Module Overview

I. Stem Cell Medicine
II. Stem Cell Biochemistry
III. Regenerative Medicine
IV. Stem Cell Engineering
V. Stem Cell Lecture Series I & II
VI. Biomedical Ethics / Legal Aspects
VII. Scientific Writing
VIII. Laboratory Techniques I & II
IX. Laboratory Project/ Master Thesis Planning
X. Master Thesis

Title of module	**I Stem Cell Medicine**		
Coordinator	Prof. Dr. Beate Brand-Saberi		
Credit points	5	**Semester in which the module is taught**	1
Contact hours	3	**Workload**	150 hours
Lecturer(s)	Prof. Beate Brand-Saberi		
Type of teaching	Lecture (2 hours per week) Seminar (1 hour per week) Discussions in context with lectures and seminar; lecturers ask for feedback regarding understanding and progress; Moodle Skills for efficient research interactions will be trained during the seminars which will be taught in a compact course organized as a mini-symposium organized by the students themselves.		
Relation to curriculum	Compulsory; For master students of Biology/Biotechnology and Biochemistry of RUB, this module is suitable as an elective lecture.		
Recommended prerequisites	No prerequisites from curriculum; Students taking this module will be expected to have a basic understanding of cell biology.		
Aims	The module “Stem Cell Medicine” provides a molecular, cytological and developmental basis by which students will acquire a deep insight into the physiology, derivation and characteristics of well-known types of stem cells.		
Learning outcome	Knowledge: Students can describe the principles and chronology of vertebrate development and stem cell types.		

	Skills: Students have understood and are able to explain basic processes of development. They can summarize and interpret developmental and stem cell related primary literature. Students can interpret basic and advanced problems in stem cell biology and relate morphological data. Competencies: Students can integrate and evaluate relevant stem cell-related textbook knowledge and research data at the morphological, developmental and molecular level. They can design and adequately present advanced level Power-Point based talks, relate them to background knowledge and critically discuss new data. They are capable of communicating in a scientific context in front of an international audience.
Contents of module	Cell cycle control and its implications for stem cell biology Principles of vertebrate development Gametogenesis and fertilization Early development: cleavage, blastocyst, gastrulation, neurulation The three germ layers: ectoderm, mesoderm, endoderm and their derivatives Species-specific aspects of development Stem cell classification: • Hematopoietic stem cells • Mesenchymal stem cells, mesangioblasts • Embryonic stem cells • Fetal stem cells • Adult stem cells • Induced pluripotent stem cells • Stem cells in invertebrates • Reproductive medicine • Embryoid bodies and embryoids
Study and examination requirements; Forms of examination	Students performance during discussions and interactions in the context of the lectures and in the seminar with lecturers and fellow students; Presentations during the seminar The mode of examination will be a multiple choice test. Each examination will be of one hour and the question paper will consist of 30 questions with five choices for each question. The assessment will be based on the average mark obtained in the two semesters. Each exam thus contributes 50% to the overall module mark.
Literature	Essential Current Concepts in Stem Cell Biology, 2020, Brand-Saberi (Editor), Springer Nature Developmental Biology, 12th edition 2020 Barresi, Gilbert, Sinauer Principles of Development, 6th edition 2015 Lewis Wolpert Oxford University Press

	Embryology Keith Moore, Vidhya Persaud edition 2007 Elsevier Langman's Medical Embryology, 12th edition 2011 Thomas W. Sadler Lippincott, Williams & Wilkens

Title of module	**II Stem Cell Biochemistry**		
Coordinator	Prof Günther-Pomorski		
Credit points	5	**Semester in which the module is taught**	2
Contact hours	2	**Workload**	150 hours
Lecturer(s)	Prof. Thomas Günther-Pomorski, Prof. Beate Brand-Saberi		
Type of teaching	Lecture (2 hours per week) Discussions in context with lectures; lecturers ask for feedback regarding understanding and progress; Moodle Skills for efficient research interactions will be trained during the seminars which will be taught in a compact course organized as a mini-symposium organized by the students themselves.		
Relation to curriculum	Compulsory; For master students of Biology/Biotechnology and Biochemistry of RUB, this module is suitable as an elective lecture.		
Recommended prerequisites	No prerequisites from curriculum; Students taking this module will be expected to have a basic understanding of cell biology.		
Aims	The module “Stem Cell Biochemistry” provides a molecular, cytological and biochemical basis by which students will acquire a deep insight into the physiology, derivation and characteristics of well-known types of stem cells.		
Learning outcome	Knowledge: Students can outline the molecular background underlying differentiation control versus stem cell self-maintenance, including cell-to cell and ECM-to-cell signaling cascades (Stem Cell Physiology II). Skills: Students have understood and are able to explain basic processes of development. They can summarize and interpret developmental and stem cell related primary literature. Students can interpret basic and advanced problems in stem cell biology and relate morphological data. Competencies: Students can integrate and evaluate relevant stem cell-related textbook knowledge and research data at the morphological, developmental and molecular level. They can design and adequately present advanced level Power-Point based talks, relate them to background knowledge and critically discuss new data. They are capable of communicating in a scientific context in front of an international audience.		

