UNIVERSITÄT BONN

Module handbook

Master study course

Immunobiology: from molecules to integrative systems

LIMES
Life & Medical Sciences Institute

published Oct. 2021

Modul: **Methods in life sciences and statistics**				
Module Number LIMES-001	Workload 90 h	CP 3	Duration 1 Semester	Cycle Annual
Person responsible Deputy	Prof. Dr. Christoph Thiele Prof. Dr. Matthias Schmid			

	Study course	Category	Semester
	Biochemistry (MSc) Immunobiology: from molecules to integrative systems (MSc) Medical Immunosciences and Infections (MSc)	P	1.

Learning objective	Students should learn theoretical background of common techniques and methodological approaches from the area of life sciences. Additionally, students will gain an understanding of hypothesis testing and correct interpretation of different types of test statistics. They will improve their skills in statistical calculations and adequate planning of experiments.
Skills	Profound knowledge on methodology in life sciences Being able to perform statistical analysis of obtained results
Content	Dealing with DNA, RNA, proteins and lipids, electrophoresis, western blotting, RT-PCR, protein purification, cloning technologies, analysis of lipids, immunoprecipitation, histology, ELISA, Flow cytometry, FRET, microscopy Statistics: Basic test theory, Chi²-tests for contingency tables, t-tests, Non-parametric tests, Power calculations, Calculation rules for probabilities, Correlation, Regression, Software implementations, Graphics and visualization
Requirements	None

Courses	Kind	Subject	Group size	SWS	Workload [h]
	Lecture	Methods in Life sciences and statistics	85	2	90

Examinations	Type of examination	graded/ungraded
	Written exam	Graded
Requirements for admission to exam		
Miscellaneous		

Modul: **Methods course I**				
Module Number LIMES-002	Workload 450 h	CP 15	Duration 1 Semester	Cycle Annual
Person responsible Deputy	PD Dr. Anne Gäbler Prof. Dr. Günter Mayer			
	Study course		Category	Semester
	Biochemistry (MSc) Immunobiology: from molecules to integrative systems (MSc)		P	1.
Learning objective	Students should learn to plan and conduct basic biochemical and immunological experiments either on their own or within groups based on a simple task.			
Skills	By the end of the course, students should understand the conducted methods in life science research. They should be able to apply the principles of planning and performing an experiment, searching for references and literature, reading, understanding and discussing the content of primary research papers. Students should be able to document and analyze experimental data and present them in a written form after completing the course.			
Content	Photometric, fluorometric and luminometric measurements, including underlying physical principles, instrumentation and calculations. Enzyme kinetics. Enzyme inhibitors. Performing and designing enzymatic assays. Fluorescence resonance energy transfer (FRET). Generation and purification of antibodies. Basic cell culture techniques. Limiting dilution in hybridoma cells. Protein gel electrophoresis and Western Blotting. Bioinformatical tools and analyses in the Life Sciences.			
Requirements	None			
Courses	Kind	Subject	Group size	SWS	Workload [h]
	Practical course	Methods in Life sciences	65	10	450
Examinations	Type of examination			Graded/ungraded	
	Written exam Protocol			Graded (50%) Graded (50%)	
Requirements for admission to exam	Active participation in practical course, Records of conducted experiments			Ungraded	
Miscellaneous					

Module: **Immunology I**				
Module Number Immuno-001	Workload 180 h	CP 6	Duration 1 Semester	Cycle Annual
Person responsible Deputy	Prof. Dr. Sven Burgdorf PD Dr. Bernhard Fuß			
Representative of the Medical Faculty	Prof. Dr. Latz			

	Study course	Category	Semester
	Immunobiology: from molecules to integrative systems (MSc) Medical Immunosciences and Infection (M.Sc.)	P	1.

