TUM School of Life Sciences
Technische Universität München

Module Catalog

M.Sc. Agricultural Biosciences

TUM School of Life Sciences
Technische Universität München

www.tum.de/
www.wzw.tum.de/index.php?id=2&L=1

Module Catalog: General Information and Notes to the Reader

What is the module catalog?
One of the central components of the Bologna Process consists in the modularization of university curricula, that is, the transition of universities away from earlier seminar/lecture systems to a modular system in which thematically-related courses are bundled together into blocks, or modules.
This module catalog contains descriptions of all modules offered in the course of study.
Serving the goal of transparency in higher education, it provides students, potential students and other internal and external parties with information on the content of individual modules, the goals of academic qualification targeted in each module, as well as their qualitative and quantitative requirements.

Notes to the reader:

Updated Information
An updated module catalog reflecting the current status of module contents and requirements is published every semester. The date on which the module catalog was generated in TUMonline is printed in the footer.

Non-binding Information
Module descriptions serve to increase transparency and improve student orientation with respect to course offerings. They are not legally-binding. Individual modifications of described contents may occur in praxis.
Legally-binding information on all questions concerning the study program and examinations can be found in the subject-specific academic and examination regulations (FPSO) of individual programs, as well as in the general academic and examination regulations of TUM (APSO).

Elective modules
Please note that generally not all elective modules offered within the study program are listed in the module catalog.

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Module Description

WZ0626: Genetics and Genomics | Genetics and Genomics

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the written examination (60 min, Klausur) students demonstrate by answering questions under time pressure and without helping material their theoretical understanding of components, processes, mechanisms and methods to study crop and livestock genetics and genomics.
In the seminar presentation of 30-45 min (depending on the article) students show their ability to present a scientific research article in a concise way to a peer group. The presentation will be evaluated based on scientific correctness, precise summary and discussion of strengths, weaknesses and the methodology of the research, clearly designed slides and interesting as well as clear presentation style.

The goals of the module have been reached and the module has been passed when the total grade of written exam and presentation (3:2) is better than 4.1.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Fundamental knowledge in genetics and molecular biology is highly recommended. The participants should have passed one or more bachelor level lectures in genetics, genomics, systems biology or developmental genetics.

Content:
The module is organized into topical sections, moving from classical genetics to modern genomics.

1) Classical Genetics:

a) Gene structure and function, duplication and redundancy
b) Mutations, allele types, Mendelian Genetics
c) Transposons
d) Transcriptional regulation by transcription factors

2) Genomics:
a) Genome structure and function
b) Genomic and functional variation
c) Population/Quantitative Genomics
d) Evolutionary Genomics

Intended Learning Outcomes:
At the end of the module the students can:
1) identify the key research questions and goals in the field of genetics and genomics
2) name the major molecular and technological tools used in genetics and genomics
3) explain how these tools are currently applied to crop (plant) and livestock (animal) research
4) critically analyze published results in these area of crop and livestock genetics and genomics
5) present the content of published results to their peers

Teaching and Learning Methods:
Teaching method:
The module is organized into topical sections, moving from classical genetics to modern genomics. Each section consists of lectures (2 SWS), providing the necessary conceptual/theoretical background. The content of each section is reinforced by seminars (2 SWS), in which students analyze, present and discuss selected research papers on current research covering these topics. The research papers are chosen to illustrate how the concepts and tools discussed in the lectures are applied to solve concrete research questions in crop (plant) and livestock (animal) research. Where necessary the lectures and seminars will emphasize key differences in the genetics and genomics of plants and animals.

Lectures:
The lectures will provide the conceptual/theoretical background of Genetics and Genomics. Focus will be on displaying and extracting the key research questions and tools used in these fields.

Seminars:
In the seminars, the students will analyze published articles in the field of plant and livestock Genetics and Genomics, with a particular focus on key crop (e.g. maize, rice, tomato) and livestock (e.g. cow, pig, chicken) species. The students will be able to assess how the basic research questions and tools introduced in the lectures are applied to specific breeding goals in the agricultural sector.

Learning Activity:
Study and critically analyze scientific articles in crop and livestock Genetics and Genomics
Summarize and present the content of scientific articles to a peer group

Discuss the content of scientific articles with a peer group

Media:
Presentations with PowerPoint, videos, black board

Reading List:
LECTURE:
Anthony Griffith et al, Introduction to genetic analysis, 2015 11th edition (or newer)
James Watson et al, Molecular Biology of the Gene, 2014 7th edition (or newer)
Hartl and Clark, Principles of Population Genetics 4th Edition (2007);
Charlesworth and Charlesworth, Elements of Evolutionary Genetics (2010).
Original articles used to increase the content of the lecture will be cited on the PowerPoint slides.

SEMINAR:
Original articles will be distributed to the individual speakers in the first seminar session.

Responsible for Module:
Gutjahr, Caroline; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Genetics and Genomics (Vorlesung, 2 SWS)
Gutjahr C, Johannes F, Tellier A

Genetics and Genomics (Seminar, 2 SWS)
Gutjahr C [L], Gutjahr C, Johannes F, Tellier A
For further information in this module, please click campus.tum.de or here.

Module Description

WZ0625: Immunology: Crop and Livestock Health and Disease | Immunology: Crop and Livestock Health and Disease

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module is rated via written examination (Klausur, essay exam, no multiple choice, without the use of learning aids, (100 % of the grade; 90 min). The written exam tests the ability of the student to remember the principles of immunology and to transfer the knowledge to new practical problems and scientific questions. Student have to show their ability to design experiments suitable to test a given hypothesis from molecular host-parasite interactions. Students have to show their ability to extract scientific progress from original data or experiments presented in the exam. They have to show their ability to analyze and compare common and specific features of plant and animal immunity.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of plant and animal sciences and pathology at the B.Sc. level

Content:
In this module, students are introduced to plant-pathogen interactions at the molecular level as well as the function of the vertebrate immune system. In the obligatory lecture (plants) students gain knowledge about theoretical background of molecular plant parasite interactions, which is extracted and focused by the lecturers from review literature.
In the obligatory lecture (animals) students gain knowledge about theoretical background of the mammalian immune system with a strong focus on the adaptive immune system.
This comprises pattern-triggered immunity, effector-triggered susceptibility, effector-triggered immunity and translational research in plants and the innate and adaptive immune response in vertebrates. Common principles (innate immunity) and specific features of plant and animal immunity are taught (e.g. adaptive and cellular immunity, systemic acquired resistance). This

is not restricted to model plants, humans and mice but extends to crops and livestock animals and fills the gap between basic research and applied animal and plant sciences in breeding and biotechnology for disease resistance.

Intended Learning Outcomes:
Education to understand the principles of molecular plant immunology (lecture + seminar: Crop plant immunity) or of animal and livestock immunology (lecture + seminar: Comparative Immunology-Livestock). Students learn to judge and design approaches for increasing disease resistance in model and crop plants and principles of comparative immunology. They are able to judge and design approaches to analyze the vertebrate immune system with regards to diseases resistance and autoimmune diseases. Deep understanding of the molecular basis of plant pathogen interactions and the innate and adaptive immune response in vertebrates. Upon completion of the module, students are able to remember theoretical background and definitions of molecular host parasite interactions as well as the innate and adaptive immune response in vertebrates with a strong focus on disease control and autoimmune diseases. They are able to understand and analyze animal and plant immune responses. Students gain the ability to collect new theoretical knowledge from literature and understand innovative technologies in animal and plant immunity and susceptibility. This enables students for the experimental design and evaluation of plant disease resistance tests in model and crop plants (focus on plant/crop immunity). Students with a focus on 'comparative immunology' are enabled to analyze the immune response of various vertebrate species towards relevant pathogens. Additionally, students can extract, process and present complex information from original literature. They are able to distinguish common principles of plant and animal immunity from specific types of immunity of plants or animals.

Teaching and Learning Methods:
The module is dived in two obligatory lectures and two electable seminars, from which the student have to choose one. The obligatory parts introduce common and kingdom-specific principles of immunology to enable comparative view on the plant and animal systems. According to the students individual preferences on either crop or livestock sciences, the electable seminar enables then deepening the knowledge and application to recent problems and research questions.
In the electable plant seminar/journal club, students are guided in small groups how to critically read original research papers, digest information and present most central findings from a recent original paper. In interactive learning structures with small groups, we train reading and understanding of original animal and plant immunity literature and corresponding methodology (Seminar/Journal Club).They learn to critically interpret original work and current hypotheses in plant immunity.
In the electable comparative immunology - livestock seminar, students are guided how to analyze research papers and how to present the most central findings. They learn critical interpretation of original work and current hypotheses in comparative immunology.

Media:
Powerpoint presentations, round table discussions

Reading List:
Agrios 2005, Plant Pathology, Buchanan 2015, Biochemistry & Molecular Biology of Plants.
Janeways Immunobiology 9th edition, Norton&Company 2016
Avian Immunology 2nd edition, Elsevier 2013
Veterinary Immunology 10th edition, Elsevier 2017

Review and original literature is additionally provided.

Responsible for Module:
Hückelhoven, Ralph; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Immunity of plants (Vorlesung, 1 SWS)
Hückelhoven R

Crop Plant Immunity (Seminar, 2 SWS)
Hückelhoven R [L], Hückelhoven R, Engelhardt S, Stam R, Stegmann M

Immunity of mammals (Vorlesung, 1 SWS)
Schusser B [L], Berghof T, Schusser B, Vikkula H, Zehn D

Comparative Immunology - Livestock (Seminar, 2 SWS)
Schusser B [L], Schusser B, Sid H, Vikkula H, Zehn D
For further information in this module, please click campus.tum.de or here.

Module Description

WZ0623: Physiology | Physiology

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment of this module consists of a 120 min. written exam (Klausur). It aims to proof the successful acquisition of knowledge in animal and plant cell physiology in relation to agriculture and livestock. Moreover, students have to demonstrate their ability to make use of the acquired concept to answer specific problems and to transfer the knowledge to a related but different context.
For the plant biology, students have to show for instance how processes coordinating plant growth interact with the processes controlling the C-economy to maximize C-gain and water use. Eventually they should be able to describe Crop Production on the basis of the physiological processes presented in the lecture.
In the cell physiology area, transfer questions could involve to apply acquired knowledge to particular disease situations. For instance, a questions could be to ask students to explain the consequences and underlying mechanisms why a strong and sudden loss of blood decreases exercise performance and vice versa why blood doping is so popular in sports.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of cell biology, biochemistry, molecular biology as well as physics, chemistry at bachelor level.

Content:
Lecture Plant Physiology:
- Germination
- Hormone physiology of shoot growth, Hormonal control of root architecture
- Floral transition
- Fertilization, Seed and fruit development

- C-economy of plants

Lecture animal Physiology:
- Cell biology
- Heart, Kidney, Liver physiology, Immune system, blood
- General elector, biosynthesis, metabolism and hormone physiology

Intended Learning Outcomes:
Upon successful completion of this module, students are able to:
- Identify the principal physiological processes coordinating plant growth and development at the tissue and organism level with a focus on plant hormone function in germination, shoot elongation, shoot branching, root architecture control, vegetative to reproductive transition and formation of reproductive organs.
- Understand the role of these physiological processes in crop production.
- Understand C-economy of plants, the interaction of C-gain by photosynthesis and C-loss by respiration as well as C-allocation, interaction of C-economy with other plant resources as Nitrogen, light and water. This covers basic plant physiological methods like photosynthesis measurements and the use of stable isotopes.
- Explain how environmental parameters such as light, water availability and temperature are detected by the plant and converted into adequate growth responses.
- Remember major genetic factors controlling physiological pathways with an impact on yield quality and quantity.
- explain key principles of cell biology and functional adaption of cells in a specific organ context, cell physiology in the context of specific organs and linked to specific organ function (i.e heart [electrophysiology, muscle cell biology], kidney [transport processes, circulation, basics of electrolyte physiology], liver [metabolism, protein biosynthesis]
- describe Physiology of selected organs and functions: digestive system, skin, central nervous and sensory system, bones, lungs
- discuss the General design and function of the immune system and the blood
- understand Basics of hormon physiology and animal growth

Teaching and Learning Methods:
The learning contents are disseminated in PowerPoint-supported lectures to impart the relevant theoretical background and concepts in the Physiological Sciences of agriculturally important organisms. Furthermore, generation and use of this knowledge is exemplified by providing application-relevant case studies from current literature.

Media:
PowerPoint-supported presentations; the corresponding slide contents are available as PDF-files on the Moodle platform.

Reading List:
Taiz, L. and Zeiger, E. (2014): Plant Physiology and Development.
Alberts B. (2014), Molecular Biology of the Cell

Guyton and Hall Textbook of Medical Physiology, 2015 (or Brandes, Lang, Schmidt, Physiologie des Menschen, 2019)

Responsible for Module:
Zehn, Dietmar; Prof. Dr.med.

Courses (Type of course, Weekly hours per semester), Instructor:
Plant Physiology (Vorlesung, 2 SWS)
Sieberer T [L], Bienert G, Schäufele R, Sieberer T

Animal Physiology (Vorlesung, 2 SWS)
Zehn D [L], Zehn D, Pfaffl M, Schusser B, Farschtschi S
For further information in this module, please click campus.tum.de or here.

Module Description

WZ0624: Plant and Animal Cell Biology | Plant and Animal Cell Biology

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The acquired knowledge will be assessed in a written exam (90 minutes) in which the students show that they understood the basic principles of how cells function, replicate, differentiate and interact and how their functions can be experimentally altered.
They should prove their ability to describe, interpret and structure the newly obtained information and to combine it with previous knowledge and use it in slightly altered circumstances, e.g. by analyzing a hypothetical scientific question in the exam. They also show that they have acquired knowledge about the suitable stat-of-the-art technologies that are used to address specific questions.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
For master students in their first or second semester.

Content:
The content of this module covers the general organisation of a plant or animal cell:
- introduction to the organisation of the cellular genome, transcription and protein production.
- genetic engineering of the plant or animal genome
- structure of the cell including cell membrane and intracellular compartments and their function.
- mechanism of cell division
- mechanisms of cell interactions
- introduction to the development of multicellular organisms (plants and animals).

Intended Learning Outcomes:
After successful participation in both lecture and seminar the student will have fundamental knowledge regarding plant and animal cells, their similarities and differences, how cells function, replicate and interact with each other. And finally how different cell types are being generated.

The student will be able to:
- investigate scientific problems regarding cell biology, cellular re-organization, cell replication, gene expression and epigenetic modulation.
- use the acquired knowledge to solve new problems and provide answers to scientific questions.
- understand which technologies (imaging, molecular analysis, cell culture and genetic manipulation) they may have to use to do so.
- know how to obtain both practical skills and theoretic knowledge for very specific questions regarding structural elements of the cell, different cell types or cell-cell-interaction.

Teaching and Learning Methods:
Part of the course will be a lecture in which the students are requested to participate. They should study the provided script and are encouraged to ask and answer questions during the lecture. It is essential that knowledge acquisition is examined throughout the course by discussing technical and scientific problems which occurred during cell biology research and how these hurdles could be overcome.

For the seminar and practical part student will work in groups, they will be encouraged to carry out an in-depth study of literature, assess the presented results and learn to question the validity of published results. Some hands-on experience will bring the subject to live and connect the theoretical and practical knowledge.

Media:
Presentation via PowerPoint, films, download of required information and literature

Reading List:
To be announced

Responsible for Module:
Schnieke, Angelika; Prof. Ph.D.

Courses (Type of course, Weekly hours per semester), Instructor:
Plant and Animal Cell Biology (Seminar, 2 SWS)
Fischer K, Hückelhoven R, Schnieke A

Plant and Animal Cell Biology (Vorlesung, 2 SWS)
Schnieke A, Hückelhoven R, Fischer K, Flisikowska T
For further information in this module, please click campus.tum.de or here.

Module Description

MA9613:

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the written exam (60 min) the students solve problems to selected statistical topics. The solution requires the application of the skilled and practiced calculations and heuristics. First the students have to identify and to classify the problem and secondly choose and apply a suitable method.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Bachelor's course in statistics

Content:
Basic statistics review
Categorical data
Analysis of variance and experimental design
Robust methods
Simple regression
Multiple regression
Specification
Model diagnostics
Lack of fit
Model selection
Nonlinear and time series regression
Survival regression
Logistic and poisson regression
Linear mixed models
Sample size and power calculations

Intended Learning Outcomes:
1) Become experienced in all facets of the R statistical package.
2) Apply data handling methods for visualization and communication.
3) Select and apply appropriate statistical methods to design and analyze experimental data.
4) Apply appropriate hypothesis tests and confidence interval procedures.
5) Perform multiple Normal linear-, mixed-effect-, time-series-, non-linear-, Poisson- and survival-regression.

Teaching and Learning Methods:
In the lectures the concepts are introduced and discussed in case studies. In the exercise classes the students solve problems and case studies on their own using the statistical package R. The problems of the case studies are chosen to provide the students guided, hands-on experience to acquire the necessary skills in the projects.

Media:
Slides, exercise sheets, R statistical package

Reading List:
Abram, B., Ledolter, J., Introduction to Regression Modeling, Thomson Brooks/Cole
Fitzmaurice, G. M., Laird, N. M., Ware, J. H., Applied longitudinal analysis, Wiley
Collett, D., Modelling Survival Data in Medical Research, Chapman & Hall CRC
Van Belle, G., Fisher, L D., Heagerty, P. J., Lumley, T., Biostatistics: a methodology for the health sciences, Wiley
Peck, R., Olsen, C., Devore, J., Introduction to Statistics and Data Analysis, Brooks/Cole Cengage Learning

Lecture notes, additional material in moodle course

Responsible for Module:
Ankerst, Donna; Prof. Ph.D.

Courses (Type of course, Weekly hours per semester), Instructor:
Exercises for Statistical Computing and Data Analysis (TUM School of Life Sciences) [MA9613] (Übung, 1 SWS)
Ankerst D, Neumair M

Statistical Computing and Data Analysis (TUM School of Life Sciences) [MA9613] (Vorlesung, 2 SWS)
Ankerst D, Neumair M
For further information in this module, please click campus.tum.de or here.

Elective Modules | Wahlmodule

Lab Courses | Lab Courses

Module Description

WZ0628: Lab Course Immunology | Lab Course Immunology

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module is rated via written examination (Klausur, essay exam, no multiple choice, without the use of learning aids, (100 % of the grade; 90 min). The written exam tests the ability of the student to remember the principles of performing immunological experiments and to transfer the knowledge on new practical problems and scientific questions. Student have to show their ability to design experiments suitable to test a given hypothesis from molecular host-parasite interactions. Students have to show their ability to extract scientific progress from experiments presented in the exam. They have to show their ability to analyze data extracted from experiments.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of plant and animal sciences and pathology at the B.Sc. level and the module Immunology.

Content:
In this module, students are introduced to planning and performing immunological experiments in order to analyze the immune system of plants and animals. Students gain knowledge about theoretical background of technologies used to analyze the immune system.
The following methods/technologies will be performed during the exercise:
- Measuring calcium signaling in plants and animal cells
- Measuring reactive oxygen species
- Transfection of plants for interference with immuno-competence
- Isolation of lymphocytes by density gradient centrifugation

- Characterization of lymphocyte populations by FACS
- in silico analyze of FACS data
- ELISA
- Stimulation of macrophages and NO measurement

Intended Learning Outcomes:
After successful participation of the module, students are able to understand the principles of experimental molecular plant immunology or of animal and livestock immunology. Students can design and perform experiments for manipulating disease resistance in model and crop plants and technologies to analyze the vertebrate immune system. They are able to judge the suitability of an experimental approach and to select to most appropriate technology to test a given hypothesis. Students gain the ability to collect new practical skills and understand the set-up of immunological experiments. This enables students for evaluation of non-specific and specific plant disease resistance in model and crop plants. Students will also be enabled to analyze the composition of the immune cells of various animal species.
Additionally, students can extract, process and present data obtained from their own experiments. They learn critical interpretation and discussion of experimental data.

Teaching and Learning Methods:
The module consist of a two one week lab courses. In small parallel groups the students will be guided by each one lecturer/supervisor to plan experiments in order to analyze the plant and animal immune system. The students will independently perform experiments and analyze the resulting data in a supervised way. Analyzed data will be presented to the supervisor and the group and results are carefully discussed.

Media:
PowerPoint presentations, round table discussions

Reading List:
Agrios 2005, Plant Pathology, Buchanan 2015, Biochemistry & Molecular Biology of Plants.
Janeways Immunobiology 9th edition, Norton&Company 2016
Avian Immunology 2nd edition, Elsevier 2013
Veterinary Immunology 10th edition, Elsevier 2017
Review and original literature is additionally provided.

Responsible for Module:
Schusser, Benjamin; Prof. Dr.med.vet.

Courses (Type of course, Weekly hours per semester), Instructor:
lab course plant immunology (Übung, 2 SWS)
Hückelhoven R, Engelhardt S, Stam R, Stegmann M

lab course – animal immunology (Übung, 2 SWS)
Schusser B [L], Schusser B, Sid H, Vikkula H, Zehn D

For further information in this module, please click campus.tum.de or here.

Module Description

WZ0636: Lab Course Introduction to Mammalian Cell Culture | Lab Course Introduction to Mammalian Cell Culture

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 75	**Contact Hours:** 75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The acquired knowledge will be assessed in a written exam (90 minutes) in which the students demonstrate that they understood the theoretical and scientific basis for mammalian cell culture, such as how primary cell cultures are being established, how to distinguish different cell types, how to manipulate cells and why and which is the most appropriate method to do so. They should demonstrate that they are able to combine methods to solve problems in cell biology.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
BSc in Agriculture, Molecular biology, Biology or related areas. Basic knowledge about cell biology.

Content:
The accompanying lectures provide basic knowledge about the isolation, characterization and genetic manipulation of mammalian cells. Contents are among others: sterile working, microscopy, culture conditions, establishment and preservation of cell lines and primary cultures, determination of cell numbers, transfection methods, isolation and expansion of cell clones, application and detection of marker genes. This theoretical knowledge is than the basis for the practical course in which the theoretical knowledge will be translated into hands-on experiments from working in a sterile environment to the manipulation of the mammalian cell. In the accomplishing seminar the students will read, exam, discuss and present a summary of relevant literature in the area of cell biology.

Intended Learning Outcomes:
After participating in this module the students will have a fundamental understanding and the theoretical know-how for the isolation, cultivation and genetic manipulation of mammalian cells.

In addition they have learned basic practical skills, methods and techniques essential to cell biology. They have learned and understood a number of techniques relevant to the manipulation of mammalian cells and are able to apply the acquired knowledge to solve problems and design necessary experiments.
The module provides the student with problem solving skills and promotes the interest in cell biology and its application.

Teaching and Learning Methods:
Part of the course will be in form of a lecture in which the students are requested to participate. Prior to the lectures they should have studied the provided script so they can ask and answer questions during the presentation which will be in preparation for the practical work. It is essential that knowledge acquisition is examined throughout the course by discussing technical, scientific and practical problems. All practical techniques will be demonstrated to the students prior to their first hands-on experiments, during experiments they will be continuously monitored and supervised and if required corrected. They will be working in small groups 4-6 students, each group will have a supervisor. For the seminar students will work in groups, they will be encouraged to carry out an in-depth study of literature, assess the presented results and learn to question the validity of published results

Media:
Presentation via PowerPoint, films, download of required information, script and literature

Reading List:
To be announced

Responsible for Module:
Schnieke, Angelika; Prof. Ph.D.

Courses (Type of course, Weekly hours per semester), Instructor:
Questions in Cell Biology and Use of Genome Editing Tools (Seminar, 2 SWS)
Fischer K, Flisikowska T, Rieblinger B, Schnieke A

Introduction to Mammalian Cell Culture (Übung, 3 SWS)
Fischer K, Flisikowska T, Rieblinger B, Schnieke A
For further information in this module, please click campus.tum.de or here.

