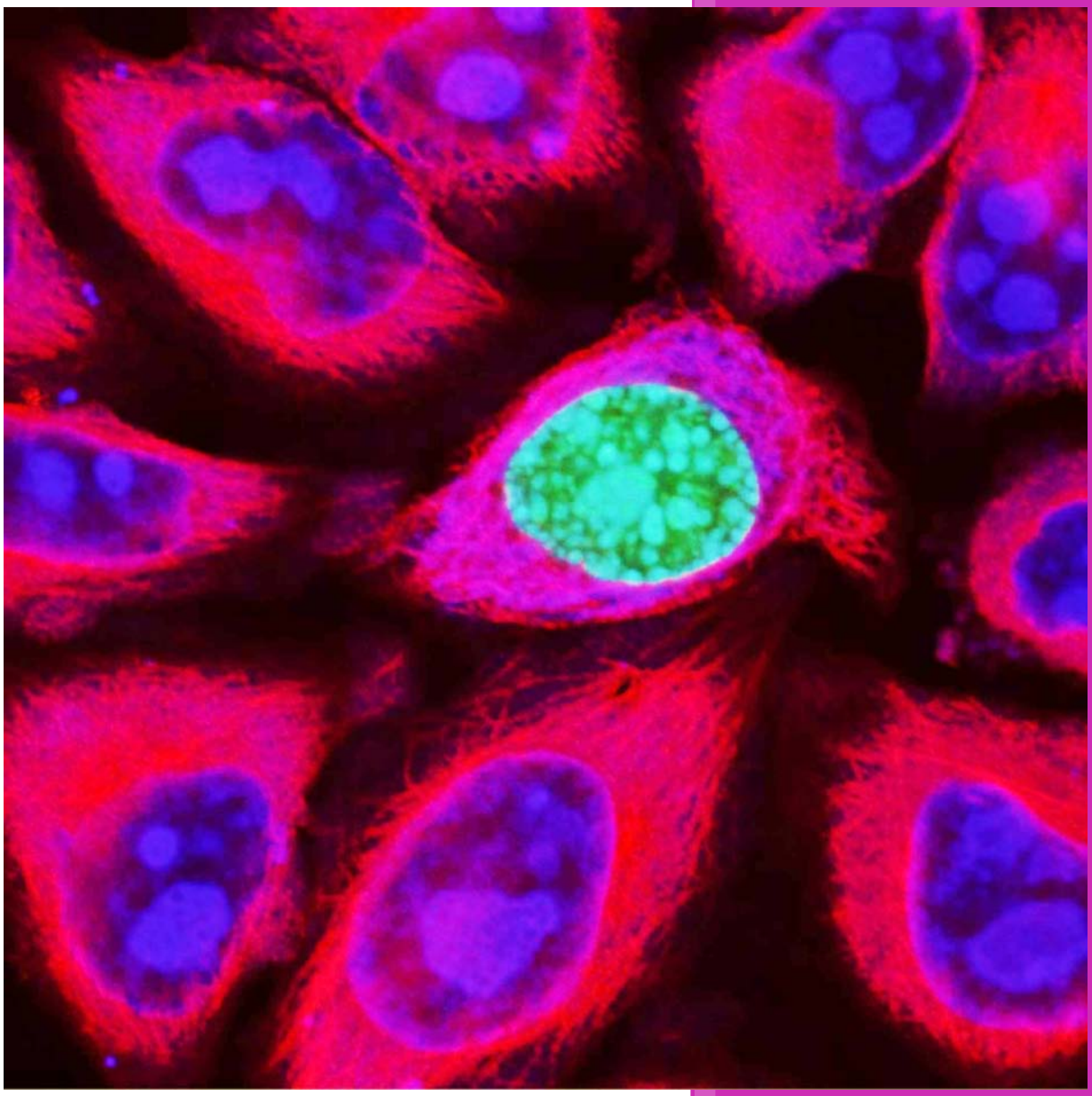

Module descriptions: Master's programme Medical Life Sciences

Medizinische Fakultät der
Christian-Albrechts-Universität zu Kiel

Module descriptions for the
Master's programme **Medical Life Sciences**
November 2021
www.medlife.uni-kiel.de
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General explanations

Faculty

The Master's programme ***Medical Life Sciences*** is hosted, organised and coordinated by the Medical Faculty of Kiel University. Information on individual module coordinators is provided in the module descriptions.

Organisers

The organiser of the module is indicated by the abbreviated name of the institute in charge of it. The lecturers' affiliation is given in brackets. The lecturer responsible for the respective module component is printed in bold.

The key to the abbreviations for institute names is as follows:

IKMB – Institut für Klinische Molekularbiologie
IEM – Institut für Experimentelle Medizin
IMIS – Institut für Medizinische Informatik und Statistik
Pathology – Institut für Pathologie
Immunology – Institut für Immunologie
Med. Department I – Klinik für Innere Medizin I mit den Schwerpunkten Gastroenterologie, Hepatologie, Pneumologie, internist. Intensivmed., Endokrinologie, Infektiologie, Rheumatologie, Ernährungs- u. Alterungsmedizin
Med. Department II – Klinik für Innere Medizin II mit den Schwerpunkten Hämatologie und Onkologie
Med. Department III – Klinik für Innere Medizin II mit den Schwerpunkten Kardiologie und Angiologie
IET – Institut für Experimentelle Tumorforschung
Dermatology – Klinik für Dermatologie, Venerologie und Allergologie
Neurology – Klinik für Neurologie
IfE – Institut für Epidemiologie
Human Genetics – Institut für Humangenetik
Experimental Trauma Surgery - Klinik für Orthopädie und Unfallchirurgie

Examination office

Exam registration and administration are managed by
Prüfungsamt der Agrar- und Ernährungswissenschaftlichen Fakultät der
Christian-Albrechts-Universität zu Kiel
Frau Manuela Senkbeil, Frau Susanne Ruhberg
Hermann-Rodewald-Str. 4, 24118 Kiel
Email: pruefungsamt@agrar.uni-kiel.de

Teaching language

The sole teaching language is English. Students do not need German language skills to be able to study Medical Life Sciences.

Workload per credit point

The workload for one credit point is equaled by 30 hours. The total workload for a module does not exceed the maximum that results from multiplying the number of points for the module with 30 hours/point. Workload details for each module component are given in the individual module descriptions. If hours/credit point are less than 30, this is indicated in the respective module description.

Exams and evaluation

If modules or module components are concluded by an exam, the exam is mandatory in the form indicated, there are no alternative exam forms. It is indicated in each module description which components have exams.
Likewise, the module evaluation as graded or ungraded is indicated. If a module is evaluated as ungraded, the respective exam(s) are always ungraded.
All graded modules are considered for calculating the final Master's grade.

Weight of exams

If a module has more than one exam and the module is evaluated as graded, each exam contributes in equal parts to the final module grade. Deviations would be indicated in the individual module description.
If there is one graded exam for a module, the weight of the exam for the module grade is 100%.

Types of modules

All modules that are not marked as electives are mandatory for all students, they must participate in each of those modules.
Electives offer students a choice between three or four different subject courses, one of which they must participate in, they are "elective-compulsory" courses. Electives are indicated as such.
The focus areas are electives since students can choose from various focus areas. The chosen focus area with its respective components/modules needs to be continued through to the Master's thesis. The topic of the Master's thesis falls within the student's chosen focus area.

Application of modules within the university

All modules are designed for and used in the Master's programme ***Medical Life Sciences***.

Abbreviations used

CH = contact hours in lectures, practicals, seminars, tutorials, retreats
CP = credit point(s)

Basics of medical science and pharmacology	
Abbreviation	MedCompact
Subtitle	-
Components	Lectures, practical
When	Semesters 1+2 (Human biology: Summer semester; Pharmacology: winter semester)
Coordinator Organiser	E. Hütten B. Kurz Pharmacology
Lecturers	**V. Wätzig**, T. Herdegen, I. Cascorbi and colleagues (Pharmacology) **B. Kurz** (Human Biology)
Contact hours	Lecture Human Biology 3 CH Practical Human Biology 1 CH Lecture Pharmacology 3 CH
Workload Total: 180 h	Lecture and integrated practical Human Biology (semester 1): 90 h Attendance time 49 h, preparation 20 h, revision 21 h Lecture Pharmacology (semester 2): 90 h Attendance time 38 h, preparation 20 h, revision 32 h
Credit points	6 (Human Biology lecture with practical 3 CP, Pharmacology lecture 3 CP)
Requirements	-
Expected outcome	Knowledge: Students - have gained a sound foundation in human biology with particular emphasis on cytological and anatomical knowledge of organ groups and their function - have acquired enough pharmacological knowledge to understand medical research questions - are familiar with basic terminology in pharmacology - know the fundamental principles of pharmacodynamics and pharmacokinetics -are familiar with the major classes of pharmaceutically active agents and the biochemical mechanisms they exploit. Skills: Students - understand the anatomical and physiological connections between different organ groups in the human body; they can point out their location in the human body and describe their functions - are able to classify pharmacological mechanisms on a molecular level for major disease indications. Competencies: Students - are able to put the acquired knowledge into medical contexts on a molecular level - can relate it to other areas of knowledge (e.g. pathology) - can transfer the acquired pharmacology knowledge to new scientific questions when designing lab experiments in medical research - are able to combine pharmacological knowledge and information on clinical manifestations of diseases and implement this information into molecular research work during their studies.
Content:	Basics of cytology, anatomy (e.g. exocrine glands, bones and cartilage, skin, nervous tissue, muscle tissue, motor end plate, blood-brain barrier, autonomic and central nervous system, blood, lymphatic organs, respiratory organs, liver,

	gastro-intestinal tract, heart function/ECG). Pharmacokinetics and pharmacodynamics; pharmaceutical agents and pharmacological mechanisms for major indications on a molecular level; toxicokinetics; drug safety and approval.
Module evaluation/ exam	Graded Exam interview Human Biology (1st semester) Written exam Pharmacology (2nd semester)
Media used	PPT presentations, macroscopic/microscopic specimens
Literature	**Human biology** Marieb Elaine N, Hoehn Katja, Human Anatomy and Physiology (Pearson Education 2013). Ross Michael H., Wojciech Pawlina, Histology, a Text and Atlas. (Lippincott Raven 2010). **Pharmacology** Rang HP, Dale MM, Ritter JM, Flower RJ, Henderson G, Rang and Dale's Pharmacology (Elsevier Churchill Livingstone 2015)
Clinical manifestations of diseases and cell biology for clinical research	
Abbreviation	IntroMed
Subtitle	-
Module components	Lectures, tutorial, seminar
When	Semester 1 (summer semester)
Module coordinator Organiser	E. Hütten A. Klettner (Ophthalmology) + H. Emmert (Dermatology); K. Reiß (Dermatology)
Lecturers	Clinical manifestations of diseases: **A. Klettner** (Ophthalmology), K. Aden, D. Schulte (Med. Department I), **H. Emmert**, G. Heinze (Dermatology), G. Kuhlenbäumer (Neurology) and colleagues Clinical Cell Biology: **K. Reiß** (Dermatology), H. Schäfer (IET), H. Emmert (Dermatology), C. Geismann (Med. Department I)
Contact hours	Lecture Clinical manifestations 2 CH Tutorial Clinical manifestations 1 CH Lecture Clinical cell biology 2 CH Seminar Clinical cell biology 1 CH
Workload Total: 180 h	Lecture Clinical manifestations of diseases: 60 h Attendance time 26 h, preparation 10 h, revision 24 h Tutorial Clinical manifestations of diseases: 30 h Attendance time 14 h, preparation 6 h, revision 10 h Lecture Clinical cell biology: 60 h Attendance time 26 h, preparation 10 h, revision 24 h Seminar Clinical cell biology: 30 h Attendance time 14 h, preparation 10 h, revision 6 h
Credit points	6 (lecture Clinical manifestations 2 CP, tutorial 1 CP; lecture Clinical cell Biology 2 CP, seminar 1 CP)
Requirements	-
Expected outcome	Knowledge: Students - can apply and explain the most important medical terms correctly - have an overview knowledge of the structure of organs/organ groups and can describe the diseases discussed in the lecture - can describe the methods of examination introduced in the tutorials - are familiar with the basics of cell biological processes and their relevance for disease-related alterations