Learning objective	At the end of this module the students have acquired detailed and differentiated knowledge the cellular and humoral components of the immune system and the necessary and sufficient conditions to mount an immune response. Furthermore, they can describe current model systems and techniques used to study the immune system. Students have acquired advanced conceptual and methodological thinking skills based on the discussion of current scientific literature in immunology.
Skills	Understanding the principles of the immune system Know the key methods and their applications Being able to read, understand and present fundamental issues in innate immunity.
Content	Evolution of the immune system from bacteria to higher vertebrates. Cellular and humoral components of the immune system, different model organisms, basic principles of immune responses, anti-microbial peptides, effector functions of immune cells, Pattern-associated molecular patterns (PAMPs), Damage-associated molecular patterns (DAMPs), Pattern recognition receptors (PRRs) at the cell membrane and in the cytoplasm, signaling pathways of PRRs and other receptor's signaling pathways, inflammasomes, complement system.
Requirements	None

Courses	Kind	Subject	Group-size	SWS	Workload [h]
	Lecture	Biology of immune responses	55	2	90
	Tutorial			1	45
	Seminar			1	45

Examination(s)	Type of examination	Graded/ungraded
	Written exam	Graded
Requirements for admission to exam	Oral presentation	Graded/ungraded
		Ungraded

Miscellaneous	Recommended Reading: Janeway's Immunobiology; Kenneth Murphy, Paul Travers, Mark Walport, Charles Janeway; New York: Garland Science, 8E, 2012 Roitt's Essential Immunology; Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt; Wiley-Blackwell 12th Edition 2011

Modul: **Introduction in experimental animal techniques and bioethics**					
Module Number LIMES-003	Workload 90 h	CP 3	Duration 1 Semester	Cycle Annual	
Person responsible Deputy	PD Dr. Heike Weighardt Prof. Dr. Waldemar Kolanus				
	Study course			Category	Semester
	Biochemistry (MSc) Immunobiology: from molecules to integrative systems (MSc)			P	2.
Learning objective	Students should obtain a comprehensive overview of available animal models and be acquainted with the relevant legal and bioethical guidelines of animal experimentation, as well as general rules for good scientific practice.				
Skills	Understanding the advantages and disadvantages of different animal models and their possible application in biomedical research; knowledge of the methodology of animal experimentation and gene targeting techniques; ability to observe animal protection laws and to apply 3R strategies .				
Content	Common laboratory animal models (drosophila; zebra fish, mouse); breeding requirements and animal welfare; importance of genetic background and environmental influences (nutrition; microbiota); in vivo studies of development, metabolism, immunology, neurobiology and behavior; anesthesia and analgesia; gene targeting techniques (homologous recombination in embryonic stem cells; TALEN and CRISPR-Cas technology); German/European legislation for the protection of animals; bioethics and the 3Rs; experimental design and good scientific practice.				
Requirements	None				
Courses	Kind	Subject	Group size	SWS	Workload [h]
	Lecture	Experimental animals and statistics	65	2	90
Examinations	Type of examination			graded/ungraded	
	Written exam			Graded	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					

Module: **Immunology II**				
Module Number MedImmun-04	Workload 180 h	CP 6	Duration 1 Semester	Cycle Annual
Providing institution	LIMES-Institute			
Person responsible Deputy	Prof. Dr. Irmgard Förster Prof. Dr. Andreas Schlitzer			
Representative of the Medical Faculty	Prof. Dr. Natalio Garbi			

	Study Program	Category	Study Semester
	Medical Immunosciences and Infection (M.Sc.) Immunobiology: from molecules to integrative systems (MSc)	P	2.

Learning objective	At the end of this module students have acquired comprehensive knowledge of molecular mechanisms of lymphocyte development and differentiation, and in immunogenetics, covering epigenetic patterns, genetic predisposition, gene rearrangement and polymorphisms. Students can explain cell-cell interactions, chemokine and cytokine mediated cross-talk. Students are familiar with the relevant methodology applied in the field and have acquired advanced conceptual and methodological thinking skills based on the discussion of current scientific literature in immunology.
Skills	Understanding the principles of the immune system Know the key methods and their applications Being able to read, understand and present fundamental issues in innate immunity.
Content	B cell development, T cell development and thymic selection; organization of the Immunoglobulin and T cell receptor locus; mechanism of somatic gene rearrangement, immunoglobulin class switch and somatic hypermutation; BCR and TCR signal transduction; B cell subsets, T helper cell subsets, regulatory T and B cells; lymphocyte migration; intercellular communication; tolerance mechanisms, immunological memory; epigenetic patterns, genetic predisposition, gene rearrangement and polymorphisms.
Requirements	None