Contents of module	• The stem cell niche • Neural stem cells as a paradigm for stem cell physiology • Neural development from neural induction to synaptic plasticity • Signaling processes in stem cells • Signal transduction pathways: protein kinaseA as a paradigm for molecular mechanisms of action; structure–function relationships of the kinase superfamily • receptor protein tyrosine kinases and their signaling mechanisms: subclasses: insulin-receptor, FGF-receptor, PDGF-receptor, intracellular signaling pathways: Ras-MAPkinase, PI3-kinase • non-receptor tyrosine kinases: structure-function relationship of src Kinase family • signal transduction for cellular survival and apoptosis: TNFalphaR , PI3Kinase: Bcl-2 protein family, Bcl-xL, Bak, • Serine-threonine receptor kinases: TGF-ß receptors • Phosphotyrosin • phosphatases: catalytic mechanism, PDZ-domains • Cytokine (class I to IV) receptors and signaling mechanism, class I: growth-hormone, erythropoietin. Janus kinases (JAKs), (STATs), IL-6 receptor-family. Concepts of gene-therapy, class II : interferon a, ß, g, class III: (Fas, TNFR1, p75NTR), signaling: TRAFs, TRADD, FAAD, RIP, death-domains, initiator- and effector-caspases (9,3,1) class IV: interleukin-1-receptor, IRAP • GPCRs: GTPase-cycle, G-proteins, transducin signaling as paradigm, calcium-dependent signaling, Ca/Calmodulin, arrestin • Stem cells and autophagy pathways
Study and examination requirements; Forms of examination	Students performance during discussions and interactions in the context of the lectures and in the seminar with lecturers and fellow students; Presentations during the seminar The mode of examination will be one multiple choice test for each semester. Each examination will be of one hour and the question paper will consist of 30 questions with five choices for each question. The assessment will be based on the average mark obtained in the two semesters. Each exam thus contributes 50% to the overall module mark.
Literature	Developmental Biology, 12th edition 2020 Barresi, Gilbert, Sinauer Principles of Development, 6th edition 2015 Lewis Wolpert Oxford University Press Langman's Medical Embryology, 12th edition 2011 Thomas W. Sadler Lippincott, Williams & Wilkens D Voet/J. Voet:4th edition , Biochemistry, John Wiley

Title of module	**III Regenerative Medicine**		
Coordinator	PD Zähres		
Credit points	5	**Semester in which the module is taught**	2
Contact hours	3	**Workload**	150 hours
Lecturer(s)	PD Holm Zähres (and Guests)		
Type of teaching	Lecture (2 hours per week) Seminar (1 hour per week / Block Seminar) Discussions in context with lectures and seminar; lecturers ask for feedback regarding understanding and progress; Moodle Skills for efficient research interactions will be trained during the seminars which will be taught in a compact course organized as a mini-symposium organized by the students themselves.		
Relation to curriculum	Compulsory; For master students of Biology/Biotechnology and Biochemistry of RUB also suitable as elective lecture.		
Recommended prerequisites	No prerequisites from curriculum		
Aims	In the module “Regenerative Medicine” the students will obtain an overview of current approaches of tissue engineering and reconstruction. Students will become familiar with the macroscopic and microscopic anatomy and function of the main organ systems including their regenerative capacities; they will familiarize with the technical approaches and current limitations for the repair of these organ systems.		
Learning outcome	Knowledge: Students have learned the macroscopic and microscopic anatomy and function of organ systems, cell-based therapies and gene therapies for tissue-specific replacement. Skills: Students can apply principles of tissue culture and of “Good manufacturing practice” (GMP), which will be taught theoretically as a general preparation for practical modules. Competencies: Students are capable of developing approaches for solving tissue-specific problems of tissue reconstitution and have the ability to integrate different disciplines to this purpose.		
Contents of module	• Morphogenesis and Tissue Engineering • Biomaterials in Tissue Engineering • Stem cells for toxicological and pharmacological assays		

	• Gene Transfer and Gene Therapy • Generation of iPS • Tissue Engineering using Adult Stem Cells (HSC/MSC/NSC) • Tissue Engineering using Pluripotent Stem Cells (ES/iPS) • Organoids • Cardiovascular Cell Engineering • Hematopoietic Cell Engineering • Isolation of mesenchymal stem cells from bone marrow aspirate/adipose tissue • Musculoskeletal Cell Engineering • Neural Cell Engineering • Biological Bionics – regeneration of tissues in situ and in vivo (not a major topic in current schedule) • Clinical Experience, Regulations and Ethics • Molecular Pharming (Protein production in animal and plants) (not a major topic in current schedule)
Study and examination requirements; Forms of examination	Students performance during discussions and interactions in the context of the lectures and in the seminar with lecturers and fellow students; appreciation of interdisciplinary approaches will be given a high priority. Presentations will be given by the students during the seminar; communication skills will be trained during discussions. The mode of examination will be one multiple choice test at the end of the semester. The examination will be of one hour and the question paper will consist of 30 questions with five choices for each question. The module mark will be based on the exam.
Literature	Lanza; Robert, Langer; Robert and Vacanti, Joseph (2007): Principles of Tissue Engineering. Third Edition, Academic Press Palsson, Bernhard O.; Bhatia, Sangeeta N. (2003): Tissue Engineering. First Edition, Prentice Hall Denecke B, Horsch LD, Radtke S, Fischer JC, Horn PA, Giebel B. (2013) Human endothelial colony-forming cells expanded with an improved protocol are a useful endothelial cell source for scaffold-based tissue engineering. J Tissue Eng Regen Med. Epub Essential Current Concepts in Stem Cell Biology, 2020, Brand-Saberi (Editor), Springer Nature