Module Description

WZ0637: Lab Course Methods for Analysis of Next Generation Sequencing Data | Lab Course Methods for Analysis of Next Generation Sequencing Data

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The grade is based on the report by the student who will describe in 10-20 pages their analysis of a dataset they have chosen. Up to five weeks are given for data analysis and writing of the report. The report should indicate the description of methods, statistical analyses and discussion of the results. The report serves as a basic scientific document summarizing the pipeline of analysis, possible pitfalls and bias in the results, as well as a general conclusion about the chosen datasets. The datasets will be prepared by the lecturer and downloaded by the students.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic knowledge in statistics and genetics

Content:
1) Introduction to NGS data.
2) Analysis of genomic NGS data: type of files, download NGS data from databases, barcoding, trimming, read quality control, perform read-mapping with a reference genome, perform SNP calling, gene annotation, statistical bias in SNP calling. Use of SAMtools and Galaxy.
3) Analysis of gene expression data from RNAseq: type of files, perform read-mapping of a transcriptome, assembly of transcriptome, annotation of genes, gene expression analysis, bias in gene expression analysis.
4) de novo genome assembly: de novo assembly of a simple genome, annotation of assembly.
5) Exercise and practice of analysis based on a dataset from initial data to statistical analysis and writing a report with discussion about the data.

Intended Learning Outcomes:
After the course the students know the different type of data generated by NGS, they know how to perform all the steps from raw data until obtaining SNPs or gene expression results. They master the analysis of genomic data up to SNP calling, and the analysis of gene expression data from RNAseq. Moreover, they know the possible bias in performing SNP calling and gene expression using different software, and understand the statistical issues with NGS data. By learning how to use different software, they know how to produce accurate data analysis from NGS sequencing data (and RNAseq data) and can write a scientific description of the pipeline of analysis. They are also confident in using the classic tools for bioinformatics of NGS data, the Linux operating system and a computer cluster.

Teaching and Learning Methods:
The lectures and exercise are intermixed during the sessions, and most sessions comprise only exercises and hands on practice. Typically, a first part of short lecture introduces the concepts and the tools with key concepts of the statistical analysis. The exercises are performed on computers under Linux and on a computer cluster. The students code and implement the analysis using different software. A Wiki page is given as a document for the course on which all command lines and exercises are documented. The wiki serves a guideline for the students to go through the pipeline of the analysis. The exercises are for the whole group, and students are encouraged to discuss their results with their colleagues, before a summary is made by the lecturer.

Media:
Software training: Linux environment, basic command line, statistical software R, SAMtools, Trimmomatic, bwa, trinity, velvet, Galaxy

Reading List:
The wiki page covers all information on software and pipeline for the course.

Responsible for Module:
Tellier, Aurélien; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
NGS Datenanalyse (Übung, 4 SWS)
Tellier A [L], Ortiz Valencia E, Schäfer H, Shigita G, Silva Arias G, Tellier A
For further information in this module, please click campus.tum.de or here.

Module Description

WZ0627: Lab Course Physiology | Lab Course Physiology

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The practical course concludes with a laboratory assignment (course work) in which the students prepare a report. The report presents their laboratory results in a scientific way. The report has to be submitted on a specific date in the week following the course.

A graded oral exam (max. 30 min per student) will be held during which specific aspects of the submitted report and general topics of plant and animal physiology will be assessed. For example, students are confronted with gas exchange and stable isotope data, which they have to evaluate and interpret.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of cell biology, biochemistry, molecular biology as well as physics, chemistry at bachelor level.

Content:
Lab Course Plant Physiology:
- Basic technical principles of gas exchange measurements, including determination of possible pitfalls
- Separate C-fluxes in photosynthesis: Carboxylase and oxygenase activity, dark respiration
- Manipulating photosynthesis by environmental parameters: CO2, light and water
- Comparison C3- and C4-photosyntesis
- Determination of mesophyll conductance (C3) and bundle sheath leakiness (C4) by use of stable isotopes

Lab Course Animal Physiology:

- The key topic of the course will be to assess organ function through multi-dimensional phenotypic and functional profiling at single cell level
- The course will cover practical methods to:
- Isolate cells from organs
- Characterization of protein expression and function at single cells level using state of the art flow cytometry
- In silico work with existing data sets of single cell resolved RNA expression (Single cell resolved RNAseq)
- Analysis of multi-dimensional single-cell resolved datasets

Intended Learning Outcomes:
Upon successful completion of this module, students are able to:
- conduct Photosynthesis measurements with state-of-the art Infrared gas analyzer systems
- evaluate and interpret CO2- and light-response curves
- understand the basic difference between C3- and C4-photosynthesis
- understand the benefit of combining gas exchange measurements with stable isotope measurements
- process organs and to isolate single cells from organs, tests of cell viability and viability, expose cells them to defined stimuli and assess the functional consequences
- perform 'Flow cytometry' to assess cell differentiation at single cell level
- use basic principles for analyzing complex single cell resolved multi-parameter data sets
- conduct experiments and present the results in a written form according to scientific standards

Teaching and Learning Methods:
Lab Course Plant Physiology:
The learning contents are disseminated in short PowerPoint-supported lectures of the basic principles. The main focus of the Lab Course is the presentation of gas exchange measurements and the execution of measurements by the students. This is followed by an introduction of evaluation of gas exchange data produced by the students.

Lab Course Plant Physiology:
- Participants will a priori receive a script that informs them of the content, aims, and methods of the practical course
- The course will start with a 2-3 hour introduction during which all general aspects will be explained and discussed. This will take place in free discussions and in parts with the help of PowerPoint-assisted short presentations.
- Then the student will participate in 4 topics/units that are distributed over the 4 days. Content of the units will be discussed upfront, then the practical work will be carried out, finally there will be a discussion of results.
- The course will end with an afternoon during which all topics and aims of the course will be recapitulated.
- Students will work in groups >2, numbers depends on the total number of participants, not more than 5 per group

Media:
PowerPoint-supported presentations; the corresponding slide contents are available as PDF-files on the Moodle platform.

Reading List:
Taiz, L. and Zeiger, E. (2014): Plant Physiology and Development.
Alberts B. (2014), Molecular Biology of the Cell

Responsible for Module:
Zehn, Dietmar; Prof. Dr.med.

Courses (Type of course, Weekly hours per semester), Instructor:
Lab Course Physiology (Praktikum, 4 SWS)
Pfaffl M [L], Pfaffl M, Zehn D, Schäufele R, Bienert G
For further information in this module, please click campus.tum.de or here.

Research Tools | Research Tools

Module Description

WZ0630: Analysis of Epigenomic Data | Analysis of Epigenomic Data

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 150	**Contact Hours:** 150

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students will be evaluated by a report which is supplemented by a short presentation:
1. Written summary report (students will prepare a 10 page, double-spaced) summary report. The report will test their ability to summarize the datasets, analysis steps, and discuss the results of the analysis in the context of a specific biological hypothesis.
2. Presentation students will prepare a 15 min. presentation based on their written report. The presentation displays their ability to present their findings in a concise way to a peer group. They discuss their approach and results in the context of the research field and defend their work in a scientific debate.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic knowledge of computer systems and epigenetics.

Content:
Epigenetic modifications, such as DNA methylation or histone modifications, have a central role in the regulation of gene expression, particular in response to environmental and developmental cues. Next Generation Sequencing (NGS) technologies now allow us to measure the genome-wide patterns of various epigenetic modifications at unprecedented resolution. These technologies have opened up novel research avenues in basic and applied plant biology, including studies of development, stress response and natural variation. In this module students will be familiarized with the following NGS analysis steps:
- Introduction to Linux and R.

- Downloading NGS datasets from GEO public repository.
- Importing and manipulating NGS datasets.
- Alignment, trimming and quality filtering of ChIP-seq and WGBS sequencing reads.
- WGBS: Methylation state calling and detection of differentially methylated regions (DMRs).
- ChIP-seq: peak calling and differential enrichment analysis.
- Integration of WGBS and ChIP-seq with gene expression data.

Intended Learning Outcomes:
Upon successful completion of this module students are able to:
- Use Linux and the R computing environment.
- Distinguish epigenomic sequencing technologies such as chromatin immunoprecipitation followed by sequencing (ChIP-seq) and whole genome bisulphite sequencing (WGBS).
- Understand the structure of sequencing files.
- Manipulate and preprocess sequencing files.
- Apply software tools for analyzing ChIP-seq and WGBS data.
- Interpret the output from the data analysis.
- Query the results to answer specific biological questions.

Teaching and Learning Methods:
In the framework of this practical course students will work under close supervision on current research topics in plant epigenetics and epigenomics.

Teaching techniques:
- Computer practical.
- Individualized instructions.
- Critical discussion of analysis results with experienced supervisors and members of the research group.

Learning tasks:
- Literature studies.
- Hands-on computer-oriented tasks
- Preparation of research summaries in the form of a presentations and a written report.

Media:
Tutorials

Reading List:
Tutorials

Responsible for Module:
Frank Johannes f.johannes@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Analysis of Epigenomic Data (Forschungspraktikum, 10 SWS)
Johannes F [L], Johannes F
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1549: Research Project 'Plant Nutrition' | Research Project 'Plant Nutrition'

Version of module description: Gültig ab winterterm 2021/22

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 150	**Contact Hours:** 150

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination of the module is done in the form of a research paper and includes a written lab / project report of about 3000 words / 20 pages and a presentation (30 min).
The final grade is an averaged grade from the written lab report (75 %) and from the presentation (25 %).

The learning outcome is tested by a graded project report (75%). Students show that they are able to introduce (state-of-the-art, hypothesis, research question), record, structure, analyze, evaluate, and summarize their research work and that they can conclude on the achieved results from the experiments and analyses. In the report they show that they can relate background knowledge, e.g. reactions of plants to abiotic stress, to the own performed research in the lab. They show how the specific methods are applied, critically evaluate the suitability of the methods, present results in a structured way in relation to the research question, discuss their results with respect to the present state-of-the art knowledge and formulate perspectives.
The students demonstrate with the report to have gained deeper knowledge on employed methods and on the investigated research topic.
The project report will be complemented by a graded oral presentation (25%) in which students show their communication competency in presenting their scientific work and project to a scientific audience. The students are expected to present (about 20 min) and discuss (about 10 min) their research results according to scientific standards.

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
Basic knowledge in (molecular) plant nutrition and plant physiology

Content:
Current research topics in molecular plant nutrition e.g., plant responses to abiotic stress (nutrient deficiency, nutrient toxicity, drought, salinity, heat, changing wheather extremes), nutrient efficiency mechanisms, nutrient transport in the plant and in the substrate/soil, and nutrient turnover and losses to the environment.
Studies focus on specific experimental and methodological skills employed in current plant nutritional approaches in order to investigate and understand yield formation, root system architecture development, nutrient acquisition and nutrient translocation at the cellular and the whole plant level, as well as the nutrient- and/or water status of plants.

Intended Learning Outcomes:
At the end of the module students will be able to:

- apply theoretical background knowledge on the selected research area in plant nutrition (e.g. molecular, biochemical, morphological or physiological causes and consequences of abiotic stress such as nutrient deficiency or nutrient toxicity to plants, challenges in nutrient efficiency and in nutrient losses to the environment);
- judge on plant cultivation growth set-ups suitable to phenotype and evaluate root- and shoot growth and development under nutrient limiting conditions;
- operate up-to-date and modern techniques ranging from molecular biological to classical plant nutritional techniques (methodological competencies) to understand the nutritional status of (crop) plants as well as their response reactions to deficient or toxic nutrient levels;
- assess open questions related to crop growth and health using molecular, physiological, and analytical methods;
- execute specific and appropriate methods for data acquisition in the selected research area (e.g., molecular biological and chemical analyses, non-destructive or minimal-invasive imaging techniques);
- apply specific techniques of data analysis (e.g., specific statistical evaluation methods, phenotyping and architecture analysis software);
- develop critical thinking ability for experimental approaches understanding current challenges in plant nutrition;
- evaluate the achieved results with respect to suitability of different current and developing analytical research methods;
- structure achieved knowledge and results for a written report and an oral presentation;
- present their work to an audience and defend their results in a scientific discussion after the oral discussion;

Teaching and Learning Methods:
In the laboratory course students will be supervised and trained individually or in small groups to practically use specific methods of plant nutrition (by e.g. molecular, chemical, biochemical, physiological analyses, imaging techniques, plant growth cultivation techniques, statistical evaluation methods, etc.). Thereby, they will achieve basic hands-on experiences in molecular plant nutritional and crop physiological skills to solve subsequently own-defined open questions

in plant nutrition. Students will get the chance to self-dependently test current and developing methods so that they become able to evaluate their suitability.
The module also includes the individual search on current literature, a training in the generation of a research report and a training in presentation techniques.

Media:
Presentations (e.g., PowerPoint), scripts, instruction manuals, whiteboard work, data analysis software (e.g., EXCEL), Zoom, lab-book, TUM-Moodle

Reading List:
-Marschner, H., 1995: Mineral Nutrition of Higher Plants, Academic Press London, 2nd Edition.
-Marschner, P. (ed) 2012: Marschner's Mineral of Higher Plants, Academic Press London, 3rd Edition
-Journal articles
-Topical and up-to-date Journal reviews (provided by the supervisor)

Responsible for Module:
Bienert, Gerd Patrick, Prof. Dr. patrick.bienert@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Research Project Plant Nutrition (Praktikum, 10 SWS)
Bienert G, von Tucher S, Liu Z, Alcock T
For further information in this module, please click campus.tum.de or here.

Module Description

WZ6428: Analytical Methods in Horticulture, Agriculture and Plant Biotechnology | Analytical Methods in Horticulture, Agriculture and Plant Biotechnology

Version of module description: Gültig ab summerterm 2019

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Grading is based on laboratory assignments, which include the assessment of the practical work (40% of the grade), the written documentation of the data and results (40% of the grade) and an oral presentation of the key findings (20% of the grade). For grading of the practical work particularly the accuracy and correctness of the results is assessed. The written documentation of the data includes the description of the theoretical background, presentation of raw data, calculations, application of statistical tests and evaluation, interpretation and discussion of the results. In an oral presentation the students demonstrate their ability to visualise and communicate their data, results and conclusions to an audience and to discuss their scholarly work in front of their peers.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
None.

Content:
This course focuses on basic methods in molecular plant biology, plant nutrition, biochemistry and analytical chemistry. The students have the opportunity to apply methods including:
- DNA isolation and quantification
- Analysis of DNA by restriction digest and sequencing
- Amplification of DNA by PCR
- Cloning of PCR products or restriction fragments in cloning or expression vectors
- Protein quantification by spectrophotometry
- Analysis of plant metabolites and plant growth regulators by HPLC, GC and spectroscopy

- Analysis of plant nutrients by atomic emission spectroscopy, ion chromatography and photometry

Intended Learning Outcomes:
After successful participation of the practical course the students are able to:
- isolate and quantify DNA and proteins
- apply molecular biological methods including PCR, restriction digest and DNA sequencing
- apply electrophoretic methods for analysis of DNA and proteins (agarose gel electrophoresis, SDS-PAGE)
- use chromatographic and spectroscopic techniques for quantification of plant metabolites and nutrients
- apply different types of calibration for quantitative analyses: external standard, internal standard and standard addition
- evaluate data by basic statistical methods and interpret results
- plan experiments and laboratory work
- present the experimental results in a scientific way

Teaching and Learning Methods:
The theoretical background is presented in two lectures ahead of the practical part. Equipped with a detailed step-by-step script and the close supervision of the teachers the students execute the experiments independently. This offers the students to plan their schedule independently and enables them to learn/improve their time management in the laboratory. The students are guided in evaluating and summarizing the obtained results in individual discussions with the supervisors. Finally, the students give short presentations of their results and the data are discussed in the class.

Media:
Black board illustrations, presentation slides (PowerPoint), scriptum (Moodle), application of specific software (e.g. evaluation of chromatograms and sequences), calculation and statistical evaluation of data (mainly with Excel), discussion of results.

Reading List:
The scriptum (provided via Moodle) provides the theoretical background and detailed protocols for the experiments. Additional information (e.g. original articles) is provided via Moodle if required.

Responsible for Module:
Rozhon, Wilfried; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ6429: Biotechnology in Horticulture | Biotechnology in Horticulture

Version of module description: Gültig ab summerterm 2019

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Grading is based on laboratory assignments. By performing the individual experiments autonomously, the students proof their ability to conduct plant transformation protocols and the characterisation of genetically modified plants under the stipulated safety regulations.
In a written documentation of the data and results (approx. 10 pages) the students show their skills in describing and graphically presenting the results of the individual experiments and demonstrate their ability to interpret data with appropriate statistical tools and to discuss them critically in the context of the literature.
The grade will be based on the student's motivation and participation in class (50% weight) and the quality of the written report (50% weight), which has to be handed in 6 weeks after the block course has been concluded.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Ideally, the students should have basic knowledge and experience in laboratory work. Theoretical knowledge in plant physiology (Module Crop Physiology) molecular biology and biotechnology (Module Crop Biotechnology) is recommended.

Content:
This course focusses on plant biotechnology and molecular biology. Subsequently, the students have the opportunity to apply plant biotechnological methods including:
- DNA isolation;
- Restriction analysis;
- PCR genotyping;
- Transient transformation of plants using Agrobacterium tumefaciens;
- Stable transformation of plants using Agrobacterium tumefaciens;

- Selection of transformants;
- Segregation analysis;
- Analysis of gene expression using reporter genes;
- Modification of compounds by biotechnological approaches;
- Purification and analysis of the obtained products using chromatographic methods.

Intended Learning Outcomes:
After successful participation of the practical course the students are able:
- to apply modern tools of molecular biology for the analysis and manipulation of plants;
- to generate transiently and stably transformed transgenic plants;
- to analyse transgenic plants by PCR-based genotyping;
- to use marker genes for expression analysis;
- to prepare, isolate and analyse plant metabolites by biotechnological methods;
- to evaluate data by basic statistical methods;
- to interpret the results of performed experiments;
- to present the experimental results in a scientific way.

Teaching and Learning Methods:
The theoretical background in Plant Biotechnology required to perform the experiments is presented in PowerPoint-supported lectures ahead of the practical part. Equipped with a detailed step-by-step script and the close supervision of the teachers the students practice experiments to generate and characterize transgenic plants and to synthesize and purify secondary plant metabolites in bacteria. Moreover in lectures and class discussions the students are guided how to summarize the obtained results in a written report.

Media:
Black board illustrations, presentation slides (PowerPoint), Book chapters in pdf Format, Scriptum (Moodle), documented results (Moodle).

Reading List:
The script for the course provides detailed protocols for the experiments.
For the theoretical background the following books are recommended:
Slater, Scott & Fowler: Plant Biotechnology 2nd edition (2008) Oxford University Press.
Griffiths, Wessler, Carroll and Doebley: Introduction to genetic analysis 10th edition (2011) W.H. Freeman.

Responsible for Module:
Sieberer, Tobias; Dr. nat. techn.

Courses (Type of course, Weekly hours per semester), Instructor:
Biotechnology in Horticulture (Übung, 4 SWS)
Sieberer T
For further information in this module, please click campus.tum.de or here.

Module Description

WZ0631: Data Processing and Visualization in R | Data Processing and Visualization in R

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In-class (60 min) computer exam (Exercise test): The exam has the following format. Students will be given a new dataset with the instruction to reformat/clean the data, and to generate and export specific plots based on these data. Finally, the students will be asked to use these plots to write a short interpretation of the data. The exam grade will be based on the correctness of the reformatted datasets, the correctness of the plots and their interpretation of the data. Students will be able to use the course tutorials and hand-outs during the exam.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic knowledge of computer systems.

Content:
Most students in the Life Sciences will collect empirical data at some point during their research projects. This data can come from quite heterogeneous sources such as from ecological, phenotypic or molecular measurements, and can range considerable in size (from a few kb to several Gb). An important preliminary step in data analysis is to be able to read, processes and visualize datasets. Proper visualization will guide downstream analysis decisions, aid in the interpretation of the results, and is key to communicating results to the scientific community in the form of publishable figures.

Introduction to Linux and R
- Managing data folders and datasets
- Managing the R environment and R libraries

Data processing in R
- Data import functions and libraries
- Data cleaning functions and libraries
- Reformatting datasets

Data visualization in R
- Overview of plotting functions and libraries (with particular focus on the ggplot2)
- Preparing and exporting publishable figures

Intended Learning Outcomes:
Upon successful completion of this module students are able to:

- Use Linux and the R computing environment.
- Manage and manipulate data folders and datasets.
- Import, reformat and clean diverse datasets.
- Make informed data visualization decisions.
- Apply a wide range of R plotting functions and libraries.
- Interpret data through figures.
- Prepare publishable figures.

Teaching and Learning Methods:
The lectures and exercise are intermixed during the sessions, and most sessions comprise only exercises and hands on practice. Typically, a first part of a short lecture introduces the concepts, tools and main learning goals of the session. The exercises are performed on computers under Linux and on a computer cluster. The students execute code and scripts using a tutorial. The tutorial guides the students through the analysis steps with individualized feedback from the instructors. The exercises are for the whole group, and students are encouraged to discuss their results with their colleagues, before a summary is made by the lecturer.

Media:
Tutorials, PowerPoints, software training.

Reading List:
Tutorials

Responsible for Module:
Johannes, Frank; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ0228: Exercises in Precision Agriculture and Plant Phenotyping | Exercises in Precision Agriculture and Plant Phenotyping

Version of module description: Gültig ab summerterm 2022

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination uses the format of Report (project report + presentation), in which students should demonstrate that they are able to apply the gained skills to address certain questions in research or applications, in the context of (but not limited to) precision agriculture and plant phenotyping. The final grades are calculated from the following elements:
- On the topic of choice, each group of students (e.g., 3-4 persons but can also be solo) writes a project report (8-10 pages of A4 single line format, excluding references) (75% of the total grade), and
- Each group presents project results in 15 min following 5 min discussion (25% of the total grade).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
- Knowing the basics of scientific programming (e.g., R, Matlab) is recommended.
- Knowledge gained in the course module "Precision Agriculture" is recommended, but not mandatory.

Content:
The module aims to transfer the practical methods and skills of using novel technologies for precision agriculture and plant phenotyping. Main topics include:

1. cameras, sensors, and integrated systems used in precision agriculture and plant phenotyping;
2. basics of using Matlab, R, and other related software packages;
3. drone (UAV) operation, image data acquisition and analysis pipeline;
4. spectrometer operation, plant and soil spectral measurements, and spectral data analysis;
5. digital image analysis methods and software packages;

6. GIS tools for spatial data analysis and visualization;
7. satellite imagery data acquisition, processing, and analysis;
8. detection of plant biotic and abiotic stresses using different sensors;
9. measuring field spatiotemporal variability and crop yield;
10. data science methods in precision agriculture and plant phenotyping;

Intended Learning Outcomes:
Upon completion of the module, students will be able to:
- understand the basics of characterizing plant traits and crop field variability using non-destructive methods;
- apply basic sensors and software packages (e.g. R, Matlab) in practices;
- evaluate the potentials and limitations of different sensors and data science methods (e.g. for image segmentation and classification);
- design sensing and data analysis pipelines for solving practical problems;
- develop critical and systematical thinking skills;
- to present their results in a clear and comprehensible manner to an audience

Teaching and Learning Methods:
- The module delivers the practical skills of precision agriculture and plant phenotyping through demonstrations of operational and analytic methods, hands-on practices, and computer exercises.
- Students actively participate in the exercises and discussion, and write learning journals to reflect the critical aspects in the exercises, e.g., application potentials and limitations of methods.
- Students conduct exercises through teamwork, write reports on topics of choice, and present the results and discuss with classmates.

Media:
Zoom, Scripts, PowerPoint

Reading List:
- Current literature related to the topics

Responsible for Module:
Yu, Kang; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Precision Agriculture (Exercises) (Übung, 4 SWS)
Yu K
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2400: Practical Course: Computing for Highthroughput Biology | Forschungspraktikum Computeranwendungen für Hochdurchsatz-Biologie

Version of module description: Gültig ab winterterm 2020/21

Module Level: Master	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 150	**Contact Hours:** 150

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the course, students work on large-scale genomic data sets. The scientific problem, the applied methods, the results and the interpretation and discussion of the results will be documented in a scientific report (ca. 20 pages) which will be graded.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of computer systems. Familiarity with UNIX/Linux and basic programming skills in R or Python are an advantage.

Content:
Agricultural biosciences demand computational skills and in depth knowledge of biological data. During the course, students will practice with some common data analysis methods of high throughput technology, such as next generation sequencing, gene expression analysis, high-throughput genotyping in individual projects. They will gain knowledge on how to utilize existing biological databases in their research and how to interpret their own results in the context of current literature.