	- understand the pathomechanisms of specific disease manifestations (e.g. inflammatory processes, malignant diseases, neuron diseases). Skills: Students - can demonstrate/explain how to use basic methods of examination - can determine a suitable method of examination for different disease manifestations - can apply cell biological principles in developing diagnostic biomarkers and therapy concepts. Competencies: Students - have a thorough overview of the clinical aspects of their studies and are aware of the clinical implications of the courses they are taught during the Master's programme - are capable of recognising the clinical aspects that are part of the different focus areas - understand cell biological processes in disease development conceptually.
Content	Lecture Clinical manifestations of diseases: Important fields of medicine and typical disease manifestations, basic medical terminology, theoretical introduction to clinical problems (e.g. allergies, anatomy and physiology of the kidneys/kidney diseases, stroke, Parkinson's disease, MS, epilepsy, physiology of the skin, skin diseases, cardiovascular system; pain management). Tutorial Clinical manifestations of diseases: Basic examination methods (e.g. tactile examinations; blood pressure measurement; imaging techniques such as MRI, X-ray, PET scan), areas of application and demonstrations. Lecture Clinical cell biology: Carbohydrate/Lipid and energy metabolism, liver metabolism, cell communication, basics of signal transduction, regulation/deregulation of ligand-receptor interactions, Ubiqitin-Proteasome System, oxidative and genotoxic stress, proteolysis as regulative mechanism in cell biology and pathophysiology: classes of proteases, ectodomain proteolysis, intramembrane proteolysis, regulation of signal transduction by proteolysis; transcription factor NFκB, phospholiophase A2 family, signal transduction in antigen presentation and co-stimulation, compartmentalisation of signalling pathways. Seminar Clinical cell biology: Knowledge consolidation via current publications
Module evaluation/ exam	Graded Clinical cell biology: oral exam [individual exam] Clinical manifestations of diseases: written exam [individual exam] Weight of each exam part for final grade: 50%
Media used	PPT presentations, clinical case studies, handouts, textbooks.
Literature	**Clinical manifestations of diseases** Longmore M, Wilkinson B, Baldwin A, Wallin E, Oxford Handbook of Clinical Medicine (OUP 2014, 9th edition) Runge M, Greganti M, Netter's Internal Medicine (Saunders 2008, 2nd edition) Longo D, Fauci A, Kasper D, Hauser S, Jameson J, Loscalzo J, Harrison's Manual of Medicine, 18th edition (McGraw-Hill Professional 2012) Kandel E, Schwarz J, Jessell T, Siegelbaum S, Hudspeth A, Principles of Neural Sciences (McGraw-Hill Publishing Company, 5th edition, 2012) **Clinical cell biology** Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P, Molecular Biology of the Cell (Garland Science 2007) Heinrich PC, Müller M, Graeve L, Löffler/Petrides Biochemie und Pathobiochemie (Springer 2014, 9th edition) Gaw A, Murphy M, Srivastava R, Clinical biochemistry – an illustrated colour

	text, 5th edition (Elsevier 2013) Nelson DL, Cox MM, Lehninger Principles of Biochemistry: International Edition (Macmillan Education 6th edition, 2013) Current scientific publications
Basics of molecular biology	
Abbreviation	MolBio
Subtitle	-
Module components	Lecture, practical, retreat, tutorial
When	Semester 1 (summer semester)
Module coordinator/ Organiser	A. Nebel (IKMB)
Lecturers	A. Tholey, J. Baines (IEM); **A. Nebel**, F. Sommer, S. Jabs, R. Häsler (IKMB), S. Fuchs (Experimental Trauma Surgery), K. Reiß (Dermatology)
Contact hours	Lecture 3 CH Practical 5 CH Retreat 2 CH Tutorial 1 CH
Workload Total: 270 h	Lecture: 60 h Attendance time 38 h, preparation 8 h, revision 14 h Tutorial: 30 h Attendance time 14 h, preparation 6 h, revision 10 h Practical: 150 h Attendance time 60 h, preparation 46 h, revision 24 h Career Day – Molecular biology as a career: 30 h Attendance time 15-20 h, preparation 8-12 h, revision 2-3 h
Credit points	9 (lecture 2 CP, tutorial 1 CP, practical 5 CP, retreat 1 CP)
Requirements	-
Expected outcome	Knowledge: Students - can explain and correctly use molecular-biological terminology -have a thorough basic knowledge of genomics, proteomics and cell biology - understand the most important lab techniques in the research areas mentioned above and can explain the respective underlying principles and concepts. Skills: Students - can apply the basic techniques for safe, precise and tidy lab work - can apply techniques for DNA, RNA and protein analytics and work with cell cultures in the lab efficiently - can write experimental protocols. Competencies: Students - understand the molecular-biological and chemico-physical principles behind lab experiments - are able to interpret, critically review and discuss the acquired data - can transfer their knowledge to other scientific questions.
Content	Lecture and practical: Basics of molecular biology and genomics (DNA/RNA), proteomics, cell biology; lab safety, basic lab techniques (weighing, measuring, pipetting, error analysis, titration, photometric measurements); SDS-PAGE proteins, Western Blotting; protein identification, enzyme kinetics, phosphory-lation, mass spectrometry analytics, plasmid DNA: preparation, processing, agarose gel electrophoresis; cell cultures (laminar flow, cell splitting, cell proliferation, cell viability assays, apoptosis, FACS, ELISA, biological barriers; contamination, transient transfections, transfection analysis, cell stimulation); DNA extraction, PCR, Sanger sequencing, sequence analysis, polymorphism

	detection; RNA extraction, RT-PCR; immunofluorescence staining, live cell imaging. Tutorial: Exercises to corroborate knowledge gained in lecture Retreat: Discussion of focus areas; research-oriented project game.
Module examination/ exam	Ungraded (pass/fail distinction) Written exam lecture + tutorial [individual exam] Lab interviews for practical [compound exam]
Media used	PPT presentations, show-case experiments, manuals and instructions for lab work
Literature	Berg JM, Gumport RI, Stryer L, Tymoczko JL, Biochemistry (W.H. Freeman 2006, 6th edition) Strachan T, Read AP, Human Molecular Genetics (Garland Science 2010, 4th edition) Jones A, Chemistry – An Introduction for Medical and Health Sciences (Wiley 2005) [still valid] Green M, Sambrook J, Molecular Cloning: A Laboratory Manual (Cold Spring Harbor Laboratory Press, 4th edition, 2012) Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P, Molecular Biology of the Cell (Taylor & Francis 2007, 5th edition) Nelson DL, Cox MM, Lehninger Principles of Biochemistry: International Edition (Macmillan Education 6th edition, 2013).
Pathology and Immunology	
Abbreviation	MolPatho/Immu
Subtitle	-
Module components	Lectures, seminar
When	Semesters 1+2 (duration for each part: 2 semesters, starting in the summer semester)
Module coordinator/ Organisers	E. Hütten
Lecturers	Pathology: **P. Rosenstiel** (IKMB) Immunology: **O. Janssen**, H. Oberg, D. Adam, D. Wesch, M. Lettau, A. Scheffold (Immunology)
Contact hours	Lecture Pathology 3 CH Lecture Mol. Pathology 1 CH Seminar Pathology 1 CH Lecture Basic immunology 2 CH Lecture Molecular immunology 2 CH [Immunology also for Biochemistry + Molecular Biology/Biology MSc students]
Workload Total: 240 h	Lecture Pathology 1st semester: 90 h Attendance time 38 h, preparation 20 h, revision 32 h Lecture Molecular Pathology 2nd semester: 30 h Attendance time 14 h, preparation 6 h, revision 10 h Seminar Molecular pathology 2nd semester: 60 h Attendance time 14 h, preparation 24 h, revision 22 h Lecture Introduction to immunology 1st semester: 30 h Attendance time 26 h, revision 4 h Lecture Introduction to molecular immunology 2nd semester: 30 h Attendance time 26 h, revision 4 h
Credit points	8 (lecture Pathology 3 CP; lecture Mol. Pathology 1 CP, seminar 2 CP; lecture Immunology 1 CP, lecture Mol. immunology 1 CP)
Requirements	-

Expected outcome	Knowledge: Students - understand pathological processes of primary disease entities - understand neoplastic and inflammatory processes and their impact on tissue - understand the principles of molecular and cellular change in degenerative diseases of different organ systems (e.g. Alzheimer's disease, Parkinson's disease, prion diseases of the CNS) - are familiar with the development, roles and interaction of cellular and humoral components of innate and adaptive immunity - have a good understanding of the molecular basics of the development of the immune system demonstrated at model systems of various species - are familiar with the molecular basics to differentiate between leucocyte populations (surface antigens, flow cytometry) - have gained thorough knowledge about the molecular interactions of antigen receptor-induced activation and cytokine-induced activation, differentiation and effector function of various leucocytes populations - understand the molecular context of selected key signal transduction pathways in cell growth and cell death - understand normal and pathological immune responses for e.g. allergies, autoimmune diseases, infections, congenital/ acquired immune deficiencies, tumour development, prion diseases, graft rejections. Skills: Students - recognise macro- and microscopic pathological changes and can link them to molecular processes - recognise, understand and can explain cellular processes such as cell differentiation, cell division and cell death for chosen examples. Competencies: Students - understand pathology of malign processes as a concept and can transfer their knowledge to other topics within their studies.
Content	Lectures and seminar Pathology, Molecular pathology: Organisation of the cell/ cell layers/organs; injury and cell death; cell organelles and specific diseases (storage diseases, mitochondrial diseases); regeneration and proliferation; basics of neoplastic diseases; inflammation and diseases of the immune system; bacterial infectious diseases, sepsis, viral infectious diseases; haemorrhage and ischaemia; senescence and age-related changes in cells; degenerative processes; diagnostic techniques; animal models in researching human diseases. Lecture Basic immunology: Basics of immunology, evolution of the immune system; innate and adaptive immunity; antigen presentation and dendritic cells; T-cell and their subpopulations; B-cells and antibodies; allergy, autoimmunity, immunology of infection, tumour immunology, immune deficiencies, tolerance and transplantation immunology, immunology of the skin, immunodiagnostics, tissue typing. Lecture Molecular immunology: Receptor evolution in the innate/adaptive immune system; animal models in immunology; specificity of the immune system: T-cell and B-cell receptors; immune response regulation by cytokines and growth factors; cell growth and apoptosis; compartmentalisation of pathways; techniques in cellular and molecular immunology.
Module evaluation/ exam	Graded Oral exam in Pathology (2nd semester); no exam in Immunology
Media used	PPT presentations, handouts
Literature	**Pathology** Kumar V, Abbas AK, Aster J, Robbins and Coltran Pathologic Basis of Disease

	(Elsevier, 10th edition 2020) Coleman WB, Tsongalis GJ, Molecular Pathology: The Molecular Basis of Human Disease (Academic Press 2009) **Immunology** Murphy K M, Janeway's Immunobiology (Taylor and Francis, 8th edition 2011)
Methodology of scientific research	
Abbreviation	ScienceMethod
Subtitle	Medical statistics
Module components	Lecture, tutorial
When	Semester 1 (summer semester)
Module coordinator/ Organiser	IMIS
Lecturers	A. Caliebe, S. Freitag-Wolf (IMIS)
Contact hours	Lecture 2 CH Tutorial 1 CH
Workload Total: 120 h	Lecture: 60 h Attendance time 26 h, preparation 12 h, revision 22 h Tutorial: 60 h Attendance time 14 h, preparation 26 h, revision 20 h
Credit points	4 (lecture 2 CP, tutorial 2 CP)
Requirements	-
Expected outcome	Knowledge: Students - understand the theoretical and methodological foundations of evidence-based medicine - know the different designs of medico-scientific research approaches including their respective advantages and disadvantages - are familiar with common statistical methods - are familiar with the ethical principles of Good Clinical Practice. Skills: Students can apply common statistical methods. Competencies: Students are able to assess the appropriateness of scientific statements and can evaluate them.
Content	Lecture: Basics of statistics with regard to their application in medicine: GCP, descriptive statistics, probability theory, estimation theory, epidemiology, diagnostic testing, statistical testing, regression and correlation, statistical models. Tutorial: Application and consolidation of knowledge and skills taught in the lecture via exercises and examples.
Module evaluation/ exam	Graded Written exam
Media used	Equation/formula development in class, lecture notes
Literature	Kirkwood BR, Essential Medical Statistics (Wiley-Blackwell, 3rd edition) van Emden H, Statistics for Terrified Biologists (Wiley 2008) Fletcher RH, Fletcher SW, Clinical Epidemiology – the essentials (Lippincott Williams & Wilkins 2012, 5th edition).

Soft Skills	
Abbreviation	-
Subtitle	Skills for scientific research: Introduction to Systems Biology//Studies and Career
Module components	Lecture, tutorial, seminar
When	Semester 1 (summer semester)
Module coordinator/ Organiser	A. Nebel IKMB
Lecturers	A. Nebel
Contact hours	Systems Biology tutorial 2 CH Systems Biology lecture 1 CH Studies and career seminar 2 CH
Workload Total: 120 h	Tutorial and lecture Systems biology (consecutive sessions): 60 h Attendance time 32 h, preparation 28 h Seminar Studies and career: 60 h Attendance time 26 h, preparation 22 h, revision 12
Credit points	4 (Systems biology lecture 1 CP, Systems biology tutorial 1 CP, Studies and career seminar 2 CP)
Requirements	-
Expected outcome	Knowledge: Students - have a thorough understanding of the concepts of systems biology - have a sound grasp of bioinformatical workflows used in systems biology - know the most important data processing techniques for interpretation of large data sets - have gained an overview of potential careers and comprehend what the specific requirements in various career paths are - have familiarized themselves with important principles of working in science. Skills: Students - can formulate potential hypotheses based on bioinformatical data analysis results - can discuss topics in systems biology adequately with informatics fellow students (terminology and argumentation in discussions subject related and relevant) - can use their knowledge to work with modeling approaches in future research projects - can implement knowledge about careers in sciences and the main principles for working in research to their own studies for better progress. Competencies: Students - can structure their studies in accordance with their career plans - can see the use of a wide range of knowledge in different fields and implement it into their studies.
Content	Systems biology: Basic concepts, aims and uses of modeling biological systems; modeling paradigms, modeling metabolic networks, modeling for integration and interpretation of large-scale experimental data sets. Studies and career orientation: Introduction to possible medical research career choices; characteristics of working in science; Good Scientific Practice.
Module evaluation/ exam	Ungraded (pass/fail distinction) Systems biology:

	Written assignments during semester [compound exam] Studies and career: No exam
Media used	PPT presentations, hand-outs, textbook, programming scripts, current publications
Literature	Systems biology: Klipp E, Liebermeister W, Wierling C, Kowald A, Systems biology: A Textbook (Wiley 2016, 2nd edition) Studies and career: Current publications on working in science Literature researched by students on group work topics
Projects	
Abbreviation	-
Subtitle	Project planning
Module components	Seminar, block seminar
When	Semesters 2+3 (duration of module: 2 semesters starting in the winter semester)
Module coordinator/ Organiser	D. Ellinghaus/ IKMB
Lecturers	**D. Ellinghaus** (IKMB); B. Wittig and guest lecturers
Contact hours	Project planning and management 2 CH Block seminar 3 CH
Workload Total: 150 h	Seminar Project planning and management: 60 h Attendance time 26 h, preparation 24 h, revision 10 h Block seminar Meet the expert: 90 h Attendance time 32 h, preparation 52, revision 6 h
Credit points	5 (Seminar Project planning 2 CP, block seminar 3 CP)
Requirements	Active preparation of block seminar
Expected outcome	Knowledge: Students - are familiar with structures and organizations in research funding - know international and national funding agencies, their proposal guidelines - are familiar with the principals of Good Scientific Practice - have a basic understanding of project planning in general and milestone/ timeline planning. Skills: Students - can implement knowledge about project management for their own studies - are able to research suitable project layouts for a given task (internet, funding agency guidelines, internal research) Competencies: Students - can structure their studies better using project management skills - can design ideas and project sketches for lab experiments in preparation for their Master's thesis - can see the use of a wide range of knowledge in different fields and implement it into their studies - can assemble a draft for a small research proposal/project with realistic timelines and budgets.
Content	Project Management: Design and structure of successful research proposals, work plan development for scientific projects, sample acquisition – ground rules, sample processing, data security, Good Scientific Practice. Meet the expert: Defining and inviting a suitable guest speaker for an over-

	arching topic of interest to all students, planning and attending the 3-day block seminar.
Module evaluation/ exam	Ungraded (pass/fail distinction) Oral group presentation (Project management)
Media used	PPT, original papers, student work group presentations
Literature	Current articles
Genetics	
Abbreviation	HumGen
Subtitle	Human genetics/Scientific studies in medical research
Module components	Lectures, practical, seminar
When	Semester 3 (summer semester)
Module coordinator/ Organisers	E. Hütten Human Genetics, IfE
Lecturers	Human genetics: A. Caliebe (Human Genetics) Scientific studies: **W. Lieb** (IfE); B. Wittig (guest lecturer)
Contact hours	Lecture Human genetics 2 CH Practical Human genetics 1 CH Lecture Scientific studies 1 CH Seminar Scientific studies 1 CH
Workload Total: 150 h	Lecture Human genetics: 60 h Attendance time 26 h, preparation 8 h, revision 18 h Practical Human genetics: 30 h Attendance time 14 h, preparation 6 h, revision 10 h Lecture Scientific studies: 30 h Attendance time 14 h, preparation 4 h, revision 12 h Seminar Scientific studies: 30 h Attendance time 14 h, preparation 16 h
Credit points	5 (lecture Human genetics 2 CP, practical 1 CP; lecture Scientific studies 1 CP, seminar 1 CP)
Requirements	-
Expected outcome	Knowledge: Students - are familiar with the essential characteristics of monogenic, polygenic and multifactorial inheritance - are familiar with common numerical and structural chromosomal aberrations and can describe the respective clinical manifestations - have a basic understanding of prenatal genetic diagnostics, epigenetic causes for disease development and somatic genetics - are familiar with the legal requirements regarding the execution of genetic tests - are familiar with general principles of genetic counselling and have a basic understanding of the guidelines for genetic testing -can explain the most important features of evidence-based medicine - are familiar with the various forms of scientific studies and can summarise them (aspects of design, execution, evaluation and interpretation, areas of application) - can explain the concept, structure and applications of biobanking - are familiar with the main principles of interpreting scientific studies and can explain them - are familiar with common statistics software. Skills: Students - can develop family trees and define respective underlying inheritance patterns

	- can calculate disease risks - are able to select a suitable type of scientific study for a specific scientific question - can apply relevant statistics software reasonably well - know how to apply data security and ethical standards to studies and biobanks. Competencies: Students - can interpret simple molecular-genetic and molecular cyto-genetic analyses - can assess the relevance of clinical studies for medical research and take the complexity of studies adequately into account when analysing their results - can evaluate studies with regard to their validity for the question at hand.
Content	Human genetics: Cytogenetic, molecular-genetic and molecular-cytogenetic techniques; formal genetics; prenatal genetic diagnostics, epigenetics, somatic genetics, principles of human genetics, legal provisions for genetic counselling and genetic testing. Scientific studies: Design of and areas of applications for scientific studies and examples (clinical studies, epidemiological studies, biobanks); field reports; basics of study designing, execution and analysis; biobanks (biosample acquisition, organisational structure, technologies, sustainability; national/ international examples); data security aspects in biobanks and clinical studies; ethical aspects (e.g. rights and information of study participants); Good Clinical Practice.
Module evaluation/ exam	Graded Written test for each practical unit (3-4), all tests count in equal parts to form an accumulated grade (Human genetics) [compound exam] Oral presentation (Scientific studies) [individual exm] Weight of exam parts for final grade: 50% each
Media used	PPT presentations, textbooks, scientific papers, internet data bases, example experiments.
Literature	**Human Genetics** Read A, Donnai D, New Clinical Genetics (Scion Publishing 2015, 3rd edition) Strachan T, Read A, Human Molecular Genetics (Garland Science 2010, 4th revised edition) **Scientific studies** Current original publications and review articles
English scientific writing	
Abbreviation	WritEng
Subtitle	-
Module components	Seminars, tutorials
When	Semesters 2+3 (duration of module: 2 semesters starting in the winter semester)
Module coordinator/ Organiser	D. Unterweger, A. Nebel IEM, IKMB
Lecturers	**D. Unterweger, A. Nebel**
Contact hours	Seminar 2nd semester 1 CH Seminar 3rd semester 2 CH Tutorial 2nd semester 1 CH Tutorial 3rd semester 1 CH
Workload	Seminar and tutorial 2nd semester: 60 h Attendance time 26 h, preparation 34 h Seminar and tutorial 3rd semester: 90 h

Total: 150 h	Attendance time 38 h, preparation 42 h, revision 10 h
Credit points	5 (seminar 2nd sem. 1 CP, tutorial 2nd sem. 1 CP, seminar 3rd sem. 2 CH, tutorial 3rd sem. 1 CP)
Requirements	-
Expected outcome	Knowledge: Students -are familiar with the most important grammatical structures of the English language - have acquired the basics of English molecular-biology terminology - have an overview knowledge of different text forms - are familiar with the basics of scientific writing as well as with the structural components of a scientific publication. Skills: Students - are able to draft a grammatically correct, lucid scientific text in English - can use (monolingual) dictionaries and reference books to extract information as efficiently as possible. Competencies: Students - can apply their understanding of the process of writing a scientific publication to writing an own paper - can plan and write (the outline for) a scientific presentation taking into account the envisaged audience, the particularities of the topic and suitable media.
Content	Seminars: English grammar, introduction to relevant dictionaries and reference books, how to use them and what for; techniques for building up vocabulary; the structure of different forms of scientific texts; stylistics (which presentation/text form for which aim and audience, which media?); citation rules, bibliographies/good scientific practice. Tutorials: Developing a concept and draft for a scientific publication, rules and ways of writing and submitting conference abstracts, manuscripts, etc.
Module evaluation/ exam	Ungraded (pass/fail distinction) Written assignments during semester [compound exam]
Media used	PPT presentations, handouts
Literature	Glasman-Deal H, Science Research Writing (Imperial College Press 2010) Oxford Advanced Learner's Dictionary (Cornelsen 2015) Oxford Collocations Dictionary for students of English (OUP 2013, 2nd edition) Swan M, Practical English Usage (OUP 2005) [still valid] Kipfer, B A (ed.), Roget's International Thesaurus (Collins Reference 2011, 7th revised edition) Skern T, Writing Scientific English – a workbook (UTB 2011, 2nd edition)
Bioinformatics	
Abbreviation	BioInfo
Subtitle	-
Module components	Lecture, seminar, tutorial
When	Semester 2 (winter semester)
Module coordinator/ Organiser	D. Ellinghaus/ IKMB
Lecturers	**D. Ellinghaus** (IKMB) and assistants
Contact hours	Lecture 2 CH Seminar 1 CH Tutorial 2 CH
Workload	Lecture: 60 h Attendance time 26 h, preparation 14 h, revision 20 h Seminar: 30 h

Total: 150 h	Attendance time 14 h, preparation 14 h, revision 2 h Tutorial: 60 h Attendance time 26 h, revision 34 h
Credit points	5 (lecture 2 CP, seminar 1 CP, tutorial 2 CP)
Requirements	-
Expected outcome	Knowledge: Students - are familiar with the basics and common terminology of bioinformatics (developing solutions for collecting, managing and interpreting biological data) - can name the most important software applications and resources and describe them exemplarily. Skills: Students - can explain how algorithms discussed in the lecture work (e.g. BLAST) - can elucidate how a short R-script functions - can apply analytical tools. Competencies: Students - can select and apply suitable software for a specific bioinformatics problem - can interpret results the analytical tools used in the tutorial deliver.
Content	Lecture: Overview of bioinformatical work areas; phylogenetic relationships; sequence alignment (e.g. BLAST); gene prediction, genome assembly, protein structure prediction, pathway reconstruction (protein-protein interactions), genetic algorithms (linkage/association). Tutorial: LINUX command line (e.g. processing of large text files); introduction to R, different browsers (NCBI, ENSEMBL, UCSC); data bases and queries; sequence alignment, protein structure prediction; *in silico* evaluation of mutations; developing phylogenetic family trees with sequencing data, analysing gene expression data, eQTL analysis, linkage study analysis, GWAS. Seminar: Consolidation of knowledge by discussing current scientific publications.
Module evaluation/ exam	Graded Written exam
Media used	PPT presentations, scripts
Literature	Alterovitz G, Ramoni M (ed.), Knowledge-based bioinformatics: From analysis to interpretation (John Wiley & Sons 2010) Current scientific publications
New technologies in biomedical research*	
Abbreviation	Techno
Subtitle	-
Module components	Excursions, seminars
When	Semester 3 (summer semester)
Module coordinator/ Organiser	B. Krause-Kyora, E. Hütten IKMB
Lecturers	**B. Krause-Kyora** (IKMB) and guest lecturers
Contact hours	Lecture 2 CH Seminar 1 CH
Workload Total: 75 h	Lecture and seminar with excursions: 75 h Attendance time 50 h (travel time included) Preparation 20 h, revision 5 h
Credit points	3 (lecture 2 CP, seminar 1 CP), ***NOTE: 1 CP for module "Techno" = 25 hrs***
Requirements	-

Expected outcome*	Knowledge: Students - have an understanding of the molecular and technical principles and the areas of application of the biomedical technologies presented - are familiar with the areas of application of the various technologies and know the differences that distinguish one from the other - are aware of possibilities and limitations of defined technologies. Skills: Students can explain the principles on which the presented technologies are based. Competencies: Students - can assess the potential new technologies have for future research and their relevance for different applications - can research potential technology applications for their own research (also by searching the literature efficiently) and discuss possibilities with the respective experts - can integrate methods and technologies into their research projects after assessing their benefits.
Content	Lecture: High throughput sequencing (3rd gen. sequencing), genome and transcriptome analysis, siRNA-mediated gene silencing, microscopy (e.g. LSM, FRET); mass spectrometry in proteome and metabolome analytics and isotopic research; smart materials/micro- and nanotechnology; incorporation of latest technological developments into module syllabus. Seminar: Visits to institutes for instrument demonstrations and presentations
Module evaluation/ exam	Graded Oral presentation
Media used	PPT presentations, handouts, technology demonstrations at the actual instruments
Literature	Current scientific publications
***The knowledge, skills and competencies to be acquired in this module depend on the presented biomedical technologies. Since the module descriptions are designed as a general source of information, for this module the description reflects a general expected outcome due to the fact that the technologies introduced will change over time to reflect the latest developments in biomedical research.**	
Epidemiological and translational research approaches (elective)	
Abbreviation	EpiBio
Subtitle	-
Module components	Lectures, seminars
When	Semesters 2+3 (duration of module: 2 semesters, starting in the winter semester)
Module coordinator/ Organisers	W. Lieb IfE (Epidemiology) 3rd semester electives: Experimental Trauma Surgery (Regen. Medicine), Dermatology (Epithelial barrier functions), Neurology (Neurosciences), IKMB (Metabolomics), University Cancer Center Schleswig-Holstein [UCCSH] (Molecular Diagnostics)
Lecturers	Cardiovascular epidemiology (elective semesters 2+3): **W. Lieb** and staff (Epidemiology) **3rd-semester electives:** a. Regenerative medicine and tissue engineering: S. Fuchs (Experimental Trauma Surgery) b. Epithelial barrier functions: Molecular interaction epithelium – environment:

	J. Harder (Dermatology), c. Clinical, molecular and diagnostic neurosciences: F. Leypoldt (Neurology and Clinical Chemistry), **G. Kuhlenbäumer** (Neurology) d. Metabolomics: H. Zacharias (IKMB) e. Molecular Diagnostics: S. Lipinski (UCCSH), L. Bastian, C. Baldus, M. Brüggemann, C. Pott (Klinik für Innere Medizin II)
Contact hours	Semester 2 Cardiovascular epidemiology: Lecture 2 CH Seminar 1 CH Semester 3 Cardiovascular epidemiology: Lecture 2 CH Seminar 1 CH Semester 3 elective: Lecture 1 CH Seminar 2 CH
Workload Total: 240 h	Lecture Cardiovascular epidemiology semester 2: 60 h Attendance time 26 h, preparation 10 h, revision 24 h Seminar Cardiovascular epidemiology semester 2: 30 h Attendance time 14 h, preparation 10 h, revision 6 h Lecture Cardiovascular epidemiology semester 3: 60 h Attendance time 26 h, preparation10 h, revision 24 h Seminar Cardiovascular epidemiology semester 3: 30 h Attendance time 14 h, preparation 12 h, revision 4 h Elective semester 3 lecture: 30 h Attendance time 14 h, preparation 6 h, revision 10 h Elective semester 3 lab seminar: 30 h Attendance time 26 h, preparation 4 h
Credit points	8 (lectures Epidemiology each 2 CP, seminars each 1 CP; lecture and seminar 3rd-sem. elective 1 CP each)
Requirements	-
Expected outcome	**Cardiovascular epidemiology** Knowledge: Students - have a good understanding of essential methods used in cardiovascular epidemiology - are familiar with the clinical manifestation of major cardiovascular diseases and their traditional risk factors - have a good understanding of new, emerging risk factors (e.g. biomarkers) for cardiovascular diseases. Skills: Students - can explain the interrelation of risk factors and disease risks for cardiovascular diseases - are able to understand and discuss relevant scientific publications. Competencies: Students - can assess diagnostic and screening markers and evaluate their potential areas of application - can assess different models of risk prediction and judge the additional contribution of new biomarkers beyond established risk factors - can conduct literature research to acquire knowledge on a specific topic in cardiovascular epidemiology and assess and discuss the insights gained - are able to prepare the discussion of a scientific paper in team work and present it to their peers.