Title of module	**IV Stem Cell Engineering**		
Coordinator	PD Zähres		
Credit points	5	**Semester in which the module is taught**	2
Contact hours	3	**Workload**	150 hours
Lecturer(s)	PD Holm Zähres		
Type of teaching	Lecture: 2 hours per week Exercises and Seminar: 1 hour per week / Block Lectures and exercises will be assisted by power point presentations and e-learning facilities (Moodle). Development of understanding is supported in team exercises. Interactive presentation in front of an audience, note-taking during lectures, unsolicited post-preparation of module contents and of relevant literature.		
Relation to curriculum	Compulsory; For master students of Biochemistry of RUB also suitable as elective lecture.		
Recommended prerequisites	Students taking this module will be expected to have a basic understanding of molecular genetics.		
Aims	Students will acquire up to date background of molecular genetics, genomic organization and evolution, genomic sequencing, genetic engineering, genes in medicine and disease in context with cells, tissues and laboratory animals.		
Learning outcome	Knowledge: Students have learnt: Cloning (Enzymes, Prokaryotic vector systems, cDNA, Ligation / Recombination techniques), Gene expression / Protein analysis, Sequencing / Epigenetic analysis, Gene transfer and expression (Eukaryotic vector systems), Gene targeting, Genome editing, Transgenic animals Skills: Students have acquired skills in gene and genome analysis, skills in cloning of gene constructs, cell and animal manipulation, protein expression Competencies: Students have acquired concepts and strategies for gene and genome analysis and manipulation according to experimental requirements		
Contents of module	• Essentials of cloning in prokaryotic vector systems: DNA restriction by natural and by artificial, custom made enzymes, modification systems, • Prokaryotic vector systems, selection modes, cDNA synthesis, ligation, recombination site associated exchange of gene cassettes • Gene expression in E. coli / Protein analysis		

	• State of the art sequencing techniques / Epigenetic genome analysis • In vitro / in vivo mutagenesis • Gene transfer and expression (Eukaryotic vector systems, viral, non-viral, episomal expression vectors) • Gene targeting / RNA interference (HR, shRNAs, nucleases) / Genome editing (CRISPR/Cas9) • Transgenic animals (Constitutive, conditional, inducible mice) • RNA methods (Modification, mRNA transfer, miRNAs) • Cell physiology methods 1 (FACS) • Cell physiology methods 2 (Electrophysiology)
Study and examination requirements; Forms of examination	Discussion and interaction during lectures and presentation of exercises are required. The assessment is based on an end of term written exam. The mode of examination will be as follows: 8 questions in free text have to be answered within 2 hours to obtain the full number of points.
Literature	Recombinant DNA: Short Course 2006, Watson; Freeman and Company Recombinant DNA, 1992, Watson, Freeman and Company Kim E. et al., Precision genome engineering with programmable DNA-nicking enzymes. Genome Res. 2012 Jul;22(7):1327-33 Manrao E.A. et al., Reading DNA at single-nucleotide resolution with a mutant MspA nanopore and phi29 DNA polymerase. Nat Biotechnol. 2012 Mar 25;30(4):349-53 Liu X. & Fortin K., MicroRNAs: Biogenesis and Molecular Functions. Brain Pathology 18 (2008) 113–121 Naldini L. et al., In Vivo Gene Delivery and Stable Transduction of Nondividing Cells by a Lentiviral Vector. Science. 1996 Apr 12;272(5259):263-7 Takahashi K. & Yamanaka S., Induction of Pluripotent Stem Cells from Mouse Embryonic and Adult Fibroblast Cultures by Defined Factors. Cell. 2006 Aug 25;126(4):663-76 Soldner F. et al., Generation of Isogenic Pluripotent Stem Cells Differing Exclusively at Two Early Onset Parkinson Point Mutations. Cell. 2011 Jul 22;146(2):318-31

Title of module	**V Stem Cell Lecture Series**		
Coordinator	Prof Brand-Saberi / PD Zähres		
Credit points	5 (2+3)	**Semesters in which the module is taught**	1 and 2
Contact hours	4	**Workload**	300 hours
Lecturer(s)	NN		
Type of teaching	Lecture (2 hours per week) in the first semester Lecture (2 hours per week) in the second semester Scientific lectures presenting original research work, Moodle support of the presentations, further reading recommendations. Critical discussions concerning the presented research data. Moodle support of the presentations, further reading recommendations. Skills for feedback of self-assessment of the learning progress; Developing a general awareness of stem cell related topics in society Making first contacts to PIs of international standing in their fields		
Relation to curriculum	Compulsory; For master students of Biology/Biotechnology and Biochemistry of RUB also suitable as elective lecture.		
Recommended prerequisites	No prerequisites from curriculum; Students taking this module will be expected to have a basic understanding of molecular biology, genetics, cell biology and cell physiology.		
Aims	Students should develop an awareness of specific scientific questions related to stem cell biology and will be able to discuss them in context of current literature.		
Learning outcome	Knowledge: Students have acquired an overview about views, problems and current research topics and know research fields and research groups related to stem cell biology Skills: Students are capable of understanding original research work and relate current research to basic knowledge Competencies: Students have learned to a) Relate current original research results to a theoretical background b) Follow-up recent achievements in the field c) Put relevant problems into a scientific context They are capable of communicating in a scientific context in front of an international audience.		