Intended Learning Outcomes:
In individual research projects, students will become familiar with computational strategies for the analysis of high dimensional data. Upon completion of this module, students are able to handle large datasets and process them with appropriate tools using programming languages like R or Python. They will be able to analyze datasets and use suitable tests for evaluating the plausibility of the data and to do quality filtering. They will be able to apply custom pipelines for data analysis.

Depending on the specific project this will include the use of public databases, text manipulation with R or Python, gene expression analysis with bioconductor R, sequence analysis with blast, vmatch, Clustalw, BWA, genome visualization with GBrowse and Next Generation Sequencing workflows. Students will be able to test the significance of the results and to interpret them in the context of current literature.

Teaching and Learning Methods:
The advisors will provide experimental data from current research projects or from public datasets. In computer exercises, students will learn to write programming scripts for handling and analyzing the data. Results will be discussed with the advisors and interpreted using current literature.

Media:
Case studies, computer exercises.

Reading List:
Project-specific current literature will be provided for each project.

Responsible for Module:
Schön, Chris-Carolin; Prof. Dr.sc.agr. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum Computeranwendungen für Hochdurchsatz-Biologie (Forschungspraktikum, 10 SWS)
Avramova V, Lanzl T, Urzinger S, Mayer M
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1578: Project Management in Molecular Plant Biotechnology | Project Management in Molecular Plant Biotechnology

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a bipartite presentation (20 min + 20 min) followed by a group discussion (10 min + 10 min). By presenting their own research project (part 1) the student's ability is tested to summarize the scientific background, to formulate specific research questions, to present the relevant results and to hold a discussion about the key conclusions. By presenting and discussing the key findings of a chosen scientific publication (part 2) the student's skills are analysed to evaluate other peoples work in a constructive manner. The quality of the two presentation parts will be evaluated and equally weighted.

Repeat Examination:

(Recommended) Prerequisites:
Basics in genetics, molecular biology and biochemistry. It is recommended to enrol the course in parallel to the master thesis work.

Content:
The key aim of the module is to equip master level students with a basic understanding of the research process in the field of Molecular Plant Biotechnology, particularly to establish a relevant research question, to develop experimental strategies, to conceive a realistic research plan, to perform experiments applying good laboratory practice, to assemble and interpret data at a publication-quality level and to critical discuss these data with peers. The course consists of two parts: 1) The students analyze, present and critically discuss an actual relevant publication in the field of Molecular Plant Biotechnology 2) They will develop and present their own research project, carried out in one of the participating labs. Moreover, the students will participate in other student’s presentations and will be able to contribute ideas in discussions following the presentation. They will learn how to critically evaluate their own work and those of others.

Intended Learning Outcomes:
At the end of the module students are able to:
- extract relevant data from a scientific publication in the field of Plant Molecular Biology/Plant Biotechnology;
- assemble these data in a presentation;
- orally present the data to an auditorium;
- discuss the data and scientific conclusions with teachers and colleagues;
- conceive a project proposal in the area of Molecular Plant Biotechnology;
- structure it in specific objectives;
- design a research plan based on a reasonable combination of experimental approaches;
- present and discuss the proposal with peers.

Teaching and Learning Methods:
To develop required skills to present their own research project as well as to critically discuss published studies with peers, each student will prepare and hold a bipartite multimedia-supported presentation of their own research project (master thesis) and of one recent, relevant scientific publication followed by a constructive discussion and feedback by the other course participants.

Media:
Multimedia presentation (PowerPoint/Keynote), relevant publications.

Reading List:
At the Bench: A Laboratory Navigator, K. Parker; Cold Spring Harbor Laboratory Press, 2005
Preparing and Delivering Scientific Presentations; J. Giba and R. Ribes, Springer, 2011

Responsible for Module:
Sieberer, Tobias; Dr. nat. techn.

Courses (Type of course, Weekly hours per semester), Instructor:
Wissenschaftliches Arbeiten in der Pflanzenbiotechnologie (Seminar, 4 SWS)
Poppenberger-Sieberer B, Sieberer T
For further information in this module, please click campus.tum.de or here.

Module Description

WZ0632: Research Internship Plant Immunology | Research Internship Plant Immunology

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 150	**Contact Hours:** 150

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination is done in a project report. This is split in a 5-10 pages written report (50% of the grade) and 15 min oral presentation (50% or the grade; defense) in front of the supervisor, the examiner and the hosting working group.

The written report covers the theoretical background, research question, methods, obtained results and conclusions of the laboratory work.

In the presentation, the students have to present their scientific achievements and collected data in a concise way. Furthermore, the presentation focuses on the student´s ability to discuss their results in front of a critical scientific audience and to put her/his results into a bigger context of the literature that has been provided by the supervisors.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of plant immunology at the B.Sc. level

Content:
In the exercise, the students are taught how to read relevant literature, extract a specific research question from that, and how to apply research methodology relevant to the research question they want to answer. They learn how to document, process, statistically evaluate and display their data. In the research lab training, they apply learned methods on a specific research questions in a one-to-one supervised situation.

Intended Learning Outcomes:
After finishing this module, students are able to self-sufficiently plan and design a focused research project.
They can design experiments to answer a specific research question based on review and original literature. They can apply trained research techniques, document, evaluate, present and critically discuss the obtained results in publication quality style.

Teaching and Learning Methods:
In the exercise, the students are first introduced to the field of research in a round table presentation with the help of a PowerPoint presentation of the supervisor. Subsequently, they are get reading material from the supervisor, which they are supposed to read for supervised development of the research question and the methodological approach. In a one-to-one teaching situation, students are introduced to the hands-on laboratory methods for studying the research question, which they exercise in a supervised form. Once, the students obtained own data, the supervisor shows the students how to process and evaluate data, and how to prepare publication-style data presentation.

In research lab training the students are supervised on the basis of regular discussion of their own raw data with the supervisor. They are involved in the research group´s weekly progress report, in which they learn how to briefly summarize their actual research question and discuss raw data in front of the research group.

Media:
PowerPoint presentations, round table discussions

Reading List:
Buchanan 2015, Biochemistry & Molecular Biology of Plants.
Review and original literature is additionally provided.

Responsible for Module:
Hückelhoven, Ralph; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ2619: Research Project: in silico Evolutionary Genetics of Plants and Pathogens | Forschungspraktikum: in silico Evolutionsgenetik von Pflanzen und Pathogenen

Version of module description: Gültig ab winterterm 2012/13

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 60	**Contact Hours:** 240

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Writing a paper-like research report

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of computer system

Content:
Modern research in evolutionary biology demands the integration of sequence data with theoretical tools of simulations. This requires solid computational skills, including knowledge of various biological data resources, and usage of simulation softwares. During the course, students will 1) practice with some common data analysis methods of high throughput technology, such as next generation sequencing and whole genome sequencing, 2) learn how to make use of existing biological databases and 3) perform coalescent simulations to tests evolutionary scenarios.

Intended Learning Outcomes:
Common computational strategies to process and analyze high throughtput data, including Perl, statistical analyses with R, sequence analysis with blast, BWA, Stampy, Dnasp, and coalescent simulations with ms, msms and C++ and java codes.

Teaching and Learning Methods:
Practice sessions for computers

Media:
Case studies

Reading List:
Hartl and Clark, Principles of Population Genetics 4th Edition (2007); Hedrick, Genetics Of Populations 4th Edition (2009); Wakeley, Coalescent Theory: An Introduction (2008)

Responsible for Module:
Aurelien Prof. Tellier (tellier@wzw.tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum: in silico Evolutionsgenetik von Pflanzen und Pathogenen (Forschungspraktikum, 10 SWS)
Silva Arias G [L], Silva Arias G, Tellier A
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1577: Research Project 'Biotechnology of Horticultural Crops' | Research Project 'Biotechnology of Horticultural Crops'

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 150	**Contact Hours:** 150

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The students conduct a six-week research project in the lab. The work-schedule can be adjusted to the curriculum of the students. After the practical work, a report (approximately 15 to 20 pages) has to be prepared and handed in usually within 4 weeks after the laboratory work has been concluded. By preparing a report the students demonstrate the ability to summarise the theoretical background and key aims of the performed experiments and to present the acquired results in a concise and coherent manner and to interpret and discuss the experimental data in the context of available literature. The grade of the report is based on the accuracy and correctness of the results (50%) and the quality of presentation and evaluation of the data (50%), particularly the description of the theoretical background, presentation of raw data, calculations, application of statistical tests and interpretation and discussion of the results.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in plant molecular biology, biochemistry, genetics and development. Practical experience with basic lab working techniques such as pipetting and working under sterile conditions. Successful completion of the lecture(s) Crop Biotechnology and/or Plant Biotechnology.

Content:
The students work on a research project in the lab on one of the following topics:
a) plant hormone signalling
b) impact of environmental cues on plant growth and development
c) heterologous expression of plant proteins
Methods and techniques applied in the framework of the course will depend on the individual project and may include: cloning, plant transformation, PCR, qPCR, Western blot analysis, protein

expression and purification, assays for enzymatic activity, EMSA, chromatin IP, fluorescence and electron microscopy, phenotypic characterisation of plants, cold or heat stress assays, ion leakage assays, dose response assays and quantification of metabolites and nutrients by chromatographic and spectroscopic techniques. Statistical methods are applied for data evaluation. Many of these techniques are applicable to other (non-plant) organisms.

Intended Learning Outcomes:
Upon completion of this module students:
- have acquired competence in several laboratory techniques related to biotechnology in horticultural crops including cloning of genes, heterologous expression of plant proteins and generation and analysis of transgenic plants
- can perform experiments in an efficient, time saving manner
- can evaluate data and apply statistical tests
- are able to design experiments with all necessary controls and interpret the results
- have increased their competence in scientific reading and writing
- can display scientific data in publication quality

Teaching and Learning Methods:
Close theoretical and practical supervision combined with autonomous lab work. Reading original research articles. Reading and application of laboratory protocols. Discussion of the protocols and the underlying principles of the experiments. Writing of a laboratory book. Written documentation of the experiments and results.

Media:
Oral instructions, lab protocols, relevant scientific publications.

Reading List:
The literature depends on the individual project and will be provided ahead of the course.

Responsible for Module:
Rozhon, Wilfried; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum Biotechnologie gartenbaulicher Kulturen (Forschungspraktikum, 10 SWS)
Poppenberger-Sieberer B, Dündar G, Sieberer T
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1575: Research Project 'Chemical Genetics' | Research Project 'Chemical Genetics'

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 150	**Contact Hours:** 150

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The students conduct a six-week research project in the lab. The work-schedule can be adjusted to the curriculum of the students. After the practical work, a report (approximately 15 to 20 pages) has to be prepared and handed in usually within 4 weeks after the laboratory work has been concluded. By preparing a report the students demonstrate the ability to summarise the theoretical background and key aims of the performed experiments and to present the acquired results in a concise and coherent manner and to interpret and discuss the experimental data in the context of available literature. The grade of the report is based on the accuracy and correctness of the results (50%) and the quality of presentation and evaluation of the data (50%), particularly the description of the theoretical background, presentation of raw data, calculations, application of statistical tests and interpretation and discussion of the results.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in plant molecular biology, biochemistry, genetics and chemistry. Practical experience with basic lab working techniques such as pipetting and working under sterile conditions. Successful completion of the lecture(s) Crop Biotechnology and/or Plant Biotechnology.

Content:
Chemical Genetics is a novel interdisciplinary approach in which small molecules are used to identify proteins responsible for the expression of a specific phenotype (forward chemical genetics) or to affect the function of a specific protein and assess the morphological, physiological and molecular consequences within the organism (reverse chemical genetics). Chemical genetic approaches are not only useful in basic research questions, they can also directly lead to the development of drugs and agrochemicals.

This module will teach students a subset of the following techniques by participating in a research project in the lab:
- Storage and handling of a chemical library;
- Design of a chemical genetic screen;
- Set up of a chemical genetic screen in conformity with the required quality standards;
- Phenotype-based small molecule screening in Arabidopsis thaliana
- Phenotype-based small molecule screening horticulturally relevant plant species;
- Expression marker-based small molecule screens;
- Hit confirmation assays;
- Dose response assays;
- Structure/function analysis using cheminformatic methods;
- Establishment of an in vitro assay to test ligand-target interaction.

Intended Learning Outcomes:
Upon completion of this module students are able:
- to understand the principles of chemical genetic research approaches;
- to assess for which scientific questions a chemical genetic approach might be helpful;
- to plan and to carry out basic chemical genetic experiments in plants according to the required quality standards;
- to interpret and evaluate the results obtained in chemical genetic screens in a written report.

Teaching and Learning Methods:
Close theoretical and practical supervision combined with autonomous lab work enables the student to understand and apply basic experiments in Plant Chemical Genetics. By discussing lab protocols the student analyses the underlying methodological principles of the experiments. By reading original research articles the student learns to assess quality standards for chemical genetic approaches. By writing a research report the student learns to summarize the obtained results and discusses it in the context of relevant literature.

Media:
Oral instructions, lab protocols, relevant scientific publications.

Reading List:
Plant Chemical Genomics: Methods and Protocols (2014) G. R. Hicks and S. Robert, Humana Press;
Plant Chemical Biology (2014) D. Audenaert and P. Overvoorde, John Wiley & Sons

Responsible for Module:
Sieberer, Tobias; Dr. nat. techn.

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum Chemische Genetik (Forschungspraktikum, 10 SWS)
Poppenberger-Sieberer B, Ramirez V, Sieberer T
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1697: Research Project 'Metabolite Analyses in Crops' | Research Project 'Metabolite Analyses in Crops'

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 150	**Contact Hours:** 150

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The students conduct a six-week research project in the lab. The work-schedule can be adjusted to the curriculum of the students. After the practical work, a report (approximately 15 to 20 pages) has to be prepared and handed in usually within 4 weeks after the laboratory work has been concluded. By preparing a report the students demonstrate the ability to summarise the theoretical background and key aims of the performed experiments and to present the acquired results in a concise and coherent manner and to interpret and discuss the experimental data in the context of available literature. The grade of the report is based on the accuracy and correctness of the results (50%) and the quality of presentation and evaluation of the data (50%), particularly the description of the theoretical background, presentation of raw data, calculations, application of statistical tests and interpretation and discussion of the results.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in plant molecular biology, biochemistry, genetics and development. Practical experience with basic lab working techniques such as pipetting and working under sterile conditions. Successful completion of the lecture(s) Crop Biotechnology and/or Plant Biotechnology.

Content:
The students work on a research project independently in the laboratory. The project will focus on quantification of primary metabolites, secondary metabolites and/or nutrients in crop plants and factors/methods for altering the metabolite composition of crops.
Methods and techniques applied in the framework of the course will depend on the individual project and may include:

- methods for sample preparation including extraction, liquid-liquid extraction and solid phase extraction
- chemical derivatisation of analytes
- chromatographic techniques including HPLC, UHPLC, GC, TLC, ion chromatography and column chromatography
- spectroscopic methods including UV/VIS, fluorescence and IR spectroscopy and flame photometry
- mass spectrometry
- chiroptical methods including optical rotation dispersion and circular dichroism
- luminometry (chemiluminescence and biolominescence)
- chemical synthesis of compounds
- stable isotope labelling of compounds
- application of statistical statistic methods are applied for data evaluation

Intended Learning Outcomes:
Upon completion of this module students:
- have acquired competence in several laboratory techniques related to metabolite analysis in cops
- can apply chromatographic and spectroscopic methods
- can perform experiments in an efficient, time saving manner
- can evaluate data and apply statistical tests
- are able to design experiments with all necessary controls and interpret the results
- have increased their competence in scientific reading and writing
- can display scientific data in publication quality

Teaching and Learning Methods:
Close theoretical and practical supervision combined with autonomous lab work. Reading original research articles. Reading and application of laboratory protocols. Discussion of the protocols and the underlying principles of the experiments. Writing of a laboratory book. Written documentation of the experiments and results.

Media:
Oral instructions, lab protocols, relevant scientific publications.

Reading List:
The literature depends on the individual project and will be provided ahead of the course.

Responsible for Module:
Rozhon, Wilfried; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ2401: Research Project 'Molecular Plant Breeding' | Forschungspraktikum Molekulare Pflanzenzüchtung

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 150	**Contact Hours:** 150

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a project report (approx. 15-20 pages), which is to be submitted at the end of the module and is graded. The report contains a short introduction to the topic, the scientific research questions, the applied material and methods, the results and a discussion of the results in the context of current literature.

Repeat Examination:

(Recommended) Prerequisites:
Basic knowledge in molecular genetics and plant breeding. Previous practical experience with molecular techniques and/or handling of plants is an advantage.

Content:
The individual projects that students will work on encompass current topics of plant breeding and address different aspects of ongoing research projects. The projects cover the acquisition of scientific methods and comprise molecular genetic laboratory and/or modern phenotyping methods for agronomic traits. Depending on the individual project, different molecular techniques are applied (e.g. DNA extraction from plant material, PCR, DNA cloning and sequencing, analysis of molecular markers, gene expression analysis). We also offer topics related to drought stress in field or greenhouse experiments with a strong focus on application in crop plants, where physiological and agronomic traits are assessed. In projects with a focus on phenotyping, students will learn how to plan and conduct field or greenhouse experiments and how specific phenotypes are measured. During the project, the appropriate scientific analysis and interpretation of the data will be addressed, which includes e.g. statistical data analysis, mapping of genes/QTL, characterization of genes, literature work.

A list of current projects is available at www.wzw.tum.de/plantbreeding. Upon agreement own topics can be suggested.

Intended Learning Outcomes:
In the research project "Molecular Plant Breeding" the students will learn to design experiments in the lab or greenhouse/field in individual case studies. They gain experience in planning and conducting the experiments, organizing the work and analyzing experimental data. Upon successful completion of the research project, students are able to scientifically analyze, interpret, discuss and present their obtained results in the context of current literature.

Teaching and Learning Methods:
Depending on the individual project, the students will gain and practice laboratory skills and/or knowledge on handling of plants in greenhouse/field experiments through hands-on lab practicals and/or hands-on phenotyping methods. Through instruction by their advisor, they will learn to define specific scientific questions related to their individual topic, to find solutions to solve these questions and to discuss the results. By preparing an oral presentation and a final written report, students learn how to adequately describe their experiments, how to structure the results and how to discuss the results in view of current literature.

Media:
Experimental studies related to current research projects, current literature

Reading List:
Project-specific current literature will be provided for each project.
General:
- Grotewold, Chappell and Kellogg: Plant Genes, Genomes and Genetics. Wiley-Blackwell, 2015. ISBN: 978-1-119-99887-7
- Brown: Genomes 4. Garland Science, 2017. ISBN 978-0-815-345084
- Abraham Blum: Plant Breeding for Water-limited Environments, Springer Science + Business Media S.A.; ISBN-10:1441974903

Responsible for Module:
Schön, Chris-Carolin; Prof. Dr.sc.agr. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum Molekulare Pflanzenzüchtung (Forschungspraktikum, 10 SWS)
Avramova V, Eggels S, Mohler V, Polzer C, Urzinger S
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2481: Practical Course in Developmental Genetics of Plants 2 | Forschungspraktikum Entwicklungsgenetik der Pflanzen 2

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 150	**Contact Hours:** 150

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Successful participation of the module is assessed by a graded presentation (20 min presentation, 10 min discussion). Students are still being supervised but perform experiments in a largely independent fashion. Advanced techniques of plant developmental genetics will be used (for example, qRT-PCR, protein purification, confocal microscopy, etc) and documented. Students work out the scientific background of the experiments and participate in the seminar series of the lab. Results will be presented and discussed in a short seminar. Language will be English.

Repeat Examination:

(Recommended) Prerequisites:
Advanced students of biochemistry, biology, molecular biotechnology and agricultural biosciences.

Content:
Students work in the lab consisting of group leader, PhD students, postdocs and technical personnel. They will address experimentally a given problem in a partly supervised and partly independent fashion. The work and results will be documented and discussed in a written lab protocol. Students regularly participate in the lab's seminar series.

Intended Learning Outcomes:
After attending the lab course students are able to perform advanced experimental techniques in plant developmental genetics and cell biology. Students also gained additional experience in the documentation and presentation of results. Furthermore, students are able to work in an independent fashion.

Teaching and Learning Methods:
Personal supervision of experimental work. Self-study of literature.

Media:
Lab work, discussions with group members, oral presentation, documentation of results.

Reading List:
Orginal research literature and reviews.

Responsible for Module:
Schneitz, Kay Heinrich; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum Entwicklungsgenetik der Pflanzen 2 (Forschungspraktikum, 10 SWS)
Schneitz K, Boikine R, Freifrau von Thielmann A, Lesniewska B
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1576: Research Project 'Plant Growth Regulation' | Research Project 'Plant Growth Regulation'

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 150	**Contact Hours:** 150

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The students conduct a six-week research project in the lab. The work-schedule can be adjusted to the curriculum of the students. After the practical work, a report (approximately 15 to 20 pages) has to be prepared and handed in usually within 4 weeks after the laboratory work has been concluded. By preparing a report the students demonstrate the ability to summarise the theoretical background and key aims of the performed experiments and to present the acquired results in a concise and coherent manner and to interpret and discuss the experimental data in the context of available literature. The grade of the report is based on the accuracy and correctness of the results (50%) and the quality of presentation and evaluation of the data (50%), particularly the description of the theoretical background, presentation of raw data, calculations, application of statistical tests and interpretation and discussion of the results.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in plant molecular biology, biochemistry, genetics and development. Practical experience with basic lab working techniques such as pipetting and working under sterile conditions. Successful completion of the lecture(s) Crop Biotechnology and/or Plant Biotechnology.

Content:
As primary resource of biomass, plants grow by continuous formation of modular organs. The net growth is the result of different growth parameters including the rate of organ formation, the size of the single organs and the overall amount of formed organs. Moreover, it is strongly dependent on environmental conditions (nutrients, water, light and temperature) and the germplasm (constitution of limiting genetic factors and overall genome structure). Plant growth optimization is thus a multifactorial process and strongly dependent on the specific utilization of the crop.

The present research project deals with the molecular characterization of genetic factors which act limiting on the different growth parameters mentioned above. Known and novel important yield affecting loci are identified and positioned in the established regulatory network. Methods and techniques applied in the framework of the course will depend on the individual project and may include: Quantitative analysis of shoot growth (leaf formation rate, determination of meristem size), quantitative analysis of shoot regeneration in tissue culture, gene expression analysis (GUS reporter/qPCR/Western blotting), cloning of T-DNA constructs, plant transformation, PCR genotyping, protein expression and purification, fluorescence and electron microscopy.

Intended Learning Outcomes:
Upon completion of this module students are able:
- to understand key scientific aims in the field of Plant Growth Regulation;
- to assess methods to identify relevant molecular factors controlling plant growth;
- to experimentally characterize regulatory pathways affecting leaf formation rate, elongation growth and shoot architecture;
- to interpret results from biochemical, genetic and physiological experiments dealing with Plant Growth Regulation.
- to present the obtained data in a written report and to discuss the results in the context of relevant literature.

Teaching and Learning Methods:
Close theoretical and practical supervision combined with autonomous lab work enables the student to understand and apply basic experiments in Plant Growth Regulation. By discussing lab protocols the student analyses the underlying methodological principles of the experiments. By reading original research articles the student learns to assess quality standards for experiments analyzing plant growth parameters. By writing a research report the student learns to summarize the obtained results and discusses it in the context of relevant literature.

Media:
Oral instructions, lab protocols, relevant scientific publications.

Reading List:
Plant Physiology and Development (2014) L. Taiz and E. Zeiger, Sinauer Associates Inc.,U.S.; Plant Biotechnology and Agriculture: Prospects for the 21st Century (2011) A. Altman and P. M. Hasegawa, Academic Press.

Responsible for Module:
Sieberer, Tobias; Dr. nat. techn.

