Module Catalogue

for the Master Degree Programme

Molecular Life Sciences

Status: 2016

Faculty of Biology and Pharmacy

List of abbreviations

cp	credit point(s)
L	Lecture
S	Seminar
E	Exercise
P	Practical course
Ex	Excursion
SS	Summer Semester
WS	Winter Semester
hpw	hours per week
Mc	Module coordinator

Curriculum Master Molecular Life Sciences

1. General overview according to academic years

1st academic year		2nd academic year	
WS	**SS**	**WS**	**SS**
MMLS.G1 7 hpw Molecular Developmental Biology	MMLS.A1 7 hpw Mol. Devel. of Model Systems	**MMLS.T1** Specialisation Module MMLS	**MMLS.T3** Master Thesis MMLS
MMLS.G2 7 hpw Molecular Genetics	MMLS.A2 7 hpw Evol. Devel. Biology	**MMLS.T2** Project Module MMLS	
MMLS.G3 6 hpw Molecular Cell Biology	1 hpw		
	MMLS.A3 7 hpw Developmental Control Gene		
	MMLS.A4 7 hpw Gene Regulation		
	MMLS.A5 7 hpw Theoretical Systems Biology		
	MMLS.A6 7 hpw Applied Systems Biology		
	MMLS.A7 7 hpw Signal transduction		
	MMLS.A9 7 hpw Biological Clock and Temporal Gene Expression		
	MMLS.A10 7 hpw Mol. Med. of Ion Transport		
	MMLS.A17 7 hpw Genome Integrity, Tumors and Ageing		
	MMLS.A12 7 hpw Organelles: Devel. a. Function		
	MMLS.A13 7 hpw Cellular Networks		
	MMLS.A14 8 hpw Systematic Neurobiology		
	MMLS.A15 8 hpw Development and Plasticity of Nervousl System II		
	MMLS.A16 7 hpw Symbiosis, Signalling and Metabolism		

Basic modules (compulsory) Advanced modules (compulsory elective)

Interdisciplinary module:

Modules from other degree programmes will be included after mandatory mentors advise if they particularly enhance the interdisciplinary character of the study course. Examples could be – aside from other life science subjects (e. g. offered within the Master programme Biochemistry, Molecular Medicine or Microbiology) – specifically Ethics, Scientific English, Nanotechnologies, Photonics. Also an internship at external research institutions can be accredited after previous student advisory service within the scope of an advanced module.

International mobility / Mobility window

Study stays abroad within the Master degree programme Molecular Life Sciences are possible and desired. For the support of students, who want to go abroad, a special entry on the website publishes links to the International Office, the Erasmus Programme, the networking amongst Coimbra Universities, current links (such as RISE) and the offer of an individual mentoring.

To make the recognition of achievements easier, a “Learning Agreement” about the planned study programme should be arranged with the responsible professor of the degree programme and should be provided to the Study and Examination Office. Possibilities of a degree programme related mobility can be given by the responsible professor of the degree programme as well as the Study and Examination Office.

2. General Overview According to Subject-Related Semesters and Credit Points

Module number	Module name	Credit points
1st Semester	3 Basic modules	
MMLS.G1	Basic module „Molecular Developmental Biology“	10
MMLS.G2	Basic module „Molecular Genetics“	10
MMLS.G3	Basic module „ Molecular Cell Biology “	10
2nd Semester	3 Advanced modules [1]	
MMLS.A1	Advanced module „Molecular Developmental Biology of Model Systems “	10
MMLS.A2	Advanced module „Evolutionary Developmental Biology“	10
MMLS.A3	Advanced module „Developmental Control Genes“	10
MMLS.A4	Advanced module „Gene Regulation“	10
MMLS.A5	Advanced module „Theoretical Systems Biology“	10
MMLS.A6	Advanced module „Applied Systems Biology“	10
MMLS.A7	Advanced module „Signal Transduction“	10
MMLS.A9	Advanced module „Biological Clock and Temporal Gene Expression“	10
MMLS.A10	Advanced module „Molecular Medicine of Ion Transport“	10
MMLS.A17	Advanced module „Genome Integrity, Tumors and Ageing”	10
MMLS.A12	Advanced module „Organelles: Development and Function“	10
MMLS.A13	Advanced module “Cellular Networks”	10
MMLS.A14	Advanced module “Systematic Neurobiology”	10
MMLS.A15	Advanced module “Development and Plasticity of Nervous System II”	10
MMLS.A16	Advanced Module “Symbiosis, Signalling and Metabolism”	10
3rd Semester	2 Modules	
MMLS.T1	Specialisation Module	10
MMLS.T2	Project Module	20
4th Semester	Master thesis	
MMLS.T3	Master thesis	30

[1] The Advanced modules can be freely chosen.