	Electives 3rd semester **a. Regenerative medicine and tissue engineering** Knowledge: Students - are familiar with the principles and potential fields of application of tissue engineering and regenerative medicine including the use of adult stem cells, biomaterials, bioactive molecules. - can define different cellular and molecular mechanisms in tissue repair - understand 3-D cultures. Skills: Students - can define and isolate adult stem cells in cell cultures in the laboratory; - can handle co-culture models in the laboratory - can apply models to study angiogenesis and wound repair - can apply methods to evaluate repair mechanisms. Competencies: Students -are able to apply interdisciplinary approaches to support tissue regeneration - can develop translational strategies. **b. Epithelial barrier functions: Molecular interaction epithelium – environment** Knowledge: Students - are familiar with the importance of epithelia as physiological barrier against potentially detrimental environmental factors - understand the molecular mechanisms of epithelia for protecting the integrity of their barrier function. Skills: Students can associate disruptions of the epithelial barrier with specific disease manifestations. Competencies: Students - can assess the impact of epithelial barrier disruptions for specific disease manifestations - are able to understand scientific papers, to evaluate and discuss them critically with colleagues. **c. Clinical, molecular and diagnostic neurosciences** Knowledge: Students - have a general understanding of clinical assessment, clinical syndromes, major categories of neurological diseases and diagnostic procedures - have a general understanding of molecular mechanisms underlying neurological disease, their disease models and techniques used in studying them. Skills: Students - are able to apply disease models to human diseases and develop them into translational research - are able to critically discuss relevant scientific publications and draw conclusions for own research projects. - can perform literature research self-reliantly. Competencies: Students - are able to select suitable methods to address specific neuroscientific questions - are able to communicate with clinical neurologists. **d. Metabolomics**: Knowledge: Students - understand the key concepts of metabolomics, metabolism, metabolites, and metabolic networks - are familiar with basic principles of metabolomics analytical tools (nuclear magnetic resonance (NMR) spectroscopy and hyphenated mass spectrometry) and workflows in metabolomics research

	- are familiar with basic principles of high-dimensional statistics/machine learning data analysis in metabolomics Skills: Students - can prepare samples for NMR spectroscopy - can preprocess NMR spectroscopic data - can perform basic statistical data analysis with metabolomics data (e.g. hypothesis testing) - can write R code for selected analysis tasks Competencies: Students - are able to identify metabolites from NMR spectra - are aware of advantages/disadvantages of specific metabolomics analytical tools - are able to select suitable statistical methods for specific research questions in metabolomics. **e. Molecular diagnostics:** Knowledge: Students - understand which influence molecular biology has on state-of-the-art diagnostic methods in medicine, with a particular view to cancer - can explain what precision/personalized medicine is and why this requires particular diagnostic tools - have a good understand of current immunotherapy approaches (e.g. immune checkpoint inhibitors) - are familiar with the theoretical background of basic diagnostic approaches in molecular biology - understand the workflow from sample processing to treatment recommendation. Skills: Students - can conduct a set series of diagnostic routines including samples preparation (e.g. extraction of nucleic acids from blood and tissues, quality check, qPCR, ddPCR, exome sequencing) - can apply software (self-programmed and software packages) to analyse data resulting from sample processing - can use quality control measures to ensure correct sample processing and error eradication in data analysis - are able to establish complete documentation of sample processing and data analysis, case based. Competencies: Students - can establish connections between theoretical knowledge in molecular biology and determined tumour samples to arrive at the best suitable diagnostic approaches for individual samples. - can use gene data bases for extracting relevant information for a given data set of a processed tumour sample with regard to formulating potential treatment suggestions. - are able to transfer case knowledge onto a meta level for further research in precision medicine.
Content	**Cardiovascular epidemiology** Lecture: Primer on epidemiological methods and study designs; contribution of cohort studies to cardiovascular epidemiology; global burden of cardiovascular disease; traditional risk factors for cardiovascular disease; novel risk factors for cardiovascular disease, including genomic and metabolomic markers; assess-ment of new biomarkers and their performance; concepts of screening and risk prediction for cardiovascular disease; subclinical cardiovascular disease; various

	forms of clinical manifestations of cardiovascular disease (e.g. stroke, myocardial infarction, heart failure). Seminars: Discussion of scientific papers and important concepts of cardiovascular epidemiology. Electives 3rd semester **a. Regenerative medicine and tissue engineering** Lecture: Definitions of and examples for regenerative medicine and tissue engineering; interdisciplinary approaches in regenerative medicine; adult stem cells; biocompatibility and functionality of implant materials, bioactive molecules, vascularization as key issue for tissue repair, co-culture models, models for studying angiogenesis, inflammation and tissue repair. Seminar: Discussions of scientific papers on tissue engineering and regenerative medicine with integrated lab experience in experiments using techniques introduced in both lecture and seminar. **b. Epithelial barrier functions: Molecular interaction epithelium – environment** Lecture: Structure and cellular components of epithelia (skin, intestine and respiratory tract); physical barrier functions; strategies for identification and differentiation of pathogenic micro-organisms and members of the commensal microbiota; extracellular and intracellular effector mechanisms for controlling microbial growth; provision of mediators for activation and recruitment of effector cells. Seminar: Hypotheses and discussion: how can dysregulation of the epithelial barrier lead to epithelial infectious and inflammatory diseases; discussion of scientific papers, presentation of current research results. **c. Clinical, molecular and diagnostic neurosciences** Lecture: Clinical diagnostic techniques, movement/neurodegenerative disorders, neuroimmunology, neurovascular diseases, peripheral nervous system, neuroscience of pain, neuroscience of epilepsy. Seminar: Presentation of scientific articles by the students followed by critical group discussion. **d. Metabolomics:** Lecture: Overview of metabolomics and its different applications, important aspects of metabolomics study design, introduction to metabolomics analytical tools (NMR spectroscopy and hyphenated mass spectrometry) and metabolite identification, introduction to metabolomics data preprocessing, statistics and bioinformatics data analysis in metabolomics and interpretation of results in biomedical context Analysis seminar: Preparing samples for NMR spectroscopy (practical lab work), metabolite identification from NMR spectra, computer-based analysis of data in R, writing R code for individual data analysis routines. **e. Molecular diagnostics:** Lecture: Somatic cancer mutations and driver genes, concept of personalized medicine, classes of biomarkers, diagnostic tools: qPCR, ddPR, panel diagnostics; data analysis and interpretation: limits of detection, SNP analysis, databases; practicalities in medicine: health insurance coverage and diagnostics, time-sensitivity, patient-based science. Lab seminar: Workflow and methods in a diagnostic lab, conducting lab diagnostics Computer seminar: Data analysis using bioinformatics and databases
Module evaluation/ exam	Graded Oral exam

Media used	PPT presentations, handouts, textbooks, example experiments
Literature	**Cardiovascular epidemiology** Rothman K, Epidemiology - An introduction (OUP 2012, 2nd edition) Oleckno WA, Epidemiology: Concepts and Methods (Waveland Press Inc. 2008) Selected articles **Regenerative medicine and tissue engineering** von Blitterswijk C, de Boer J, Tissue Engineering (Elsevier 2014, 2nd edition) Current scientific papers **Epithelial barrier functions** Kabelitz D, Schröder J-M, Mechanisms of Epithelial Defense (Karger 2005) Current scientific publications **Clinical, molecular and diagnostic neurosciences** Kandel et al., Principles of Neural Science (McGraw Hill 2012, 5th edition) Ropper A, Samuels M, Klein J, Adams and Victor's Principles of Neurology (McGraw Hill 2014, 10th edition) Research and review articles **d. Metabolomics** Gowda, GA Nagana, and Daniel Raftery, eds. NMR-based Metabolomics: Methods and Protocols. Humana Press, 2019. Cavanagh, John, et al. Protein NMR spectroscopy: principles and practice. Elsevier, 1995. Wehrens, Ron, and Reza Salek, eds. Metabolomics: practical guide to design and analysis. CRC Press, 2019. James, Gareth, et al. An introduction to statistical learning. Vol. 112. New York: springer, 2013. Review and research articles **e. Molecular diagnostics:** William Coleman, Gregory Tsongalis: The Molecular Basis of Human Disease (Academic Press, 1st Edition, 2009) Gregory Tsongalis: Advances in Molecular Pathology, 2021, Volume 4-1 (Elsevier 2021, 1st Edition) Matthew H. Bailey et al.: Comprehensive Characterization of Cancer Driver Genes and Mutations, Cell, Volume 173, Issue 2, 2018, Pages 371-385.e18, ISSN 0092-8674, https://doi.org/10.1016/j.cell.2018.02.060. (https://www.sciencedirect.com/science/article/pii/S009286741830237X)
Inflammatory and degenerative diseases of the eye and translational research approaches (elective)	
Abbreviation	MolOcular
Subtitle	-
Module components	Lectures, seminars
When	Semesters 2+3 (duration of module: 2 semesters, starting in the winter semester)
Module coordinator/ Organisers	A. Klettner Ophthalmology 3rd semester electives: Experimental Trauma Surgery (Regen. Medicine), Dermatology (Epithelial barrier functions), Neurology (Neurosciences), IKMB (Metabolomics), University Cancer Center Schleswig-Holstein [UCCSH] (Molecular Diagnostics)
Lecturers	MolOcular: **A. Klettner** (Ophthalmology) **Electives 3rd semester:** a. Regenerative medicine and tissue engineering: S. Fuchs (Experimental trauma surgery)

	b. Epithelial barrier functions: Molecular interaction epithelium – environment: J. Harder (Dermatology), c. Clinical, molecular and diagnostic neurosciences: F. Leypoldt (Neurology and Clinical Chemistry), G. Kuhlenbäumer (Neurology) d. Metabolomics: H. Zacharias (IKMB) e. Molecular Diagnostics: S. Lipinski (UCCSH), L. Bastian, C. Baldus, M. Brüggemann, C. Pott (Klinik für Innere Medizin II)
Contact hours	Semester 2: Lecture Tracing disease 2 CH Seminar Tracing disease 1 CH Semester 3: Lecture Tracing disease 1 CH Seminar Tracing disease 2 CH Semester 3 elective: Lecture 1 CH Seminar 2 CH
Workload Total: 240 h	Lecture semester 2: 60 h Attendance time 26 h, preparation 14 h, revision 20 h Seminar semester 2: 30 h Attendance time 14 h, preparation 6 h, revision 10 h Lecture semester 3: 30 h Attendance time 14 h, preparation 10 h, revision 6 h Seminar semester 3: 60 h Attendance time 26 h, preparation 20 h, revision 14 h Elective semester 3 lecture: 30 h Attendance time 14 h, preparation 6, revision 10 h Elective semester 3 seminar: 30 h Attendance time 26 h, preparation 4 h
Credit points	8 (semester 2 lecture Tracing disease 2 CP, semester 2 seminar 1 CP, semester 3 lecture 1 CP, semester 3 seminar 2 CP; lecture and seminar 3rd-sem. elective 1 CP each)
Requirements	-
Expected outcome	**MolOcular** Knowledge: Students - are familiar with the role of ocular cells and tissue in physiology and pathology of the eye - have a general understanding of the immune privilege and the ocular immune defense - have a general understanding of pathological mechanisms of selected ocular diseases - have a general understanding of scientific models in ocular research - have a general understanding of conceptualization and planning of research projects Skills: Students - can identify different cells and tissue and prepare primary cultures from the eye - can connect physiological functions and disease processes - can critically discuss the benefits and drawbacks of different model systems and apply this knowledge to their own research projects Competencies: Students - are able to generally assess, discuss and apply research models - are able to apply theoretical and practical knowledge in ocular research.