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum Wachstumsregulation der Pflanzen (Forschungspraktikum, 10 SWS)
Poppenberger-Sieberer B, Sieberer T, Dündar G
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2380: Research Project Plant Systems Biology | Forschungspraktikum Pflanzensystembiologie

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 150	**Contact Hours:** 150

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Following this six week practical training, each participant writes a research report (20 - 30 pages) and presents(20 - 30 min.) his results at the progress report meeting of the department in German or English language. Besides scientific criteria also the graphic representation of the results figures following publication quality guidelines (Adobe Photoshop, Adobe Illustrator) will be paid attention to. The students can decide themselves on a date for handing in the report, to ensure that sufficient time is available for compiling it.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of plant biology, morphology and cell biology is recommended. Basic techniques for working in the molecular biology laboratory is strongly recommended such as clean pipetting.

Content:
The practical training teaches profound skills in one of the following techniques: (I) gene expression analysis (evaluation of microarray data, quantitative real time PCR, reporter gene analysis in intact organisms), (II) cell biology (confocal microscopy, analysis of different cell compartments using GFP-fusion proteins etc.) or (III) biochemistry (expression and purification of recombinant proteins from bacteria, functional assays). The participants are being introduced into current topics in molecular plant biology, that are being worked on in the department.

Intended Learning Outcomes:
Following participation in the practical course, students will have detailed practical and technical knowledge to answer systems biology problems in biology, specifically but not exclusively in plant biology.

Teaching and Learning Methods:
Form of studies/study techniques: Study of the lecture script, lecture comments and appropriate literature. Preparation of a written report with publication quality figures. Working with time pressure. Meeting deadlines.

Media:
Working with the handout. Basic skills in using one of the two softwares, Adobe Photoshop or Adobe Illustrator. Working independently on a fluorescence microscope or other state-of-the-art equipment.

Reading List:
Plant Physiology (Taiz/Zeiger) 5th edition. Molecular Biology of the Cell (Alberts).

Responsible for Module:
Schwechheimer, Claus; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum I, II, III und IV (PlaSysBiol PR I, II, III, IV) – M.Sc. (Forschungspraktikum, 10 SWS)
Schwechheimer C [L], Schwechheimer C, Hammes U, Denninger P, Bassukas A, Graf A, Sala J, Schröder P
For further information in this module, please click campus.tum.de or here.

Elective Modules Agricultural Biosciences | Wahlmodule Agricultural Biosciences

Module Description

WZ1671: Crop Physiology: Growth and Development of Plants | Crop Physiology: Growth and Development of Plants [WZ1671]

Crop Physiology: Growth and Development of Plants

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Aufgrund des Pandemiegeschehens hat der/die Studierende auch die Möglichkeit, an einer mündlichen Onlineprüfung (Aufsicht mit Zoom, 30 min.) teilzunehmen (Onlineprüfung: WZ1671o). Eine Präsenz-Prüfung wird zeitgleich parallel angeboten (WZ1671).

Students demonstrate their ability to understand the physiological processes affecting horticultural crop production and to evaluate limiting factors during the different growth stages of vegetable and ornamental cultures by answering comprehension questions and solving sample problems in a written examination (120 min). Furthermore, students will be tested for their ability to outline cultivation-specific and genetic approaches to improve qualitative and quantitative yield traits in horticultural crops. The use of learning aids during the examination is not allowed. Examination questions should be answered by writing self-formulated text.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in genetics, plant physiology and plant production.

Content:
Flower formation, seed and fruit development. Physiology of vegetable crops as growth and development processes determining quality and yield of harvested products. Scientific basis of

floricultural practice: Vegetative propagation; genetic/chemical/cultivation-dependent control of branching; genetic/chemical/cultivation-dependent control of shoot growth; leaf/flower variegation; flower development in floricultural crops; physiology of flower color; postharvest physiology of cut flowers.

Intended Learning Outcomes:
Upon successful completion of this module, students are able:
- to understand the influence of environmental factors on major ontogenetic processes of vegetable crops such as flowering and the formation of the harvested products;
- to understand the underlying physiological principles of ornamental crop production methods including vegetative propagation, optimization of plant architecture and flower quality and improving longevity of ornamental crop products;
- to analyze growth conditions of important crop species to optimize yield;
- to evaluate molecular parameters affecting qualitative and quantitative yield traits in horticultural crops.

Teaching and Learning Methods:
The learning contents are presented as PowerPoint-supported lectures to impart the relevant theoretical background in plant physiology and to provide application-relevant examples in horticulture. In addition, class discussions of case studies from literature are conducted to deepen the knowledge in relevant topics.

Media:
Black board illustrations, presentation slides, lecture, scriptum (Moodle), selected articles in scientific journals.

Reading List:
Scriptum.
Taiz, L. and Zeiger, E. 2006: Plant Physiology.
Wien, H.C. 1997: The Physiology of Vegetable Crops.
Actual articles from scientific journals will be provided.

Responsible for Module:
Sieberer, Tobias; Dr. nat. techn.

Courses (Type of course, Weekly hours per semester), Instructor:
Crop Physiology: Growth and Development of Plants (Vorlesung, 4 SWS)
Sieberer T [L], Bienert G, Sieberer T
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2620: Applications of Evolutionary Theory in Agriculture: Population Genomics of Crop Pathogens and Disease Management | Applications of Evolutionary Theory in Agriculture: Population Genomics of Crop Pathogens and Disease Management

Version of module description: Gültig ab summerterm 2020

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The exam is a research paper in the form of a written essay to be handed to the lecturer at a given date. The Essay consists of up to 7 pages (without references). The students have to answer in their essay one key question related to the evolution of pathogens in response to disease management. Several case studies (articles) will be provided as examples. The students will need to 1) analyze the methods used in the studies and the results, 2) explain the concepts of Evolutionary genetics applied to disease management, 3) describe the theoretical models used in the course which are adapted to answer the question of the essay, 4) evaluate critically the management strategy used in the studies, and 5) propose new better disease management strategies based on the knowledge of the pathogen genomics. Additional references and studies searched by the students can be added to help answer the question.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic knowledge in statistics and genetics, additional basic knowledge of phytopathology

Content:
This module covers a profound overview of the evolutionary mechanisms driving the changes in crop pathogen populations and their implications for disease management.
It is built in four major blocks (four topics). They are enclosed by seminar and discussion block where students mobilize their theoretical knowledge to interpret data and propose new disease management strategies for major crops (rice, wheat, barley, banana, maize, apple, tomato).

1) Introduction to evolutionary genomics: we describe the neutral theory of molecular evolution (including genetic drift, random mutation, transposable elements insertion). How is a genome organized? What is the spatial structure of pathogen populations (between fields, regions, and continents). We describe how natural selection acts at the level of major genes and of quantitative traits, and give examples of such genes in crop pathogens. This part is mainly a lecture with small exercise to compute genetic drift using R.
2) Pathogen genomics: range of genome sizes found in pathogens. What is the effect of recombination (sexual reproduction) and accumulation of deleterious mutations by Muller's ratchet. This part is mainly lecture with small exercise on a model of sexual recombination in pathogens.
3) Disease epidemiology: disease epidemiology principles, SIR models, models of disease spread in a field (SEIR), herd immunity concept, evolution of aggressiveness. This block consists of a lecture and long exercise sessions in R where simulations of SIR and SEIR models are performed.
4) Host-parasite coevolution: introduction to models of coevolution, importance of gene-for-gene interactions in plants. We study simple dynamical systems and predict the outcome of coevolution, that is occurrence of arms race or trench warfare dynamics. This part includes a short lecture and exercise sessions with R codes simulating coevolutionary dynamics. Simulations are used to exemplify and understand the possible outcome of coevolution and to understand the implications of deploying major resistance genes in disease management.
Synthesis: what is an optimal disease management taking pathogen evolution into account? This part consists of a lecture and a seminar part (paper presentation) where the students have to propose new disease management strategies for some crop pathogens based on case studies and the theory they learned during the course.

Intended Learning Outcomes:
The students have a profound understanding of the evolutionary mechanisms driving evolutionary and genomic changes in crop pathogen populations. For example, they can describe how the genomes of pathogens change in time due to coevolution with their host, the action of humans and certain disease management strategies. Furthermore, the students are able to describe the genome evolution of pathogens and use knowledge from published full genome data analyses of crop pathogens.
The students understand the principles of disease epidemiology. They can build basic mathematical models and implement them in R to perform simulations and analyze their behavior. The students are able to describe and explain the mechanism of coevolution between hosts and their pathogens. To do so they are able to build a mathematical model of coevolution, analyze its long-term dynamics and implement it in R. Finally, the students can integrate aspects of pathogen evolution into disease management, and are able to design their own new management strategies for different crop diseases. They have basic skills in coding with the software R and are therefore able to perform basic statistics for plant pathology.

Teaching and Learning Methods:
The lectures and exercises are intermixed during the sessions. Typically, a first part of lecture introduces the concepts and the mathematical models. Then students will implement the model in R and perform simulations under different parameters. Thereby, they gain a direct understanding of the behavior and outcome of the mathematical model. The exercises are done by the whole group,

and students are encouraged to discuss their results with their colleagues, before a summary is presented by the lecturer. There is also a seminar session, where students by groups of two will present a research paper which is a case study of population genomic data of a crop pathogen. The students perform a PowerPoint presentation of this case study and afterwards will discuss it with the lecturer and the other students. The aim of the presentation is to describe, analyze and interpret population genomic data of crop pathogens, critically evaluate the results and propose new disease management strategies.

Media:
PowerPoint, computer program R, whiteboard, published articles

Reading List:
Madden, Hughes, and van den Bosch, The Study of Plant Disease Epidemics (2007);
Hartl and Clark, Principles of Population Genetics 4th Edition (2007);
Hedrick, Genetics Of Populations 4th Edition (2009);
Otto and Day, A Biologist's Guide to Mathematical Modeling in Ecology and Evolution (2007);
Milgroom, Population Biology of Plant Pathogens: Genetics, Ecology and Evolution. American Phytopathological Society Press (2015)

Responsible for Module:
Tellier, Aurélien; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Applications of Evolutionary Theory in Agriculture: pathogen population genomics and disease management (Seminar, ,7 SWS)
Tellier A

Applications of Evolutionary Theory in Agriculture: pathogen population genomics and disease management (Vorlesung, 3,3 SWS)
Tellier A
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1488: Perspectives of Genetic Engineering in Agriculture | Perspectives of Genetic Engineering in Agriculture

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination of the module is done in the form of a written exam (Klausur, 90 min) and includes methods and challenges of genetic engineering. The exam consists of individual exam questions from each lecturers, which require their own corresponding text formulations. The overall grade of the module is calculated from equally weighted individual assessments by the lecturers.

By answering these questions, the students should prove that they are familiar with the diverse methods and challenges of genetic engineering in agriculture and that they are able to comment on the resulting requirements for society, research, nutrition and food.
It is also checked whether and to what extent they can reproduce and assess the respective new technologies and research results as well as their advantages and disadvantages with regard to the above-mentioned specialization areas.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
A bachelor's degree. Basic principles of genetic engineering.

Content:
Overview of application areas and backgrounds of genetic engineering methods in agriculture: transgenic plants, transgenic livestock, diversity of applied methods, detection methods, biosecurity, impact on the soil and the environment, safety assessment, official surveillance, social problems.

Extract from the lecture topics:

Prof. Michael Pfaffl: Introduction and overview of areas of application and background of genetic engineering methods in agriculture.
Prof. Ilona Grunwald Kadow: Genetechnology as a means to control insect pests.
Prod. Claus Schwechheimer: Examples of the application of genetic engineering in crops.
Dr. P. Gürtler: Official surveillance of genetically modified organisms
Dr. K. Flisikowski: Fundamentals of genetic engineering in farm animals and application examples.
Prof. M. Schloter: Influence of transgenic plants on soil quality, horizontal gene transfer, stability of DNA in the soil, problem area antibiotic markers.
Prof. R. Hückelhoven: New methods of genetic engineering plant protection
Prof. Benjamin Schusser: Creation of genetically modified chickens and examples of use.
Dr. Maaria Rosenkranz: Genetic engineering to improve the performance of trees (poplars) for sustainable biomass production and phytoremediation.
Prof. Johannn Benz: Use of genetic engineering in fungi for the use of plant biomass and agricultural residues in modern biorefineries.
Dr. Corina Vlot-Schuster: Perspectives of Gemon Editing (CRISPR-Cas) in Grain.
Prof. Patrick Bienert: Current framework conditions and their consequences for genetic engineering approaches in agriculture.

Intended Learning Outcomes:
After the successfully participating in this module, the students are able to focus on the social, technical and global challenges of genetic engineering in agriculture. They will recognize the challenges and opportunities of genetic engineering in various context.
In particular, with regard to the areas of specialization in genetic engineering in the plant sector (with a specialization in forestry), in the animal sector and in the focus on genetic engineering methods, the students can discuss and competently argue which techniques and approaches appear suitable in the future, contributing to the solution of global agricultural problems, and what methods and innovative concepts are being pursued.
In addition, the students are able to evaluate various old and new genetic engineering methods and the GMOs itself generated from them with regard to their effectiveness, biological safety and their advantages and disadvantages.
Furthermore, the students can assess genetic engineering in the context of the worldwide different social acceptance (especially the comparison between Germany, Europe, USA and worldwide).
In addition, the students are able to address research projects presented in the courses and to assess their results against the background of upcoming challenges.

Teaching and Learning Methods:
The subjects mentioned are brought closer to the students in a colorful series of lectures given by experts from the respective agricultural departments. The students are encouraged to discuss selected issues again and again, whereby they should learn to consider different points of view and perspectives, to critically question facts and then to classify them objectively and correctly.
The lectures are mainly given by TUM lecturers, but also by external guest lecturers.

Media:
Lecture series by various lecturers in a multimedia presentation style.

Reading List:

Responsible for Module:
Pfaffl, Michael; Apl. Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Perspectives of Genetic Engineering in Agriculture (Vorlesung, 4 SWS)
Pfaffl M, Benz J, Bienert G, Hückelhoven R, Schloter M, Flisikowski K, Schusser B, Schwechheimer C, Rosenkranz M, Torabi S, Gürtler P
For further information in this module, please click campus.tum.de or here.

Module Description

LS10003: Remote Sensing of Agriculture and Vegetation | Remote Sensing of Agriculture and Vegetation

Version of module description: Gültig ab winterterm 2021/22

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module assessment is based on a written report (10 pages - A4 single line excluding references; 70% of grade) in combination with a presentation (15 min; 30% of grade). In the report, the students design a strategy of applying remote sensing to gain insights into improving decision making for solving practical problems (e.g., food security, overuse of agrichemicals, biodiversity) in agricultural and vegetation systems.

The students are examined based on the extent to which they are able to:
- situate the problems and strategy in a relevant context
- describe the start of the art and knowledge gaps in the relevant field
- demonstrate deep understanding on methodology
- break down the strategy into workable tasks
- discuss the strategy critically from interdisciplinary perspectives
- show communicative competence

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in agricultural engineering is an advantage

Content:
Remote sensing provides a versatile tool for earth observation and environmental informatics from varied spatial and temporal scales. This module explores the potential and the future trend of the state-of-the-art remote sensing techniques in facilitating the understanding on as well as decision making in agricultural and vegetation systems. We will discuss the fundamentals of remote sensing science, including but not limited the topics below:

- Biophysical-spectral models (e.g., electromagnetic radiation (EMR), radiative transfer, spectral feature extraction, chlorophyll fluorescence);
- Sensor systems (e.g., satellite, drone) and spectral-radiometric measurements;
- Image processing and pattern recognition (e.g., classification, time-series)
- Applications in agriculture and ecology (e.g., crop stress, productivity and biodiversity monitoring)

Through integrated exercise, the students will learn about innovative methods of remote sensing and the use of remote sensing in interdisciplinary fields of agricultural and environmental sciences.

Intended Learning Outcomes:
Upon successful completion of this module, students are able to:
- Understand the important aspects of remote sensing;
- Relate the technologies to research questions and practical problems in other disciplines;
- Apply innovative concepts and methods to agricultural and vegetation systems;
- Evaluate the feasibility of remote sensing from the perspectives of agriculture and ecology;
- Develop a strategy of integrating remote sensing with domain knowledge for decision making in agricultural and vegetation systems;
- Communicate their strategy with good understanding and evidence.

Teaching and Learning Methods:
- This module combines lectures, guest seminars, field trips and computer exercises.
- The teaching content will be organized by topics instructed in both theoretical (e.g., seminar) and practical ways (e.g., hands-on demonstrations, computer programing).
- The students will learn the important concepts and methods of remote sensing, as well as the applications in addressing environmental and societal problems, in a highly interactive manner, e.g., discussion in seminars, collaborations in exercises.

Media:
- Present and virtual lectures
- PowerPoint, instruction manuals, scripts and codes;
- Field and lab hands-on demonstrations;

Reading List:
Literature will be provided according to individual topics and events.

Responsible for Module:
Yu, Kang; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Remote Sensing of Agriculture and Vegetation (Vorlesung mit integrierten Übungen, 4 SWS)
Yu K [L], Yu K (Camenzind M, Mokhtari A)
For further information in this module, please click campus.tum.de or here.

Module Description

LS10005: Simulation of Agricultural and Biological Systems | Simulation of Agricultural and Biological Systems

Version of module description: Gültig ab winterterm 2021/22

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination will be in an oral format (30 minutes). No learning aids are allowed. Based on the examination, students demonstrate that they can place all soil-atmosphere interactions in the context of crop models, as well as know the most important properties and understand their interactions. They also demonstrate that they can use and evaluate the main mathematical and statistical techniques. They prove which parameters are among the most important factors influencing crop models and can discuss them critically. In addition, they demonstrate that they can develop and apply plant models using the R programming language.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Plant physiology, soil science, Basics in R programming, Statistics

Content:
Crop models are the basic tools for asking "what if?" questions in agronomy, such as "what if the climate were like projected future climate; how would crop production be affected?". To answer such questions as reliably as possible, requires knowledge of crop-soil-atmosphere interactions, which is used to develop the model equations, but also requires mathematical and statistical techniques to estimate the model parameters, to analyze model behavior and to evaluate the model. This course will briefly describe a simple but realistic crop model (appropriately called SIMPLE), to introduce the elements that one generally finds in crop models, but the emphasis of the course is on the mathematical and statistical techniques of modeling, specifically on parameter estimation, uncertainty analysis, sensitivity analysis and model evaluation. Students will learn the underlying principles as well as practical methods for carrying out each of those activities using the R statistical programming language. The methods will be applied in practice to the SIMPLE

model. At the end of the course the student should be able to understand and critically evaluate studies involving parameter estimation, analysis and evaluation of crop models, and should be able to correctly implement those activities himself/herself. A module will deal specifically with the development and analysis of model ensembles, which is major recent innovation in crop modeling.

Intended Learning Outcomes:
After participating in this course, the students are able to:

• Understand what a dynamic system model is
• Understand basic statistical notions that are relevant to dynamic system models
• Understand parameter estimation: linear regression, nonlinear regression, non-independent data.
• Apply the R programming language on crop models
• Apply model ensembles
• Differentiate the specific difficulties for crop models.
• Evaluate crop models regarding uncertainty and sensitivity

Teaching and Learning Methods:
The lecture will be held as a 2-weeks block course as an external lecturer from another European country should participate here. This makes it not possible to have it as a weekly semester course. Presentations and exercises will be combined during each day.

Media:
Presentations, Quizzes, Exercises

Reading List:
Wallach, D., D. Makowski J. W. Jones and F. Brun. 2019. Working with Dynamic Crop Models. Methods, Tools and Examples for Agriculture and Environment. Third Edition. Academic Press, London.
Keen and Spain, 1992, Computer Simulation in Biology: A BASIC Introduction. Wiley. Relevant excerpts will be provided.

Responsible for Module:
Asseng, Senthold; Prof. Prof. Dr. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1720: Crop Breeding | Crop Breeding

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The final examination is a written test (120 min, Klausur) without additional material. Students demonstrate in the exam that they are capable to design field and laboratory experiments, to analyze different genetic parameters and to interpret the results. They can explain important quantitative genetic parameters and their relevance for selection and for the optimization of horticultural crop breeding programs. They can show how the phenotypic and molecular diversity of plant breeding populations and genetic resources is characterized. Students are able to explain the molecular tools for genomic and genetic analyses and to evaluate which methods are appropriate for specific scenarios. The grade of the exam will be the final grade of the module.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Successful Bachelor courses in biology, genetics, plant breeding, and applied statistics.

Content:
This module presents molecular tools for forward and reverse genetic analysis, such as linkage analysis, tilling, transposon tagging and gene editing. Different experimental designs and their underlying randomization will be shown. The module presents the theoretical concepts behind an analysis of variance of phenotypic and molecular data (ANOVA, AMOVA). Specific properties of breeding schemes of horticultural crops will be connected to their biological properties. The importance of native biodiversity for plant breeding will be discussed. Methods for valorization of plant genetic resources are presented.

Intended Learning Outcomes:
After successful completion of the module, students can design field and laboratory experiments relevant for crop breeding. They will be able to perform a profound statistical analysis on these experiments, interpret their results, understand the relevance of different variance component estimators for breeding and calculate derived genetic parameters such as trait heritability. They will become familiar with trait correlations and how these correlations can be relevant for selection. Students will be able to characterize and evaluate plant breeding populations and plant genetic resources with respect to their phenotypic and molecular diversity. They acquire an understanding of molecular tools employed in genomic and genetic analysis. Students will be able to integrate the different methods and tools they have learnt to design and optimize breeding programs of horticultural crops.

Teaching and Learning Methods:
The module consists of a lecture with PowerPoint presentations accompanied with practical demonstrations at the computer and in the lab. Students will perform a greenhouse experiment in which they will collect phenotypic data, connect it to molecular data and will perform analyses taught during the course. Students are encouraged to present literature studies.

Media:
PowerPoint presentations, panel work, exercises, presentation of current literature.

Reading List:
Rex Bernardo (2014): Essentials of Plant Breeding, Stemma Press, ISBN: 978-0-9720724-2-7
Michael Lynch and Bruce Walsh (1998): Genetics and Analysis of Quantitative Traits; Sinauer Verlag, ISBN 978-0878934812

Responsible for Module:
Schön, Chris-Carolin; Prof. Dr.sc.agr. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Crop Breeding (Vorlesung, 4 SWS)
Schön C, Avramova V, Eggels S, Lanzl T
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1696: Crop Genomics | Crop Genomics

Version of module description: Gültig ab winterterm 2022/23

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the written exam (90 min, Klausur) students explain without additional helping material the principles of genetic and bioinformatics strategies of genome analysis in crop plants. They demonstrate that they understand the different layers of genome analysis in crop plants, and that they are able to apply the required genomic and bioinformatics approaches in case studies and judge which methods can be applied in specific cases. They can explain the use of genomic data to analyze genotype-phenotype associations. The grade of the exam will be the final grade of the module.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Successful completion of Bachelor’s courses in genetics, molecular biology, plant breeding and statistics is required. Basic knowledge in bioinformatics and skills in R programming or a computer language like Python is highly recommended.

Content:
- Genome organization in crop plants (theory)
- Next generation sequencing and genotyping technologies (theory)
- Genome sequencing and annotation (theory)
- Accessing biological sequence information from databases (theory, exercises)
- DNA sequence comparison and alignment, homology searches (theory, exercises)
- Analysis of genomic sequence data, detection of sequence variants (theory, exercises)
- Analysis of gene expression through genome-wide approaches (theory, exercises)
- Comparative genome analysis (theory)
- Genotype-phenotype association for complex agronomic traits (theory, exercises)
- Application of genomic methods in applied plant breeding programs (theory)

Intended Learning Outcomes:
Upon completion of the module students are able to evaluate molecular methods and the bioinformatic and genetic concepts of genome analysis in crops. They understand the genome organization of crop plants and can explain the concepts of next generation genome sequencing, genome annotation and functional analysis of crop plants. They will be able to access biological sequence information from databases and understand the concept of DNA sequence comparison and alignment. Students will be able to analyze plant genomics data and to use bioinformatic/ statistical approaches for the analysis of genotype-phenotype associations. Successful students can judge which approaches are appropriate for specific situations.

Teaching and Learning Methods:
Theoretical concepts are demonstrated in PowerPoint presentations. Practical application of these concepts will be through computer exercises and tutorials using experimental data sets.
In individual or group work on specific topics with presentations students show their ability to understand and solve problems using current literature and to analyze and evaluate the required methods.
Students are encouraged to attend the weekly talks of the SFB924 seminar series (dates and topics announced under http://sfb924.wzw.tum.de), which are given by national and international experts in plant molecular biology and plant genomics.