Contents of module	Semester 1: • Research and Publication Ethics • Ethical Issues in Biomedical Research • Cancer Stem Cells • Early human Hematopoiesis • Cell Replacement therapy in the Brain • Gene Therapy of Hematopoietic Stem Cells • Cellular Reprogramming Semester 2: • Muscle Stem Cells and Myogenesis • Cancer stem cells • Stem Cell Epigenetics • Induction of pluripotent stem cells • Neural Crest-derived Stem Cells • Intracellular Signaling in Stem Cells • Mesenchymal Stem Cells • Neural Stem Cell Niche • Cell Migration in Cancer • Limbal Stem Cells - from bedside back to bench • Extracellular Vesicles • - Advances in neonatal stem cells research and application
Study and examination requirements; Forms of examination	Discussions during and after the lectures are required. The mode of examination on which the module mark is based will be a Multiple Choice Test. The examination will be 90 minutes and the question paper will consist of 9 questions with five choices for each question.
Literature	Essential Current Concepts in Stem Cell Biology, 2020, Brand-Saberi (Editor), Springer Nature Eaves (2008) Cancer stem cells: Here, there, everywhere? Nature 456, 581–582 Hauser et al. (2012) Isolation of Novel Multipotent Neural Crest-Derived Stem Cells from Adult Human Inferior Turbinate. Stem Cells and Development Volume 21, Number 5, 742–756 Hennen E, Faissner A (2012) LewisX: a neural stem cell specific glycan? Int J Biochem Cell Biol 44:830-833. Chakrabarty, K., and Heumann, R. (2008). Prospective of Ras signaling in stem cells. Biological Chemistry 389, 791–798. Kim et. al., (2009) Direct reprogramming of human neural stem cells by OCT4 Nature 461: 649-653. Kögler et al. (2004) A New Human Somatic Stem Cell from Placental Cord Blood with Intrinsic Pluripotent Differentiation Potential JEM 200 no. 2 123-135 Manns, M., Leske, O., Gottfried, S., Bichler, Z., Lafenetre, P., Wahle, P., and Heumann, R. (2011). Role of neuronal ras activity in adult hippocampal neurogenesis and cognition. Front Neurosci 5, 18.

	Yusuf F. and Brand-Saberi B. (2012). Myogenesis and muscle regeneration. Histochemistry and Cell Biology, 138(2):187-199 Stem Cells (Handbook of Experimental Pharmacology) (2006). Anna M. Wobus and Kenneth R. Boheler (eds.), Springer Verlag

Title of module	**VI Biomedical Ethics / Legal Aspects**		
Coordinator	PD Braun / PD Zähres		
Credit points	5	**Semester in which the module is taught**	1
Contact hours	2	**Workload**	150 hours
Lecturer(s)	Biomedical Ethics: PD Dr. Esther Braun Legal Aspects: PD Dr. Holm Zähres		
Type of teaching	Lecture (2 hours per week) Seminar (1 hour / Block Seminar) Practical (1 hour – Animal care) Introductory lectures with presentation of papers by the participants and discussion Case Studies concerning legal aspects (solutions for complex issues, e.g. Genetically modified organism (GMO) - risk assessment)		
Relation to curriculum	compulsory		
Recommended prerequisites	Module V “Stem Cell Lecture Series” in parallel is recommended.		
Aims	The module “Scientific Responsibility in Biomedicine” gives a general survey of legal aspects and the role of professional Biomedical Scientists. Students are expected to have developed a sense of responsibility for their practical work at the end of this module.		
Learning outcome	Knowledge: Students a) acquire knowledge about the contributions of different moral theories to current controversies in biomedical ethics b) understand the peculiarities of normative questions and moral problems, c) recognize moral problems in different areas of applied ethics, d) recognize the German Stammzellgesetz (StZG) and the German Embryonenschutzgesetz (ESG) e) are able to differentiate biosafety levels (1-4) in laboratories where GMOs are handled and assembled; including technical safety precautions on every level, based on the GenTG. f) know the general rules of the animal facility, where procedures are carried out g) know the theoretical background of tasks an investigator is expected to do, so as to safeguard animal well-being and ensure the relevance of scientific advance h) know the basic biology of relevant laboratory animal species i) know the physiology and behaviour of laboratory animals		