Record sheet Master Molecular Life Sciences

Module	**Work performed**	**Grade**	**Signature**
Basic module 1	Lectures		
	Seminar		
Basic module 2	Lectures		
	Seminar		
Basic module 3	Lectures		
	Seminar		
Advanced module 1 (can be freely chosen from the range of the courses offered in Molecular Life Sciences)			
Advanced module 2 (can be freely chosen from the range of the courses offered in Molecular Life Sciences)			
Advanced module 3 (can be freely chosen from the range of the courses offered in Molecular Life Sciences)			
Specialisation module			
Project module			
Master thesis			

Module Overview for the Master's Programme Molecular Life Sciences (MMLS)

G Basic module (compulsory module)
A Advanced module (compulsory elective module)
T Thesis (Master thesis)

1st Semester:

MMLS.G1: Molecular Developmental Biology (Mc: Theißen)			WS/SS	hpw	**cp**
L	Molecular Developmental Biology I	Theißen, Damen	WS	2	
L	Molecular Developmental Biology II	Olsson, Englert, Baniahmad	WS	2	
L	Gene Regulatory Networks	Theißen, Damen	WS	1	
S	Comparative and Evolutionary Developmental Biology	Damen, Olsson, Theißen	WS	2	
				7	**10**

MMLS.G2: Molecular Genetics (Mc: Baniahmad)			WS/SS	hpw	**cp**
L	Molecular Genetics I	Baniahmad, Heinzel, Theißen	WS	2	
L	Molecular Genetics II	Baniahmad, Saluz, Damen	WS	2	
L	Systems Biology	Schuster, Platzer, Dittrich	WS	1	
S	Molecular Genetics	Baniahmad	WS	2	
				7	**10**

MMLS.G3: Molecular Cell Biology (Mc: Sasso)			WS/SS	hpw	**cp**
L	Molecular Cell Biology I	Jungnickel, Hemmerich	WS	2	
L	Molecular Cell Biology II	Oelmüller, Sasso	WS	2	
L	Molecular Cell Biology III	Mittag	WS	2	
S	Molecular Cell Biology	Hemmerich, Oelmüller, Sasso, Mittag	WS/SS	1	
				7	**10**

2nd Semester: 3 advanced modules can be freely chosen

MMLS.A1: Molecular Developmental Biology of Model Systems (Mc: Englert)			WS/SS	hpw	**cp**
S	Molecular Developmental Biology of Model Systems	Englert, Theißen, Damen	SS	2	
P	Molecular Developmental Biology of Model Systems	Englert, Theißen, Damen	SS	5	
				7	**10**

MMLS.A2: Evolutionary Developmental Biology (Mc: Theißen)			WS/SS	hpw	**cp**
S	Evolutionary Developmental Biology	Theißen, Damen	SS	2	
P	Evolutionary Developmental Biology	Theißen, Damen	SS	5	
				7	**10**

MMLS.A3: Developmental Control Genes (Mc: Theißen)			WS/SS	hpw	**cp**
S	Developmental Control Genes	Theißen, Damen	SS	2	
P	Developmental Control Genes	Theißen, Damen	SS	5	
				7	**10**

MMLS.A4: Gene Regulation (Mc: Baniahmad)			WS/SS	hpw	**cp**
S	Gene Regulation	Baniahmad	SS	2	
P	Gene Regulation	Baniahmad, Heinzel, Englert, NN	SS	5	
				7	**10**

MMLS.A5: Theoretical Systems Biology (Mc: Schuster)			WS/SS	hpw	**cp**
L	Analysis of Gene Expression	Guthke	SS	2	
L	Metabolic and Regulatory Networks	Schuster	SS	2	
E	Metabolic and Regulatory Networks	Schuster	SS	1	
P	Metabolic and Regulatory Networks	Schuster	SS	2	
				7	**10**