Media:
PowerPoint presentations, whiteboard. Lecture slides will be provided online in pdf format.
Computer exercises, application training (analysis of sequence data, genotype-phenotype associations)
Current literature

Reading List:
Brown: Genomes 4. Garland Science, 2017. ISBN 978-0-815-345084
Grotewold, Chappell and Kellogg: Plant Genes, Genomes and Genetics. Wiley-Blackwell, 2015. ISBN: 978-1-119-99887-7

Current literature from specific journals will be announced during the lecture.

Responsible for Module:
Schön, Chris-Carolin; Prof. Dr.sc.agr. habil.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1044: Reproductive Biotechnology and Basic Molecular Developmental Biology | Reproductive Biotechnology and Basic Molecular Developmental Biology

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The acquired knowledge will be assessed in a oral exam (20 minutes per each student) where the students provides evidence that he/she understood the priciples of reproductive biotechnology and that he/she can apply the knowledge in a new and different context. The students have to demonstrate their new skills on a hypothetical experiment such as the assessment of the sperm quality of pigs and chickens after cryoconservation. They should prove their ability that they can describe, interpret and structure the newly obtained information and that they can combine it with previous knowledge and use it in slightly altered circumstances.

Repeat Examination:

(Recommended) Prerequisites:
For master students in their first or second semester.

Content:
Content includes:
- Essential methods used in reproductive biotechnology, both theoretical and practical as well as detailed information of molecular pathway involved in the early development of mammalian and avian embryos.
- The function of genes in embryo development.
- The formation of germ layers and organ formation.
- The molecular mechanisms determining the sex in mammals and avian.
- The function of male and female reproductive tracts.
- Basic knowledge about function of reproductive hormones.
- Application of biotechnology in reproduction.

Intended Learning Outcomes:
After successful participation of the module the students will have basic knowledge regarding reproduction and the molecular mechanisms involved in early development of mammals and birds. They will have gained theoretical and practical knowledge regarding reproductive biotechnology and will understand when and which reproductive technology is suitable for which livestock species.

The student will be able to:
- describe methods of reproduction in mammals and bird with a strong emphasis on livestock
- assess quality of sperm and oocytes
- judge when methods such as ovum pick up, in vitro embryo production or embryo transfer should be applied
- describe molecular pathway involved in the early development of mammalian and avian embryos
- describe the formation of germ layers and organs
- describe the regulation of sex determination

Teaching and Learning Methods:
Part of the course will be a lecture. Students should study the provided script and be encouraged to ask and answer questions during the lecture. It is essential that knowledge acquisition is examined throughout the course by discussing technical and scientific problems which may occur during reproduction and early embryo development and how technical hurdles could be overcome.

For the seminar and practical part student will work in groups, they will be encouraged to carry out an in-depth study of literature, assess the presented results and learn to question the validity of published results. Some hands-on experience will bring the subject to live and connect the theoretical and practical knowledge.

Media:
PowerPoint presentations, Lab experimentations, download of required information and literature.

Reading List:
To be announced.

Responsible for Module:
Schusser, Benjamin; Prof. Dr.med.vet.

Courses (Type of course, Weekly hours per semester), Instructor:
Practical introduction to methods in livestock transgenesis (Übung, 1 SWS)
Schusser B [L], Bauer B, Fischer K, Flisikowska T, Flisikowski K

Molecular Developmental Biotechnology and Reproductive Biotechnology current literature overview (Seminar, 1 SWS)

Schusser B [L], Bauer B, Fischer K, Flisikowska T, Flisikowski K, Schnieke A, Schusser B

Molecular Developmental Biotechnology and Reproductive Biotechnology (Vorlesung, 2 SWS)
Schusser B [L], Bauer B, Fischer K, Flisikowska T, Flisikowski K, Schnieke A, Schusser B
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1588: Evolutionary Genetics of Plants and Microorganisms | Evolutionary Genetics of Plants and Microorganisms

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of an oral exam (30 min). The students are given a dataset to analyze for 30 mins of preparation time. The aim of this study is to demonstrate that the students can analyze and interpret genetic diversity data obtained as sequence of few genes or full genomes. The exam questions cover in particular the interpretation of the computed statistics. This includes, for example, analyzing published data using the program DnaSP (on their own computer provided or provided one), explaining the underlying principles of evolutionary genetics and population genetics, as well as the evaluation and interpretation of the results. The students should for example, explain how the effects of evolution influence sequence data polymorphism, and how the mathematical models of this course predict these outcomes

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic knowledge in genetics and statistics.

Content:
1) Molecular evolution: Hardy-Weinberg equilibrium, neutral … evolution, mutation-drift equilibrium, natural selection, models of speciation, molecular clock, sexual reproduction and recombination. …
2) Population genetics and their application in the genome analysis of plants and microorganisms: coalescence models, application of the coalescent in genome analysis for detection of selection, analysis of population structure, inference of past demographic history. …
3) Population genetics and plant breeding: history of plant breeding, examples of domestication processes, effects of domestication on the genome.

Intended Learning Outcomes:
At the end of the module the students can 1) apply general methods for acquiring published data from internet databases. They 2) can independently analyze DNA sequences with the software DnaSP. 3) The students understand the principles of evolutionary genetics and population genetics, for example the effects and change in frequencies of mutations in populations, the role of natural selection and link to phenotyping, and the role and importance of stochastic processes in evolution. They can analyze the effects of these mechanisms in genetic data, and independently apply such analyses on full genomes. 4) The students can apply, evaluate and critically discuss the basics of population genetics theory, especially for its application to plant breeding. In principle, the students can use this knowledge also in the field of animal breeding, evolutionary ecology or human evolution. They are able to critically analyze published results in these areas, possibly further develop novel data analyses using full genomes and apply the concepts and techniques to any species.

Teaching and Learning Methods:
Teaching method: The course includes 2 SWS lectures and 2 SWS exercises. The lectures provide the theoretical and mathematical background to the theory of evolution. During exercises, the software DnaSP is used for sequence data analysis. In the exercises, the students apply the classical statistics computed from population polymorphism and also discuss their interpretation in connection to the theory.
Learning Activity: Study of scientific articles on plant breeding or human evolution and critical analysis of the published results. The exercises develop the process of problem solving and finding interpretation of the data.

Media:
Presentations with PowerPoint, software used: DnaSP, R statistics and coalescent simulators.

Reading List:
Hartl and Clark, Principles of Population Genetics 4th Edition (2007);
Hedrick, Genetics Of Populations 4th Edition (2009); Wakeley, Coalescent Theory: An Introduction (2008)

Responsible for Module:
Tellier, Aurélien; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ0635: Genetic Engineering of Livestock | Genetic Engineering of Livestock

Genetic engineering of livestock for applications in agriculture and biomedicine

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The acquired knowledge will be assessed in an oral exam (20 minutes per each student) where the students provide evidence that he/she understood of genome engineering and that he/she can apply the knowledge in a new and different context. The students have to demonstrate their new skills on a hypothetical experiment such as the generation of a pig with a tissue specific reporter gene expression. They should prove their ability that they can describe, interpret and structure the newly obtained information and that they can combine it with previous knowledge and use it in slightly altered circumstances.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
BSc in Agriculture, Molecular biology, biology or related areas. Basic knowledge about genetics and molecular biology.

Content:
Content includes:
- detailed information of the animal genome organization including eukaryotic gene structure.
- The function of the main structural and regulatory gene elements.
- Principles of DNA recombination, cloning vector design, usage of restriction enzymes, bacterial transformation, random transgene integration, DNA microinjection, methods for identification of a genetically modified organism,
- Generation of vectors for gene targeting, homologous recombination, tissue-specific recombination.
- Genome editing, CRISPR-Cas9 technology in livestock.

- Examples of genetically modified livestock.
- Ethical aspects of genome modification in livestock.

Intended Learning Outcomes:
After participation in lecture and seminar the student will have fundamental knowledge regarding genome modification in livestock (mammals and birds) and their application in agriculture and biomedicine.

The student will be able to:
- recognise strengthens and weaknesses of different methods for genome modification in mammalian and avian livestock
- use the acquired knowledge to select and design the optimal genome modification strategy to achieve a defined goal, such as disease resistance.
- describe examples of existing genetically modified livestock and can discuss what the possible benefit could be for either humans or animals
- manipulate animal cells in the laboratory
- understand the ethical issues connected to genome modifications in livestock
- read and discuss literature about genetically engineering of livestock animals

Teaching and Learning Methods:
Part of the module will be a lecture. Students should study the provided script and are encouraged to ask and answer questions during the lecture. It is essential that knowledge acquisition is examined throughout the course by discussing technical and scientific problems such as, which method is applicable to change large areas of the genome, which if only a single base should be exchanged.
For the seminar and practical part student will work in groups, they will be encouraged to carry out an in-depth study of literature, assess the presented results and learn to question the validity of published results. Some hands-on experience will bring the subject to live and connect the theoretical and practical knowledge.

Media:
PowerPoint presentations, Lab experimentations, download of required information and literature.

Reading List:
To be announced.

Responsible for Module:
Schnieke, Angelika; Prof. Ph.D.

Courses (Type of course, Weekly hours per semester), Instructor:
Genetically modified livestock (Vorlesung, 2 SWS)
Bauer B, Fischer K, Flisikowska T, Flisikowski K, Schnieke A, Schusser B

Genetically modified livestock- current literature overview (Seminar, 1 SWS)

Fischer K, Flisikowska T, Flisikowski K, Schnieke A, Schusser B

Practical introduction to methods of genetic engineering (Übung, 1 SWS)
Schnieke A [L], Fischer K, Flisikowska T, Flisikowski K
For further information in this module, please click campus.tum.de or here.

Module Description

WZ0629: Genomics of Livestock Populations | Genomics of Livestock Populations

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The final examination is a written test (120 min, Klausur). Students demonstrate in the exam that they understand the principles of analyzing genome data of livestock species. They know the pertinent analysis tools and can describe scenarios of their application. They can explain and evaluate genomic prediction approaches including their pitfalls. The students are able to derive hypotheses of causal DNA-variation and to design experiments for their appropriate testing.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successful Bachelor courses in biology, genetics, livestock breeding, and applied statistics.

Content:
- Structure and organization of genes and genomes
- Sequencing and re-sequencing of livestock genomes
- Variant calling and annotation
- High-throughput genotyping
- Haplotyping and imputation
- Building genomic relationship matrices
- Analysis of population stratification by principal component analysis
- Estimating SNP effects and genomic prediction
- Genome-wide association studies (logistic, linear regression)
- Identification of genomic regions of reduced or missing homozygosity
- Identification selection signatures
- Approaches to the identification of causal variants

Intended Learning Outcomes:
The students understand the structure of genomes in general and the specifics of livestock genomes. They are able to extrapolate population genetic principles to the genomic level. They recognize the file formats for storing genomic information. They are able to apply standard tools for analyzing genomic data like bwa, samtools, bcftools, vcftools, plink and gcta. They are able to use a scripting language such as python for data preparation, the automation of analysis steps (pipelines) and the parsing of analysis results. They are able to assess and discuss different approaches to the identification of loci and causal variants for Mendelian and complex traits and genomic prediction in livestock populations (emphasis on Bos taurus, Sus scrofa and Gallus gallus).

Teaching and Learning Methods:
Basic principles and concepts are taught in (interactive) lectures. Application of analysis tools is practiced on laptop computers. Example code and instructions are provided in the form of Jupyter notebooks.

Media:
LibreOffice presentations, coding exercises, anonymized genomic data sets, Jupyter notebooks, panel work

Reading List:
Ju Han Kim (2019); Genome Data Analysis, Springer, ISBN 978-981-13-1941-9

Responsible for Module:
Fries, Hans Rudolf; Prof. Dr. agr. habil.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1589: Marker-assisted Selection | Marker-assisted Selection

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the written examination (Klasur, 120 min) students show without additional material that they are able to explain the basic concepts of marker-assisted selection. They demonstrate that they understand the required statistical and genetic methods. They are able to apply the methods in case studies and place them in the context of a breeding program. They can explain different methods in the analysis of quantitative trait loci. They show that they understand the basic concepts of genomic prediction and selection. They are able to evaluate the efficiency of marker assisted prediction and selection in breeding programs.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Successful Bachelor courses in biology, genetics, plant breeding, biotechnology and applied statistics.

Content:
Technical and genetic principles of molecular markers; building genetic and physical maps; theoretical background and experimental data sets for QTL- and association mapping as well as for genome wide prediction; theoretical background and experimental results for marker-assisted selection

Intended Learning Outcomes:
After successful completion of the module students are able to understand the basic concepts of marker-assisted selection, to apply statistical methods to experimental data sets and to use the respective genetic information in breeding programs. Students will be familiar with different regression methods (e.g. single marker regression, multiple marker regression) in the analysis of quantitative trait loci through linkage or genome wide association mapping. Using regularized

regression, they will be able to perform genomic prediction and selection. Based on examples from the literature they will be able to apply the above mentioned statistical methods to data. Using resampling methods, students will know how to evaluate the efficiency of marker-assisted prediction and selection and will be able to judge under which scenarios they are a useful tool for making breeding decisions.

Teaching and Learning Methods:
The module consists of a lecture, in which the theoretical foundations are developed together with the students through lecture and chalkboard work in dialog. PowerPoint presentations are used to visualize the concepts presented. The theoretical knowledge will be extended in computer exercises through the analysis of experimental data sets.

Media:
PowerPoint presentations, chalkboard
Computer exercises, application training

Reading List:
Lynch and Walsh (1998): Genetics and Analysis of Quantitative Traits; Sinauer Verlag, ISBN 978 0878934812
Risk . A Multidisciplinary Introduction (2014), Chapter 7 by Schön and Wimmer: Statistical Models for the Prediction of Genetic Values, Springer Verlag, ISBN 978-3-319-04486-6

Responsible for Module:
Schön, Chris-Carolin; Prof. Dr.sc.agr. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Marker-gestützte Selektion (Vorlesung, 4 SWS)
Schön C, Mayer M, Ouzunova M, Lanzl T
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2581: Plant Biotechnology | Pflanzenbiotechnologie

Version of module description: Gültig ab winterterm 2021/22

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the written, supervised examination (Klausur, 90min), by answering questions under time pressure and without helping material, students demonstrate that they have obtained knowledge in the areas of plant biotechnology, plant molecular biology and plant biochemistry.
The examination assesses the theoretical background and applied knowledge obtained on up-to-date aspects of current research.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
A basic knowledge in genetics, genomics, plant development, biochemistry and/or botany is highly recommended

Content:
The module consists of a lecture and a seminar part.
In the lecture, state-of-the-art methods in plant biotechnology and plant molecular biology are introduced, and advantages and disadvantages are discussed. Current challenges are highlighted.
Topics of the lecture include:
- Genetically modified plants: status, regulations, cultivation, concepts;
- Generation of genetically modified plants: methods, vector systems;
- Concepts for yield improvement;
- Concepts for quality improvement;
- New potentials derived from basic research;
- Model system Arabidopsis: development of new techniques;
- Metabolic engineering.

In the seminar part different speakers from the TUM, which are active in research in plant biotechnology or plant molecular biology, introduce cutting-edge research projects that take place

on campus. The seminar part is conceived to highlight the exciting research that currently takes place and advertise opportunities for master thesis projects.

Intended Learning Outcomes:
The students have a profound knowledge in plant biotechnology, plant biochemistry and plant molecular biology. They are aware of new technological approaches and methodology applied in the fields, including plant transformation, construct and vector design, reporter systems and essential DNA, RNA and protein techniques. They are able to comment critically and reflect on technologies and aims of plant biotechnology. They have insight into latest research developments in the respective areas, in particular also in research projects that currently take place at the TUM

Teaching and Learning Methods:
Lecture: PowerPoint presentations, short movies and use of the black board. Questions to the audience will actively encourage discussion and enable students to ask questions more freely.
Seminar: Power point presentations and use of the black board. The seminar talks are followed by discussions to actively invite students to ask questions. Review papers will be provided as background reading.

Media:
Lecture: PowerPoint, black board, discussion.
Seminars: PowerPoint, black board, discussion.
PDFs of the lectures will be made available to the students. Review publications will be made available for background reading on the seminar contends.

Reading List:
Biochemistry and Molecular Biology of Plants. Buchanan, Gruissem and Jones, John Wiley & Sons, 2015

Responsible for Module:
Poppenberger-Sieberer, Brigitte; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Pflanzenbiotechnologie (Seminar, 2 SWS)
Gutjahr C, Benz J, Assaad-Gerbert F, Avramova V, Sieberer T, Schwechheimer C, Tellier A, Hückelhoven R, Johannes F, Schneitz K, Dawid C

Pflanzenbiotechnologie (Vorlesung, 2 SWS)
Poppenberger-Sieberer B
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2480: Plant Developmental Genetics 2 | Plant Developmental Genetics 2

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 60	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the oral examination (30 min.) students explain without additional helping material principles of plant developmental genetics, describe experimental strategies of plant developmental genetics and evaluate the relevance of plant developmental genetics for horticulture and plant breeding. The grade of the exam will be the final grade of the module.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Genetics (WZ0703). Plant Developmental Genetics I (WZ0305). A basic understanding of genetics, molecular biology and cell biology is required.

Content:
- photomorphogenesis
- flowering time control
- floral meristem identity
- floral organ identity
- floral organogenesis
- gametophyte, apomixis
- fertilization process
- parental control of embryogenesis/seed development

Intended Learning Outcomes:
After successful completion of the module students are able to understand the basic concepts of plant developmental genetics and to evaluate their relevance for problems in horticulture and plant breeding.

Teaching and Learning Methods:
The lecture provides the theoretical background and concepts. During the exercises, in individual or group work on specific selected original literature with presentations students show their ability to understand the concepts and to critically analyse and evaluate the obtained scientific models.

Media:
PowerPoint presentations, chalkboard
Slides will be provided online in pdf format. Taped recordings of the lectures will be provided online as audio- and videopodcasts.
Current literature,

Reading List:
Taiz et.al. Plant Physiology and Development 2015 6th edition, Oxford University Press; Smith et al. Plant Biology 2010, Garland Science.
Current literature from specific journals will be announced during the lecture.

Responsible for Module:
Schneitz, Kay Heinrich; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Entwicklungsgenetik der Pflanzen 2 (Vorlesung, 2 SWS)
Schneitz K [L], Schneitz K

Journal Club Entwicklungsgenetik der Pflanzen (Seminar, 2 SWS)
Schneitz K, Torres Ruiz R
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1185: Plant Epigenetics and Epigenomics | Plant Epigenetics and Epigenomics

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 75	**Contact Hours:** 75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a presentation (20 min) followed by discussion (10 min). The presentation should summarize and interpret the results obtained from analyzing published epigenomic datasets using the computational skills aquired during the Computer Practical sessions. The presentation is a means to measure the student's ability to understand a technical/ scientific subject, to analyze and evaluate facts and factors of influence, to summarize the subject and present it to an audience, and to conduct a discussion about the presented subject

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic knowledge of genetics, cell biology, statistics

Content:
The course will cover:
- Components and functions of the plant epigenome: DNA methylation, histone modifications
- Measuring epigenomes: array-based and NGS based bulk and single cell technologies
- Analyzing plant epigenomic data: Array and NGS based computational tools for bulk and single cells
- Plant epigenome and environmental variation
- Plant epigenome and genetic variation
- Epigenetic inheritance in plants: Mitotic and meiotic inheritance
- Current perspectives on the agricultural and evolutionary implications of epigenetic inheritance in pl

Intended Learning Outcomes:
Students will be able to:
- Interpret the molecular components of epigenomes
- Interpret functions of epigenomes
- Identify the sources of population level epigenomic variation
- Explain modern measurement technologies
- Distinguish the conceptual background of different computational tools
- Apply computational tools to epigenomic data
- Analyze the implications of epigenetic and epigenomics
- Carry out presentation skills

Teaching and Learning Methods:
The following teaching methods will be used:
- Lectures: The goal of the lectures is to provide an in-depth overview of the main concepts, approaches and research questions in plant epigenetics and epigenomics.

- Computer tutorial: The goal of the computer tutorials is to reinforce the lecture contents with hands-on experience. The main aims are: 1) to get hands-on experience with the type of epigenomic datasets that is routinely generated in this field; 2) to get hands-on experience with software tools for the analysis of epigenomic datasets; 3) to be able to evaluate the output from these software tools, and to use the output as a way to answer concrete biological research questions.

- Seminars: The goal of the seminars is to discuss recent scientific literature in plant epigenetic and epigenomics . The aim is to demonstrate how the concepts, approaches and research questions presented in the course provide a means to decode complex scientific articles in this field.

Media:
PowerPoint presentations, software practicals

Reading List:
Hand-outs

Responsible for Module:
Johannes, Frank; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Plant Epigenetics and Epigenomics (Vorlesung, 3 SWS)
Johannes F

Plant Epigenetics and Epigenomics - Computer Practical (Praktikum, 2 SWS)
Johannes F, Hazarika R
For further information in this module, please click campus.tum.de or here.

Module Description

WZ0047: Plant Stress Physiology | Plant Stress Physiology

Version of module description: Gültig ab winterterm 2021/22

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 75	**Contact Hours:** 75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination contains a written exam (Klausur; essay exam, no multiple choice, without the use of learning aids, 100 % of the grade; 90 min): The written exam assesses how well the students remember the theoretical background and methodology and can judge plant stress parameters. Additionally, students are assessed for their ability to translate the obtained knowledge and practically applied methodology of measuring and qualification of stress responses to a new topic in plant stress physiology (e.g. by designing an experimental setup to measure plant stress).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of Plant Physiology at the B.Sc. level

Content:
Definition, symptoms and physiology of stress in crop and model plants (e.g. barley, Arabidopsis thaliana). Influence of diverse biotic and some abiotic stress factors on development, hormone homeostasis, physiology and yield parameters of plants. Relevance of diverse plant stresses for plant performance in agroecological context. Methods of measuring and quantification of stress responses in plants (e.g. marker gene expression, calcium influx). Stress resistance, tolerance of plants and its experimental assessment. Measuring stress parameters such as chlorophyll fluorescence, lipid peroxidation, enzyme activities, reactive oxygen species formation as proxies for plant resilience under stress conditions. In discussion parts, lecturers link specific plant stress responses and stress resistance to agricultural production systems and value their agroeconomic relevance (e.g. for production under climate change conditions).

Intended Learning Outcomes:
Upon completion of the module, students are able to remember theoretical background and definitions of plant stress physiology. They are able to understand and analyze plant stress parameters. Students gain the ability to collect new theoretical knowledge and understand innovative technologies in plant stress physiology. They are able to self- sufficiently select and apply suitable methods from literature and exercises for measuring plant stress and to evaluate and interpret data. This enables students for the experimental design, methods application and evaluation of plant performance including yield parameters and stress resistance tests under diverse environmental conditions.

Teaching and Learning Methods:
In the lecture students gain knowledge about theoretical background, definitions, kinds, physiology and relevance of plant stress and innovations in assessment and measurement of plant stress physiology. In the exercise, students practice in small groups, how to apply key methods for quantification of plant stress parameters. They document their data and discuss it with group members and tutors. In the seminar, students are guided to critically read original research papers and present most recent findings in the field. They learn to critically interpret original work and current hypotheses in plant stress physiology. Discussions on lectures and student presentations support reflection of contents at a higher scale (e.g. from cell to plant organ, from plant organ to whole plant, from plant to field, from field to yield).