	j) are familiar with European and national laws and guidelines relating to the conduct of experimental or other scientific procedures on animals especially the FELASA guidelines (category B) for the education of persons carrying out animal experiments. Skills: Students have acquired the a) ability to identify the strengths and weaknesses of different theories b) ability to explain and observe limits of StZG and ESG c) ability to explain biological safety precautions and impact on the environment d) ability to reflect on the moral problems concerning the own research activity e) ability to discuss these problems with others f) ability to describe and explain duties of responsible persons working in a genetic engineering laboratory (e.g. Biosafety Officer, project manager) and describe the assignment of duties to the relevant staff g) ability to analyse and identify different biosafety relevant organisms with regard to the biosafety level. Students have also strengthened their argumentation and presentation skills in an interdisciplinary context and their abiltities to read and understand texts of other disciplines, and to acquire sources of information and bioethics. Competencies: Students have gained the a) capability of putting relevant problems into a scientific as well as legal and ethical context, b) capability to deal with stem cell technology in a responsible way, c) competence in handling and other techniques investigators are expected to carry out administration of substances, sampling techniques, euthanasia and anaesthesia, analgesia, d) competence to plan licensing procedures for biosafety laboratories and genetic engineering, e) competence to plan experiments with regard to the biosafety levels and rules, based on GenTG and genetic engineering safety regulation (GenTSV), f) ability to recognize pain and discomfort, and to assess the welfare status of animals with which the investigator is working, g) capability of taking appropriate action when adverse outcomes occur during or following procedures.
Contents of module	Bioethics: Introduction to ethics and bioethics The moral status of human embryos and fetuses Ethical problems of reproductive medicine

	Stem cell research and therapeutic cloning Questions of justice and responsibility concerning patents and the protection of intellectual property The ethics of clinical trials Moral problems of clinical trials involving stem cells Legal aspects: Security relevant, important parts of GenTG, GenTSV, BioStoffV with regard to the impact on environment and staff. Biosaftey levels of laboratories, technical facilities and working equipment. Licensing procedures according to GenTG. Important parts of StZG with regard to experiments with stemcells. Limitations of these experiments based on StZG.
Study and examination requirements; Forms of examination	Students active participation in discussions and interactions in the context of the lecture with lecturers and fellow students and individual oral presentations during the lecture are required;
Literature	Bioethics: Tom L. Beauchamp, James F. Childress, Principles of Biomedical Ethics, 6th edition, New York: Oxford University Press, 2008. Cynthia B. Cohen, Renewing the Stuff of Life. Stem Cells, Ethics, and Public Policy, New York: Oxford University Press, 2007. Dena S. Davis, Genetic Dilemmas: Reproductive Technology, Parental Choices, and Children's Futures, 2nd edition, New York: Oxford University Press, 2010. Ezekiel Emmanuel et al. (eds.), The Oxford Textbook of Clinical Research Ethics, New York: Oxford University Press, 2008. Louis M. Guenin, The Morality of Embryo Use, New York: Cambridge University Press, 2008. Jonathan Kimmelman, Gene Transfer and the Ethics of First-in-Human-Research. Lost in Translation, New York: Cambridge University Press, 2010. Michael Kremer, Rachel Glennerster, Strong Medicine. Ceating Incentives for Pharmaceutical Research on Neglected Diseases, Princeton: Princeton University Press, 2004. Paul Lauritzen (ed.), Cloning and the Future of Human Embryo Research, New York: Oxford University Press, 2001. Adrianna Petryna, When Experiments Travel. Clinical Trial and the Global Search for Human Subjects, Princeton: Princeton University Press, 2009. Joseph Stiglitz, Making Globalization Work. The Next Steps to Global Justice, New York: Allen Lane, 2006. Legal aspects: Stammzell Gesetz (StZG); Gentechnik Gesetz (GenTG); GenTSV; Gentechnik-Aufzeichungsverordnung (GenTAufZV); Gentechnik-Notfallverordnung (GenTNotfV); Biostoffverordnung (BioSToffV), Gute Mikrobiologische Praxis (GMP)

	Laboratory animal sciences: Review Article: A L Whittaker, G S Howarth and D L Hickman Effects of space allocation and housing density on measures of wellbeing in laboratory mice: a review Lab Anim November 2011 la.2011.011049; published ahead of print 23 November 2011, doi:10.1258/la.2011.011049

Title of module	**VII Scientific Writing**		
Coordinator	Prof Brand-Saberi		
Credit points	5	**Semesters in which the module is taught**	1
Contact hours	2	**Workload**	150 hours
Lecturer(s)	Prof Brand-Saberi		
Type of teaching	Compact course; Seminar		
Relation to curriculum	Compulsory; elective		
Recommended prerequisites	There are no prerequisites		
Aims	Scientific Writing is accompanying the module “Laboratory Techniques” (VIII) and the Seminar of “Stem Cell Medicine” (I). Students will learn how to describe lab experiments as wells as how to give presentations of their work using technical terms and appropriate scientific language and style. They will also be able to design a research proposal for a suitable funding source.		
Learning outcome	Knowledge: Students have learned how to acquire data; students know how to document and interpret experimental research data. They have obtained knowledge of funding agencies. Skills: Students can express themselves in the appropriate way and have a command of technical terms and scientific language. The students are able to participate actively in planning research projects and to identify relevant research methods. They can interpret obtained research data. They are capable of assembling a research proposal. Students have gained in self-dependence, responsibility and self-organization.		
Contents of module	The ’Scientific Writing’ seminar topics comprise: Scientific Language Relevant methods available in the lab of choice Lab security Standards of documentation Designing appropriate scientific positive and negative controls in experiments Structure of research proposals Funding agencies		
Study and examination	The assessment is based on an explicitly written laboratory report.		