	Electives 3rd semester **a. Regenerative medicine and tissue engineering** Knowledge: Students - are familiar with the principles and potential fields of application of tissue engineering and regenerative medicine including the use of adult stem cells, biomaterials, bioactive molecules. - can define different cellular and molecular mechanisms in tissue repair - understand 3-D cultures. Skills: Students - can define and isolate adult stem cells in cell cultures in the laboratory - can handle co-culture models in the laboratory - can apply models to study angiogenesis and wound repair - can apply methods to evaluate repair mechanisms. Competencies: Students - are able to apply interdisciplinary approaches to support tissue regeneration - can develop translational strategies. **b. Epithelial barrier functions: Molecular interaction epithelium – environment** Knowledge: Students - are familiar with the importance of epithelia as physiological barrier against potentially detrimental environmental factors - understand the molecular mechanisms of epithelia for protecting the integrity of their barrier function. Skills: Students can associate disruptions of the epithelial barrier with specific disease manifestations. Competencies: Students - can assess the impact of epithelial barrier disruptions for specific disease manifestations - are able to understand scientific papers, to evaluate and discuss them critically with colleagues. **c. Clinical, molecular and diagnostic neurosciences** Knowledge: Students - have a general understanding of clinical assessment, clinical syndromes, major categories of neurological diseases and diagnostic procedures - have a general understanding of molecular mechanisms underlying neurological disease, their disease models and techniques used in studying them. Skills: Students - are able to apply disease models to human diseases and develop them into translational research - are able to critically discuss relevant scientific publications and draw conclusions for own research projects. - can perform literature research self-reliantly. Competencies: Students - are able to select suitable methods to address specific neuroscientific questions - are able to communicate with clinical neurologists. **d. Metabolomics** Knowledge: Students - understand the key concepts of metabolomics, metabolism, metabolites, and metabolic networks - are familiar with basic principles of metabolomics analytical tools (nuclear

	magnetic resonance (NMR) spectroscopy and hyphenated mass spectrometry) and workflows in metabolomics research - are familiar with basic principles of high-dimensional statistics/machine learning data analysis in metabolomics Skills: Students - can prepare samples for NMR spectroscopy - can preprocess NMR spectroscopic data - can perform basic statistical data analysis with metabolomics data (e.g. hypothesis testing) - can write R code for selected analysis tasks Competencies: Students - are able to identify metabolites from NMR spectra - are aware of advantages/disadvantages of specific metabolomics analytical tools - are able to select suitable statistical methods for specific research questions in metabolomics. **e. Molecular diagnostics** Knowledge: Students - understand which influence molecular biology has on state-of-the-art diagnostic methods in medicine, with a particular view to cancer - can explain what precision/personalized medicine is and why this requires particular diagnostic tools - have a good understand of current immunotherapy approaches (e.g. immune checkpoint inhibitors) - are familiar with the theoretical background of basic diagnostic approaches in molecular biology - understand the workflow from sample processing to treatment recommendation. Skills: Students - can conduct a set series of diagnostic routines including samples preparation (e.g. extraction of nucleic acids from blood and tissues, quality check, qPCR, ddPCR, exome sequencing) - can apply software (self-programmed and software packages) to analyse data resulting from sample processing - can use quality control measures to ensure correct sample processing and error eradication in data analysis - are able to establish complete documentation of sample processing and data analysis, case based. Competencies: Students - can establish connections between theoretical knowledge in molecular biology and determined tumour samples to arrive at the best suitable diagnostic approaches for individual samples. - can use gene data bases for extracting relevant information for a given data set of a processed tumour sample with regard to formulating potential treatment suggestions. - are able to transfer case knowledge onto a meta level for further research in precision medicine.
Content	**MolOcular** Lecture: Structure, function and culture of ocular cells and tissues, development, molecular basis of vision, immune privilege, immunology of the eye, animal models, pathomechanisms of selected ocular diseases Seminar: Intensifying the understanding of disease mechanisms, therapeutic

	development, introduction into lab techniques, tutorial for development of research projects. **Electives 3rd semester** **a. Regenerative medicine and tissue engineering** Lecture: Definitions of and examples for regenerative medicine and tissue engineering; interdisciplinary approaches in regenerative medicine; adult stem cells; biocompatibility and functionality of implant materials, bioactive molecules, vascularisation as key issue for tissue repair, co-culture models, models for studying angiogenesis, inflammation and tissue repair. Seminar: Discussions of scientific papers on tissue engineering and regenerative medicine with integrated lab experience in experiments using techniques introduced in both lecture and seminar. **b. Epithelial barrier functions: Molecular interaction epithelium – environment** Lecture: Structure and cellular components of epithelia (skin, intestine and respiratory tract); physical barrier functions; strategies for identification and differentiation of pathogenic micro-organisms and members of the commensal microbiota; extracellular and intracellular effector mechanisms for controlling microbial growth; provision of mediators for activation and recruitment of effector cells. Seminar: Hypotheses and discussion: how can dysregulation of the epithelial barrier lead to epithelial infectious and inflammatory diseases; discussion of scientific papers, presentation of current research results. c. Clinical, molecular and diagnostic neurosciences Lecture: Clinical diagnostic techniques, movement/neurodegenerative dis-orders, neuroimmunology, neurovascular diseases, peripheral nervous system, neuroscience of pain, neuroscience of epilepsy. Seminar: Presentation of scientific articles by the students followed by critical group discussion. **d. Metabolomics** Lecture: Overview of metabolomics and its different applications, important aspects of metabolomics study design, introduction to metabolomics analytical tools (NMR spectroscopy and hyphenated mass spectrometry) and metabolite identification, introduction to metabolomics data preprocessing, statistics and bioinformatics data analysis in metabolomics and interpretation of results in biomedical context Seminar: Preparing samples for NMR spectroscopy (practical lab work), metabolite identification from NMR spectra, computer-based analysis of data in R, writing R code for individual data analysis routines. **e. Molecular diagnostics** Lecture: Somatic cancer mutations and driver genes, concept of personalized medicine, classes of biomarkers, diagnostic tools: qPCR, ddPR, panel diagnostics; data analysis and interpretation: limits of detection, SNP analysis, databases; practicalities in medicine: health insurance coverage and diagnostics, time-sensitivity, patient-based science. Lab seminar: Workflow and methods in a diagnostic lab, conducting lab diagnostics Computer seminar: Data analysis using bioinformatics and databases
Module evaluation/ exam	Graded Oral exam

Media used	PPT presentations, handouts, textbooks, example experiments
Literature	**MolOcular** Forrester et al., The eye – basic science in practice (Saunders) Dartt et al., Immunology, Inflammation and disease of the eye (Academic Press) Review and research articles. **a. Regenerative medicine and tissue engineering** von Blitterswijk C, de Boer J, Tissue Engineering (Elsevier 2014, 2nd edition) Current scientific papers **b. Epithelial barrier functions** Kabelitz D, Schröder J-M, Mechanisms of Epithelial Defense (Karger 2005) Current scientific publications **c. Clinical, molecular and diagnostic neurosciences** Kandel et al., Principles of Neural Science (McGraw Hill 2012, 5th edition) Ropper A, Samuels M, Klein J, Adams and Victor's Principles of Neurology (McGraw Hill 2014, 10th edition) Research and review articles **d. Metabolomics** Gowda, GA Nagana, and Daniel Raftery, eds. NMR-based Metabolomics: Methods and Protocols. Humana Press, 2019. Cavanagh, John, et al. Protein NMR spectroscopy: principles and practice. Elsevier, 1995. Wehrens, Ron, and Reza Salek, eds. Metabolomics: practical guide to design and analysis. CRC Press, 2019. James, Gareth, et al. An introduction to statistical learning. Vol. 112. New York: springer, 2013. Review and research articles **e. Molecular diagnostics** William Coleman, Gregory Tsongalis: The Molecular Basis of Human Disease (Academic Press, 1st Edition, 2009) Gregory Tsongalis: Advances in Molecular Pathology, 2021, Volume 4-1 (Elsevier 2021, 1st Edition) Matthew H. Bailey et al.: Comprehensive Characterization of Cancer Driver Genes and Mutations, Cell, Volume 173, Issue 2, 2018, Pages 371-385.e18, ISSN 0092-8674, https://doi.org/10.1016/j.cell.2018.02.060. (https://www.sciencedirect.com/science/article/pii/S009286741830237X)
Tracing disease through time and translational research approaches (elective)	
Abbreviation	DiseaseTrace
Subtitle	Biomolecular paleopathology
Module components	Lectures, seminars
When	Semesters 2+3 (duration of module: 2 semesters, starting in the winter semester)
Module coordinator/ Organisers	A. Nebel/ IKMB 3rd semester electives: Experimental Trauma Surgery (Regen. Medicine), Dermatology (Epithelial barrier functions), Neurology (Neurosciences), IKMB (Metabolomics), University Cancer Center Schleswig-Holstein [UCCSH] (Molecular Diagnostics)
Lecturers	Tracing disease through time: **A. Nebel**, K. Fuchs, B. Krause-Kyora (IKMB) and guest lecturers

	Electives 3rd semester: a. Regenerative medicine and tissue engineering: S. Fuchs (Experimental trauma surgery) b. Epithelial barrier functions: Molecular interaction epithelium – environment: J. Harder (Dermatology), c. Clinical, molecular and diagnostic neurosciences: F. Leypoldt (Neurology and Clinical Chemistry), **G. Kuhlenbäumer** (Neurology) d. Metabolomics: H. Zacharias (IKMB) e. Molecular Diagnostics: S. Lipinski (UCCSH), L. Bastian, C. Baldus, M. Brüggemann, C. Pott (Klinik für Innere Medizin II)
Contact hours	Semester 2: Lecture Tracing disease 2 CH Seminar Tracing disease 1 CH Semester 3: Lecture Tracing disease 1 CH Seminar Tracing disease 2 CH Semester 3 elective: Lecture 1 CH Seminar 2 CH
Workload Total: 240 h	Lecture semester 2: 60 h Attendance time 26 h, preparation 14 h, revision 20 h Seminar semester 2: 30 h Attendance time 14 h, preparation 6 h, revision 10 h Lecture semester 3: 30 h Attendance time 14 h, preparation 10 h, revision 6 h Seminar semester 3: 60 h Attendance time 26 h, preparation 20 h, revision 14 h Elective semester 3 lecture: 30 h Attendance time 14 h, preparation 6, revision 10 h Elective semester 3 seminar: 30 h Attendance time 26 h, preparation 4 h
Credit points	8 (semester 2 lecture Tracing disease 2 CP, semester 2 seminar 1 CP, semester 3 lecture 1 CP, semester 3 seminar 2 CP; lecture and seminar 3rd-sem. elective 1 CP each)
Requirements	-
Expected outcome	**Tracing disease through time** Knowledge: Students - are familiar with analytical techniques (e.g. genetic, biochemical, chemical) and approaches used for the study of ancient biomolecules, diets and diseases - understand how specimens are recovered from field situations, archived sources and collections - have a basic knowledge of human osteology, paleopathology, epidemiology - have gained an understanding of historical events as an important factor in disease etiology and epidemiology - have acquired insights not only into the health status in past societies but also into how new diseases emerge in present-day populations. Skills: Students - can demonstrate the use of analytical methods for the investigation of ancient biomolecules, diets and diseases - can apply basic osteological methods - can perform literature research and give presentations on a specific topic in front of their peers. Competencies: Students - can assess the importance of the interrelations between environmental and

	societal conditions that contribute to the onset and human impact of disease through time - recognize which key questions need to be asked for investigating scientific problems concerning disease spreading geographically and chronologically and can formulate them accordingly. **Electives 3rd semester** **a. Regenerative medicine and tissue engineering** Knowledge: Students - are familiar with the principles and potential fields of application of tissue engineering and regenerative medicine including the use of adult stem cells, biomaterials, bioactive molecules. - can define different cellular and molecular mechanisms in tissue repair - understand 3-D cultures. Skills: Students - can define and isolate adult stem cells in cell cultures in the laboratory - can handle co-culture models in the laboratory - can apply models to study angiogenesis and wound repair - can apply methods to evaluate repair mechanisms. Competencies: Students - are able to apply interdisciplinary approaches to support tissue regeneration - can develop translational strategies. **b. Epithelial barrier functions: Molecular interaction epithelium – environment** Knowledge: Students - are familiar with the importance of epithelia as physiological barrier against potentially detrimental environmental factors - understand the molecular mechanisms of epithelia for protecting the integrity of their barrier function. Skills: Students can associate disruptions of the epithelial barrier with specific disease manifestations. Competencies: Students - can assess the impact of epithelial barrier disruptions for specific disease manifestations - are able to understand scientific papers, to evaluate and discuss them critically with colleagues - are able to communicate with clinical neurologists. **c. Clinical, molecular and diagnostic neurosciences** Knowledge: Students - have a general understanding of clinical assessment, clinical syndromes, major categories of neurological diseases and diagnostic procedures - have a general understanding of molecular mechanisms underlying neurological disease, their disease models and techniques used in studying them. Skills: Students - are able to apply disease models to human diseases and develop them into translational research - are able to critically discuss relevant scientific publications and draw conclusions for own research projects. - can perform literature research self-reliantly. Competencies: Students - are able to select suitable methods to address specific neuroscientific questions.

	d. Metabolomics: Knowledge: Students - understand the key concepts of metabolomics, metabolism, metabolites, and metabolic networks - are familiar with basic principles of metabolomics analytical tools (nuclear magnetic resonance (NMR) spectroscopy and hyphenated mass spectrometry) and workflows in metabolomics research - are familiar with basic principles of high-dimensional statistics/machine learning data analysis in metabolomics Skills: Students - can prepare samples for NMR spectroscopy - can preprocess NMR spectroscopic data - can perform basic statistical data analysis with metabolomics data (e.g. hypothesis testing) - can write R code for selected analysis tasks Competencies: Students - are able to identify metabolites from NMR spectra - are aware of advantages/disadvantages of specific metabolomics analytical tools - are able to select suitable statistical methods for specific research questions in metabolomics. **e. Molecular diagnostics:** Knowledge: Students - understand which influence molecular biology has on state-of-the-art diagnostic methods in medicine, with a particular view to cancer - can explain what precision/personalized medicine is and why this requires particular diagnostic tools - have a good understand of current immunotherapy approaches (e.g. immune checkpoint inhibitors) - are familiar with the theoretical background of basic diagnostic approaches in molecular biology - understand the workflow from sample processing to treatment recommendation. Skills: Students - can conduct a set series of diagnostic routines including samples preparation (e.g. extraction of nucleic acids from blood and tissues, quality check, qPCR, ddPCR, exome sequencing) - can apply software (self-programmed and software packages) to analyse data resulting from sample processing - can use quality control measures to ensure correct sample processing and error eradication in data analysis - are able to establish complete documentation of sample processing and data analysis, case based. Competencies: Students - can establish connections between theoretical knowledge in molecular biology and determined tumour samples to arrive at the best suitable diagnostic approaches for individual samples. - can use gene data bases for extracting relevant information for a given data set of a processed tumour sample with regard to formulating potential treatment suggestions. - are able to transfer case knowledge onto a meta level for further research in precision medicine.