Media:
PowerPoint

Reading List:
Reviews and original research papers are provided

Responsible for Module:
Hückelhoven, Ralph; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Stressbiologie und -physiologie der Pflanzen (Seminar, 1 SWS)
Hückelhoven R [L], Hückelhoven R, Schempp H, Engelhardt S, Vlot-Schuster A, Durner J, Lindermayr C, Rosenkranz M, Stegmann M

Stressbiologie und -physiologie der Pflanzen (Vorlesung, 2 SWS)
Schempp H [L], Hückelhoven R, Vlot-Schuster A, Schempp H, Engelhardt S, Lindermayr C, Durner J, Rosenkranz M, Stegmann M

Stressbiologie und -physiologie der Pflanzen (Übung, 2 SWS)
Schempp H [L], Schempp H, Vlot-Schuster A, Stegmann M
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1584: Quantitative Genetics and Selection | Quantitative Genetics and Selection

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the written examination (Klausur, 120 min) students show without additional material that they are able to explain the basic concepts of quantitative genetics and population genetics and their relevance for breeding. They demonstrate their ability to use the acquired knowledge for the design of optimized breeding strategies. The grade of the exam will be the final grade of the module.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Successful Bachelor courses in applied statistics (e.g. module Statistische Methoden)

Content:
Population genetics: genetic constitution of populations, selection and mutation
Quantitative genetics: Inbreeding and heterosis, epistasis, phenotypic and genetic variance, resemblance between relatives, heritability, genotype-environment interaction
Selection theory: response to selection

Intended Learning Outcomes:
After successful completion of the module, students are able to understand the basic concepts of quantitative genetics and to evaluate their relevance for problems in plant breeding. They can explain important population genetic concepts such as the Hardy-Weinberg Law, understand the concepts of linkage and linkage disequilibrium and how they can be estimated in experimental populations. The students become familiar with the theoretical concepts underlying breeding values and combining ability and their application in estimating heritability. They can identify and quantify resemblance between relatives. They are able to apply these concepts to selection theory for the optimization of breeding programs.

Teaching and Learning Methods:
The module consists of a lecture, in which the theoretical background and concepts are developed through PowerPoint presentations and chalkboard work. The analysis of experimental data sets in computer exercises extends the theoretical knowledge.

Media:
PowerPoint presentations, chalkboard
Computer exercises, application training

Reading List:
Falconer and Mackay (1995) Introduction to quantitative genetics; Pearson Education Limited, ISBN: 978-0582243026, 4th edition

Lynch and Walsh (1998): Genetics and Analysis of Quantitative Traits; Sinauer Verlag, ISBN 978 0878934812

Responsible for Module:
Schön, Chris-Carolin; Prof. Dr.sc.agr. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Quantitative Genetik und Selektion (Vorlesung, 4 SWS)
Schön C, Lanzl T
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2763: Transcriptional and Posttranscriptional Regulation in Eukaryotes | Transcriptional and Posttranscriptional Regulation in Eukaryotes

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the written examination (60 min, Klausur) students demonstrate by answering questions under time pressure and without helping material the theoretical knowledge of components, processes and mechanisms of transcriptional and posttranscriptional regulation in eukaryotes and of methods to study them.
By comparing different techniques applied to the study of transcriptional regulation student demonstrate that they can evaluate their advantages and disadvantages for answering a given experimental question.
Their ability to analyse and evaluate a research paper and to structure the content such that they can clearly explain it to an audience, is examined during their presentation of a research paper assigned to them in a PowerPoint presentation. To demonstrate that they have acquired the ability to discuss scientific data the students generate questions about the paper to guide a discussion after their presentation.
The goals of the module have been reached and the module has been passed when the total grade of written exam and presentation (3:2) is better than 4.1.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamental knowledge in genetics and molecular biology is highly recommended. The participants should have passed one or more bachelor level lectures in genetics, genomics, systems biology, developmental genetics of plants and/or developmental genetics of animals.

Content:
The development of an organism and its developmental and physiological responses to the environment are based on a precise spatio-temporal regulation of genes. The lecture and associated seminar will cover mechanisms of gene regulation. They are suitable for MSc students as well as highly motivated and advanced BSc students.

The lecture (90 mins per week) will cover:
- Transcriptional machinery
- Structure of eukaryotic chromatin
- Epigenetic modifications and chromatin remodelling
- Gene activation and repression
- Transcription factors
- Combinatorial transcription factor complexes in signal integration
- Regulation of transcription factors by posttranslational modification
- Transcription factor evolution and its role in acquisition of novel traits
- RNA molecules and RNA processing
- Regulatory RNAs
- Methods to study transcriptional regulation

The accompanying seminar (90 min per week), will include discussions on a range of original landmark papers covering different aspects of transcriptional regulation comprised in the lecture (most examples will be from plants). Furthermore, students will get advice on how to give a good presentation and will get feedback on the quality of their own presentation and advice for possible improvement.

Intended Learning Outcomes:
At the end of the module students have a profound understanding of the role and of different mechanisms of transcriptional and posttranscriptional regulation in eukaryotes. They know different techniques of how to study eukaryotic chromatin, transcription factor-DNA interactions (such as promoter deletion series for identification of cis-elements, ChIP, DIP, EMSA, microscale thermophoresis), their advantages and disadvantages. Thus, they are able to determine the correct experimental approach to address research questions in transcriptional and posttranscriptional regulation. Additionally, they are able to critically evaluate unfamiliar results in original papers related to transcriptional and posttranscriptional regulation. In the seminar, they have acquired practice in presenting original research data and gained the ability to discuss such data with their colleagues.

Teaching and Learning Methods:
LECTURE: Presentation with PowerPoint and black board. The presentation will be interrupted with questions to the students to keep their active attention and to induce reflection on the content of the lecture (Sokrates' midwife method). Short breaks will give the possibility to students to ask questions during the lecture.
SEMINAR: Students will use PowerPoint to present a research paper, which has been assigned to them. The instructor will help in guiding the discussions and will contribute questions to make

students aware of details and induce their reflection of the content. They acquire practice in presenting original research data and gained the ability to discuss such data with their colleagues.

Media:
LECTURE: Power point, black board, discussion. PDFs of the lectures will be made available to the students.
SEMINAR: Powerpoint, black board, discussion.

Reading List:
LECTURE:
Benjamin Pierce, Genetics: a conceptual approach, 2013 5th edition (or newer)
James Watson, Molecular Biology of the Gene, 2014 7th edition (or newer)
Michael Carey et al. Transcriptional regulation in Eukaryotes, 2009, 2nd edition (or newer)
Original articles used to increase the content of the lecture will be cited on the power point slides.
SEMINAR:
Original articles will be distributed to the individual speakers in the first seminar session.

Responsible for Module:
Gutjahr, Caroline; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Transcriptional and Posttranscriptional Regulation in Eukaryotes with Special Emphasis on Plants (Seminar, 2 SWS)
Gutjahr C

Transcriptional and posttranscriptional regulation in eukaryotes (Vorlesung, 2 SWS)
Gutjahr C, Torres Ruiz R
For further information in this module, please click campus.tum.de or here.

Module Description

LS10000: Research Internship Agricultural Biosciences | Research Internship Agricultural Biosciences

Version of module description: Gültig ab winterterm 2021/22

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 30	**Contact Hours:** 120

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students prepare a written report (max. 20 pages) which is assessed as course work (pass/ fail) based on their understanding of the research question, their ability to learn and apply new methods, the accuracy in reporting progress in data acquisition and data analyses and their ability to study and work autonomously.

Repeat Examination:

(Recommended) Prerequisites:
Required modules in Statistical Computing, Cell Biology, Immunology, Physiology and Genetics, Lab course

shedule:

1. The students search themselves one TUM internal supervisor from the given list of classes. They do so by contacting a chair of TUM School of Life Sciences that already has a class connected to the offer-node within the module-node of LS10000 in TUMonline. If a preferred supervisor’s class and exam is already listed a topic or supervisor needs no further approval by the Examination Board.
If there should be another potential TUM internal supervisor whose chair is not yet part of the list of classes and/or exams, the students can ask for an extension of the list by the preferred supervisor writing a conclusive e-mail to recognition.co@ls.tum.de.

2. The students register for the supervisor’s class connected to the respective offer-node.

3. It will be the TUM internal supervisor who will (re-)read the report and finally submits the grade and the title.

Content:
The internship can be carried out at TUM research groups or at external research facilities. Students apply their theoretical and practical knowledge acquired during the first semesters to a specific research question either on a basic or applied level. The topic is dependent on the research focus of the host laboratory.

Intended Learning Outcomes:
After successful participation, students have acquired theoretical and practical skills to answer scientific research questions. They have gained experience in the design of experiments and in the application of the required methods. They understand the background of the applied technologies. They know how to document the progress of their work including the applied methods, the acquired data and the results obtained. In a written report, they can explain the scientific context of their research project, analyze the acquired data and interpret these results in relation to current literature. They are able to explain their project in short oral presentations.

Teaching and Learning Methods:
The internship involves the planning of a scientific research project, the implementation of the research plan and the writing of a scientific report about the project. Students are trained to identify a selected basic or applied research question in the context of agricultural biosciences. Supervision by experienced scientific personnel throughout the internship supports the training success. Students prepare a written report with a detailed description of the applied methods, the acquisition and analysis of the data and the final outcome. The progress is discussed in regular meetings with the supervisors. At the end of the internship students prepare an oral presentation summarizing the goal and the main findings of their research project

Media:

Reading List:
Review articles and current literature related to the topic of the research internship.

Responsible for Module:
Schön, Chris-Carolin; Prof. Dr.sc.agr. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Research Internship Report Crop Physiology (Praktikum, ,4 SWS)
Bienert G

Research Internship Report Livestock Biotechnology (Prof. Schnieke) - Master (Forschungspraktikum, ,4 SWS)
Flisikowski K

Research Internship Report Plant Genetics (Prof. Gutjahr) (Praktikum, ,4 SWS)
Gutjahr C

Research Internship Report Chair of Phytopathology (Prof. Hückelhoven) (Praktikum, ,4 SWS)
Hückelhoven R

Research Internship Population Epigenetics & Epigenomics (Prof. Johannes) (Praktikum, ,4 SWS)
Johannes F

Research Internship Report Plant Breeding (Prof. Schön) (Praktikum, ,4 SWS)
Schön C

Research Internship Report Reproductive Biotechnology (Praktikum, ,4 SWS)
Schusser B
For further information in this module, please click campus.tum.de or here.

Module Description

WZ0261: Simulation of Cropping Systems | Simulation of Cropping Systems

Simulation

Version of module description: Gültig ab summerterm 2022

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 82.5	**Contact Hours:** 67.5

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination performance will be in the form of a project work presentation. The project report will describe a systems problem in cropping, its translation into a scientific question and the application of a crop model in R to answer this question. The project report will be about 12 pages and must be presented at the end of the semester in a final presentation. The report, presentation and discussion should show that participants have an ability to sufficiently understand the context of cropping systems, the interactions between different plant resources such as light and water and have developed a critical view of model abstraction versus real systems. They need to show an ability to understand the potential of models to gain new inside in to cropping systems as well as the limitations of crop models to simulate such system. The report and the presentation are the final type of assessment. By passing additional brief quizzes that are offered during the semester each students gets the chance to get an 0.3 grade bonus if the final assessment is passed and 75% of the quizzes are passed, too. A repetition of the midterm assessments is not possible. If a repetition exam is taken in the following semester and the grade bonus was achieved, it will be transferred.
The possibility of repetition of the exam is given at the end of the semester.

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
Basic knowledge in biology, crop physiology, physics, chemistry, hydrology, mathematics, statistics and programming language R, based on the bachelor's degree in Agricultural and Horticultural Sciences

Content:
The module includes aspects of the yield physiology of crops: C-balance (photosynthesis, respiration, C-allocation), water balance, light uptake, growth and development and model representations of these components in a cropping system with numerical solutions, crop models and coding in R.

The course will contain two components. First, students will be exposed to basic concepts of systems analysis, modeling and computer simulation of agricultural and biological systems. Emphasis will be placed on continuous simulation of dynamic models with examples that give students a broad exposure to dynamic simulation models. An overview of applications of models in agricultural and biological systems will be given. Basics of working with R and a simple crop model developed in R will be taught via e-learning tools and seminars during this first half of the semester.

The second part of the course will introduce students to a simple dynamic crop simulation model. They will apply their knowledge of R and the simple crop model in R, to modify the model and apply it for a class projects. Lectures will expose the students to various methods for working with dynamic models, including parameter estimation, model evaluation, and sensitivity analysis which they will apply in a project work. Students will also be exposed to uncertainties in models associated with uncertainties in model parameters, inputs, and structure.

Intended Learning Outcomes:
After successfully completing the module, students are able to:
- Understand general concepts of cropping systems and crop simulation models, including Systems Approach, Model development, Example models and Numerical Simulation,
- Create basic routines to simulate dynamic behavior using numerical solutions,
- Understand a simple crop simulation model in R, supplied from the literature, with the basic structures of a cropping system,
- Apply a simple crop model in R to a new problem using Parameter estimation, Model evaluation and Sensitivity analysis,
- Evaluate crop model performance in R with field experimental data,
- Understand the potential of models to gain new systems inside in cropping systems analysis,
- Understand the limitations of crop models to simulate a cropping system,
- Analyze model uncertainty.

Teaching and Learning Methods:
The basic modeling approaches of cropping systems processes are presented and supplemented in the lectures by example from different models and recent research. In the accompanying exercises, parallel to lecture material, student will individually read scientific literature and carry out exercises on methods of model development, parameterization, evaluation, sensitivity analysis and uncertainty analysis. In a seminar setting, the first part of the semester will be accompanied with e-learning developed for this module, they will learn the basics of R and how a simple model is applied in R (1SWS for first half of semester). Students will prepare homework exercises on model creation and discuss these and literature in class. The lectures will be accompanied with

regular brief quizzes to test their comprehension of new definitions and concepts. Students are encouraged to assist each other in homework (understanding reading material and in performing specific modeling tasks) and during discussion in class.

Media:
PowerPoint Presentations, leaflet of the lecture in pdf format, E-modules (brief videos), exercise portfolio and quizzes.

Reading List:
Handouts will include pages from:
Wallach, D., D. Makowski J. W. Jones and F. Brun. 2019. Working with Dynamic Crop Models. Methods, Tools and Examples for Agriculture and Environment. Third Edition. Academic Press, London.
Keen, R.E. and J.D. Spain. 1992. Computer simulation in Biology: A Basic Introduction. Wiley-Liss Inc. New York. (Selected Chapters - Book out of print.)
Jones, J.W. and Luyten, J.C. 1998. simulation of Biological Processes. In: Peart, R.M. and Curry, R.B. (eds). Agricultural Systems Modeling and Simulation. Marcel Dekker Inc. ISBN 0-827-0041-4.
Thornley, John H.M. and Ian R. Johnson.2000. Pland and Crop Modeling: A Mathematical Approach to Plant and Crop Physiology. Oxford University Press. New York. Blackburn Press (Second Printing.)

Additional Readings:
De Wit, C.T., 1992. Resource use efficiency in agriculture. Elsevier Applied Science, London.
Landau, S., Mitchell, R.A.C., Barnett, V., Colls, J.J., Craigon, J., Moore, K.L., Payne, R.W., 1998. Testing winter wheat simulation models' predictions against observed UK grain yields. Agricultural and Forest Meteorology 89, 85-99.
Lobell, D.B., Cassman, K.G., Field, C.B., 2009. Crop Yield Gaps: Their Importance, Magnitudes, and Causes. Annual Review of Environment and Resources 34, 179-204.
Lobell, D.B., Field, C.B., 2007. Global scale climate - crop yield relationships and the impacts of recent warming. Environmental Research Letters 2.
Sinclair, T.R., Muchow, R.C., 1999. Radiation use efficiency. Advances in Agronomy 65, 215-265.
Asseng S, et al. (2015) Rising temperatures reduce global wheat production. Nature Climate Change 5:143-147.
Asseng S, et al. (2013) Uncertainty in simulating wheat yields under climate change. Nature Climate Change 3:827-832.
Chenu K, Porter JR, Martre P, Basso B, Chapman SC, Ewert F, Bindi M, Asseng S (2017) Contribution of crop models to adaptation in wheat. Trends in Plant Science 22:472-490.
Lobell DB, Asseng S (2017) Comparing estimates of climate change impacts from process-based and statistical crop models. Environmental Research Letters 12.
Zhao C, Liu B, Xiao LJ, Hoogenboom G, Boote KJ, Kassie BT, Pavan W, Shelia V, Kim KS, Hernandez-Ochoa IM, Wallach D, Porter CH, Stockle CO, Zhu Y, Asseng S (2019) A SIMPLE crop model. European Journal of Agronomy 104:97-106.
Zotarelli et al. 2010 Step by Step Calculation of the Penman-Monteith Evapotranspiration (FAO-56 Method), IFAS Publication, University of Florida

Responsible for Module:
Asseng, Senthold; Prof. Prof. Dr. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Simulation Cropping Systems (Vorlesung mit integrierten Übungen, 4 SWS)
Asseng S [L], Asseng S, De Souza Noia Junior R

R for crop modelling (Übung, 2 SWS)
De Souza Noia Junior R [L], De Souza Noia Junior R
For further information in this module, please click campus.tum.de or here.

WZ0634: General Education | General Education

Recommended Language Modules | Recommended Language Modules

Module Description

SZ03011: Intensive Course German as a Foreign Language A1.1 | Blockkurs Deutsch als Fremdsprache A1.1

Version of module description: Gültig ab summerterm 2010

Module Level: Bachelor/Master	**Language:** Language taught	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 60	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
1 final written exam 90 min. (100%) - no learning aids permitted
The midterm exam is intended to monitor students' learning progress and reduce the amount of material covered in the final exam.
Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing. Verbal skills are evaluated using appropriate prompts from sample print dialogs.

Repeat Examination:

(Recommended) Prerequisites:
none

Content:
In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as shopping, going to a restaurant, public transport etc.
Students learn and practice basic vocabulary on topics such as family, occupation, leisure time, food and living, plural noun forms, personal and demonstrative pronouns and simple forms of negation. They become familiar with numbers, prices and time, learn how to ask and answer

simple questions about a person or family, as well as talk about matters of everyday life in simply structured sentences in the simple present.
Students learn different strategies for effective, self-motivated, independent learning. Students acquire teamwork skills through collaborative work in multinational mixed groups.

Intended Learning Outcomes:
The module is based on level A1 of GER.
Upon completion of this module, students are able to express themselves using everyday expressions and simple sentences. They are able to introduce themselves and other people, they can ask and answer simple questions about personal details, describe daily routines in a simple manner and provide information about themselves in writing in simple sentences.
Furthermore, students are able to communicate their wishes, if dialog partners are willing to help and to speak slowly and clearly.

Teaching and Learning Methods:
The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.
Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

Media:
Textbook; multimedia teaching and learning materials (chalk/white board, overheads, worksheets, images, films, etc.) and online resources

Reading List:
Textbook (to be announced in class)

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

SZ03021: Intensive Course German as a Foreign Language A1.2 | Blockkurs Deutsch als Fremdsprache A1.2

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor/Master	**Language:** Language taught	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 60	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
1 final written exam 90 min. (100%) - no learning aids permitted
The midterm exam is intended to monitor students' learning progress and reduce the amount of material covered in the final exam.
Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing. Verbal skills are evaluated using appropriate prompts from sample print dialogs.

Repeat Examination:

(Recommended) Prerequisites:
Firm knowledge of level A1.1; placement test with the achievement A1.2

Content:
In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as shopping, going to a restaurant, public transport etc.
Students learn and practice basic vocabulary on topics such as family, occupation, leisure time, food and living. They learn to talk about matters of everyday life in simply structured sentences in the tenses simple present and present perfect simple and practice the usage of modal verbs, the imperative and the two-case preposition.
Students learn different strategies for effective, self-motivated, independent learning. They acquire teamwork skills through collaborative work in multinational mixed groups.

Intended Learning Outcomes:
The module is based on level A1 of GER.
Upon completion of this module, students are able to express themselves using everyday expressions and simple sentences.
Students are able to answer simple questions about themselves and their family and pose questions, in kind, to a dialog partner. They are able to arrange meetings and provide information about themselves in writing. They are able to describe daily routines in the past and present tense and can successfully communicate their wishes in everyday situations, such as going shopping or eating in a restaurant, with dialog partners who are willing to help and speak slowly and clearly.

Teaching and Learning Methods:
The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.
Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

Media:
Textbook; multimedia-based teaching and learning materials (black board, overheads, exercise sheets, image, film, etc.) also online

Reading List:
Textbook (to be announced in class)

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

SZ03031: Intensive Course German as a Foreign Language A2.1 | Blockkurs Deutsch als Fremdsprache A2.1

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 60	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
1 final exam 90 min. (100%) - no learning aids permitted
The midterm exam is intended to monitor students' learning progress and reduce the amount of material covered in the final exam. Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing.
Verbal skills are evaluated using appropriate prompts from sample print dialogs.

Repeat Examination:

(Recommended) Prerequisites:
Firm knowledge of level A1.2; placement test with the achievement A2.1

Content:
In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as traveling, at the doctor’s office, searching for an apartment, in a department store, among colleagues, friends or neighbors.

Students learn and practice basic vocabulary and expressions on topics such as education, profession, health and traveling. Students learn and practice using simply structured main and subordinate clauses (that, because, and, than, etc.), employing the preterit (modal verbs) and perfect, as well as the comparative, the superlative and the declination of the adjective. They reinforce and expand the usage of the prepositions in the accusative and dative case.

Students learn strategies for successful verbal and written communication despite minimal language skills. Opportunities will be made available for effective, self-motivated, independent learning. Students acquire teamwork skills through collaborative work in multinational mixed groups.

Intended Learning Outcomes:
The module is based on level A2 of GER.
Upon completion of this module, students are able to understand and use simple sentences and expressions in conversations on a broad spectrum of familiar topics. These conversations are based on basic information concerning everyday life and subjects relevant to studying or working, including sociocultural aspects of German-speaking countries.
For example, students are able to describe themselves and other people, their living situation, state of health, leisure time activities and job situation.
Students are able to understand longer texts and letters about familiar topics that include foreseeable information and are written in simple language about everyday life or job related topics. Students are able to compose short, informative texts or notifications about basic situations in everyday life or situations related to studying.

Teaching and Learning Methods:
The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.
Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

Media:
Textbook; multimedia-based teaching and learning materials (black board, overheads, exercise sheets, image, film, etc.) also online

Reading List:
to be announced in the Class

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Blockkurs Deutsch als Fremdsprache A2.1 (Seminar, 4 SWS)
Gemaljevic J, Kretschmann A, Niebisch D, Semeraro G
For further information in this module, please click campus.tum.de or here.

Module Description

SZ03041: Intensive Course German as a Foreign Language A2.2 | Blockkurs Deutsch als Fremdsprache A2.2

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 60	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
1 final exam 90 min. (100%) - no learning aids permitted
The midterm exam is intended to monitor students' learning progress and reduce the amount of material covered in the final exam. Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing.
Verbal skills are evaluated using appropriate prompts from sample print dialogs.

Repeat Examination:

(Recommended) Prerequisites:
Firm knowledge of level A2.1; placement test with the achievement A2.2

Content:
In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as traveling, at the doctor’s office, searching for an apartment, in a department store, among colleagues, friends or neighbors.
Students reinforce and augment basic vocabulary and expressions on topics such as education, profession, living and traveling. Students learn and practice classifying and using an extended spectrum of main and subordinate clauses (final clause, indirect questions, temporal subordinate clause, causal sentence). They also learn to employ the preterit (modals verbs) and perfect and will repeat and expand the usage of the prepositions and the declination of the adjective.

Students learn strategies for successful verbal and written communication despite minimal language skills. Opportunities will be made available for effective, self-motivated, independent learning. Students acquire teamwork skills through collaborative work in multinational mixed groups.

Intended Learning Outcomes:
The module is based on level A2 of GER.
Upon completion of this module, students are able to understand and use simple sentences and expressions in conversations on a broad spectrum of familiar topics. These conversations are based on basic information concerning everyday life and subjects relevant to studying or working, including sociocultural aspects of German-speaking countries.
For example, students are able to describe themselves and other people, their living situation, state of health, leisure time activities and job situation. Students are able to communicate in various situations, for example, when searching for an apartment, traveling or on holiday, and are able to report about their experiences in simple standard language.
Students are able to understand longer texts and letters about familiar topics that include foreseeable information and are written in simple language about everyday life or job related topics. Students are able to compose short, informative texts or notifications about basic situations in everyday life or situations related to studying.

Teaching and Learning Methods:
The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.
Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

Media:
Textbook; multimedia-based teaching and learning materials (black board, overheads, exercise sheets, image, film, etc.) also online

Reading List:
Textbook (to be announced in class)

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Blockkurs Deutsch als Fremdsprache A2.2 (Seminar, 4 SWS)
Heiligensetzer M, Hoff L, Kretschmann A, Meuschel G, Niebisch D
For further information in this module, please click campus.tum.de or here.

