once and within the first four weeks. • In special circumstances the M.Sc. Biochemistry and Molecular Medicine Degree Committee may prolong the duration of a Master Thesis by four weeks.

3 Study help

3.1 Sample Study Plans

Start of studies in the **winter term**

Term	Module	Number of Exam Elements Type of Exam	CP
1	Advanced Biochemistry and Molecular Medicine	1, written exam	6
	Subject Module 1	2-3, seminar presentation, (protocol,) written or oral exam	12
	Subject Module 2	2-3, seminar presentation, (protocol,) written or oral exam	12
2	Hot Topics in Biochemistry and Medicine	1, written home work	6
	Scientific Writing	1, written home work	6
	Laboratory Project 1	2, protocol and seminar presentation	18
3	Laboratory Project 2	2, protocol and seminar presentation	18
	Project Proposal	1, written home work	6
4	Master Thesis & Defense	2, master thesis and colloquium	36
		Total number of elements: 12-14 (excluding master thesis and colloquium)	**Total number = 120**

Start of studies in the summer term

Term	Module	Number of Exam Elements Type of Exam	CP
1	Hot Topics in Biochemistry and Medicine	1, written home work	6
	Subject Module 1	2-3, seminar presentation, (protocol,) written or oral exam	12
	Subject Module 2	2-3, seminar presentation, (protocol,) written or oral exam	12
2	Advanced Biochemistry and Molecular Medicine	1, written exam	6
	Scientific Writing	1, written home work	6
	Laboratory Project 1	2, protocol and seminar presentation	18
3	Laboratory Project 2	2, protocol and seminar presentation	18
	Project Proposal	1, written home work	6
4	Master Thesis & Defense	2, master thesis and colloquium	36
		Total number of elements: 12-14 (excluding master thesis and colloquium)	**Total number = 120**

3.2 **Exam Advice**

The chairperson of the examination board, his or her deputy, the head of the respective examination office and his or her deputy can provide legally binding information on examination requirements and performance. The academic advising is carried out by the academic advisors of the Department of Chemistry and by the university lecturers as well as the academic staff who are involved in the training in this study program during office hours. The office hours are posted in the institutes and on the Internet. It is recommended that you make use of an individual course counseling service.

3.3 **Further Counselling Offers**

The Central Student Advisory Service of the University of Cologne (Zentrale Studienberatung der Universität zu Köln) is available for general study advice, in particular about study options and study requirements. Faculty-wide advisory services are available for interdisciplinary study advice. The General Student Committee (Allgemeine Studierendenausschuss, AStA) and the Chemistry Department and the Biology Department offer advice on general issues relating to study organization. The International Office of the University of Cologne (Akademisches Auslandsamt der Universität zu Köln) and the Center for International Relations (Zentrum für internationale Beziehungen, ZiB) of the Faculty of Mathematics and Natural Sciences offer advice for special questions from foreign students and for preparing for a study abroad. In the case of study-related personal difficulties, the psycho-social counseling of the Kölner Studentenwerk can be used. Students with special study requirements can take advice from the university administration (Department 23: Special Study Matters) and the Rector's representative for the needs of students with disabilities and chronic illnesses.