	Kind	Subject	Group-size	SWS	Workload [h]
Courses	Lecture Seminar Tutorial	Advanced concepts in immunology	55	2 1 1	90 45 45

Examination(s)	Type of examination	Graded/ungraded
	Written exam	Graded
Requirements for admission to exam	Oral presentation	Graded/ungraded Ungraded
Miscellaneous		

Modul: **Methods course II**				
Module Number LIMES-004	Workload 180 h	CP 6	Duration 1 Semester	Cycle Annual
Person responsible Deputy	PD Dr. Anne Gäbler Prof. Dr. Günter Mayer			
	Study course		Category	Semester
	Biochemistry (MSc) Immunobiology: from molecules to integrative systems (MSc)		P	2.
Learning objective	Students should learn to plan and conduct basic biochemical, immunological and molecular biological experiments within groups based on a simple task.			
Skills	By the end of the course, students should understand the conducted methods in life science research. They should be able to apply the principles of planning and performing an experiment, searching for references and literature, reading, understanding and discussing the content of primary research papers. Students should be able to document and analyze experimental data and present them in a written form after completing the course.			
Content	Molecular cloning: Using molecular biology software and databases for in silico analysis of gene sequences, gene cloning strategies, practical cloning workflow. Yeast Two Hybrid Screen: Preparation of competent yeast cells and their transformation with reporter-, bait- and prey plasmids. Interaction tests of two proteins using appropriate selective media. Autoactivation test of the bait protein choosing selective media and genetic controls. DNA gel electrophoresis. Protein purification: Purification of recombinant and endogenous proteins from *E.coli*. Monitoring protein purification (yield/ purity/ function).			
Requirements	None			
Courses	Kind	Subject	Group size	SWS / Workload [h]
	Practical course	Methods in Life sciences	65	4 / 180
Examinations	Type of examination			graded/ungraded
	Written exam Protocol			Graded (50%) Graded (50%)
Requirements for admission to exam	Active participation in practical course, Records of conducted experiments			ungraded
Miscellaneous				

Modul: **Good Scientific Practice**				
Module Number LIMES-005	Workload 90 h	CP 3	Duration 1 Semester	Cycle Annual
Person responsible Deputy	Prof. Dr. Michael Famulok Dr. Martina van Uelft			
	Study course		Category	Semester
	Biochemistry (MSc) Immunobiology: from molecules to integrative systems (MSc)		P	2.
Learning objective	Students should get insight into aspects of scientific integrity in various practices of daily laboratory work documentations, publications, theses, mentoring, data treatment etc.			
Skills	Being able to understand, judge, and apply ethics and good scientific practice in all aspects of science at all levels of scientific education, with a focus on biochemistry, systems immunology or related life sciences. Being able to spot and identify examples of fraudulent science (e.g. unethical image manipulation, plagiarism, fraudulent application of statistics, cherry-picking etc.). Learning about the consequences of unethical behavior in scientific practice. Post-publication review. Handling misconduct.			
Content	Students will be introduced into: The rules of good scientific practice according to the guidelines of the DFG and other agencies; Examples of data manipulation and research misconduct; Keeping a laboratory notebook; Digital image ethics; Differences between honest errors, differences of opinion, and misconduct; Discussion of case studies; Interactive movie “The Lab” (https://ori.hhs.gov/TheLab/ ; https://www.science.org/content/article/interactive-film-misconduct-infiltrates-lab-rev2)			
Requirements	None			
Courses	Kind	Subject	Group size	SWS / Workload [h]
	Lecture	Scientific Integrity	≤65	1 / 90
Examinations	Type of examination			graded/ungraded
	Written exam			Ungraded
Requirements for admission to exam	None			graded/ungraded
Miscellaneous				