Module Description

SZ03051: Intensive Course German as a Foreign Language B1.1 | Blockkurs Deutsch als Fremdsprache B1.1

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 60	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
1 schriftlicher End Term Test 90 min. (100%) - keine Hilfsmittel erlaubt
In der schriftlichen Prüfung werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhaltet Fragen zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Leseverstehen, sowie Aufgaben zur freien Textproduktion. Das Hörverstehen wird anhand von Hörbeispielen mit Hörverstehens-Fragen überprüft, die schriftlich beantwortet werden müssen. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft.

Repeat Examination:

(Recommended) Prerequisites:
Sound knowledge of level A2.2; placement test level B1.1

Content:
In this module, knowledge of German as a foreign language will be further developed, enabling students to express themselves in German independently and confidently in familiar situations, e.g. in the classroom, at work, in free time and with the family, on topics of general interest, e.g. films, music, sports, etc, when standard German is spoken. Students expand and test a basic repertoire of logical main and subordinate clauses (final clauses, consecutive clauses, relative clauses), learn and practice the use of reflexive verbs, the function and use of second subjunctive and the passive. They review and develop elementary aspects of grammar, such as the use of the tenses and prepositions. They examine specific cultural features with regard to festivals and traditions, the educational system, the business world, lifestyles and leisure activities, and obtain insight into contemporary culture in Germany.

Intended Learning Outcomes:
The module is aimed at level B1 of the CEFR. Students acquire knowledge of German as a foreign language at the standard language level with a focus on intercultural, cultural and academic aspects. Students obtain team competence through collaborative work in mixed, multinational groups. Following completion of this module, students can make themselves understood in most situations which occur in the context of studies, career and leisure time in German speaking regions. They can report on academic and business careers; express hopes and wishes; make, accept or reject invitations; give advice and directions; express and discuss opinions. They can understand and summarize the general content of simple, authentic texts from the everyday world and take part in spontaneous discussions on familiar topics. Students can compose longer personal letters and texts on personal experiences.

Teaching and Learning Methods:
The module consists of a seminar in which course objectives will be achieved in an activity-oriented, communicative atmosphere through listening, reading, writing and speaking exercises in individual, partner and group work. The fundamental language skills conveyed in the classroom are reinforced through the use of guided self-learning in the form of prepared (and online) materials.

Media:
Textbook; multimedia teaching and learning materials (chalk/white board, overheads, worksheets, images, films, etc.) and online resources.

Reading List:
Textbook (to be announced in class)

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Blockkurs Deutsch als Fremdsprache B1.1 (Seminar, 4 SWS)
Niebisch D, Oelmayer J, Schimmack B, Stoephasius J
For further information in this module, please click campus.tum.de or here.

Module Description

SZ03061: Intensive Course German as a Foreign Language B1.2 | Blockkurs Deutsch als Fremdsprache B1.2

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 60	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
1 schriftlicher End Term Test 90 min. (100%) - keine Hilfsmittel erlaubt
In der schriftlichen Prüfung werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhaltet Fragen zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Leseverstehen, sowie Aufgaben zur freien Textproduktion. Das Hörverstehen wird anhand von Hörbeispielen mit Hörverstehens-Fragen überprüft, die schriftlich beantwortet werden müssen. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft.

Repeat Examination:

(Recommended) Prerequisites:
Sound knowledge of module B1.1; placement test level B1.2

Content:
In this module, knowledge of German as a foreign language will be further developed, enabling students to express themselves in German independently and confidently in familiar situations, e.g. in the classroom, at work, in free time and with family, on topics of general interest, e.g. films, music, sports, etc, when standard German is spoken. Students develop an expanded spectrum of vocabulary, figures of speech and idioms, discussion patterns, understand and use a basic repertoire of logical main and subordinate clauses (temporal clauses, causal clauses, infinitive clauses, final clauses, consecutive clauses and relative clause), verbs and nouns and expand their use of prepositions. They review and develop elementary aspects of grammar, such as the use of tenses, prepositions, adjective declensions and comparatives. They examine specific features of culture with regard to festivals and traditions, the educational system, the business world, lifestyles and leisure activities, and obtain insight into contemporary culture in Germany.

Intended Learning Outcomes:
The module refers to level B1 Independent Language Use of the CEFR. Students acquire knowledge of German as a foreign language at the standard language level with a focus on intercultural, cultural and academic aspects. Students obtain team competence through collaborative work in mixed, multinational groups. After completion of this module, students can make themselves understood in most situations likely to occur in the context of work, school and leisure, or while traveling in German-speaking regions. They can report on academic and business careers; describe plans and express hopes and wishes; make, accept or reject invitations; give advice and directions; express and discuss opinions. They can understand and summarize the general content of simple, authentic factual texts, literary texts, and radio and television programs and take part in spontaneous discussions on topics of general interest. Students can compose simple formal letters and longer personal letters and describe personal experiences. They can speak on everyday topics of personal interest in a structured fashion and produce a written text, taking a logically-defensible position on a current issue, when given assistance.

Teaching and Learning Methods:
The module consists of a seminar in which course objectives will be achieved in an activity-oriented, communicative atmosphere through listening, reading, writing and speaking exercises in individual, partner and group work. The fundamental language skills conveyed in the classroom are reinforced through the use of guided self-learning in the form of prepared (and online) materials. The basics of presenting and discussing everyday topics will be conveyed by means of the prescribed criteria and communicative patterns.

Media:
Textbook; multimedia teaching and learning materials (chalk/white board, overheads, worksheets, images, films, etc.) and online resources.

Reading List:
Textbook (to be announced in class)

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Blockkurs Deutsch als Fremdsprache B1.2 (Seminar, 4 SWS)
Aristakesyan V, Niebisch D, Scherer M
For further information in this module, please click campus.tum.de or here.

Module Description

SZ03071: Intensive Course German as a foreign language B2.1 | Blockkurs Deutsch als Fremdsprache B2.1

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 60	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
1 End Term Test 90 Min. (100%) - keine Hilfsmittel erlaubt
In der schriftlichen Prüfung werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft.
Sie beinhaltet Fragen zur Anwendung von Wortschatz und Grammatik, Redemitteln, Text- bzw. Lese- und Hörverstehen. Das Hörverstehen wird anhand von Hörbeispielen mit Hörverstehens-Fragen überprüft, die schriftlich beantwortet werden müssen. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft.
Den Schwerpunkt bildet eine Aufgabe zur freien Textproduktion.

Repeat Examination:

(Recommended) Prerequisites:
Sound knowledge of module B1.2; placement test level B2.1

Content:
In this module, students will increase their knowledge of German as a foreign language, enabling them to actively and almost fluently communicate with a native speaker on topics of general interest or in familiar fields using logically-structured arguments. Students develop a broad and differentiated vocabulary on a wide spectrum of topical issues. They increase their knowledge of word formation, the possibilities of nominalizing in German, as well as prepositional phrases and noun-verb collocations, and expand their repertoire of nouns, verbs and adjectives with prepositions. They review and increase their use of subjunctive II (e.g. in unreal comparisons), practice the use of two part (correlative) conjunctions and work on problems of sentence construction such as the placement of complements and adjuncts in complex main and

subordinate clauses. Students deal with culturally-specific manifestations of German society and cultural life in modern-day Germany.

Intended Learning Outcomes:
The module is aimed at level B2 Independent Language Use of the CEFR. Students acquire knowledge of German as a foreign language at the standard language level with a focus on intercultural, cultural and academic aspects. Students can independently understand the main points of authentic articles and reports from their own fields and areas of interest and identify positions. Students can understand longer discussions and lectures on contemporary topics, provided that speakers clearly enunciate. They are able to compose longer texts on general or popular scientific topics and can use more complex sentence structures as well as specialized vocabulary. They are able to present their position in discussions in a detailed and logically-structured fashion. They can interact clearly and coherently on many subjects in their fields or areas of interest.

Teaching and Learning Methods:
The module consists of a seminar in which course objectives will be achieved in an activity-oriented, communicative atmosphere through listening, reading, writing and speaking exercises in individual, partner and group work. The fundamental language skills conveyed in the classroom are reinforced through the use of guided self-learning in the form of prepared (and online) materials. Following assigned criteria and communication patterns, various options for giving speeches or making presentations as well as participating in discussions including moderated (role play) discussions on topics of general interest will be made available.

Media:
Textbook; multimedia teaching and learning materials (chalk/white board, overheads, worksheets, images, films, etc.) and online resources

Reading List:
Lehrbuch (wird im Kurs bekannt gegeben)

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

SZ03081: Intensive Course German as a Foreign Language B2.2 | Blockkurs Deutsch als Fremdsprache B2.2

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 60	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
1 End Term Test 90 Min. (100%) - keine Hilfsmittel erlaubt
In der schriftlichen Prüfung werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft.
Sie beinhaltet Fragen zur Anwendung von Wortschatz und Grammatik, Redemitteln, Text- bzw. Lese- und Hörverstehen. Das Hörverstehen wird anhand von Hörbeispielen mit Hörverstehens-Fragen überprüft, die schriftlich beantwortet werden müssen. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft.
Den Schwerpunkt bildet eine Aufgabe zur freien Textproduktion.

Repeat Examination:

(Recommended) Prerequisites:
Sound knowledge of module B2.1; placement test level B2.2

Content:
In this module, students will increase their knowledge of German as a foreign language, enabling them to actively and for the most part fluently communicate with a native speaker on topics of general interest or in familiar fields and to form a structured argument. Students develop a broad and differentiated vocabulary on a wide spectrum of topical issues. They increase their knowledge of word formation, the possibilities of nominalizing in German, as well as prepositional phrases and noun-verb collocations, and expand their repertoire of nouns, verbs and adjectives with prepositions. They analyze problems of sentence construction, review and increase the use of the passive, including the passive sentence forms, the use of modal verbs (including the

subjective meaning) and work on forms of indirect speech. Students deal with culturally-specific manifestations of German society and contend with current cultural life in Germany.

Intended Learning Outcomes:
The module refers to level B2 Independent Language Use of the CEFR. Students acquire knowledge of German as a foreign language at the standard language level with a focus on intercultural, cultural and academic aspects. Students can often independently understand the main points of articles and reports from their own fields and areas of interest, without strain, and identify positions. Students can read contemporary prose texts and understand current television reports and most films, when standard German is spoken. They can follow longer discussions and lectures on topical issues as well as topics within their field, provided that speakers enunciate clearly. They are able to compose detailed texts on current topics and those in their field of study using coherent arguments and specialist vocabulary. Students are able to present their position in discussion in a detailed and logically-structured fashion. They can orally communicate clearly and coherently on many subjects in their fields or areas of interest and take positions they can defend.

Teaching and Learning Methods:
The module consists of a seminar in which course objectives will be achieved in an activity-oriented, communicative atmosphere through listening, reading, writing and speaking exercises in individual, partner and group work. The fundamental language skills conveyed in the classroom are reinforced through the use of guided self-learning in the form of prepared (and online) materials. Following assigned criteria and using communication patterns, various options for giving speeches or making presentations as well as participating in discussions including moderated (role play) discussions on topics of general interest will be made available.

Media:
Textbook; multimedia teaching and learning materials (chalk/white board, overheads, worksheets, images, films, etc.) and online resources

Reading List:
Lehrbuch (wird im Kurs bekannt gegeben)

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

SZ0303: German as a Foreign Language A2.1 | Deutsch als Fremdsprache A2.1

Version of module description: Gültig ab winterterm 2019/20

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
1 final exam 90 min. (100%) - no learning aids permitted
The midterm exam is intended to monitor students' learning progress and reduce the amount of material covered in the final exam. Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing.
Verbal skills are evaluated using appropriate prompts from sample print dialogs.

Repeat Examination:

(Recommended) Prerequisites:
Firm knowledge of level A1.2; placement test with the achievement A2.1

Content:
In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as traveling, at the doctor’s office, searching for an apartment, in a department store, among colleagues, friends or neighbors.

Students learn and practice basic vocabulary and expressions on topics such as education, profession, health and traveling. Students learn and practice using simply structured main and subordinate clauses (that, because, and, than, etc.), employing the preterit (modal verbs) and perfect, as well as the comparative, the superlative and the declination of the adjective. They reinforce and expand the usage of the prepositions in the accusative and dative case.

Students learn strategies for successful verbal and written communication despite minimal language skills. Opportunities will be made available for effective, self-motivated, independent learning. Students acquire teamwork skills through collaborative work in multinational mixed groups.

Intended Learning Outcomes:
The module is based on level A2 of GER.
Upon completion of this module, students are able to understand and use simple sentences and expressions in conversations on a broad spectrum of familiar topics. These conversations are based on basic information concerning everyday life and subjects relevant to studying or working, including sociocultural aspects of German-speaking countries.
For example, students are able to describe themselves and other people, their living situation, state of health, leisure time activities and job situation.
Students are able to understand longer texts and letters about familiar topics that include foreseeable information and are written in simple language about everyday life or job related topics. Students are able to compose short, informative texts or notifications about basic situations in everyday life or situations related to studying.

Teaching and Learning Methods:
The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.
Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

Media:
Textbook; multimedia-based teaching and learning materials (black board, overheads, exercise sheets, image, film, etc.) also online

Reading List:

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Deutsch als Fremdsprache A2.1 (Seminar, 4 SWS)
Aßmann J, Bauer G, Comparato G, Geishauser C, Gemaljevic J, Keza I, Kovacs O, Kutschker T, Nierhoff-King B, Schlüter J, Semeraro G
For further information in this module, please click campus.tum.de or here.

Module Description

SZ0304: German as a Foreign Language A2.2 | Deutsch als Fremdsprache A2.2

Version of module description: Gültig ab winterterm 2019/20

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
1 final exam 90 min. (100%) - no learning aids permitted
Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing.
Verbal skills are evaluated using appropriate prompts from sample print dialogs.

Repeat Examination:

(Recommended) Prerequisites:
Firm knowledge of level A2.1; placement test with the achievement A2.2

Content:
In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as traveling, at the doctor’s office, searching for an apartment, in a department store, among colleagues, friends or neighbors.
Students reinforce and augment basic vocabulary and expressions on topics such as education, profession, living and traveling. Students learn and practice classifying and using an extended spectrum of main and subordinate clauses (final clause, indirect questions, temporal subordinate clause, causal sentence). They also learn to employ the preterit (modals verbs) and perfect and will repeat and expand the usage of the prepositions and the declination of the adjective.
Students learn strategies for successful verbal and written communication despite minimal language skills. Opportunities will be made available for effective, self-motivated, independent

learning. Students acquire teamwork skills through collaborative work in multinational mixed groups.

Intended Learning Outcomes:
The module is based on level A2 of GER.
Upon completion of this module, students are able to understand and use simple sentences and expressions in conversations on a broad spectrum of familiar topics. These conversations are based on basic information concerning everyday life and subjects relevant to studying or working, including sociocultural aspects of German-speaking countries.
For example, students are able to describe themselves and other people, their living situation, state of health, leisure time activities and job situation. Students are able to communicate in various situations, for example, when searching for an apartment, traveling or on holiday, and are able to report about their experiences in simple standard language.
Students are able to understand longer texts and letters about familiar topics that include foreseeable information and are written in simple language about everyday life or job related topics. Students are able to compose short, informative texts or notifications about basic situations in everyday life or situations related to studying.

Teaching and Learning Methods:
The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.
Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

Media:
Textbook; multimedia-based teaching and learning materials (black board, overheads, exercise sheets, image, film, etc.) also online

Reading List:

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Deutsch als Fremdsprache A2.2 (Seminar, 4 SWS)
Aßmann J, Bauer G, Comparato G, Feistle C, Hagner V, Hanke C, Kostial M, Reulein C, Schimmack B, Selent D, Stiebeler H, Thiessen E
For further information in this module, please click campus.tum.de or here.

Module Description

SZ0305: German as a Foreign Language B1.1 | Deutsch als Fremdsprache B1.1

Version of module description: Gültig ab winterterm 2019/20

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
1 End Term Test 90 Min. (100%) - keine Hilfsmittel erlaubt
In der schriftlichen Prüfung werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhaltet Fragen zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Leseverstehen, sowie Aufgaben zur freien Textproduktion. Das Hörverstehen wird anhand von Hörbeispielen mit Hörverstehens-Fragen überprüft, die schriftlich beantwortet werden müssen. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft.

Repeat Examination:

(Recommended) Prerequisites:
Sound knowledge of level A2.2; placement test level B1.1

Content:
In this module, knowledge of German as a foreign language will be further developed, enabling students to express themselves in German independently and confidently in familiar situations, e.g. in the classroom, at work, in free time and with the family, on topics of general interest, e.g. films, music, sports, etc, when standard German is spoken. Students expand and test a basic repertoire of logical main and subordinate clauses (final clauses, consecutive clauses, relative clauses), learn and practice the use of reflexive verbs, the function and use of second subjunctive and the passive. They review and develop elementary aspects of grammar, such as the use of the tenses and prepositions. They examine specific cultural features with regard to festivals and traditions, the educational system, the business world, lifestyles and leisure activities, and obtain insight into contemporary culture in Germany.

Intended Learning Outcomes:
The module is aimed at level B1 of the CEFR. Students acquire knowledge of German as a foreign language at the standard language level with a focus on intercultural, cultural and academic aspects. Students obtain team competence through collaborative work in mixed, multinational groups. Following completion of this module, students can make themselves understood in most situations which occur in the context of studies, career and leisure time in German speaking regions. They can report on academic and business careers; express hopes and wishes; make, accept or reject invitations; give advice and directions; express and discuss opinions. They can understand and summarize the general content of simple, authentic texts from the everyday world and take part in spontaneous discussions on familiar topics. Students can compose longer personal letters and texts on personal experiences.

Teaching and Learning Methods:
The module consists of a seminar in which course objectives will be achieved in an activity-oriented, communicative atmosphere through listening, reading, writing and speaking exercises in individual, partner and group work. The fundamental language skills conveyed in the classroom are reinforced through the use of guided self-learning in the form of prepared (and online) materials.

Media:
Textbook; multimedia teaching and learning materials (chalk/white board, overheads, worksheets, images, films, etc.) and online resources.

Reading List:

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Deutsch als Fremdsprache B1.1 (Seminar, 4 SWS)
Brössler G, Dechant S, Hartkopf D, Heiligensetzer M, Kouhi S, Kraut-Schindlbeck S, Oelmayer J, Pöschl A, Sabel B, Schlömer A, Stiebeler H, Stoephasius J, Witzig B, Zendath I
For further information in this module, please click campus.tum.de or here.

Module Description

SZ0306: German as a Foreign Language B1.2 | Deutsch als Fremdsprache B1.2

Version of module description: Gültig ab winterterm 2019/20

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
1 End Term Test 90 Min. (100%) - keine Hilfsmittel erlaubt
In der schriftlichen Prüfung werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhaltet Fragen zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Leseverstehen, sowie Aufgaben zur freien Textproduktion. Das Hörverstehen wird anhand von Hörbeispielen mit Hörverstehens-Fragen überprüft, die schriftlich beantwortet werden müssen. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft.

Repeat Examination:

(Recommended) Prerequisites:
Gesicherte Kenntnisse der Stufe B1.1; Einstufungstest mit Ergebnis B1.2.

Content:
In this module, knowledge of German as a foreign language will be further developed, enabling students to express themselves in German independently and confidently in familiar situations, e.g. in the classroom, at work, in free time and with family, on topics of general interest, e.g. films, music, sports, etc, when standard German is spoken. Students develop an expanded spectrum of vocabulary, figures of speech and idioms, discussion patterns, understand and use a basic repertoire of logical main and subordinate clauses (temporal clauses, causal clauses, infinitive clauses, final clauses, consecutive clauses and relative clause), verbs and nouns and expand their use of prepositions. They review and develop elementary aspects of grammar, such as the use of tenses, prepositions, adjective declensions and comparatives. They examine specific features of culture with regard to festivals and traditions, the educational system, the business world, lifestyles and leisure activities, and obtain insight into contemporary culture in Germany.

Intended Learning Outcomes:
The module refers to level B1 Independent Language Use of the CEFR. Students acquire knowledge of German as a foreign language at the standard language level with a focus on intercultural, cultural and academic aspects. Students obtain team competence through collaborative work in mixed, multinational groups. After completion of this module, students can make themselves understood in most situations likely to occur in the context of work, school and leisure, or while traveling in German-speaking regions. They can report on academic and business careers; describe plans and express hopes and wishes; make, accept or reject invitations; give advice and directions; express and discuss opinions. They can understand and summarize the general content of simple, authentic factual texts, literary texts, and radio and television programs and take part in spontaneous discussions on topics of general interest. Students can compose simple formal letters and longer personal letters and describe personal experiences. They can speak on everyday topics of personal interest in a structured fashion and produce a written text, taking a logically-defensible position on a current issue, when given assistance.

Teaching and Learning Methods:
The module consists of a seminar in which course objectives will be achieved in an activity-oriented, communicative atmosphere through listening, reading, writing and speaking exercises in individual, partner and group work. The fundamental language skills conveyed in the classroom are reinforced through the use of guided self-learning in the form of prepared (and online) materials. The basics of presenting and discussing everyday topics will be conveyed by means of the prescribed criteria and communicative patterns.

Media:
Textbook; multimedia teaching and learning materials (chalk/white board, overheads, worksheets, images, films, etc.) and online resources.

Reading List:

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Deutsch als Fremdsprache B1.2 (Seminar, 4 SWS)
Aristakesyan V, Bauer-Hutz B, Gärtner A, Hartkopf D, Kouhi S, Kraut-Schindlbeck S, Lechle K, Niehaus B, Oelmayer J, Schmidt-Bender S, Steidten R
For further information in this module, please click campus.tum.de or here.

Module Description

SZ0329: German as a Foreign Language B2+C1: Academic Writing | Deutsch als Fremdsprache B2+C1: Schreiben im Studium [SZ0329]

Version of module description: Gültig ab winterterm 2016/17

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:**
Credits:* 2	**Total Hours:** 60	**Self-study Hours:** 30	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
1 Schriftliches Portfolio, aus dem 2 Texte (250-350 Wörter) jeweils mit der Durchschnittsnote der Erst- und Endfassung bewertet werden (50%)
1 End Term Test 90 Min. (50%) – einsprachiges Wörterbuch erlaubt

Repeat Examination:

(Recommended) Prerequisites:
gesicherte Kenntnisse der Stufe B2.1; Einstufungsergebnis B2.2

Content:
In diesem Modul werden in der Auseinandersetzung mit einem Gegenstand aus dem eigenen Fach Strategien bzw. Textformen erarbeitet, die es den Studierenden ermöglichen, längere Texte im eigenen Fach zu verfassen, die den strukturellen Basisanforderungen einer wissenschaftlichen Arbeit in sprachlicher und grammatischer Hinsicht entsprechen.
In der Auseinandersetzung mit einem Gegenstand aus dem eigenen Fach wird Schritt für Schritt Textwissen erarbeitet. Ausgehend von Schreibübungen, Fach- und Beispieltexten sowie mit Hilfe von ausgewählten Übungen zu Wortschatz und Grammatik schreiben die Studierenden allgemeinverständliche Texte, die sich auf das eigene Fach beziehen und die thematisch aufeinander aufbauen. Sie überprüfen und festigen dabei Wortschatz und Strukturen, die im akademischen Kontext relevant sind.
Im Fokus stehen dabei die für den akademischen Diskurs grundlegenden rhetorischen Funktionen "definieren", "erklären", exemplifizieren" und rhetorische Bausteine des Wissenschaftsdiskurses wie „argumentieren“ und „informieren“ und „bewerten“. Weiter wird in mehreren Arbeitsschritten der Transfer zum adressatenbezogenen Text sowohl für die Präsentation eines Themas, als auch für den Fachtext an sich reflektiert.

Das Modul kann ergänzend zu allen Modulen B2.2 und C1.1 absolviert werden.

