






Modulhandbuch

Master of Science


Immunobiology: from molecules to integrative systems


Modul: Methods in life sciences and statistics				 UNIVERSITÄT BONN	
Module Number LIMES-001	Workload 90	CP 3	Duration 1 Semester	cycle annual	
Representative	Prof. Dr. Christoph Thiele, Prof. Dr. Matthias Schmid				
Providing institution	LIMES-Institute Institute of Medical Biometry, Medical Informatics, and Epidemiology				
	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, Chi ² -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	Prüfungsform(en)			graded/ungraded	
	Written exam			Graded	
Requirements for admission to exam				graded/ungraded	
Miscellaneous					


Modul: Methods course I				 UNIVERSITÄT BONN	
Module Number LIMES-002	Workload 450	CP 15	Duration 1 Semester	cycle annual	
Representative	Prof. Dr. Günter Mayer				
Providing institution	LIMES-Institute				
	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 or molecular biological experiments either on their own or within groups based on a simple task.				
Skills	By the end of the course, students should know and 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. They should understand the methods in biochemical research.				
Content	Cloning of DNA, isolation of lipids, proteins, metabolites, DNA or RNA from tissues, purification of recombinant proteins, enzyme activity assays, plasmid transfection, theory and practice on buffer generation				
Requirements	none				
Courses	Kind	Subject	Group size	SWS	Workload [h]
	Practical course	Methods in Life sciences	65	10	450
Examinations	Prüfungsform(en)			graded/ungraded	
	Written exam			Graded (50%)	
	Protocol			Graded (50%)	
Requirements for admission to exam	Records of conducted experiments			graded/ungraded ungraded	
Miscellaneous					


Module: Immunology I				 UNIVERSITÄT BONN	
Module Number Immuno-001	Workload 180h	CP 6	Duration 1 Semester	cycle annual	
Person in charge of the module	Prof. Sven Burgdorf, Prof. Eicke Latz				
Teaching Unit offering the module	LIMES-Institute Institute of Innate Immunity				
Applicability of the module	Study Program		Mode	Study Semester	
	Immunobiology: from molecules to integrative systems (MSc) Medical Immunosciences and Infection (M.Sc.)		P	1.	
Learning Outcomes	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.				
Key competences	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				
Contents	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.				
Prerequisites for participation	None				
Course elements	Teaching mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Biology of immune responses	45	2	90
	Tutorial			1	45
	Seminar			1	45
Examination(s)	Type of examination(s)			Graded/ non-graded	
	Written examination			graded	
Study elements required as prerequisite for admission to the module examination	Full attendance of seminar, oral presentation in literature seminar with an accompanying written handout			Graded/ non-graded	
				Non-graded	
Additional Information	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 12 th Edition 2011
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Modul: Introduction in experimental animal techniques and bioethics				 UNIVERSITÄT BONN	
Module Number LIMES-003	Workload 90	CP 3	Duration 1 Semester	cycle annual	
Representative	Prof. Dr. Irmgard Förster				
Providing institution	LIMES-Institute				
	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	Prüfungsform(en)			graded/ungraded	
	Written exam			Graded	
Requirements for admission to exam	none			graded/ungraded	
Miscellaneous					


Module: Immunology II				 UNIVERSITÄT BONN	
Module Number MedImmun-04	Workload 180h	Extent 6 LP	Duration 1 Semester	Cycle Annual	
Person in charge of the module	Prof. Dr. Irmgard Förster, Prof. Christian Kurts				
Teaching Unit offering the module	Institute of Experimental Immunology LIMES-Institute				
Applicability of the module	Study Program		Mode	Study Semester	
	Medical Immunosciences and Infection (M.Sc.) Immunobiology: from molecules to integrative systems (MSc)		P	2.	
Learning Outcomes	<p>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.</p> <p>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.</p>				
Key competences	<p>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</p>				
Contents	<p>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.</p>				
Prerequisites for participation	None				
Course elements	Teaching mode	Topic	Group-size	SWS	Workload [h]
	Lecture	Advanced concepts in immunology	45	2	90
	Seminar			1	45
Tutorial	1			45	
Examination(s)	Type of examination(s)			Graded/ non-graded	
	Written examination			graded	
Study elements required as prerequisite for admission to the module examination	Full attendance of seminars, oral presentation in one seminar with an accompanying written handout			Graded/ non-graded	
				Non-graded	
Miscellaneous					