Content	**Tracing disease through time** Lectures: Revision of biomolecules (DNA, proteins, lipids, stable isotopes), analysis of ancient biomolecules, introduction to field work and sample acquisition, chronology and dating, preservation and taphonomy, insights into forensics, skeletal anatomy, analysis of skeletal remains (age at death, sex), skeletal pathology, genetic sex determination and kinship analysis, historical epidemiology and demography, triggers of changes in health and disease, reconstruction of diet, biomolecular diagnosis of ancient diseases, pathogen and disease gene evolution, state-of-the-art and emerging technologies (e.g. 3rd generation sequencing). Seminars: Consolidation and expansion of knowledge acquired through presentations of current articles, lab tutorials, visits of labs (with experiment demonstrations), visits to museums/archives and excavations for behind-the-scenes perspectives. **Electives 3rd semester** **a. Regenerative medicine and tissue engineering** Lecture: Definitions of and examples for regenerative medicine and tissue engineering; interdisciplinary approaches in regenerative medicine; adult stem cells; biocompatibility and functionality of implant materials, bioactive molecules, vascularisation as key issue for tissue repair, co-culture models, models for studying angiogenesis, inflammation and tissue repair. Seminar: Discussions of scientific papers on tissue engineering and regenerative medicine with integrated lab experience in experiments using techniques introduced in both lecture and seminar. **b. Epithelial barrier functions: Molecular interaction epithelium – environment** Lecture: Structure and cellular components of epithelia (skin, intestine and respiratory tract); physical barrier functions; strategies for identification and differentiation of pathogenic micro-organisms and members of the commensal microbiota; extracellular and intracellular effector mechanisms for controlling microbial growth; provision of mediators for activation and recruitment of effector cells. Seminar: Hypotheses and discussion: how can dysregulation of the epithelial barrier lead to epithelial infectious and inflammatory diseases; discussion of scientific papers, presentation of current research results. **c. Clinical, molecular and diagnostic neurosciences** Lecture: Clinical diagnostic techniques, movement/neurodegenerative dis-orders, neuroimmunology, neurovascular diseases, peripheral nervous system, neuroscience of pain, neuroscience of epilepsy. Seminar: Presentation of scientific articles by the students followed by critical group discussion. **d. Metabolomics:** Lecture: Overview of metabolomics and its different applications, important aspects of metabolomics study design, introduction to metabolomics analytical tools (NMR spectroscopy and hyphenated mass spectrometry) and metabolite identification, introduction to metabolomics data preprocessing, statistics and bioinformatics data analysis in metabolomics and interpretation of results in biomedical context Analysis seminar: Preparing samples for NMR spectroscopy (practical lab work), metabolite identification from NMR spectra, computer-based analysis of data in R, writing R code for individual data analysis routines.

	e. Molecular diagnostics: Lecture: Somatic cancer mutations and driver genes, concept of personalized medicine, classes of biomarkers, diagnostic tools: qPCR, ddPR, panel diagnostics; data analysis and interpretation: limits of detection, SNP analysis, databases; practicalities in medicine: health insurance coverage and diagnostics, time-sensitivity, patient-based science. Lab seminar: Workflow and methods in a diagnostic lab, conducting lab diagnostics Computer seminar: Data analysis using bioinformatics and databases
Module evaluation/ exam	Graded Oral exam
Media used	PPT presentations, handouts, textbooks, example experiments
Literature	**Tracing disease through time** Brown Terry and Keri, Biomolecular Archaeology: An introduction (Wiley-Blackwell 2011) Butler John M, Advanced Topics in Forensic DNA Typing: Methodology (Academic Press 2011) Dupras Tosha L, Schultz John J, Wheeler Sandra M, Forensic Recovery of Human Remains: Archaeological Approaches (Crc Pr Inc 2011) White T, Folkens PA, Human Bone Manual (Academic Press 2005, 2nd edition) Mays S, The Archeology of human bones (Routledge 2010, 2nd edition) **a. Regenerative medicine and tissue engineering** von Blitterswijk C, de Boer J, Tissue Engineering (Elsevier 2014, 2nd edition) Current scientific papers **b. Epithelial barrier functions** Kabelitz D, Schröder J-M, Mechanisms of Epithelial Defense (Karger 2005) Current scientific publications **c. Clinical, molecular and diagnostic neurosciences** Kandel et al., Principles of Neural Science (McGraw Hill 2012, 5th edition) Ropper A, Samuels M, Klein J, Adams and Victor's Principles of Neurology (McGraw Hill 2014, 10th edition) Research and review articles **d. Metabolomics** Gowda, GA Nagana, and Daniel Raftery, eds. NMR-based Metabolomics: Methods and Protocols. Humana Press, 2019. Cavanagh, John, et al. Protein NMR spectroscopy: principles and practice. Elsevier, 1995. Wehrens, Ron, and Reza Salek, eds. Metabolomics: practical guide to design and analysis. CRC Press, 2019. James, Gareth, et al. An introduction to statistical learning. Vol. 112. New York: springer, 2013. Review and research articles **e. Molecular diagnostics:** William Coleman, Gregory Tsongalis: The Molecular Basis of Human Disease (Academic Press, 1st Edition, 2009) Gregory Tsongalis: Advances in Molecular Pathology, 2021, Volume 4-1 (Elsevier 2021, 1st Edition) Matthew H. Bailey et al.: Comprehensive Characterization of Cancer Driver Genes and Mutations, Cell, Volume 173, Issue 2, 2018, Pages 371-385.e18, ISSN 0092-8674, https://doi.org/10.1016/j.cell.2018.02.060. (https://www.sciencedirect.com/science/article/pii/S009286741830237X)

Imaging techniques in biomedicine and translational research approaches (elective)	
Abbreviation	Imaging
Subtitle	Medical imaging in diagnostics and biomedical research
Module components	Lectures, seminars
When	Semesters 2+3 (duration of module: 2 semesters, starting in the winter semester)
Module coordinator/ Organisers	C.-C. Glüer Radiology and Neuroradiology 3rd semester electives: Experimental Trauma Surgery (Regen. Medicine), Dermatology (Epithelial barrier functions), Neurology (Neurosciences), IKMB (Metabolomics), University Cancer Center Schleswig-Holstein [UCCSH] (Molecular Diagnostics)
Lecturers	Imaging (elective semesters 2+3): S. Tiwari, **C.-C. Glüer**, **M. Both**, and colleagues (Radiology) **3rd-semester electives:** a. Regenerative medicine and tissue engineering: S. Fuchs (Experimental trauma surgery) b. Epithelial barrier functions: Molecular interaction epithelium – environment: J. Harder (Dermatology) c. Clinical, molecular and diagnostic neurosciences: F. Leypoldt (Neurology and Clinical Chemistry), **G. Kuhlenbäumer** (Neurology) d. Metabolomics: H. Zacharias (IKMB) e. Molecular Diagnostics: S. Lipinski (UCCSH), L. Bastian, C. Baldus, M. Brüggemann, C. Pott (Klinik für Innere Medizin II)
Contact hours	Semester 2: Lecture Imaging 1 CH Seminar Imaging 1 CH Semester 3: Lecture Imaging 1 CH Seminar Imaging 2 CH Semester 3 elective: Lecture 1 CH Seminar 2 CH
Workload Total: 240 h	Lecture semester 2: 30 h Attendance time 14 h, preparation 10 h, revision 6 h Seminar semester 2: 60 h Attendance time 14 h, preparation 14 h, revision 32 h Lecture semester 3: 30 h Attendance time 14 h, preparation 6 h, revision 10 h Seminar semester 3: 60 h Attendance time 26 h, preparation 24 h, revision 10 h Elective semester 3 lecture: 30 h Attendance time 14 h, preparation 6, revision 10 h Elective semester 3 seminar: 30 h Attendance time 26 h, preparation 4 h
Credit points	8 (semester 2 lecture Imaging 1 CP, semester 2 seminar Imaging 2 CP; semester 3 lecture Imaging 1 CP, semester 3 seminar Imaging 2 CP, lecture and seminar 3rd-sem. elective 1 CP each)
Requirements	-
Expected outcome	**Imaging** Knowledge: Students

	-are familiar with the instruments and the underlying technology used for imaging - understand the principles of molecular imaging and can explain them - have acquired thorough overview knowledge on the application of imaging techniques in preclinical and clinical diagnostics. Skills: Students - understand which imaging techniques are indicated for which organ groups - understand relevant publications, are able to critically assess them and develop solutions for imaging tasks. Competencies: Students - can interpret imaging data in relation to specific diseases - are able to put the acquired knowledge to use in their own research work. **Electives (3rd semester)** **a. Regenerative medicine and tissue engineering** Knowledge: Students - are familiar with the principles and potential fields of application of tissue engineering and regenerative medicine including the use of adult stem cells, biomaterials, bioactive molecules - can define different cellular and molecular mechanisms in tissue repair - understand 3-D cultures. Skills: Students - can define and isolate adult stem cells in cell cultures in the laboratory - can handle co-culture models in the laboratory - can apply models to study angiogenesis and wound repair - can apply methods to evaluate repair mechanisms. Competencies: Students -are able to apply interdisciplinary approaches to support tissue regeneration - can develop translational strategies. **b. Epithelial barrier functions: Molecular interaction epithelium – environment** Knowledge: Students - are familiar with the importance of epithelia as physiological barrier against potentially detrimental environmental factors - understand the molecular mechanisms of epithelia for protecting the integrity of their barrier function. Skills: Students can associate disruptions of the epithelial barrier with specific disease manifestations. Competencies: Students - can assess the impact of epithelial barrier disruptions for specific disease manifestations - are able to understand scientific papers, to evaluate and discuss them critically with colleagues. **c. Clinical, molecular and diagnostic neurosciences** Knowledge: Students - have a general understanding of clinical assessment, clinical syndromes, major categories of neurological diseases and diagnostic procedures - have a general understanding of molecular mechanisms underlying neurological disease, their disease models and techniques used in studying them. Skills: Students - are able to apply disease models to human diseases and develop them into translational research