MMLS.A6: Applied Systems Biology (Mc: Mittag)			WS/SS	hpw	**cp**
P	Applied Systems Biology	Mittag, Saluz	SS	5	
S	Applied Systems Biology	Mittag	SS	2	
				7	**10**

MMLS.A7: Signal Transduction (Mc: Liebmann)			WS/SS	hpw	**cp**
S	Signal Transduction	Spänkuch, Heinzel, Wetzker	SS	2	
P	Signal Transduction	Spänkuch, Heinzel, Wetzker	SS	5	
				7	**10**

MMLS.A9: Biological Clock and Temporal Gene Expression (Mc: Mittag)			WS/SS	hpw	**cp**
S	Current Topics on Molecular Mechanisms of Circadian Clocks and Temporal Gene Expression	Mittag	SS	2	
P	Molecular Chronobiology - Temporal Gene Expression	Mittag and members of staff	SS	5	
				7	**10**

MMLS.A10: Molecular Medicine of Ion Transport (Mc: Heinemann)			WS/SS	hpw	**cp**
L	Ion Transport and Disease	Heinemann, Schönherr	SS	2	3
S	Current Topics on the Structure and Function of Ion Channels and Transporters	Heinemann	SS	1	2
P	Membrane Processes and Transport	Heinemann and members of staff	SS	4	5
				7	**10**

MMLS.A17: Genome Integrity, Tumors and Ageing (Mc: Jungnickel)			WS/SS	hpw	**cp**
V	Genomic Instability and Tumor Biology	Jungnickel, Grosse	SS	2	
S	Genetic and Cellular Plasticity	Jungnickel	SS	2	
P	Genetic and Cellular Plasticity	Jungnickel	SS	4	
				8	**10**

MMLS.A12: Organelles: Development and Function (Mc: Oelmüller)			WS/SS	hpw	**cp**
S	Organelles: Development and Function	Oelmüller	SS	2	
P	Organelles: Development and Function	Oelmüller	SS	5	
				7	**10**

MMLS.A13: Cellular Networks (Mc: Jungnickel)			WS/SS	hpw	**cp**
S	Cellular Networks	Jungnickel	SS	2	
P	Cellular Networks	Jungnickel	SS	5	
				7	**10**

MMLS.A14: Systems Neurobiology (Mc: Bolz)			WS/SS	hpw	**cp**
L	Systems Neurobiology	Bolz	SS	2	
S	Systems Neurobiology	Bolz	SS	2	
P	Systems Neurobiology	Bolz	SS	4	
				8	**10**

MMLS.A15: Development and Plasticity of Nervous System II (Mc: Bolz)			WS/SS	hpw	**cp**
L	Development and Plasticity of Nervous System II	Bolz, Lehmann	SS	2	
S	Development and Plasticity of Nervous System II	Bolz, Lehmann	SS	2	
P	Development and Plasticity of Nervous System II	Bolz, Lehmann	SS	4	
				8	**10**

MMLS.A16: Symbiosis, Signaling and Metabolism (Mc: Sasso)			WS/SS	hpw	**cp**
L	Symbiosis, Signaling and Metabolism	Sasso, Mahlow	SS	1	
S	Symbiosis, Signaling and Metabolism	Sasso	SS	1	
P	Symbiosis, Signaling and Metabolism	Sasso	SS	5	
				7	**10**

3rd Semester:

MMLS.T1: Specialisation Module MMLS (Mc: All persons responsible for Basic and Advanced modules of the Master programme MLS)			WS/SS	hpw	**cp**
P	Current Methods MMLS	according to agreement	WS		
					10

MMLS.T2: Project module MMLS (Mc: All persons responsible for Basic and Advanced modules of the Master programme MLS)			WS/SS	hpw	**cp**
P	Project laboratory course MMLS	according to agreement	WS		
					20

4th Semester:

MMLS.T3: Master thesis MMLS (Mc: All persons responsible for Basic and Advanced modules of the Master programme MLS)			WS/SS	hpw	**cp**
P	Master thesis MMLS	according to agreement	SS		
					30