Modul: Methods course II				 UNIVERSITÄT BONN	
Module Number LIMES-004	Workload 450	CP 15	Duration 1 Semester	cycle annual	
Representative	Prof. Dr. Günter Mayer				
Providing institution	LIMES-Institute				
	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 or molecular biological experiments either on their own or within groups based on a simple task.				
Skills	By the end of the course, students should know and 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. They should understand the methods in biochemical research.				
Content	Advanced techniques in life sciences including different types of microscopy, basic principles of fluorescence, flow cytometry and ELISA				
Requirements	none				
Courses	Kind	Subject	Group size	SWS	Workload [h]
	Practical course	Methods in Life sciences	65	4	180
Examinations	Prüfungsform(en)			graded/ungraded	
	Written exam			Graded (50%)	
	Protocol			Graded (50%)	
Requirements for admission to exam	Records of conducted experiments			graded/ungraded	
				ungraded	
Miscellaneous					


Modul: Biochemistry and Organic Chemistry				 UNIVERSITÄT BONN	
Module Number Biochem-003	Workload 90	CP 3	Duration 1 Semester	cycle annual	
Representative	Prof. Dr. Christoph Thiele and Prof. Dr. Michael Famulok				
Providing institution	LIMES-Institute				
	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	Prüfungsform(en)			graded/ungraded	
	Written exam			ungraded	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					

Modul: Cellbiology and Immunology				 UNIVERSITÄT BONN		
Module Number Immuno-002	Workload 90	CP 3	Duration 1 Semester	cycle annual		
Representative	Prof. Dr. Sven Burgdorf and PD Dr. Marc Beyer					
Providing institution	LIMES-Institute					
	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 mitochondria, 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	Prüfungsform(en)				graded/ungraded	
	Written exam				ungraded	
Requirements for admission to exam	None				graded/ungraded	
Miscellaneous						


Modul: Genetics and Molecular Biology				 UNIVERSITÄT BONN	
Module Number Immuno-003	Workload 90	CP 3	Duration 1 Semester	cycle annual	
Representative	Prof. Dr. Michael Pankratz and PD Dr. Reinhard Bauer				
Providing institution	LIMES-Institute				
	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	Prüfungsform(en)			graded/ungraded	
	Written exam			ungraded	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					


Modul: Inorganic Chemistry and Physical Chemistry				 UNIVERSITÄT BONN	
Module Number Biochem-004	Workload 90	CP 3	Duration 1 Semester	cycle annual	
Representative	Prof. Dr. Thorsten Lang				
Providing institution	LIMES-Institute				
	Study course		Category	Semester	
	Biochemistry (MSc) Immunobiology: from molecules to integrative systems (MSc)		WP	1.	
Learning objective	Students should obtain basic knowledge of inorganic chemistry and physical chemistry				
Skills	Being capable of understanding fundamental mechanisms on the level of single atoms or small molecules.				
Content	Inorganic chemistry: salts, ions, hydration, coordination chemistry, acids and bases, inorganic reactions, solubility product Physical chemistry: thermodynamics (kinetic gas theory, enthalpy, entropy, free enthalpy) 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	Prüfungsform(en)			graded/ungraded	
	Written exam			ungraded	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					


Modul: Insights in the workflow of life science companies 1				 UNIVERSITÄT BONN	
Module Number LIMES-005	Workload 90	CP 3	Duration 1 Semester	cycle annual	
Representative	Prof. Dr. Joachim Schultze				
Providing institution	LIMES-Institute				
	Study course		Category	Semester	
	Biochemistry (MSc) Immunobiology: from molecules to integrative systems (MSc)		WP	2.	
Learning objective	Students should get insights into basic work routines, operational procedures, organizational structures and employment opportunities for scientists with a master's or PhD degree in molecular and systems immunology or related life science degrees in general and particular in respect to organizations focusing on immune system-related products or services.				
Skills	Being able to understand, classify and judge the employment opportunities for scientists with a master's or PhD degree in molecular and systems immunology or related life science degrees in industry or other areas within the private sector (e.g. funding agencies, foundations, non-profit organizations, etc.) Get firsthand knowledge about employment opportunities and start networking with colleagues within the private sector				
Content	Students will get the opportunity to visit two selected organizations within the private sector to get insights into how these organizations operate, how they are organized, and what the working conditions are. An emphasis will be research and development within these organizations. Students will also learn to organize such visits autonomously. Concerning the format of the visits students will be granted sufficient freedom of decision.				
Requirements	none				
Courses	Kind	Subject	Group size	SWS	Workload [h]
	2 Excursions	Workflow in companies and institutions from life sciences	22	1	90
Examinations	Prüfungsform(en)			graded/ungraded	
	None			Ungraded	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					