	- are able to critically discuss relevant scientific publications and draw conclusions for own research projects. - can perform literature research self-reliantly. Competencies: Students - are able to select suitable methods to address specific neuroscientific questions - are able to communicate with clinical neurologists. **d. Metabolomics**: Knowledge: Students - understand the key concepts of metabolomics, metabolism, metabolites, and metabolic networks - are familiar with basic principles of metabolomics analytical tools (nuclear magnetic resonance (NMR) spectroscopy and hyphenated mass spectrometry) and workflows in metabolomics research - are familiar with basic principles of high-dimensional statistics/machine learning data analysis in metabolomics Skills: Students - can prepare samples for NMR spectroscopy - can preprocess NMR spectroscopic data - can perform basic statistical data analysis with metabolomics data (e.g. hypothesis testing) - can write R code for selected analysis tasks Competencies: Students - are able to identify metabolites from NMR spectra - are aware of advantages/disadvantages of specific metabolomics analytical tools - are able to select suitable statistical methods for specific research questions in metabolomics. **e. Molecular diagnostics:** Knowledge: Students - understand which influence molecular biology has on state-of-the-art diagnostic methods in medicine, with a particular view to cancer - can explain what precision/personalized medicine is and why this requires particular diagnostic tools - have a good understand of current immunotherapy approaches (e.g. immune checkpoint inhibitors) - are familiar with the theoretical background of basic diagnostic approaches in molecular biology - understand the workflow from sample processing to treatment recommendation. Skills: Students - can conduct a set series of diagnostic routines including samples preparation (e.g. extraction of nucleic acids from blood and tissues, quality check, qPCR, ddPCR, exome sequencing) - can apply software (self-programmed and software packages) to analyse data resulting from sample processing - can use quality control measures to ensure correct sample processing and error eradication in data analysis - are able to establish complete documentation of sample processing and data analysis, case based. Competencies: Students - can establish connections between theoretical knowledge in molecular biology

	and determined tumour samples to arrive at the best suitable diagnostic approaches for individual samples. - can use gene data bases for extracting relevant information for a given data set of a processed tumour sample with regard to formulating potential treatment suggestions. - are able to transfer case knowledge onto a meta level for further research in precision medicine.
Content	**Imaging** Lectures: Technical principles (X-ray, magnetic resonance, nuclear medicine, sonography, optical techniques); contrast media, molecular markers and reporters; image processing (acquisition, reconstruction, processing, parameterisation, quantification); examples for clinical/preclinical imaging structured by organs and diseases; quality standards, design and execution of preclinical/clinical studies using imaging techniques; quality assurance; criteria for evidence-based assessment of diagnostic studies (e.g. Oxford criteria); Seminars: Discussion of merits/shortcomings of selected scientific publications. **Electives 3rd semester** **a. Regenerative medicine and tissue engineering** Lecture: Definitions of and examples for regenerative medicine and tissue engineering; interdisciplinary approaches in regenerative medicine; adult stem cells; biocompatibility and functionality of implant materials, bioactive molecules, vascularisation as key issue for tissue repair, co-culture models, models for studying angiogenesis, inflammation and tissue repair. Seminar: Discussions of scientific papers on tissue engineering and regenerative medicine with integrated lab experience in experiments using techniques introduced in both lecture and seminar. **b. Epithelial barrier functions: Molecular interaction epithelium – environment** Lecture: Structure and cellular components of epithelia (skin, intestine and respiratory tract); physical barrier functions; strategies for identification and differentiation of pathogenic micro-organisms and members of the commensal microbiota; extracellular and intracellular effector mechanisms for controlling microbial growth; provision of mediators for activation and recruitment of effector cells. Seminar: Hypotheses and discussion: how can dysregulation of the epithelial barrier lead to epithelial infectious and inflammatory diseases; discussion of scientific papers, presentation of current research results. **c. Clinical, molecular and diagnostic neurosciences** Lecture: Clinical diagnostic techniques, movement/neurodegenerative dis-orders, neuroimmunology, neurovascular diseases, peripheral nervous system, neuroscience of pain, neuroscience of epilepsy. Seminar: Presentation of scientific articles by the students followed by critical group discussion. **d. Metabolomics:** Lecture: Overview of metabolomics and its different applications, important aspects of metabolomics study design, introduction to metabolomics analytical tools (NMR spectroscopy and hyphenated mass spectrometry) and metabolite identification, introduction to metabolomics data preprocessing, statistics and bioinformatics data analysis in metabolomics and interpretation of results in biomedical context Analysis seminar: Preparing samples for NMR spectroscopy (practical lab work), metabolite identification from NMR spectra, computer-based analysis of data in

	R, writing R code for individual data analysis routines. **e. Molecular diagnostics:** Lecture: Somatic cancer mutations and driver genes, concept of personalized medicine, classes of biomarkers, diagnostic tools: qPCR, ddPR, panel diagnostics; data analysis and interpretation: limits of detection, SNP analysis, databases; practicalities in medicine: health insurance coverage and diagnostics, time-sensitivity, patient-based science. Lab seminar: Workflow and methods in a diagnostic lab, conducting lab diagnostics Computer seminar: Data analysis using bioinformatics and databases
Module evaluation/ exam	Graded Oral exam
Media used	PPT presentations, handouts, textbooks, example experiments
Literature	**Imaging** Bushberg JT et al., The Essential Physics of Medical Imaging (3rd edition, Lippin-cott Williams & Wilkins 2011) Tian J, Molecular Imaging – Fundamentals and Applications (Springer 2013) Pomper MG, Gelovani JG, Molecular Imaging in Oncology (Informa Healthcare 2008) Suetens P, Fundamentals of Medical Imaging (2nd edition, Cambridge Medicine 2009) [3rd edition announced for March 2017] Current scientific publications **a. Regenerative medicine and tissue engineering** von Blitterswijk C, de Boer J, Tissue Engineering (Elsevier 2014, 2nd edition) Current scientific papers **b. Epithelial barrier functions** Kabelitz D, Schröder J-M, Mechanisms of Epithelial Defense (Karger 2005) Current scientific publications **c. Clinical, molecular and diagnostic neurosciences** Kandel et al., Principles of Neural Science (McGraw Hill 2012, 5th edition) Ropper A, Samuels M, Klein J, Adams and Victor's Principles of Neurology (McGraw Hill 2014, 10th edition) Research and review articles **d. Metabolomics** Gowda, GA Nagana, and Daniel Raftery, eds. NMR-based Metabolomics: Methods and Protocols. Humana Press, 2019. Cavanagh, John, et al. Protein NMR spectroscopy: principles and practice. Elsevier, 1995. Wehrens, Ron, and Reza Salek, eds. Metabolomics: practical guide to design and analysis. CRC Press, 2019. James, Gareth, et al. An introduction to statistical learning. Vol. 112. New York: springer, 2013. Review and research articles **e. Molecular diagnostics:** William Coleman, Gregory Tsongalis: The Molecular Basis of Human Disease (Academic Press, 1st Edition, 2009) Gregory Tsongalis: Advances in Molecular Pathology, 2021, Volume 4-1 (Elsevier 2021, 1st Edition) Matthew H. Bailey et al.: Comprehensive Characterization of Cancer Driver Genes and Mutations, Cell, Volume 173, Issue 2, 2018, Pages 371-385.e18, ISSN 0092-8674, https://doi.org/10.1016/j.cell.2018.02.060. (https://www.sciencedirect.com/science/article/pii/S009286741830237X)

Focus area Inflammation I (elective): Choose a focus area + continue through semesters 2-4	
Abbreviation	Inflammation I
Subtitle	Introduction to clinical inflammation research
Module components	Lecture, seminar, practical exercise
When	Semester 2 (winter semester)
Module coordinator/ Organiser	R. Häsler Dermatology
Lecturers	**R. Häsler** (Dermatology), P. Rosenstiel (IKMB); G. Kuhlenbäumer (Neurology), J. Baines (IEM), S. Sebens (IET) and colleagues
Contact hours	Lecture 2 CH Seminar 2 CH Clinical practical 2 CH
Workload Total: 150 h	Lecture: 30 h Attendance time 22 h, revision 8 h Seminar: 60 h Attendance time 22 h, preparation 22 h, revision 16 h Practical exercise: 60 h Attendance time 22 h, preparation 22 h, revision 16 h
Credit points	5 (lectures 1 CP, seminar 2 CP, practical exercise 2 CP)
Requirements	*MolBio* passed
Expected outcome	Knowledge: Students - have a basic understanding of pathophysiological processes, especially of interactions between genetic and environmental factors leading to inflammatory diseases in barrier organs - are familiar with important inflammatory diseases, their basic diagnostics and therapies - can name the main symptoms of those diseases - can define the most important pathobiochemical connections. Skills: Students - can apply statistical tests and bioinformatics software for data evaluation - approach study participants/patients adequately Competencies: Students - are able to familiarize themselves with a scientific topic through literature research - understand scientific publications and can discuss them - can develop an oral presentation on the basis of scientific publications and present it - are aware of the social and ethical implications of disease research and take them into account in their research work.
Content	Lecture: Pathogenesis of chronic inflammatory diseases [e.g. acute/chronic, mononuclear inflammatory responses; autoimmune/infection-caused inflammatory responses; asthma, sarcoidosis, psoriasis, IBD, arteriosclerosis, coronary heart diseases, inflammatory diseases of the CNS]. Seminar: Discussion of publications on chronic inflammatory disease manifestations discussed in the lecture. Practical exercise: Rotation through diagnostic labs (e.g. osteology, staining/microscopy, bacterial cell cultures) executing lab experiments under supervision.
Module evaluation/ exam	Graded Written exam
Media used	PPT presentations, scientific publications.

Literature	Lipsky PE, Radbruch A, Current Concepts in Autoimmunity and Chronic Inflammation (Springer 2006) Murray P, Rosenthal KS, Pfaller KS, Medical Microbiology (Elsevier Health Science 2008) Current reviews and original publications
Research practical Inflammation I	
Abbreviation	Practical Inflammation I
Sub title	Introduction to clinical inflammation research
Module components	1 two-week or 2 one-week 2 laboratory block practicals
When	Semester 2 (winter semester)
Module coordinator/ Organisers	R. Häsler Institutes of lab groups investigating inflammatory processes
Lecturers	Lab leaders of research groups investigating inflammatory processes
Contact hours	Practical 1: 3 CH Practical 2: 3 CH
Workload Total: 180 h	Practical 1: 90 h Attendance time 38 h, preparation 30 h, revision 22 h Practical 2: 90 h Attendance time 38 h, preparation 30 h, revision 22 h
Credit points	6
Requirements	*MolBio* passed
Expected outcome	Knowledge: Students - know how to conduct themselves in a laboratory - are familiar with the theoretical background on which the lab experiments conducted are based. Skills: Students - are able to apply essential techniques in DNA, RNA and protein analytics for investigating inflammatory processes - can apply lab and analytical techniques in inflammatory research. Competencies: Students are able to critically assess the results of their experiments and put them into a scientific context.
Content	Experimental lab work dependent on topics of lecture (e.g. DNA, RNA and protein analytics in connection with genetic, cell biological and immunological topics of inflammatory diseases).
Module evaluation/ exam	Graded Written documentation of lab work (lab book)
Media used	Lab experiments
Literature	Manuals and instructions for lab work, current scientific publications
Focus area Malignant Diseases I (elective): Choose a focus area + continue through semesters 2-4	
Abbreviation	Oncology I
Subtitle	Malignant diseases in humans - introduction
Module components	Lecture, seminar, practical exercise
When	Semester 2 (winter semester)
Module coordinator/ Organiser	S. Sebens IET
Lecturers	N. Arnold (Gynaecology), L. Lenk (Pediatrics), A. Trauzold (General and Thoracic Surgery), **S. Sebens** (IET), M. Peipp, T. Valerius (Med. Department II)
Contact hours	Lecture 2 CH Seminar 2 CH Clinical practical 2 CH

Workload Total: 150 h	Lecture: 30 h Attendance time 22 h, revision 8 h Seminar: 60 h Attendance time 22 h, preparation 22 h, revision 16 h Practical exercise: 60 h Attendance time 22 h, preparation 22 h, revision 16 h
Credit points	5 (lectures 1 CP, seminar 2 CP, practical exercise 2 CP)
Requirements	*MolBio* passed
Expected outcome	Knowledge: Students - are familiar with the essential pathogenesis of malignant diseases (selected disease examples) - are able to describe the impact of gene-environment interactions on disease manifestation on a molecular level - are familiar with the essential diagnostic and therapeutic techniques for recognising and treating tumours. Skills: Students - can apply suitable statistical tests and software for data evaluation - behave adequately towards patients. Competencies: Students - are able to familiarize themselves with a scientific topic through literature research - understand an English scientific publication and can discuss it critically - can develop an oral presentation taking into account English scientific publications - are aware of the social and ethical implications oncological research has and take them into account in their research work.
Content	Lecture: Malignant diseases in humans, pathogenesis of malignant diseases; definition and characteristics of tumours; techniques in molecular oncology; epigenetics/micro-RNA; characteristics of tumour cells; cell cycle regulation and transcription; signal transduction; apoptosis, malignant progression; viruses and cancer; oncological therapies; stem cells. Seminar: Discussion of current scientific publications. Practical exercise: Rotation through diagnostic labs (e.g. osteology, staining/microscopy, bacterial cell cultures) executing lab experiments under supervision.
Module evaluation/ exam	Graded Written exam
Media used	PPT presentations, lab experiments, manuals and instructions for lab work, case studies.
Literature	Pecorino L, Molecular Biology of Cancer Mechanisms, Targets, and Therapeutics (OUP 2012, 3rd edition) Weinberg RA, The biology of Cancer (Garland Publications 2013, 2nd revised edition) Current original publications and reviews
Research practical Malignant diseases I	
Abbreviation	Practical Oncology I
Subtitle	Introduction to oncology in lab research
Module components	1 two-week or 2 one-week 2 laboratory block practicals
When	Semester 2 (winter semester)