Modul: **Biochemistry and Organic Chemistry**					
Module Number Biochem-003	Workload 90 h	CP 3	Duration 1 Semester	Cycle Annual	
Person responsible Deputy	Prof. Dr. Christoph Thiele Prof. Dr. Michael Famulok				
	Study course			Category	Semester
	Biochemistry (MSc) Immunobiology: from molecules to integrative systems (MSc)			WP	1.
Learning objective	Students should learn the basic structures and pathways in biochemistry and the key organic reactions and reaction mechanisms of relevance for understanding how some biochemical processes work on a chemical basis, in particular enzymatic reactions.				
Skills	Basic knowledge of biochemical pathways Knowledge protein structure and function Knowledge of basic regulatory elements to regulate enzyme activity Understanding the key principles of Organic Chemistry, particularly activation of chemical bonds and reaction mechanisms. Being able to read and understand and present fundamental issues in biochemistry and organic chemistry.				
Content	Basic protein structure and folding, DNA structure and replication, Michaelis-Menten-type kinetics, basic metabolic pathways (Glycolysis, gluconeogenesis, TCA cycle, glyoxalate cycle, pentose phosphate pathway, glycogen metabolism, respiratory chain and ATP synthase, amino acid synthesis and degradation, fatty acid synthesis and beta-oxidation) Key principles of organic reaction mechanisms, key organic reactions of relevance for biological systems with an emphasis on enzymatic mechanisms, basic principles of activation / deactivation of chemical bond breakage and formation, basic principles of some synthetic procedures with emphasis on biological molecules such as DNA, RNA, and peptides.				
Requirements	None				
Courses	Kind	Subject	Group size	SWS	Workload [h]
	Lecture	Biochemistry and organic chemistry	65	2	90
Examinations	Type of examination			graded/ungraded	
	Written exam			Graded, but not included in the calculation of GPA	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					

Modul: **Cell Biology and Immunology**					
Module Number Immuno-002	Workload 90 h	CP 3	Duration 1 Semester	Cycle Annual	
Person responsible Deputy	Prof. Dr. Sven Burgdorf PD Dr. Marc Beyer				
	Study course			Category	Semester
	Biochemistry (MSc) Immunobiology: from molecules to integrative systems (MSc)			WP	1.
Learning objective	Students should apply fundamental knowledge on basic cell-biological and immunological topics on a cellular and molecular level.				
Skills	Understanding the key principles in cell biology and immunology.				
Content	Molecular biology of the cell, cellular compartments, biological membranes, nucleic acids, protein synthesis and degradation, post-translational trafficking of proteins, post-translational modifications of proteins, signaling mechanisms and second messengers, cytoskeleton, endocytosis, energy metabolism in mitchondria, extracellular matrix, cells of the immune system, basic principles of the immune system.				
Requirements	None				
Courses	Kind	Subject	Group size	SWS	Workload [h]
	Lecture	Cell Biology and Immunology	65	2	90
Examinations	Type of examination			graded/ungraded	
	Written exam			Graded, but not included in the calculation of GPA	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					

Modul: **Genetics and Molecular Biology**				
Module Number Immuno-003	Workload 90 h	CP 3	Duration 1 Semester	Cycle Annual
Person responsible Deputy	Prof. Dr. Michael Pankratz PD Dr. Reinhard Bauer			
	Study course		Category	Semester
	Biochemistry (MSc) Immunobiology: from molecules to integrative systems (MSc)		WP	1.
Learning objective	Students learn general concepts of the interactions between various systems of cell and gene regulation and how they can be studied.			
Skills	Understanding the principles of molecular biology and genetics, and combining this knowledge with biology, biochemistry, advanced genetics (genetic engineering) and genomics/bioinformatics.			
Content	Organization of eukaryotic cells and their dynamic functions. Molecular structure and function of DNA and RNA and the mechanisms of replication and transcription. Design and cloning of expression vectors and monitoring gene expression experimentally in whole animals and through quantitative PCR. Description of major mechanisms of signal transduction and how to study such mechanisms by using transgenic animals and forward and reverse genetic methods.			
Requirements	None			
Courses	Kind	Subject	Group size	SWS / Workload [h]
	Lecture	Genetics and Molecular Biology	65	2 / 90
Examinations	Type of examination			graded/ungraded
	Written exam			Graded, but not included in the calculation of GPA
Requirements for admission to exam	None			graded/ungraded
Miscellaneous				