Module descriptions

Module number	**MMLS.G1**
Module name	**Molecular Developmental Biology**
Module coordinator	Theißen
Admission requirements	none
Usability (required for)	Requirement for further modules
Type of module (compulsory, compulsory elective module)	Compulsory module, Basic module
Frequency of offer (module cycle)	Yearly, WS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	L: 5 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	Based on the module BB 3. MLS 1 (Developmental Genetics) of the Bachelor degree programme the module provides in-depth basics in Developmental Biology on the broad base, particularly in Molecular Biology, Genetics, Evolutionary Biology, Molecular Medicine. The focus is on lectures of text book knowledge about the development of model organisms, whereby animals (e.g. *Drosophila*) and plants (e.g. *Arabidopsis*) are handled comparatively. Particular attention is paid to the methods of the Molecular Developmental Genetics and the role of Gene Regulatory Networks in the development.
Learning and qualification objectives	Deepening of basics in Developmental Biology; basic knowledge for essential research directions in *Molecular Life Sciences*; deepened overview of the subject area as whole; Presentation of the scientific results giving a lecture; dealing with English scientific literature. *Regular participation in the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Written examination on the contents of all lectures (70 %), Seminar presentation (30 %)

Module number	**MMLS.G2**
Module name	**Molecular Genetics**
Module coordinator	Baniahmad
Admission requirements	None
Usability (required for)	Requirement for further modules
Type of module (compulsory, compulsory elective module)	Compulsory module, Basic module
Frequency of offer (module cycle)	Yearly, WS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	L: 5 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	The focus of the lectures is on the structure of genomes of different organisms, chromatin structure and modification, epigenetics, tumor genetics, structure of genome, transposons, immuno genetics, comparative genetics and analysis of genome. Furthermore basics in systems biology are provided. Current literature on the scientific field and the newest techniques are discussed in the seminar.
Learning and qualification objectives	Acquirement of a wide perspective at the meaning of molecular genetics for the organisms, mechanisms of the gene regulation, genomics; introduction to systems biology; learning about the newest molecular genetic techniques in theory as well as importance of the epigenetics and chromatin; acquisition of a scientific style in giving a speech and presentations. *Regular participation in the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Written examination on the contents of all lectures (70 %), Seminar presentation (30 %)

Module number	**MMLS.G3**
Module name	**Molecular Cell Biology**
Module coordinator	Sasso
Admission requirements	None
Usability (required for)	Requirement for further modules
Type of module (compulsory, compulsory elective module)	Compulsory module, Basic module
Frequency of offer (module cycle)	Yearly, WS/SS
Duration of module	2 semesters
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	L: 6 hpw S: 1 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	This module will extend the basic knowledge of molecular cell biology, particularly molecular biology, genetics, systems biology, evolution and develop-ment, and molecular medicine from module BB3.MLS9, with a wider scope. The emphasis will be on (a) principles of cell communication and signalling, structure, function and transport processes of selected membranes, organisation of the cell nucleus and the stem cell complex, (b) molecular processes in plants including genetic methods for their modification, genome sequencing and function of small RNAs, and (c) the molecular organisation of biological clocks, particularly the circadian clock of selected organisms of prokaryotes, fungi, plants and animals and the evolution of clock components.
Learning and qualification objectives	Extension of basic knowledge of molecular cell biology; acquisition of knowledge for important fields in molecular life sciences. Methods for the visualisation of molecules, organelles and cells, and for the manipulation of proteins, DNA and RNA in cells; presentation of scientific knowledge in the form of a talk; reading and discussion of scientific literature (in English) on aspects of the lecture. *Regular participation in the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Written examination on the contents of all lectures (70 %), Seminar presentation (30%)

Module number	**MMLS.A1**
Module name	**Molecular Developmental Biology of Model Systems**
Module coordinator	Englert
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module , Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	P: 5 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	 -105 h -195 h
Contents	The module provides knowledge in housing and breeding of different model organisms (e.g. Arabidopsis, Zebrafish, mouse); distinction of different developmental stages and preparation of particular organs; genotyping; expression analysis (RT-PCR and *in situ* hybridization); immunohistochemical processes; fluorescence microscopy as well as analysis of transgenic plants and animals.
Learning and qualification objectives	Deepening of knowledge in developmental genetics; acquisition and application of methods of developmental genetics and/ or developmental biology; gaining of experience in handling as well as in housing and breeding of experimental animals and plants; writing of a scientific protocol, presentation of data and communication in English. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	Writing of a practical course protocol
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Oral examination (70%), Seminar presentation (30%), major course assessment for the practical course