Modul: Insights in the workflow of life science companies 2				 UNIVERSITÄT BONN	
Module Number LIMES-006	Workload 90	CP 3	Duration 1 Semester	cycle annual	
Representative	Prof. Dr. Joachim Schultze				
Providing institution	LIMES-Institute				
	Study course		Category	Semester	
	Biochemistry (MSc) Immunobiology: from molecules to integrative systems (MSc)		WP	2.	
Learning objective	Students should get insights into basic work routines, operational procedures, organizational structures and employment opportunities for scientists with a master's or PhD degree in molecular and systems immunology or related life science degrees in general and particular in respect to organizations focusing on immune system-related products or services. They will learn about research and development of life science products and services in industry directly from representatives of selected companies that agreed to present themselves within the master program.				
Skills	<p>Being able to understand, classify and judge the employment opportunities for scientists with a master's or PhD degree in molecular and systems immunology or related life science degrees in industry or other areas within the private sector (e.g. funding agencies, foundations, non-profit organizations, etc.)</p> <p>Understanding the principles of research and development in the life science sector with an emphasis on 'red' biotechnology, pharma, medical engineering, and the life science software industry sectors. Know the key research and development approaches and their applications within these companies.</p>				
Content	<p>Students will get the opportunity to visit one selected organization within the private sector to get insights into how these organizations operate, how they are organized, and what the working conditions are. An emphasis will be research and development within these organizations.</p> <p>Additionally, they will attend one interactive workshop with company representatives from research and development, strategic management, marketing or sales, students will get to know the basic aspects of products, services and the research and development leading to these products</p> <p>Students will also get the opportunity to discuss issues concerning industrial research and development, products, services and sales with representatives of the respective companies providing the workshops.</p>				
Requirements	none				
Courses	Kind	Subject	Group size	SWS	Workload [h]
	1 Excursion	Workflow in companies and institutions from life sciences	1	1	45
	1 Seminar	Workflow in companies and institutions from life sciences	22		45


Examinations	Prüfungsform(en)	graded/ungraded
	None	Ungraded
Requirements for admission to exam	None	graded/ungraded
Miscellaneous		


Modul: Insights in the workflow of life science companies 3				 UNIVERSITÄT BONN	
Module Number LIMES-007	Workload 90	CP 3	Duration 1 Semester	cycle annual	
Representative	Prof. Dr. Joachim Schultze				
Providing institution	LIMES-Institute				
	Study course		Category	Semester	
	Biochemistry (MSc) Immunobiology: from molecules to integrative systems (MSc)		WP	2.	
Learning objective	Students will learn about research and development of life science products and services in industry directly from representatives of selected companies that agreed to present themselves within the master program.				
Skills	<p>Understanding the principles of research and development in the life science sector with an emphasis on 'red' biotechnology, pharma, medical engineering, and the life science software industry sectors. Know the key research and development approaches and their applications within these companies.</p> <p>Being able to read, understand and present fundamental issues in the area of research and development of the respective company.</p>				
Content	<p>Students will attend two interactive workshops with company representatives from research and development, strategic management, marketing or sales, students will get to know the basic aspects of products, services and the research and development leading to these products</p> <p>Students will also get the opportunity to discuss issues concerning industrial research and development, products, services and sales with representatives of the respective companies providing the workshops.</p>				
Requirements	none				
Courses	Kind	Subject	Group size	SWS	Workload [h]
	2 Seminars	Workflow in companies and institutions from life sciences	22	1	90
Examinations	Prüfungsform(en)			graded/ungraded	
	None			Ungraded	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					


Modul: Labrotation 1: Immunology				 UNIVERSITÄT BONN	
Module Number Immuno-005	Workload 360 h	CP 12	Duration (weeks) 8	Cycle Every semester	
Representative	Prof. Dr. Sven Burgdorf				
Institution	LIMES-Institute				
	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				Graded/Ungraded	
	<ul style="list-style-type: none"> - 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: Labrotation 1: Genomics, Epigenetics and Systems Immunology				 UNIVERSITÄT BONN	
Module Number Immuno-006	Workload 360 h	CP 12	Duration (weeks) 8	Cycle Every semester	
Representative	Prof. Dr. Sven Burgdorf				
Institution	LIMES-Institute				
	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				Graded/Ungraded	
	<ul style="list-style-type: none"> - 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				 UNIVERSITÄT BONN	
Module Number Immuno-006	Workload 135	CP 4,5	Duration 1 Semester	cycle annual	
Representative	Prof. Dr. Joachim Schultze				
Providing institution	LIMES-Institute				
	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	Genomics and Epigenetics	25	2	90
Seminar	25		1	45	
Examinations	Prüfungsform(en)			graded/ungraded	
	Written exam			graded	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					