Modul: **Inorganic Chemistry and Physical Chemistry**					
Module Number Biochem-004	Workload 90 h	CP 3	Duration 1 Semester	Cycle Annual	
Person responsible Deputy	Prof. Dr. Thorsten Lang Prof. Dr. Micheal Famulok				
	Study course			Category	Semester
	Biochemistry (MSc) Immunobiology: from molecules to integrative systems (MSc)			WP	1.
Learning objective	Basic understanding of atoms, molecule structure, types of reactions, types of bonding, driving force of a chemical reaction and its velocity.				
Skills	Being capable of understanding fundamental mechanisms on the level of single atoms or small molecules.				
Content	Inorganic chemistry: atomic structure, molecular structure and bonding, acids and bases, oxidation and reduction, coordination compounds. Physical chemistry: thermodynamics (kinetic gas theory, internal energy, enthalpy, entropy, free enthalpy/Gibbs energy, thermochemistry) and kinetics (reaction order, transition states, catalysis).				
Requirements	None				
Courses	Kind	Subject	Group size	SWS	Workload [h]
	Lecture	Inorganic and Physical Chemistry	65	2	90
Examinations	Type of examination			graded/ungraded	
	Written exam			Graded, but not included in the calculation of GPA	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					

Modul: **Labrotation 1: Immunology**				
Module Number Immuno-004	Workload 360 h	CP 12	Duration (weeks) 8	Cycle Every semester
Representative	Prof. Dr. Sven Burgdorf			
	Study Course		Category	Semester
	Immunobiology: from molecules to integrative systems (MSc)		WP	2.
Learning Objective	Students should acquire hands-on experience in scientific research by joining ongoing research projects in the working groups of Immunology at the LIMES Institute. They should be able to design, conduct and evaluate specific immunological or cell biological experiments. The project should be presented in a written report in analogy to a scientific publication, including an informative introduction, comprehensive and logical presentation of the data, as well as a critical discussion and interpretation of the results in light of the relevant literature.			
Skills	Experimental skills in state-of-the-art immunological and cell biological techniques; ability to design scientific experiments and to critically evaluate scientific data; Soft skills in written and oral presentation of scientific results; ability to work in a team.			
Content	The scientific topic of the lab rotation always lies within the scientific scope of the supervisor. By this means, an optimal supervision can be guaranteed.			
Requirements				

Courses	Kind	subject	group size	SWS	Workload [h]
	Laboratory course	Immunology	1	8	360

Examinations	Type of examination	Graded/Ungraded
	- Publication-like written summary of results obtained, data interpretation and discussion - Lab course	Graded (40%) Graded (60%)

Requirements for admission to exam		Graded/Ungraded
	Lab journal regular participation Data presentation in the group seminar	ungraded ungraded ungraded
Miscellaneous		

Modul: **Labrotation 1: Genomics, Epigenetics and Systems Immunology**				
Module Number Immuno-005	Workload 360 h	CP 12	Duration (weeks) 8	Cycle Every semester
Representative	Prof. Dr. Sven Burgdorf			
	Study Course		Category	Semester
	Immunobiology: from molecules to integrative systems (MSc)		WP	2.
Learning Objective	Students should acquire hands-on experience in scientific research by joining ongoing research projects in the working groups of genomics, epigenetics and systems immunology at the LIMES Institute. They should be able to design, conduct and evaluate specific scientific. The project should be presented in a written report in analogy to a scientific publication, including an informative introduction, comprehensive and logical presentation of the data, as well as a critical discussion and interpretation of the results in light of the relevant literature.			
Skills	Planning and implementation of a scientific project, ability to design scientific experiments and to critically evaluate scientific data; Hand-on experience in state-of-the-art methodology, Collecting and interpretation of project-relevant literature, Soft skills in written and oral presentation of scientific results; ability to work in a team.			
Content	The scientific topic of the lab rotation always lies within the scientific scope of the supervisor. By this means, an optimal supervision can be guaranteed.			
Requirements				
Courses	Kind	subject	group size	SWS / Workload [h]
	Laboratory course	Genomics, Epigenetics and Systems Immunology	1	8 / 360
Examinations	Type of examination			Graded/Ungraded
	- Publication-like written summary of results obtained, data interpretation and discussion - Lab course			Graded (40%) Graded (60%)
Requirements for admission to exam	Lab journal regular participation Data presentation in the group seminar			Graded/Ungraded ungraded ungraded ungraded
Miscellaneous				