Module number	**MMLS.A2**
Module name	**Evolutionary Developmental Biology**
Module coordinator	Theißen
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module , Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	P: 5 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	The focus of this module is on keeping and culturing of evolutionary biological informative organisms (e.g. shepherd's purse, orchids, frogs, and fishes). Similarities and differences of the classical model organisms (e.g. *Arabidopsis, Drosophila,* mouse), particularly comparative morphogenetic studies and sequential and gene expression analysis are analysed.
Learning and qualification objectives	Acquirement of experimental skills in developmental biology in an evolutionary biological context; providing of subject-specific terminology, approaches and methods of the evolutionary developmental biology; writing of a scientific protocol; presentation of scientific results and dealing with English scientific literature. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	Writing of a practical course protocol.
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Oral examination (70%), Seminar presentation (30%), major course assessment for the practical course

Module number	**MMLS.A3**
Module name	**Developmental Control Genes**
Module coordinator	Theißen
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module , Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	P: 5 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	Analysis of genes, regulating the developmental processes of animals or plants (e.g. homeobox genes, MADS box genes) using methods of molecular biology (e.g. cloning, sequencing, expression analysis, mutant analysis) and molecular evolution (e.g. multiple sequence alignments, phylogenetic trees, test on selection).
Learning and qualification objectives	Acquirement of experimental skills in Developmental Genetics and Molecular Biology; deepening of understanding the complex interdependence between genotype and phenotype; writing of a scientific protocol; presentation of scientific results and dealing with English scientific literature. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	Writing of a practical course protocol
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Oral examination (70%), Seminar presentation (30%), major course assessment for the practical course

Module number	**MMLS.A4**
Module name	**Gene Regulation**
Module coordinator	Baniahmad
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module, Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly , SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	P: 5 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	The content of the module comprises mechanisms of gene regulation, temporally, spatial and hormonal controlled gene regulation of gene expression, expression analysis, newest molecular genetic techniques, biological clocks, analysis of chromatin and cellular senescence.
Learning and qualification objectives	Practical experience in analysing mechanisms of gene regulation in different biological systems and on different levels, learning to write a scientific protocol, improving skills in giving a talk and presentations, data presentation and communication in English. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	Writing of a practical course protocol.
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Oral examination (70%), Seminar presentation (30%), major course assessment for the practical course

Module number	**MMLS.A5**
Module name	**Theoretical Systems Biology**
Module coordinator	Schuster
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module , Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	L: 4 hpw P: 2 hpw E: 1 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	 -105 h -195 h
Contents	The lecture **Analysis of Gene Expression** provides an overview of chip technologies and their applications; pre-processing of data (models of measurement errors and normalisation); differential gene expression; supervised learning; unsupervised learning (cluster analysis); reverse Engineering (reconstruction of gene regulatory nets); data bases for gene expression analysis, as well as ethic and legal questions. In the lecture **Metabolic and regulatory networks** the following topics are covered: Enzyme kinetics, balance equations, network analysis (incl. conservation relations and elementary modes), dynamic modelling of metabolic and regulatory networks, metabolic control analysis, modelling of enzyme cascades, ultra-sensitivity, bistability, basics in modelling of signal transduction and calcium oscillation. The content of **Exercises/ Practical course** is the analytical/ numeral solution of problems on the scientific area of the lecture (during the practical course by using provided programmes).
Learning and qualification objectives	Practical understanding of the analysis of Microarray data and the interpretation of analysis results; insight into methods of knowledge extraction from the measurement data of molecular biological high-throughput techniques, acquirement of theoretical knowledge about the mathematical modelling of metabolic and (intracellular) regulatory networks, learning about possibilities of applying linear algebra, convex analysis and differential equation for this modelling; skills to solve exercises on modelling under guidance: application of relevant programmes on simulation of metabolic and regulatory networks. *Regular participation in the practical course and the exercise is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	Writing protocols for the practical course.
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Oral examination in "Analysis of Gene Expr." (30 %), oral or written examination in „Metabol. and regul. Netw.“ (70 %), major course assessment for the practical course.