Module coordinator/ Organiser	S. Sebens IET
Lecturers	Lab leaders of research groups investigating molecular mechanisms of malignant diseases
Contact hours	Practical 1: 3 CH Practical 2: 3 CH
Workload Total: 180 h	Practical 1: 90 h Attendance time 38 h, preparation 30 h, revision 22 h Practical 2: 90 h Attendance time 38 h, preparation 30 h, revision 22 h
Credit points	6
Requirements	*MolBio* passed
Expected outcome	Knowledge: Students - know how to conduct themselves in a laboratory - are familiar with the theoretical background on which the lab experiments conducted are based. Skills: Students can apply lab and analytical techniques. Competencies: Students are able to critically assess the results of their experiments and put them into a scientific context.
Content	Experimental lab work with regard to topics of lecture (e.g. mutation analysis, apoptosis assay, FISH experiment).
Module evaluation/ exam	Graded Written documentation of lab work (lab book)
Media used	Lab experiments
Literature	Weinberg R, The biology of cancer (Taylor & Francis 2nd edition, 2014) Lauren Pecorino, Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics (OUP 4th edition, 2016) Manuals and instructions for lab work Current scientific publications
Focus area Evolutionary Medicine I (elective): Choose a focus area + continue through semesters 2-4	
Abbreviation	EvoMed I
Subtitle	Evolutionary Medicine - introduction
Module components	Lecture, seminar, practical exercise
When	Semester 2 (winter semester)
Module coordinator/ Organiser	J.Baines IEM
Lecturers	**J. Baines** (IEM), A. Nebel (IKMB), H. Schulenburg (Zoology)
Contact hours	Lecture 2 CH Seminar 2 CH Clinical practical 2 CH
Workload Total: 150 h	Lecture: 30 h Attendance time 22 h, revision 8 h Seminar: 60 h Attendance time 22 h, preparation 22 h, revision 16 h Practical exercise: 60 h Attendance time 22 h, preparation 22 h, revision 16 h
Credit points	5 (lectures 1 CP, seminar 2 CP, practical exercise 2 CP)
Requirements	*MolBio* passed
Expected outcome	Knowledge: Students - understand the basic principles of evolutionary biology, human evolution,

	evolutionary medicine - are familiar with methods of genetic analysis - are familiar with the most important theories in evolutionary biology as a basic science for medicine. Skills: Students - can apply statistical tests and software for data evaluation - behave adequately towards patients. Competencies: Students - can transfer acquired knowledge to new scientific tasks - are able to familiarize themselves with a scientific topic through literature research - understand an English scientific publication and can discuss it critically - can develop an oral presentation taking into account English scientific publications - are aware of the social and ethical implications disease research has and take them into account in their research work.
Content	Lecture: Evolutionary biology in medicine: developmental biology, anatomy, genetic variation, natural selection, population genetics, molecular development, human development and disease, life-history theory; principles of evolution in nutrition and metabolism, disease and drug resistance. Seminar: Discussion of current scientific literature. Practical exercise: Rotation through diagnostic labs (e.g. osteology, staining/microscopy, bacterial cell cultures) executing lab experiments under supervision.
Module evaluation/ exam	Graded Written exam
Media used	PPT presentations, lab experiments, manuals and instructions for lab work, case studies.
Literature	Ridley M, Evolution (John Wiley & Sons 2003) [still valid, no new edition available] Gluckman P, Beedle A, Hanson M, Principles of Evolutionary Medicine (OUP 2009) Stearns S, Medzhitov R, Evolutionary Medicine (Sinauer Associates 2015) Current original publications and reviews
Research practical Evolutionary medicine I	
Abbreviation	Practical EvoMed I
Subtitle	Introduction to evolutionary medicine in lab research
Module components	1 two-week or 2 one-week 2 laboratory block practicals
When	Semester 2 (winter semester)
Module coordinator/ Organiser	J. Baines IEM
Lecturers	Lab leaders of research groups investigating aspects relevant for evolutionary medicine
Contact hours	Practical 1: 3 CH Practical 2: 3 CH
Workload Total: 180 h	Practical 1: 90 h Attendance time 38 h, preparation 30 h, revision 22 h Practical 2: 90 h Attendance time 38 h, preparation 30 h, revision 22 h
Credit points	6

Requirements	*MolBio* passed
Expected outcome	Knowledge: Students - know how to conduct themselves in a laboratory - are familiar with the theoretical background on which the lab experiments conducted are based. Skills: Students can apply lab and analytical techniques for evolutionary biology and medicine. Competencies: Students are able to critically assess the results of their experiments and put them into a scientific context.
Content	Experimental lab work connected to topics of lecture (e.g. analysis of NGS data, microbiome analysis).
Module evaluation/ exam	Graded Written documentation of lab work (lab book)
Media used	Lab experiments
Literature	Manuals and instructions for lab work, current scientific publications
Literature	Ridley M, Evolution (John Wiley & Sons 2003) [still valid, no new edition available] Gluckman P, Beedle A, Hanson M, Principles of Evolutionary Medicine (OUP 2009) Stearns S, Medzhitov R, Evolutionary Medicine (Sinauer Associates 2015) Current original publications and reviews
Focus area Inflammation II	
Abbreviation	Inflammation II
Subtitle	Clinical inflammation research – project development
Module components	Lab seminar, lab practical, joint seminar of all focus areas
When	Semester 3 (summer semester)
Module coordinator/ Organiser	R. Häsler Dermatology
Lecturers	Principal investigators of research groups working on research topics of focus areas (joint seminars)
Contact hours	Practical 9 CH Lab seminar 1 CH Joint seminar 1 CH
Workload Total: 330 h	Lab practical: 240 h Attendance time 100 h, preparation 60 h, revision 80 h Lab seminar: 60 h Attendance time 14 h, preparation 26 h, revision 20 h Joint seminar "Current affairs": Attendance time 14 h, preparation 10 h, revision 6 h
Credit points	11 (practical 8 CP, seminar 2 CP, joint seminar 1 CP)
Requirements	*Inflammation I* passed
Expected outcome	Knowledge: Students - have an in-depth understanding of physiological and molecular/cell biological processes which influence inflammatory diseases - can comprehend literature describing lab techniques in inflammation research and explain essential methods such as immunoelectrophoresis, lymphocyte transformation - have in-depth knowledge of the experiments conducted during the practical. Skills: Students - can conduct the different steps of their lab experiments self-reliantly,

	document them correctly in lab books and explain them - are able to perform quality control measures for the results obtained - can analyse the results and put them into relation to the research area. Competencies: Students - can plan experiments self-reliantly, can analyse the data obtained and interpret results using the knowledge they have acquired - can assess their own work critically and integrate new results adequately - can familiarize themselves with new topics and develop relevant research lab research approaches - recognize the connections between topics of different focus areas and can explain and link them correctly - are aware of the connections between the topics of the different focus areas and can elucidate them.
Content	Seminar: Developing a lab project by researching literature and discussions with fellow students and lecturers for topics such as T-cell, B-cell mediated immune reactions, auto-antigens, autoantibody formation, pro-inflammatory cytokines, signal transduction pathways for activating cell migration and pathogen destruction. Practical: Preparation and execution of experimental lab project making use of methods such as ELISA, RIA, ELISPOT, allergen tests, infection/stimulation experiments with primary macrophages, transformation/transfection of model organisms, FACS analysis of Toll-like receptor expression. Joint seminar: Joint discussion of papers relevant for all focus areas.
Module evaluation/ exam	Graded Scientific project thesis with oral presentation
Media used	PPT presentations, lab/lecture notes, lab manuals and instructions, lab experiments.
Literature	Lipsky PE, Radbruch A, Current Concepts in Autoimmunity and Chronic Inflammation (Springer 2006) Murray P, Rosenthal KS, Pfaller KS, Medical Microbiology (Elsevier Health Science 2008) Current original publications and reviews
Focus area Malignant Diseases II	
Abbreviation	Oncology II
Subtitle	Oncology – project development
Module components	Lab seminar, lab practical, joint seminar of all focus areas
When	Semester 3 (summer semester)
Module coordinator/ Organiser	S. Sebens IET
Lecturers	N. Arnold (Gynaecology), L. Lenk (Pediatrics), A. Trauzold (General and thoracic Surgery), **S. Sebens** (IET); M. Peipp, T. Valerius (Med. Department II); principal investigators of research groups working on research topics of focus areas (joint seminars)
Contact hours	Practical 9 CH Lab seminar 1 CH Joint seminar 1 CH
Workload	Lab practical: 240 h Attendance time 100 h, preparation 60 h, revision 80 h Lab seminar: 60 h Attendance time 14 h, preparation 26 h, revision 20 h Joint seminar “Current affairs”:

Total: 330 h	Attendance time 14 h, preparation 10 h, revision 6 h
Credit points	11 (practical 8 CP, lab seminar 2 CP, joint seminar 1 CP)
Requirements	*Oncology I* passed
Expected outcome	Knowledge: Students - have an in-depth understanding of physiological and molecular/cell biological processes which influence malignant diseases - understand lab techniques for oncological research described in the literature and can explain essential methods - have in-depth knowledge of the experiments conducted during the practical. Skills: Students - can conduct the different steps of their lab experiments and explain them - are able to perform quality control measures for the results obtained - can analyse the results and put them into relation to the research area. Competencies: Students - can plan experiments, analyse the data and interpret results gained - can reflect their own work critically and integrate new results adequately - can familiarize themselves with a new topic and develop research approaches - are aware of the connections between the topics of the different focus areas, can link and explain them.
Content	Seminar: Planning and preparation of a project in the seminar by literature research and discussions with fellow students and lecturers. Discussion of method papers: sequencing techniques, immunohistochemistry, fluorescence in –situ hybridisation; comparative genome hybridisation on arrays; blotting techniques. Practical: Performance of experiments for a lab project on topics such as effect of oncogenes, tumour supressor genes, development of mutations; signal transduction in cells and analysis of results. Preparation of tumour cells (RNA/DNA/proteins) for their application in various lab techniques. Joint seminar: Joint discussion of papers relevant for all focus areas.
Module evaluation/ exam	Graded Scientific project thesis with oral presentation
Media used	PPT presentations, lab instructions, lab experiments.
Literature	Weinberg R, The biology of cancer (Taylor & Francis 2nd edition, 2014) Lauren Pecorino, Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics (Oxford University Press 4th edition, 2016) Current original publications and reviews
Focus area Evolutionary Medicine II	
Abbreviation	EvoMed II
Subtitle	Evolutionary medicine – project development
Module components	Lab seminar, lab practical, joint seminar of all focus areas
When	Semester 3 (summer semester)
Module coordinator/ Organiser	J. Baines IEM
Lecturers	**J. Baines** (IEM), A. Nebel (IKMB), principal investigators of research groups working on research topics of focus areas (joint seminars)
Contact hours	Practical 9 CH Lab seminar 1 CH Joint seminar 1 CH
Workload	Lab practical: 240 h Attendance time 100 h, preparation 60 h, revision 80 h Lab seminar: 60 h

Total: 330 h	Attendance time 14 h, preparation 26 h, revision 20 h Joint seminar "Current affairs": Attendance time 14 h, preparation 10 h, revision 6 h
Credit points	11 (practical 8 CP, lab seminar 2 CP, joint seminar 1 CP)
Requirements	*EvoMed I* passed
Expected outcome	Knowledge: Students - are familiar with the theories in evolutionary science important in medical research - have acquired in-depth knowledge on physiological and molecular processes important in evolutionary medicine - are familiar with lab techniques in molecular evolutionary research described in the literature and can explain them - have a thorough understanding of the experiments conducted during the practical. Skills: Students -can formulate testable evolutionary hypotheses pertaining to medical diseases and conditions -can distinguish between proximate (e.g. mechanistic) versus evolutionary explanations for medical diseases and conditions - can conduct the different steps of their lab experiments and explain them - are able to perform quality control measures for the results obtained - can analyse their results and put them into relation to the research area. Competencies: Students - can select adequate research techniques from molecular biology, evolutionary biology, human genetics and apply them to scientific questions in evolutionary medicine - can plan experiments, analyse the data obtained and interpret results - can reflect on their own work critically and integrate new results adequately - can familiarize themselves with a topic and develop research approaches - are aware of the connections between the topics of the different focus areas, can link and explain them.
Content	Seminar: Preparation of a project by literature research and discussions with fellow students and lecturers. Discussion of current papers including method papers. Practical: Execution of a lab project on topics such as identifying disease-causing candidate mutations using population genetic and/or molecular evolutionary methods, studying the phylogeny and diversification of disease genes, studying the function of a disease gene in model organisms such as mouse, fruit fly or hydra, performing experimental evolution in bacteria and/or viruses to understand principles of the evolution of antibiotic resistance or virulence. Joint seminar: Joint discussion of papers relevant for all focus areas.
Module evaluation/ exam	Graded Scientific project thesis with oral presentation
Media used	PPT presentations, handouts, lab experiments
Literature	Ridley M, Evolution (John Wiley & Sons 2003) [still valid, no new edition available] Gluckman P, Beedle A, Hanson M, Principles of Evolutionary Medicine (OUP 2009) Stearns S, Medzhitov R, Evolutionary Medicine (Sinauer Associates 2015) Original publications.

Master's thesis (written in focus area)	
Abbreviation	Master
Sub title	Preparation of Master's thesis within the Medical Life Sciences programme
Module components	Self study
When	Semester 4
Module coordinator/ Organisers	Thesis supervisors of the student/ Institutes of thesis supervisors
Contact hours	Self study, lab work and data analysis for developing Master's thesis
Workload	900 h
Credit points	30
Requirements	Proof of 79 credit points and passed written project thesis or proof of exams passed that are mandatory for acquiring those credit points
Expected outcome	Knowledge: Students - have acquired profound and specific knowledge on the topic of the Master's thesis and the surrounding scientific area in the respective focus area - are familiar with techniques for developing a written scientific presentation. Skills: Students - are able to develop a concept for their research work - can structure and execute their work in the lab and on their thesis - can present their results and reasoning according to the rules of Good Scientific Practice. Competencies: Students - can integrate the knowledge acquired through their studies into the data interpretation of their theses - are able to discuss their own work critically on the background of current scientific knowledge and can put it into relation to its social and scientific impact - can develop further research approaches based on their achievements so far.
Content	Preparation and written expression of Master's thesis on an experimental-scientific topic in the focus area
Module evaluation/ exam	Graded Master's thesis
Media used	Lab experiments, software for data analysis, data bases, scientific literature
Literature	Scientific original publications and monographs

The modules may cover more topics or different examples for the respective subject matter than listed here. The descriptions serve as a guideline for what the general content of the modules will be, which will be adapted to the needs of the students and the latest developments in science.
All courses for module components are offered annually.

Christian-Albrechts-Universität zu Kiel

Medizinische Fakultät