Modul: **Genomics and Epigenetics**				
Module Number Immuno-006	Workload 135 h	CP 4.5	Duration 1 Semester	Cycle Annual
Person responsible Deputy	Prof. Dr. Joachim Schultze PD Dr. Anna Aschenbrenner			
	Study course		Category	Semester
	Immunobiology: from molecules to integrative systems (MSc)		P	3.
Learning objective	Students should learn the role and underlying molecular working mechanisms of the genome and the epigenome in general and particular in respect to the immune system including the relevant methodology applied in the field.			
Skills	Understanding the principles of genomics and epigenomics Know the key methods and their applications Be able to read, understand and present fundamental issues in genomics and epigenetics			
Content	Basic principles of genomic and epigenetic technologies including DNA- and RNA-sequencing technologies, ChIP-sequencing and open chromatin assessment. Basic principles of single cell RNA-sequencing and other high throughput single cell technologies Applications of these technologies to important immunological questions including cell differentiation and maturation, cell heterogeneity, dynamic regulation of cell activation			
Requirements	None			
Courses	Kind	Subject	Group size	SWS	Workload [h]
	Lecture Seminar	Genomics and Epigenetics	30 30	2 1	90 45
Examinations	Type of examination			graded/ungraded	
	Written exam			graded	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					

Modul: **Systems immunology, Bioinformatics and Big Data Science**				
Module Number Immuno-007	Workload 135 h	CP 4.5	Duration 1 Semester	Cycle Annual
Person responsible Deputy	Prof. Dr. Jan Hasenauer PD Dr. Thomas Ulas			
	Study course		Category	Semester
	Immunobiology: from molecules to integrative systems (MSc)		P	3.
Learning objective	Students should learn the role and the principle approaches applied in systems immunology, bioinformatics and big data science in general and particular in respect to the immune system including the relevant methodology applied in the field.			
Skills	Understanding the principles of systems immunology, bioinformatics and big data science Know the key methods and their applications Be able to read, understand and present fundamental issues in genomics and epigenetics			
Content	Basic principles of the methods applied in systems immunology, bioinformatics and big data science including the analysis of sequencing data, the biological interpretation of high throughput data and the visualization of large dataset. Apply such skills to existing datasets addressing immunological questions. Simulate the circle of systems immunology, learn the basic concept of data-drived hypothesis generation.			
Requirements	None			
Courses	Kind	Subject	Group size	SWS	Workload [h]
	Lecture	Systems immunology, bioinformatics and big data science	30	2	90
	Seminar		30	1	45
Examinations	Type of examination			graded/ungraded	
	Written exam			graded	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					

Modul: **The immune system in barrier organs and immune regulation**					
Module Number Immuno-008	Workload 90 h	CP 3	Duration 1 Semester	Cycle Annual	
Person responsible Deputy	PD Dr. Heike Weighardt Prof. Dr. Waldemar Kolanus				
	Study course			Category	Semester
	Immunobiology: from molecules to integrative systems (MSc)			P	3.
Learning objective	Students should get acquainted with the development and function of barrier organs such as skin, lung and gut. Additionally, they should get an overview of the most important immune regulatory mechanisms				
Skills	Understanding immunity at barrier organs such as skin, lung and gut and the mechanisms underlying immune regulation. Acquisition of methods to analyze immune reactions and host defense mechanisms in the lung, gut and skin. Ability to read and to evaluate literature and to present data				
Content	Development of the barrier organs skin, gut and lung; structure and cellular composition of barrier organs; Barrier function in skin, gut and lung. Immune functions at barrier sites of the body; Specialized immune cells and immune cell compartments in barrier organs Immune regulation, regulatory T cells, regulatory B cells and other regulatory cells, functions of macrophages, immune regulation in different organs and tumors				
Requirements	None				
Courses	Kind	Subject	Group size	SWS	Workload [h]
	Lecture	Immune sytem in barrier organs and immune regulation	30	2	90
Examinations	Type of examination				graded/ungraded
	Written exam				graded
Requirements for admission to exam	None				graded/ungraded
Miscellaneous					