Module number	**MMLS.A6**
Module name	**Applied Systems Biology**
Module coordinator	Mittag
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module , Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	P: 5 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	The module provides knowledge in the following areas: automated sequencing of DNA , sequence analysis *in silico*, DNA and RNA fingerprinting, rapid PCR, enrichment of cellular sub-proteomes, preparation of samples for mass spectrometry, mass spectrometry measurements (LC-ESI-MS) and their bioinformatical analysis: „-omics“ methods.
Learning and qualification objectives	Theoretical and practical understanding concerning DNA sequence analysis, fingerprinting und rapid PCR; relevance and possibilities of functional genome, proteome and metabolome analysis; independent conduction of simple experiments on topics above including writing of scientific protocols; insight into the newest literature, data presentation and communication in English. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	Writing of a practical course protocol.
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Oral examination (70%), Seminar presentation (30%), major course assessment for the practical course

Module number	**MMLS.A7**
Module name	**Signal Transduction**
Module coordinator	Spänkuch
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module , Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	P: 5 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	The selected current problems and research trends in signal transduction of G protein-coupled receptors, cytokine receptors and receptor tyrosine kinases are discussed in the seminar on the basis of original publications and reviews; also the relevance of new scientific findings for molecular medicine and signal transduction therapy is discussed. In the practical course you work at a relevant small project in the context of current projects of the involved research group.
Learning and qualification objectives	Deepening of basic knowledge in the areas: receptors and signal transduction; independent analysis of original literature; seminar presentation on a chosen publication and development of a project proposal on the continuation of the represented scientific problem. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	Writing of a practical course protocol.
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Oral examination (70%), Seminar presentation (30%), major course assessment for the practical course

Module number	**MMLS.A9**
Module name	**Biological Clock and Temporal Gene Expression**
Module coordinator	Mittag
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module , Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	P: 5 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	The main focuses of the module are cultivation and harvesting of organisms (wild type and clock mutants) under circadian conditions; measurement of circadian rhythms with the help of reporter genes or automated equipment, characterization of clock genes and/ or clock proteins at transcriptional, translational and post-translational level.
Learning and qualification objectives	Advanced knowledge about physiological and molecular structure of circadian clocks, evolution of clock components, chronobiological relevant diseases; independent conduction of simple experiments on topics above including writing of scientific protocols; insight into the newest literature, data presentation and communication in English. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	Writing of a practical course protocol.
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Oral examination (70%), Seminar presentation (30%), major course assessment for the practical course

Module number	**MMLS.A10**
Module name	**Molecular Medicine of Ion Transport**
Module coordinator	Heinemann
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module , Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 Semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	L: 2 hpw P: 4 hpw S: 1 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	Introduction to symptoms, diagnosis and therapeutic approaches for diseases that are related to disorders of ion transport. In particular the basics in Molecular Medicine and Physiology are provided for comprehension of channels-associated diseases. During the practical course membrane transport and the function of membrane proteins are analysed with the help of modern methods. In the seminar current biomedical publications on the topic are discussed.
Learning and qualification objectives	Lecture: structure and function of relevant transport molecules and their impact on the cellular function. Learn about pathophysiological interrelations: diagnosis and therapy of diseases, which are caused by defects in ion transport. Practical course: measurement, quantitative analysis and graphical/ written presentation of transport processes. Seminar: oral presentation of current publications. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	Writing of a practical course protocol.
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Oral examination concerning contents of the lecture, seminar and practical course (100%)

Module number	**MMLS.A17**
Module name	**Genome Integrity, Tumors and Ageing**
Module coordinator	Jungnickel
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module , Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	V: 2 hpw P: 5 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	Object of the lecture are the molecular and cell biological basics of genome integrity, tumor biology, stem cell biology and of ageing of cells and tissue as well as the genetic and epigenetic basics of cellular plasticity in the immune system and the nervous system. Regular and pathological molecular mechanisms are discussed with selected literature and a scientific topic has to be prepared independently (with instructions). Each student has to attend two seminars of own choice in the field of stem cell biology, ageing, plasticity in the immune system or neuronal plasticity and has to take part actively with a presentation and discussion.
Learning and qualification objectives	It is the objective of the module to get an overview on specific cellular mechanisms which allow plasticity, degeneration and regeneration of cells and organs as well as developing an understanding of possibilities of disorders and effects on the entire organism. Development of validated, proofed results and classification into a general scientific context. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Two seminar presentations (50% each), major course assessment for the lecture and practical course