requirements; Forms of examination	Regular laboratory reports; students' performance during discussions and interactions in the context of the lab bench project and in the seminar and lectures with lecturers and fellow students;
Literature	Lindsay. D.R. (2011). Scientific Writing: Thinking in Words; CSIRO Publishing, Australia; Alley, M. (2018) The Craft of Scientific Writing, 4th Edition, Springer New York; Original publications used in module I (Stem Cell Medicine)

Title of module	**VIII Laboratory Techniques**		
Coordinator	Prof Brand-Saberi / PD Zähres		
Credit points	5 (I) + 8 (II)	**Semester(s) in which the module is taught**	1
Contact hours	6	**Workload**	150 hours
Lecturer(s)	All PIs from the associated labs		
Type of teaching	Compact course for two weeks (I); Integration of students into the laboratory work for six weeks (II) with report writing during practicals.		
Relation to curriculum	Compulsory; elective		
Recommended prerequisites	No prerequisites		
Aims	In the module "Laboratory Techniques" students are expected to acquire specific techniques related to stem cell biology, and to develop the competence to apply them and to interpret them as required. In this way, the ground will be laid for appropriate and responsible lab behaviour. The module 'Laboratory Techniques' incorporates for all students an introduction in cell culture techniques with a focus on culturing stem cells (e.g. iPSC) which corresponds to the theoretical presentation of different organ and stem cell types in the semester 1 module 'Stem Cell Medicine'. The students will be enabled to plan, perform and interpret lab experiments choosing from a range of particular methods to solve a particular scientific question. They will also be able to design a research proposal for a suitable funding source.		
Learning outcome	Knowledge: Students have learned how to acquire data; students know how to document and interpret experimental research data, they can identify appropriate controls for experiments The students have gained knowledge in relevant topics in stem cell research by gaining an advanced insight into relevant research fields and identifying relevant research methods. They have obtained knowledge of funding agencies. Skills: Students can handle specialized methods related to stem cell research, depending on the lab visited, and to work in a lab of choice appropriately.		

	Students have a command on particular research methods and the ability to document data. They can interact with others in a laboratory environment Competencies: Students have gained the a) ability to relate a technical method to a scientific question, b) capability of self-organization to manage experimental work, c) competence of planning lab experiments and of coping with experimental difficulties, d) competence to work in teams, e) insight into their own research interests and methodical strengths. The students are able to participate actively in planning research projects and to identify relevant research methods. They can interpret obtained research data. They are capable of assembling a research proposal. Students have gained in self-dependence, responsibility and self-organization.
Contents of module	The contents of this module depend on the choice of host labs. The module provides hands-on experience involving combinations of all techniques taught in the Modules I to V and can thus range from the generation of iPS cells to confocal and/or transmission electron microscopy of mutant or diseased tissues, depending on the interests and profile of the students and the choice of the lab.
Study and examination requirements; Forms of examination	Regular laboratory reports; students' performance during discussions and interactions in the context of the lab project and in the seminar and lectures with lecturers and fellow students. The assessment is based on an explicitly written laboratory report (Ia, Ib).
Literature	Yusuf F. and Brand-Saberi B. (2012). Myogenesis and muscle regeneration. Histochemistry and Cell Biology, 138(2):187-199 Lafenetre P, Leske O, Wahle P, Heumann R. (2011). The beneficial effects of physical activity on impaired adult neurogenesis and cognitive performance. Front. Neurosci. doi: 10.3389/fnins.2011.00051. Manns, M., Leske, O., Gottfried, S., Bichler, Z., Lafenetre, P., Wahle, P., and Heumann, R. (2011). Role of neuronal ras activity in adult hippocampal neurogenesis and cognition. Front Neurosci 5, 18. Full text pdf Squire, Berg, Bloom, du Lac, Ghosh, Spitzer. Fundamental Neuroscience, 3rd Ed. AP (2008) Confocal Microscopy Methods and Protocols. Stephen W. Paddock (ed.) "Methods in Molecular Biology", v. 123, Humana Press. Electron Microscopy Methods and Protocols M A Nasser Hajibagheri, (ed.), 1999, "Methods in Molecular Biology", v. 117, Humana Press Microscopy and Histology for Molecular Biologists: A Users Guide (2002). J. Kiernan and I. Mason (eds.) Portland Press limited.

	Theiss C, Meller K (2012). Fluorescence Proteins and Time-Lapse Imaging of the Cytoskeleton. Protocols in Neuroscience, Interdisciplinary Methods for Investigation of the Cytoskeleton. Ed.: R. Dermietzel. Springer Press. Stem Cells from Adult Human Inferior Turbinate STEM CELLS AND DEVELOPMENT Volume 21, Number 5, 742–756 Hennen E, Faissner A (2012) LewisX: a neural stem cell specific glycan? Int J Biochem Cell Biol 44:830-833. Kim, et. al., (2009) Direct reprogramming of human neural stem cells by OCT4 Nature 461: 649-653. Kögler et al. (2004) A New Human Somatic Stem Cell from Placental Cord Blood with Intrinsic Pluripotent Differentiation Potential JEM 200 no. 2 123-135 “Vertebrate Myogenesis: Stem Cells and Precursors” Beate Brand-Saberi (ed.) Springer-Verlag 2014, Problems and Results in Cell Differentiation Hennen E, Faissner A (2012) LewisX: a neural stem cell specific glycan? Int J Biochem Cell Biol 44:830-833. Denecke B, Horsch LD, Radtke S, Fischer JC, Horn PA, Giebel B. Human endothelial colony-forming cells expanded with an improved protocol are a useful endothelial cell source for scaffold-based tissue engineering. J Tissue Eng Regen Med. 2013 epub Klump H, Teichweyde N, Hinrichs C, Horn PA. Development of patient-specific hematopoietic stem and progenitor cell grafts from pluripotent stem cells, in vitro. Current Molecular Medicine. 2013