Modul: **Oral examination Immunology**					
Module Number Immuno-009	Workload 180 h	CP 6	Duration (weeks)	Cycle Annual	
Representative	Prof. Dr. Sven Burgdorf				
	Study Course			Category	Semester
	Immunobiology: from molecules to integrative systems (MSc)			P	3.
Learning Objective	Students should acquire profound and comprehensive knowledge on immunological topics, making interconnections between the contents of individual modules on immunology.				
Skills	Profound knowledge on immunology Making interconnections between different areas of immunology				
Content	Oral examination on content and interconnection of modules Immuno-001, MedImmun-04, Immuno-006, Immuno-007 and Immuno-008				
Requirements	Immuno-001,-006,-007,-008 and MedImmun-04				
Courses	Kind	Subject	Group size	SWS	Workload [h]
	Examination	Immunology	1		180
Examinations	Type of examination			Graded/Ungraded	
	Oral exam			graded	
Requirements for admission to exam				Graded/Ungraded	
Miscellaneous					

Modul: **Labrotation 2: Immunology**				
Module Number Immuno-010	Workload 360 h	CP 12	Duration (weeks) 8	Cycle Every semester
Representative	Prof. Dr. Sven Burgdorf			
	Study Course		Category	Semester
	Immunobiology: from molecules to integrative systems (MSc)		WP	3.
Learning Objective	Students should acquire hands-on experience in scientific research by joining ongoing research projects in the working groups of Immunology at the LIMES Institute. They should be able to design, conduct and evaluate specific immunological or cell biological experiments. The project should be presented in a written report in analogy to a scientific publication, including an informative introduction, comprehensive and logical presentation of the data, as well as a critical discussion and interpretation of the results in light of the relevant literature.			
Skills	Experimental skills in state-of-the-art immunological and cell biological techniques; ability to design scientific experiments and to critically evaluate scientific data; Soft skills in written and oral presentation of scientific results; ability to work in a team.			
Content	The scientific topic of the lab rotation always lies within the scientific scope of the supervisor. By this means, an optimal supervision can be guaranteed.			
Requirements				

Courses	Kind	Subject	Group size	SWS	Workload [h]
	Laboratory course	Immunology	1	8	360

Examinations	Type of examination	Graded/Ungraded
	- Publication-like written summary of results obtained, data interpretation and discussion	Graded (40%)
	- Lab course	Graded (60%)

Requirements for admission to exam		Graded/Ungraded
	Lab journal	ungraded
	regular participation	ungraded
	Data presentation in the group seminar	ungraded
Miscellaneous		

Modul: **Labrotation 2: Genomics, Epigenetics and Systems Immunology**				
Module Number Immuno-011	Workload 360 h	CP 12	Duration (weeks) 8	Cycle Every semester
Representative	Prof. Dr. Sven Burgdorf			
	Study Course		Category	Semester
	Immunobiology: from molecules to integrative systems (MSc)		WP	3.
Learning Objective	Students should acquire hands-on experience in scientific research by joining ongoing research projects in the working groups of genomics, epigenetics and systems immunology at the LIMES Institute. They should be able to design, conduct and evaluate specific scientific. The project should be presented in a written report in analogy to a scientific publication, including an informative introduction, comprehensive and logical presentation of the data, as well as a critical discussion and interpretation of the results in light of the relevant literature.			
Skills	Planning and implementation of a scientific project, ability to design scientific experiments and to critically evaluate scientific data; Hand-on experience in state-of-the-art methodology, Collecting and interpretation of project-relevant literature, Soft skills in written and oral presentation of scientific results; ability to work in a team.			
Content	The scientific topic of the lab rotation always lies within the scientific scope of the supervisor. By this means, an optimal supervision can be guaranteed.			
Requirements				
Courses	Kind	subject	group size	SWS / Workload [h]
	Laboratory course	Genomics, Epigenetics and Systems Immunology	1	8 / 360
Examinations				Graded/Ungraded
	- Publication-like written summary of results obtained, data interpretation and discussion - Lab course			Graded (40%) Graded (60%)
Requirements for admission to exam	Lab journal regular participation Data presentation in the group seminar			Graded/Ungraded ungraded ungraded ungraded
Miscellaneous				