Module number	**MMLS.A12**
Module name	**Organelles: Development and Function**
Module coordinator	Oelmüller
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module, Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	P: 5 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	Basic molecular methods on the development of organelles, the communication among organelles, the gene expression in organelles and the photosynthesis are provided in the practical course and seminar.
Learning and qualification objectives	Understanding of the role of organelles of plant cells and their importance for the metabolism; practical experience in molecular and physiological laboratory techniques for analysis of this context; strategical understanding to be able to solve scientific problems. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	Writing of a practical course protocol.
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Oral examination (70%), Seminar presentation (30%), major course assessment for the practical course

Module number	**MMLS. A 13**
Module name	**Cellular Networks**
Module coordinator	Jungnickel
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module, Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	P: 5 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	Topics are molecular basics in formation, maintenance, modulation and interaction of cellular networks in complex tissues such as e. g. immune system, nervous system, tumor tissue or the stem cell niche. Normal and pathological molecular mechanisms will be discussed with the help of selected literature and a scientific topic will be worked out independently (with instruction).
Learning and qualification objectives	The aim of the module is to provide an overview of specific cellular mechanisms, which enable the formation and function of complex organ systems as well as to develop a comprehension of possible disorders and their impact on the entire organism. In the practical course validated and verified results should be achieved and classified into a general scientific context. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	Writing of a practical course protocol.
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Two seminar presentations (50% each), major course assessment for the practical course

Module number	**MMLS. A 14**
Module name	**Systems Neurobiology**
Module coordinator	Bolz
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module, Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	L: 2 hpw P: 4 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	 -120 h -180 h
Contents	What and how we sense, think and feel is also affected by the architecture of our brain. The brain again is solely the product of evolution and therewith formed by incidental mutations and selection. Thus it is no design of engineers or computer scientists. This has important consequences on how we realise the world and how we experience ourselves in this world. The lecture teaches insight to the functional architecture of the brain and is dealing with neuronal mechanisms of cognition, learning and memory processes as well as neuronal biological basics of emotions and awareness. In the seminar current papers on selected topics of the lecture will be presented and discussed by the students. In the practical course, among other things, the students will perform behavioral tests with mice and optical imaging of neuronal activity in the visual cortex.
Learning and qualification objectives	The aim of this module is to get insight into the functional architecture of the brain and the neuronal mechanisms. Realisation of experiments on above mentioned topics, including writing of scientific protocols, presentation of scientific results and dealing with scientific literature. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	Writing of a practical course protocol.
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Written examination concerning contents of the lecture (70%), seminar presentation (30%), major course assessment for the practical course

Module number	**MMLS. A 15**
Module name	**Development and Plasticity of the Nervous System**
Module coordinator	Bolz
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module, Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	L: 2 hpw P: 4 hpw S: 2 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	 -120 h -180 h
Contents	This module provides an overwiew about fundamental processes in development and plasticity of the nervous system. Major points are embryonic development of the nervous system (neuronal migration, formation of specific neuronal connections), postnatal developmental plasticity (experience and activity dependent modifications of neuronal circuits, critical periods) and plasticity in the adult brain (learning induced plasticity, restoration of function in the aging brain). In the practical course different in vitro assays are performed to examine neuronal migration and axon guidance. Furthermore, the analysis of transgenic mice with modified neuronal circuits will also be part of the practical course.
Learning and qualification objectives	Overview on molecular and cellular processes of development and plasticity of the nervous system; critical discussion of current publications on this topic; independent use of methodical approach of developmental neurobiology; guided analysis of the collected data with relevant methods. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Protocols for the practical course in a group of two (70%), seminar presentation (30%)