Title of module	**IX Laboratory Projects and Master Thesis Planning**		
Coordinator	Prof Brand-Saberi / PD Zähres		
Credit points	7 (LP) + 5 (MTP)	**Semesters in which the module is taught**	2
Contact hours	4	**Workload**	150 hours
Lecturer(s)	All PIs from the associated labs		
Type of teaching	Integration of students into the laboratory work for six weeks (II) with report writing during practicals. Specific techniques to be learned in master thesis planning (MTP); a fictive proposal for the master thesis will be developed.		
Relation to curriculum	Compulsory; elective		
Recommended prerequisites	It is recommended to have attended the language course before and in parallel.		
Aims	In the module "Laboratory Project and Master Thesis Planning" students are expected to acquire specific techniques related to stem cell biology, and to develop the competence to apply them and to interpret them as required. In this way, the ground will be laid for appropriate and responsible lab behaviour. The module 'Laboratory Project' incorporates for all students an introduction in molecular biology techniques with a focus on modifying stem cells (e.g. CRISPR/Cas9) which corresponds to the theoretical presentation of these topics in the semester 2 module 'Stem Cell Engineering'. The students will be enabled to plan, perform and interpret lab experiments choosing from a range of particular methods to solve a particular scientific question. They will also be able to design a research proposal for a suitable funding source. The "Master Thesis Planning" is a part of this module with several weeks of planning the actual master thesis, while acquiring materials, performing initial experiments and designing an experimental plan for the thesis together with the supervisor.		
Learning outcome	Knowledge: Students have learned how to acquire data; students know how to document and interpret experimental research data, they can identify appropriate controls for experiments The students have gained knowledge in relevant topics in stem cell research by gaining an advanced insight into relevant research fields and		

	identifying relevant research methods. They have obtained knowledge of funding agencies. Skills: Students can handle specialized methods related to stem cell research, depending on the lab visited, and to work in a lab of choice appropriately. Students have a command on particular research methods and the ability to document data. They can interact with others in a laboratory environment Competencies: Students have gained the a) ability to relate a technical method to a scientific question, b) capability of self-organization to manage experimental work, c) competence of planning lab experiments and of coping with experimental difficulties, d) competence to work in teams, e) insight into their own research interests and methodical strengths. The students are able to participate actively in planning research projects and to identify relevant research methods. They can interpret obtained research data. They are capable of assembling a research proposal. Students have gained in self-dependence, responsibility and self-organization.
Contents of module	The contents of this module depend on the choice of host labs. The module provides hands-on experience involving combinations of all techniques taught in the Modules I to V and can thus range from the generation of iPS cells to confocal and/or transmission electron microscopy of mutant or diseased tissues, depending on the interests and profile of the students and the choice of the lab.
Study and examination requirements; Forms of examination	Regular laboratory reports; students' performance during discussions and interactions in the context of the lab project and in the seminar and lectures with lecturers and fellow students; The assessment is based on an explicitly written laboratory report (LP) and a fictive proposal for planning the master project (MTP).
Literature	Yusuf F. and Brand-Saberi B. (2012). Myogenesis and muscle regeneration. Histochemistry and Cell Biology, 138(2):187-199 Lafenetre P, Leske O, Wahle P, Heumann R. (2011). The beneficial effects of physical activity on impaired adult neurogenesis and cognitive performance. Front. Neurosci. doi: 10.3389/fnins.2011.00051. Manns, M., Leske, O., Gottfried, S., Bichler, Z., Lafenetre, P., Wahle, P., and Heumann, R. (2011). Role of neuronal ras activity in adult

	hippocampal neurogenesis and cognition. Front Neurosci 5, 18. Full text pdf Squire, Berg, Bloom, du Lac, Ghosh, Spitzer. Fundamental Neuroscience, 3rd Ed. AP (2008) Confocal Microscopy Methods and Protocols. Stephen W. Paddock (ed.) "Methods in Molecular Biology", v. 123, Humana Press. Electron Microscopy Methods and Protocols M A Nasser Hajibagheri, (ed.), 1999, "Methods in Molecular Biology", v. 117, Humana Press Microscopy and Histology for Molecular Biologists: A Users Guide (2002). J. Kiernan and I. Mason (eds.) Portland Press limited. Theiss C, Meller K (2012). Fluorescence Proteins and Time-Lapse Imaging of the Cytoskeleton. Protocols in Neuroscience, Interdisciplinary Methods for Investigation of the Cytoskeleton. Ed.: R. Dermietzel. Springer Press. Stem Cells from Adult Human Inferior Turbinate STEM CELLS AND DEVELOPMENT Volume 21, Number 5, 742–756 Hennen E, Faissner A (2012) LewisX: a neural stem cell specific glycan? Int J Biochem Cell Biol 44:830-833. Kim, et. al., (2009) Direct reprogramming of human neural stem cells by OCT4 Nature 461: 649-653. Kögler et al. (2004) A New Human Somatic Stem Cell from Placental Cord Blood with Intrinsic Pluripotent Differentiation Potential JEM 200 no. 2 123-135 “Vertebrate Myogenesis: Stem Cells and Precursors” Beate Brand-Saberi (ed.) Springer-Verlag 2014, Problems and Results in Cell Differentiation Hennen E, Faissner A (2012) LewisX: a neural stem cell specific glycan? Int J Biochem Cell Biol 44:830-833. Denecke B, Horsch LD, Radtke S, Fischer JC, Horn PA, Giebel B. Human endothelial colony-forming cells expanded with an improved protocol are a useful endothelial cell source for scaffold-based tissue engineering. J Tissue Eng Regen Med. 2013 epub Klump H, Teichweyde N, Hinrichs C, Horn PA. Development of patient-specific hematopoietic stem and progenitor cell grafts from pluripotent stem cells, in vitro. Current Molecular Medicine. 2013