Modul: Systems immunology, Bioinformatics and Big Data Science				 UNIVERSITÄT BONN	
Module Number Immuno-007	Workload 135	CP 4,5	Duration 1 Semester	cycle annual	
Representative	Prof. Dr. Joachim Schultze				
Providing institution	LIMES-Institute				
	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-driven hypothesis generation.				
Requirements	none				
Courses	Kind	Subject	Group size	SWS	Workload [h]
	Lecture	Systems immunology, bioinformatics and big data science	25	2	90
Seminar	25		1	45	
Examinations	Prüfungsform(en)			graded/ungraded	
	Written exam			graded	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					

Modul: The immune system in barrier organs and immune regulation				 UNIVERSITÄT BONN	
Module Number Immuno-008	Workload 90	CP 3	Duration 1 Semester	cycle annual	
Representative	PD Dr. Heike Weighardt				
Providing institution	LIMES-Institute				
	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 system in barrier organs and immune regulation	25	2	90
Examinations	Prüfungsform(en)			graded/ungraded	
	Written exam			graded	
Requirements for admission to exam	None			graded/ungraded	
Miscellaneous					

Modul: Oral examination Immunology				 UNIVERSITÄT BONN	
Module Number Immuno-009	Workload 180 h	CP 6	Duration (weeks)	Cycle annual	
Representative	Prof. Dr. Sven Burgdorf				
Institution	LIMES-Institute				
	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				Graded/Ungraded	
	Oral exam			graded	
Requirements for admission to exam				Graded/Ungraded	
Miscellaneous					

Modul: Labrotation 2: Immunology				 UNIVERSITÄT BONN		
Module Number Immuno-010	Workload 360 h	CP 12	Duration (weeks) 8	Cycle Every semester		
Representative	Prof. Dr. Sven Burgdorf					
Institution	LIMES-Institute					
	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				Graded/Ungraded		
	<ul style="list-style-type: none"> - 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 2: Genomics, Epigenetics and Systems Immunology				 UNIVERSITÄT BONN		
Module Number Immuno-011	Workload 360 h	CP 12	Duration (weeks) 8	Cycle Every semester		
Representative	Prof. Dr. Sven Burgdorf					
Institution	LIMES-Institute					
	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		
	<ul style="list-style-type: none"> - Publication-like written summary of results obtained, data interpretation and discussion - Lab course 			<ul style="list-style-type: none"> - 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: Master Thesis				 UNIVERSITÄT BONN	
Module Number Immuno-012	Workload 750 h	CP 30	Duration 1 Semester	Cycle Every semester	
Representative	Prof. Dr. Sven Burgdorf				
Providing Institution(s)	LIMES Institute				
	Study Course		Category	Semester	
	Immunobiology: from molecules to integrative systems (MSc)		P	4.	
Learning objective	<p>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.</p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <input type="checkbox"/> A title, which should be focused but still should contain all project-relevant information 				

	<ul style="list-style-type: none"> <input type="checkbox"/> An abstract, in which the scientific topic, the most important findings and resulting conclusions will be summarized briefly. <input type="checkbox"/> 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 <input type="checkbox"/> A material and methods section, in which the experimental procedures are explained precisely <input type="checkbox"/> The results of the scientific project, presented in clear and accurate figures <input type="checkbox"/> A discussion, in which the results are interpreted and in which is described, which consequences can be drawn from the project <input type="checkbox"/> A reference section, in which all cited literature is listed 				
Skills	<ul style="list-style-type: none"> <input type="checkbox"/> Planning and implementation of a scientific project <input type="checkbox"/> Design of scientific experiments <input type="checkbox"/> Hand-on experience in state-of-the-art methodology <input type="checkbox"/> Collecting and interpretation of project-relevant literature <input type="checkbox"/> Interpretation of obtained results <input type="checkbox"/> Generation of clear and informative figures <input type="checkbox"/> Detailed report of experimental protocols <input type="checkbox"/> Writing of a scientific report <input type="checkbox"/> Extracting the most important information for a summary <input type="checkbox"/> Pointing out the impact of the obtained results for the scientific community 				
Content	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.				
Requirements	Minimum 60 CP				
Courses	Kind	Subject	Group Size	SWS	Workload [h]
	Master Thesis	Individual research project	1		750
Examination				Graded/ungraded	
	Evaluation of the Master Thesis by two examiners			graded	
Requirements for admission to exam	Attendance of at least 20 scientific talks in the field of biomedicine			Graded/ungraded	
				ungraded	
Miscellaneous					