Module number	**MMLS.A16**
Module name	**Symbiosis, signalling and metabolism**
Module coordinator	Sasso
Admission requirements	at least 1 successfully completed Basic module
Usability (required for)	Specialisation module , Project module, Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory elective module, Advanced module
Frequency of offer (module cycle)	Yearly, SS
Duration of module	1 semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	V: 1 hpw P: 5 hpw S: 1 hpw
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	-105 h -195 h
Contents	This module discusses selected topics from symbio-sis, signalling and metabolism in plants and microor-ganisms, including the mutualism between leguminous plants and rhizobia, interactions between microalgae and bacteria, G protein-coupled receptors and calci-um signalling, and the metabolism of carbohydrates, phenylpropanoids and terpenes including involved enzymes in land plants. In the practical course, stu-dents can participate in an ongoing project of the re-search group.
Learning and qualification objectives	Basic knowledge and insights into current research questions in the fields mentioned above; molecular and microbiological laboratory methods for unicellular algae; reading and assessment of the scientific prima-ry literature and seminar talk on a selected article. *Regular participation in the practical course and the seminar is required to reach the study objectives of the module. The teaching staff will inform about further details at the beginning of the courses.*
Admission requirements for the module examination	Writing of a practical course protocol.
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Oral or written examination (70%), Seminar presentation (30%), major course assessment for the practical course (protocol)

Module number	**MMLS.T1**
Module name	**Specialisation module MMLS**
Module coordinator	Supervisor (Theißen, Baniahmad, Jungnickel, Englert, Schuster, Mittag, Sasso, Spänkuch, Görlach, Heinemann, Oelmüller, Bolz, Lehmann)
Admission requirements	at least 2 Basic modules and 2 Advanced modules
Usability (required for)	Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory module
Frequency of offer (module cycle)	Every semester (WS, SS)
Duration of module	1 semester (half of the semester, the whole day)
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	practical course
Credit points (ECTS credits)	10 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	 - 230 h - 70 h
Contents	The module provides a specialisation in current methods on special topics of MLS.
Learning and qualification objectives	Development of special techniques
Admission requirements for the module examination	none
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Oral examination (ca. 15 min) 100%

Module number	**MMLS.T2**
Module name	**Project Module MMLS**
Module coordinator	Supervisor (Theißen, Baniahmad, Jungnickel, Englert, Schuster, Mittag, Sasso, Spänkuch, Görlach, Heinemann, Oelmüller, Bolz, Lehmann)
Admission requirements	at least 2 Basic modules and 2 Advanced modules
Usability (required for)	Master thesis
Type of module (compulsory, compulsory elective module)	Compulsory module
Frequency of offer (module cycle)	Every semester (WS, SS)
Duration of module	1 Semester (half of the semester, the whole day)
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	practical course
Credit points (ECTS credits)	20 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	 - 470 h - 130 h
Contents	The module deepens knowledge of selected research areas and provides technical preparation of the Master thesis. It is guided research work including the preparation of literature data and experimental work on a special topic of MLS, which is integrated into the current research works of the offering institution.
Learning and qualification objectives	Focus on specific research work; planning experiments; setting up a work schedule; methodology of data collection; analysis of molecular biological data; record-keeping of scientific work
Admission requirements for the module examination	none
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Presentation (100 %)

Module number	**MMLS.T3**
Module name	**Master thesis MLS**
Module coordinator	Supervisor (Theißen, Baniahmad, Jungnickel, Englert, Schuster, Mittag, Sasso, Spänkuch, Görlach, Heinemann, Oelmüller, Bolz, Lehmann)
Admission requirements	successful completion of the Modules MMLS.T1 and MMLS.T2
Usability (required for)	-
Type of module (compulsory, compulsory elective module)	Compulsory module
Frequency of offer (module cycle)	Yearly (WS, SS)
Duration of module	1 Semester
Module composition/ Forms of instruction (lecture, seminar, exercise, practical course)	practical course
Credit points (ECTS credits)	30 cp
Workload in hours: - in class and - self-study (incl. examination preparation)	 - 700 h class hours - 200 h self-study
Contents	The Master thesis shall prove that the student is able to handle a scientific problem within 6 months using scientific methods. The topic of the Master thesis is supervised by one of the module-coordinators and has to be agreed with this person. A high value is set particularly on thoroughly data collection, analysis and interpretation. Experience in an independent writing of a scientific work is gained during the module. The module guides to an independent scientific work on own responsibility.
Learning and qualification objectives	Setting up a work schedule; independent experiment planning and analysis as well as writing a scientific paper
Admission requirements for the module examination	None
Requirements for the award of credit points (forms of examination, weighting of grades in %)	Master thesis (100 %)