Title of module	**X Master Thesis**		
Coordinator	Prof Brand-Saberi / PD Zähres		
Credit points	30	**Semesters in which the module is taught**	3
Contact hours	30	**Workload**	1.050 hours
Lecturer(s)	All PIs from the associated labs		
Type of teaching	Practical work and instructions accompanying lab bench work Presenting progress reports in the seminar (1 hour per week) Discussion of drafts for the master thesis		
Relation to curriculum	Compulsory; elective		
Prerequisites	The successful completion of all previous modules (except of the module X Master Project itself) is required as prerequisite.		
Aims	In the module “Master Project”, the students will be enabled to plan, perform lab experiments choosing from a range of particular methods to solve a particular question and to interpret their results in context with the relevant literature. They will be enabled to act under regular supervision independently. They will master the task to take over scientific responsibility.		
Learning outcome	Knowledge: Students have gained knowledge on research topics of the host lab and in depth-knowledge of project-related literature. Skills: Students are able to generate, document and interpret original research data. Competencies: Students are capable of critically evaluating their own research data by discussions with supervisors and lab-fellows in the context of current and historical literature; they will be able to keep up with relevant publications in the field. They are capable of adapting their time schedule. Students are self-dependent, self-organized and interact in a laboratory environment in a responsible way;		
Contents of module	The topic of research project can be worked out together with the supervisor.		
Study and examination requirements; Forms of examination	Regular progress reports and discussions with the supervisor in the context of the master project and in the seminar with lecturers and fellow students are required; The assessment will be done on the basis of a written master thesis in English language.		
Literature	Yusuf F. and Brand-Saberi B. (2012). Myogenesis and muscle regeneration. Histochemistry and Cell Biology, 138(2):187-199		

	Lafenetre P, Leske O, Wahle P, Heumann R. (2011). The beneficial effects of physical activity on impaired adult neurogenesis and cognitive performance. Front. Neurosci. doi: 10.3389/fnins.2011.00051. Manns, M., Leske, O., Gottfried, S., Bichler, Z., Lafenetre, P., Wahle, P., and Heumann, R. (2011). Role of neuronal ras activity in adult hippocampal neurogenesis and cognition. Front Neurosci 5, 18. Full text pdf Squire, Berg, Bloom, du Lac, Ghosh, Spitzer. Fundamental Neuroscience, 3rd Ed. AP (2008) Confocal Microscopy Methods and Protocols. Stephen W. Paddock (ed.) "Methods in Molecular Biology", v. 123, Humana Press. Electron Microscopy Methods and Protocols M A Nasser Hajibagheri, (ed.), 1999, "Methods in Molecular Biology", v. 117, Humana Press Microscopy and Histology for Molecular Biologists: A Users Guide (2002). J. Kiernan and I. Mason (eds.) Portland Press limited. Theiss C, Meller K (2012). Fluorescence Proteins and Time-Lapse Imaging of the Cytoskeleton. Protocols in Neuroscience, Interdisciplinary Methods for Investigation of the Cytoskeleton. Ed.: R. Dermietzel. Springer Press. Stem Cells from Adult Human Inferior Turbinate STEM CELLS AND DEVELOPMENT Volume 21, Number 5, 742–756 Hennen E, Faissner A (2012) LewisX: a neural stem cell specific glycan? Int J Biochem Cell Biol 44:830-833. Kim, et. al., (2009) Direct reprogramming of human neural stem cells by OCT4 Nature 461: 649-653. Kögler et al. (2004) A New Human Somatic Stem Cell from Placental Cord Blood with Intrinsic Pluripotent Differentiation Potential JEM 200 no. 2 123-135 “Vertebrate Myogenesis: Stem Cells and Precursors” Beate Brand-Saberi (ed.) Springer-Verlag 2014, Problems and Results in Cell Differentiation Denecke B, Horsch LD, Radtke S, Fischer JC, Horn PA, Giebel B. Human endothelial colony-forming cells expanded with an improved protocol are a useful endothelial cell source for scaffold-based tissue engineering. J Tissue Eng Regen Med. 2013 epub Klump H, Teichweyde N, Hinrichs C, Horn PA. Development of patient-specific hematopoietic stem and progenitor cell grafts from pluripotent stem cells, in vitro. Current Molecular Medicine. 2013