<table>
<tr><td colspan="4">Modul:
Master Thesis</td><td colspan="2">UNIVERSITÄT BONN</td></tr>
<tr><td>Module Number
Immuno-012</td><td>Workload
750 h</td><td>CP
30</td><td>Duration
1 Semester</td><td colspan="2">Cycle
Every semester</td></tr>
<tr><td>Representative</td><td colspan="5">Prof. Dr. Sven Burgdorf</td></tr>
<tr><td rowspan="2"></td><td colspan="3">Study Course</td><td>Category</td><td>Semester</td></tr>
<tr><td colspan="3">Immunobiology: from molecules to integrative systems (MSc)</td><td>P</td><td>4.</td></tr>
<tr><td>Learning objective</td><td colspan="5">For experimental master theses, the students will demonstrate how scientific questions can be answered using experimental approaches. They will collect and get an overview of project-relevant literature and identify the remaining open scientific questions for a specific topic. They will develop experimental strategies to answer these questions and will plan and conduct own experiments. They will apply the state of the art methodology and will gather hands-on experience using these techniques. During these experiments, the students will learn which (positive and negative) controls should be included in their experiments and which conclusions can (and cannot) be drawn from a given experimental setup. They will design an experiment in such a way that a correct and precise answer to a specific question can be given. They will interpret scientific experiments and, given a specific result from their experiments, identify the next steps to continue the project.

For non-experimental master theses in the field of computational biology, systems biology, biomathematics or bioinformatics, the students will demonstrate how a specific scientific question can be answered using computational approaches. They will collect and get an overview of project-relevant literature and identify the remaining open scientific questions for a specific topic. They will develop computational strategies to answer these questions and plan and conduct own strategies and algorithms for data analyses. They will be introduced into the state of the art methodology and will gather hands-on experience using these techniques. During computational analysis, the students will learn which (positive and negative) controls should be included in the original experiments and their own data analyses strategy and which conclusions can (and cannot) be drawn from a given experimental and computational setup. They will also learn whether the design of a given experiment (e.g. a genomic experiment) is correct and precise to answer a specific question. They will interpret the outcome of computational analysis of e.g. genomic experiments and, given a specific result from their data, identify the next steps to continue the project.

During the implementation of their master thesis, the students are supervised by a principle investigator from the hosting group.
At the end of their thesis, students will describe their project in a scientific way. Students will write a master thesis, from which the text part is in between 30 and 80 pages including

• A title, which should be focused but still should contain all project-relevant information
• An abstract, in which the scientific topic, the most important findings and resulting conclusions will be summarized briefly.
• An introduction, in which general information to understand the scientific project is provided, an overview of the current literature is given and the aim of the study is pointed out clearly</td></tr>
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<tr><td></td><td colspan="5">

- A material and methods section, in which the experimental procedures are explained precisely
- The results of the scientific project, presented in clear and accurate figures
- A discussion, in which the results are interpreted and in which is described, which consequences can be drawn from the project
- A reference section, in which all cited literature is listed

</td></tr>
<tr><td>Skills</td><td colspan="5">

- Planning and implementation of a scientific project
- Design of scientific experiments
- Hand-on experience in state-of-the-art methodology
- Collecting and interpretation of project-relevant literature
- Interpretation of obtained results
- Generation of clear and informative figures
- Detailed report of experimental protocols
- Writing of a scientific report
- Extracting the most important information for a summary
- Pointing out the impact of the obtained results for the scientific community

</td></tr>
<tr><td>Content</td><td colspan="5">The scientific topic of the master thesis always lies within the scientific scope of the supervisor. By this means, an optimal supervision can be guaranteed.</td></tr>
<tr><td>Requirements</td><td colspan="5">Minimum 60 CP</td></tr>
<tr><td rowspan="2">Courses</td><td>Kind</td><td>Subject</td><td>Group Size</td><td>SWS</td><td>Workload [h]</td></tr>
<tr><td>Master Thesis</td><td>Individual research project</td><td>1</td><td></td><td>750</td></tr>
<tr><td rowspan="2">Examination</td><td colspan="4">Type of examination</td><td>Graded/ungraded</td></tr>
<tr><td colspan="4">Evaluation of the Master Thesis by two examiners</td><td>graded</td></tr>
<tr><td rowspan="2">Requirements for admission to exam</td><td colspan="4" rowspan="2">Attendance of at least 20 scientific talks in the field of biomedicine</td><td>Graded/ungraded</td></tr>
<tr><td>ungraded</td></tr>
<tr><td>Miscellaneous</td><td colspan="5"></td></tr>
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