Intended Learning Outcomes:
Das Modul orientiert sich am Niveau B2.2/C1 des GER mit Fokus auf die Fertigkeit Schreiben. Nach erfolgreicher Teilnahme sind die TN in der Lage grundlegende rhetorische Formen wie das Beschreiben eines Gegenstands und eines Vorgangs, den Vergleich, das Erläutern einer grafischen Darstellung und das Begründen eines Sachverhalts für eine wissenschaftliche Arbeit in ihrem Fach anzuwenden. Sie transferieren dabei wissenschaftssprachliche Strukturen und allgemeinwissenschaftliche Begriffe und Phrasen. Sie können den eigenen Text anhand von Feedback und erlernten Strategien überarbeiten. Sie sind in der Lage, den eigenen Schreibprozess zu analysieren und verfügen über Strategien, gezielt Einfluss darauf zu nehmen.

Teaching and Learning Methods:
Mithilfe verschiedenster „Writing-to-learn“ Schreibübungen, Reflexionen, Partner- und Lehrer-Feedbacks und Visualisierungen erarbeiten die Teilnehmenden eigenständig und kooperativ/ kollaborativ die Bausteine für das Portfolio, das im Moodle-Kurs abgelegt wird. Schriftliche Hausaufgaben festigen das Gelernte, ermöglichen kritisches und erkenntnisbildendes Schreiben, stellen einen Teil der Prüfungsleistung dar und sind zentrales Element der Lehrveranstaltung. Der Kurs erfordert einen hohen Eigenarbeitsteil, der durch detaillierte Hausaufgabenbeschreibungen, Feedback und Online-Übungen unterstützt wird.

Media:
multimedial gestütztes Lehr- und Lernmaterial (Tafel, Folie, Übungsblätter, Bild, Film, etc.), besonders online im Moodlekurs

Reading List:
Zur Behebung von Unsicherheiten in der Grammatik kann empfohlen werden (freiwillig):
Hall, Karin und Scheiner, Barbara: Übungsgrammatik Deutsch als Fremdsprache für die Mittelstufe/Fortgeschrittene, Hueber Verlag 2005
Rug, Wolfgang und Tomaschewski, Andreas: Grammatik mit Sinn und Verstand, Edition Deutsch, Klett international 2006

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Other Recommended Modules | Other Recommended Modules

Module Description

WI001122: Introduction to Business Law (MiM) | Introduction to Business Law (MiM) [BusLawMiM]

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The final assessment will be held as a written exam of 120 minutes. The exam consists of two parts which count for approximately 50 per cent each and forming the overall mark.
In the first part of this exam, students will be asked theoretical questions. This will demonstrate to what extent they have memorized and understood principles of the law of contracts, torts, company law, IP and competition law. In the second part, students will also be asked to apply their knowledge to known and fictional cases. This demonstrates if students have developed the required legal analytical skills. Students also need to demonstrate their ability to apply their knowledge to fact settings not discussed in the lecture, and to evaluate the legal consequences.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
This module covers the legal essentials of running a business in technology driven markets in Germany and in the European Union. It focuses on typical problems which entrepreneurs and employees might encounter in practice (scenario-based approach). Topics covered will be, inter alia, the formation and termination of contracts, selected types of contract (in particular, sale of goods), torts, property law, the law of business associations, intellectual property law, competition law.

Intended Learning Outcomes:
At the end of this module students will be able
(1.) to name and understand essentials of the legal framework for technology oriented businesses in Germany and in the European Union;
(2.) to identify and avoid the problems presented by dealing with legal issues in a foreign language (in particular, English as the main business language) and/or in a transnational setting;
(3.) to grasp and apply the legal principles regulating business activity, in particular regarding liability under tort, contract, company, intellectual property and competition law;
(4.) to analyse legal implications of typical business situations and to identify their options;
(5.) to present the results of their analysis in a written analysis.

Teaching and Learning Methods:
The lecture will cover the theoretical aspects of the module in a discussion with the lecturer. The exercise will focus on case studies. It will provide the opportunity to work individually or in groups on case scenarios (known and unknown), covering various issues of German and European law. The purpose is to repeat and to intensify the content discussed in the lecture and to review and evaluate legal issues from different areas of law in everyday situations. Students will develop the ability to present these findings in a concise and well-structured written analysis.

Media:
Presentations (PPT), Cases

Reading List:
Gerhard Robbers, "An Introduction to German Law", 6th edition 2016;
additional reading material will be made available on the course Moodle site prior to the start of the semester.

Responsible for Module:
Maume, Philipp; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Introduction to Business Law (WIHN1122) MIM Heilbronn - Exercise (Übung, 2 SWS)
Haag A

Introduction to Business Law (WI001122): Exercise (Repitition) (MiM) (Übung, 2 SWS)
Haffke L, Primbs M

Introduction to Business Law (WI001122) (MiM) (Vorlesung, 2 SWS)
Maume P

Introduction to Business Law (WIHN1122) MIM Heilbronn - Lecture (Vorlesung, 2 SWS)
Rolsing N
For further information in this module, please click campus.tum.de or here.

Module Description

MCTS0036: Moderation (RESET) | Moderation (RESET)

How to guarantee efficient group discussions and moderation

Version of module description: Gültig ab winterterm 2021/22

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 68	**Contact Hours:** 22

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students must submit a research paper (2000 to 3000 words) in which they demonstrate that they have gained a deeper understanding of successful moderation. They do so by analysing a case or reflecting their own and other´s communication patterns and behaviour in group discussions and moderation situations. In the paper, students demonstrate that they have acquired a greater awareness for communication challenges and barriers with different stakeholders, as well as an empathic and also assertive communication attitude. Furthermore, they show that they are able to apply effective communication techniques for the creation and maintenance of respectful and results-oriented group discussions, and also to learn from experience and - if necessary or advisable - to modify critical group communication patterns.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
This Skills module is aimed at students currently enrolled in the M.A. program 'Responsibility in Science, Engineering and Technology'. Students from other English-language MA programs can apply to join the respective course provided there is sufficient space available.

Content:
It is a major challenge to communicate effectively with and to different stakeholders within the STS/RRI context (in project meetings, planning processes or field activities), especially when targeting the change of paradigms and behaviour. Involving different stakeholders such as fellow researchers and partners but also decision makers, entrepreneurs, and civil society in productive, interactive inter- and transdisciplinary meetings is a challenge and requires an informed and skilled intervention of the moderator. Relevant concepts for these interventions will be discussed and necessary skills will be trained.

Intended Learning Outcomes:
This module is dedicated to the challenges of successful communication in multi-stakeholder environments. Participants will acquire the following skills needed to support and moderate meetings and discussions (involving 3-20 participants) effectively and guarantee consistent outcomes:
- awareness for communication challenges and barriers with different stakeholders
- empathic and at the same time assertive communication attitude in moderation situations
- application of effective moderation techniques (e.g. active listening, rephrasing, question techniques, establishing rapport)
- ability to use these techniques for the creation and maintenance of respectful and result-oriented group discussions
- ability to learn from experience and - if necessary or advisable - to modify critical group communication patterns

Teaching and Learning Methods:
Lectures to transfer knowledge about moderation and mediation; interactive exercises and simulations (role plays) to train group communication and moderation techniques

Media:
Whiteboard, flip chart, exercise sheets, exercises, role plays, films

Reading List:
MOORE, Ch. (2014). The Negotiating Process - Practical Strategies for Resolving Conflict.- 4th revised Edition; Jossey-Bass Publishers. San Francisco, CA, USA.
FISHER, R. & Ury, W. (2012). Getting To Yes: Negotiating Agreement Without Giving In. 3rd revised Edition (1st Ed. 1983). Penguin Books. New York, NY, USA.
SCHULZ v. THUN, F. (2004) Seven Tools for Clear Communication: The Hamburg Approach in English Language; Arbeitsgruppe Beratung und Training, Fachbereich Psychologie; 69 p.

Responsible for Module:
Bauer, Victoria; M.A.

Courses (Type of course, Weekly hours per semester), Instructor:
Moderation - Facilitation Skills for Transdisciplinary Work Processes (Workshop, 1,5 SWS)
Schmitt S (Hintermeier J)
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1550: Mathematics for Economics | Mathematics for Economics

Version of module description: Gültig ab summerterm 2016

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
There will be a written exam of 90 minutes at the end of the semester, where students demonstrate their ability to solve problems of mathematical economics on their own. The questions in the exam are based on the contents and exercises discussed in the lecture. Students are allowed to use non-programmable calculators and a formulary issued by the chair.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
High School-level analysis and algebra

Content:
- Basics of Mathematical Economics
- Equilibrium Analysis in Economics
- Linear Models and Matrix Algebra
- Comparative Statics, Derivatives and Rules of Differentiation
- Logarithmic and Exponential Functions
- Optimization with one and more Choice Variables and with Equality Constraints

Intended Learning Outcomes:
Upon successful completion of the course, the students will be able to analyze and understand problems of mathematical economics on their own. Students will understand models and mathematical notation in scientific publications in the field of economics.

Teaching and Learning Methods:
Lectures will be assisted by PowerPoint presentations in order to explain the theoretical concepts behind the methods discussed. Theory will be illustrated by example exercises given by the

lecturers on the whiteboard. Additionally, a great part of the lectures will be allocated to exercising, where students can practice exercises under the supervision and with the help of the lecturers. Also, participants will be provided with exercises that can be done as a homework in order to deepen their routine in solving problems of mathematical economics.

Media:
PowerPoint, whiteboard

Reading List:
Chiang, A. C.; Wainwright, K. (2005): Fundamental Methods of Mathemetical Economics, 4th edition, McGraw-Hill.

Responsible for Module:
Johannes Sauer jo.sauer@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Lecture and exercise combined
Mathematics for Economics
4 SWS
Schickramm, Lena; Frick, Fabian

For further information in this module, please click campus.tum.de or here.

Module Description

BV400016: Scientific Paper Writing | Selbständig wissenschaftlich Arbeiten

Version of module description: Gültig ab summerterm 2020

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students have to submit a scientific paper which will be assessed based on a number of standard criteria for a scientific paper. The students demonstrate with their papers that they have gained deeper knowledge of the specific requirements of a scientific paper, including structure, appropriate presentation of information and discussion as well as the related formalities. The students are able to develop a topic for their papers and formulate the problem statement, objectives and research questions. Furthermore, the students are able to develop a conceptual frame and present as well as analyze information and formulate conclusions. Finally, the students are able to meet the formalities of a scientific paper including proper quotations, layout and language.

Note in view of the limitations on university operations as a result of the CoViD19 pandemic: If the basic conditions (hygiene, physical distance rules, etc.) for a classroom-based examination cannot be met, the planned form of examination can be changed to a written or oral online examination in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at least 14 days before the date of the examination by the examiner after consultation with the board of examiners of the respective study program.

Repeat Examination:

(Recommended) Prerequisites:
none

Content:
1. Introduction into what constitutes a scientific paper and what not. How does a scientific paper differ from a technical or consultancy paper?
2. search ing and selecting literature.

3. Technical writing skills – structure and elements of an abstract, summary, position paper, essay
4. Formulating key problem statement and objectives for a research paper
5. Reading, understanding and reviewing research papers
6. Technical writing – macro-writing, outlining
7. Referencing and citing literature using referencing software
8. Technical writing – micro-writing and technical English
9. Technical writing - Use of frameworks in research papers
10. Executing Constructive peer reviews
11. Revising and improving papers

Intended Learning Outcomes:
At the end of the module the students understand the main steps to prepare, write, revise and review a scientific paper. More specifically, students are able to formulate a relevant problem statement, research objective and key method for a scientific paper and design an outline for such a paper. Furthermore, the students are able to write a scientific paper by presenting and following a clear line of argument, discussion and conclusions. The students are also able to identify scientifically valid sources of information and provide references in an given reference style using a reference software . Finally, the students are able to conduct collaborative work in an academic environment.

Teaching and Learning Methods:
The instruction is through participatory lectures, exercises and feedback to papers. Teaching method includes presentation and group discussion which help students to understand how to do a scientific research.

Media:
Presentations followed by discussion.

Reading List:
The module works with a background script in which different aspects of scientific paper writing are addressed.

Responsible for Module:
Walter T. de Vries wt.de-vries@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Scientific Paper Writing (Vorlesung, 1 SWS)
de Vries W [L], de Vries W (Duran Diaz P)
For further information in this module, please click campus.tum.de or here.

Module Description

EI80004: Sustainable Mobility | Sustainable Mobility [SuMo]

Sustainable Mobility: Current and Future Developments

Version of module description: Gültig ab winterterm 2018/19

Module Level: Master	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module exam consists of a 90-minute written exam, in which the students work on short word problems and multiple-choice questions on the different aspects of sustainability - especially with regard to the mobility sector. In addition, simple calculation tasks are used to check the mastery of the acquired procedures based on examples. In addition, students will use a case study to carry out the Life Cycle analysis using basic mathematical calculations. Word problems examine the understanding of the methods and the proper interpretation of results.
The exam is graded and no other documents are allowed.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamentals about:
- energy systems
- renewable energies

Content:
The lecture will cover the relevant questions concerning "sustainability" and "mobility" and methods to assess the sustainability of mobility systems.
- term sustainability: definition of sustainability
- tools for sustainability: (i) environmental life cycle analysis, (ii) life cycle cost analysis, (iii) social life cycle analysis and, (iv) socio-economic Input-Output Analysis.
- sustainability deficits of existing mobility: oil based system, geo-politics, CO2-emissions, particulate emissions, noise, ...
- new mobility concepts beyond technology: car sharing, inter modal transport
- electric vehicles and smart grid: current situation and challenges for sustainability.

- autonomous driving: current situation and challenges for sustainability
- other alternative fuels: current situation and challenges for sustainability

Intended Learning Outcomes:
After completing of the course, the student is able to:
- understand the term of sustainability
- understand the challenge that mobility represents to sustainability
- conduct a Life Cycle Analysis of different mobility options and assess the environmental impact (greenhouse gases, as well as other impacts) associated to different mobility systems from a life cycle approach
- conduct a Life Cycle Cost Analysis of different mobility options
- understand the socio-economic impacts of different systems using the macro-economic Input-Output Analysis.

Teaching and Learning Methods:
Case studies will be provided to the students, who will solve them using the methods learnt during the lectures
The exercises will be solved by the students during the session. The students will be encouraged to participate in the discussions

Language of instruction, English in Winter Semester and German in Summer Semester.

Media:
Lectures, presentations, blackboard and exercises.

Reading List:
Life cycle assessment student handbook
Hrsg./Bearb.: Curran, Mary Ann
Place of Publication, Publisher, Year of Publication: Hoboken, John Wiley & Sons Inc., 2015
Umfangsangabe: XI, 299 Seiten
ISBN: 978-1-119-08354-2

Life Cycle Assessment: Quantitative approaches for decisions that matter. Available at: http://www.lcatextbook.com/

Responsible for Module:
Hamacher, Thomas; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Sustainable Mobility (Übung, 1 SWS)
de la Rua Lope C, Cadavid Isaza A

Nachhaltige Mobilität (Vorlesung mit integrierten Übungen, 3 SWS)
Hamacher T, de la Rua Lope C, Cadavid Isaza A

Sustainable Mobility (Vorlesung, 2 SWS)
Hamacher T, de la Rua Lope C, Cadavid Isaza A
For further information in this module, please click campus.tum.de or here.

Module Description

MCTS9001: Social Studies of Data Science & Engineering | Social Studies of Data Science & Engineering

Version of module description: Gültig ab winterterm 2016/17

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** irregularly
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The exam will be in written form (mid- or end-of-term paper). Students demonstrate that they have gained deeper knowledge of the political, cultural and social dimensions of producing, storing, processing and using large amounts of data. The students are expected to be able to assess and evaluate social and cultural conditions of data science, to explain social and cultural effects, and to apply relevant theoretical concepts to specific examples.

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
Courses in this module can change in focus, but generally focus on selected social, cultural and political dimensions of handling large amounts of data (i.E. data privacy and critical data studies, public discoures on big data, data neutrality, errors, failures, leaks: politics and data regulation, filter bubbles and recommender systems, ethical algorithms) that are contextualized and discussed using basic social and cultural science concepts and positions that are used to reflect on practice-oriented case studies and current public debates.

Intended Learning Outcomes:
Learning outcomes are basic concepts and methods for reflexive analysis and for responsibly dealing with social and cultural conditions of working with large amounts of data. The module enables students to understand the political, cultural and social dimensions of producing, storing, processing and using large amounts of data and deduce consequences for dealing with them. Students are enabled to use reflexive knowledge and methods for the systematical production of

reflexive knowledge in their work in data engineering and analytics and to engage in a sensible and responsible way of using big data.

Teaching and Learning Methods:
Seminar: Reading and in-class discussion of relevant literature, preparing and holding presentations, inquire and present case studies, group work

Media:
The following media are used
- White- or blackboard as well as slides and presentations

- Wikis, Blogs, etc.

Reading List:
Beer, David. 2009. „Power through the Algorithm? Participatory Web Cultures and the Technological Unconscious“. New Media & Society 11 (September): 985–1002.
boyd, danah, und Kate Crawford. 2012. „Critical Questions for Big Data: Provocations for a Cultural, Technological, and Scholarly Phenomenon“. Information, Communication & Society 15 (5): 662–79.
Bunz, Mercedes. 2013. The Silent Revolution. Palgrave Macmillan.
Ensmenger, Nathan. 2012. „Is Chess the Drosophila of Artificial Intelligence? A Social History of an Algorithm“. Social Studies of Science 42 (1): 5–30.
Fuller, Matthew, Hrsg. 2008. Software Studies: A Lexicon. Cambridge: MIT Press.
Gillespie, T. 2010. „The Politics of ‚Platforms‘“. New Media & Society 12 (3): 347–64.
Gillespie, Tarleton. 2012. „Can an Algorithm be Wrong?“ LIMN IssueNumber 2, Crowds and Clouds.
Gillespie, Tarleton. 2014. „The Relevance of Algorithms“. In Media technologies: essays on communication, materiality, and society, herausgegeben von Tarleton Gillespie, Pablo J. Boczkowski, und Kirsten A. Foot, 167–93. Inside technology. Cambridge, Massachusetts: The MIT Press.
Kitchin, R. 2014. „Big Data, New Epistemologies and Paradigm Shifts“. Big Data & Society 1 (1).
Kraemer, Felicitas, Kees van Overveld, und Martin Peterson. 2011. „Is There an Ethics of Algorithms?“ Ethics and Information Technology 13 (3): 251–60.
Ramsay, Stephen. 2011. Reading Machines: Toward an Algorithmic Criticism. Topics in the digital humanities. Urbana: University of Illinois Press.
Rieder, Bernhard. 2005. „Networked Control: Search Engines and the Symmetry of Confidence“. International Review of Information Ethics 3: 26–32.
Ziewitz, Malte. 2011. „How to think about an algorithm: Notes from a not quite random walk, Discussion paper
Symposium “Knowledge Machines between Freedom and Control”“. In . Kulturfabrik Hainburg, Österreich.

Responsible for Module:
Jan-Hendrik Passoth

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

MW2245: Think. Make. Start. | Think. Make. Start. [TMS]

Build innovative products of your ideas in 10 days!

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 60	**Contact Hours:** 120

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination consists of a project work incl. written documentation (approx. 10 pages) and presentation (10 min), in which the students develop a new product in a group project and present their idea for founding a company on this basis. The individual performance is assessed to what extent the students are able to develop a product with market potential by means of an iterative approach to prototypical implementation. The assessment also includes the ability to work in a team, the ability to make well-founded design decisions and the completeness and conclusiveness of the concept, taking into account social relevance, novelty and innovation. As part of the project work, in addition to documentation, there is a final oral presentation. Through the presentation, students are expected to show whether they can demonstrate their ability to act as a competent team.

Repeat Examination:

(Recommended) Prerequisites:
The basic requirement is a willingness to engage with new learning methods, approaches, disciplines and ways of working. Cross-role experience in project management, product development (Design Thinking, TRIZ, Systems Engineering, etc), interdisciplinary teamwork, communication skills, creativity and problem solving skills are an advantage. A lot of emphasis is placed on practical experience.

For the "Problem Expert" role, experience in the following areas is an advantage:
- User Testing, Requirements Engineering, Interviewing, Human-Centered Design, Design, Visualisation, Use Case Definition, UX/UI Design, marketing, market research, benchmarking, design thinking.

For the "Tech Developer" role, experience in the following areas is an advantage:
- Hardware (mechanical): design, manufacturing (workshop/makerspace), prototyping, CAD/CAM.
- Hardware (electronic): embedded systems engineering, microcontrollers, sensors/actuators, Arduino, Raspberry, circuitry, board design, metrology, BUS protocols, prototyping, closed-loop/ open-loop control, robotics
- Software focus: Backend development, databases, frontend development, machine learning, web development, app development, embedded systems

For the "Business Developer" role, experience in the following areas is an advantage:
- Business Plan/Strategy/Design, Marketing, Sales, Interviewing, Finance & Accounting, Business Law & Regulations, Entrepreneurship.

The number of participants is limited and there will be an application process.

Content:
During the interdisciplinary team project, students work methodically, purposefully and agilely on a development project to develop innovative new products with the intention of successfully launching them on the market. Current needs and problems from social, technological and economic systems are identified, analysed and validated in the interdisciplinary team. In doing so, they cooperatively solve challenges that arise from constraints from the different disciplines. They generate suitable market hypotheses and product ideas at an early stage and interact with initial potential customers/users. They iteratively create prototypes and evaluate their hypotheses with them in experiments.

For more information, visit www.thinkmakestart.com and www.tms.tum.de.

Intended Learning Outcomes:
After the successful participation in the module, the students are able to:
- examine the relevance of a problem and develop a solution collaboratively in an interdisciplinary team.
- to discover the innovation potentials of new products / ideas, to evaluate the novelty and social relevance.
- To convert one's own ideas into a Minimum Viable Product and thus use potentials for one's own business start-up.
- To know methods of product development (from thinking to doing), to apply them independently and to evaluate the results (prototyping, design thinking, lean startup, agile, systems engineering).
- to reproduce the principles of user-centred design, to apply them independently and to evaluate them.
- Understand the context of use and analyse customer needs (where do I serve a need and what technology/method do I use).
- To quickly develop important hypotheses involving relevant stakeholders (customer, user, ...) through proper Planning with "purposeful prototyping".
- Change perspectives across disciplines and apply project management in interdisciplinary teamwork.

- To work independently, to make and justify decisions and to learn from one's own mistakes.
- To possibly lay the foundation for one's own business start-up by identifying a start-up idea or team.

Teaching and Learning Methods:
"THINK. MAKE. START." is a two-week, practice-oriented, interdisciplinary and competitive teaching format in which students from all faculties can participate (credits are given individually related to the study program). It is organised by the different chairs of TUM, TUM ForTe, and UnternehmerTUM. They get access to the high-tech workshop Makerspace and budget to transform their own ideas into real prototypes (mechatronic products). Learning outcomes are achieved through the following teaching and learning methods:
- Milestones to be achieved, team roles to be held and predetermined course structure provide the roadmap for the project.
- Coaching and teaching expertise in prototyping, business validation, agile development, design thinking, systems engineering, lean startup and user-centred design.
- Teaching the basics of interdisciplinary collaboration through a role concept (Business Developer, Tech Developer, Problem Expert).
- All participants work in interdisciplinary teams (10 teams of 5 students each) and are encouraged to become active themselves and learn through practical experience (hands-on learning).
- Each team pursues a real business idea chosen for the seminar. Special attention is given to really understanding the customer and verifying the solution approach, through questioning, observation, prototyping or expert discussion.
- Using prototyping to bridge the gap between thinking and doing.
- Reflecting on one's own results and approach supports project decisions.
- The teams present their projects to a jury on DemoDay and present the prototypically implemented product ideas to guests from industry, the start-up scene and research.

Media:
Project manual, presentations, hand-outs, posters, videos, examples.

Reading List:
Esch Franz-Rudolf (2012) Strategie und Technik der Markenführung, 7. Auflage, Vahlen

Faltin, Günter (2008): Kopf schlägt Kapital, Hanser

Halgrimsson (2012): Prototyping and Model Making for Product Design (2012)

Kalweit Andreas, Paul Christof, Peters Sascha, Wallbaum Reiner (2012) Handbuch für Technisches
Produktdesign, Material und Fertigung, Entscheidungsgrundlage für Designer und Ingenieure, 2. Auflage, Springer

Kelly, Tom (2016): The Art of Innovation

Lindemann, U (2007): Methodische Entwicklung technischer Produkte - Methoden flexibel und situationsgerecht anwenden. 2. Auflage

Münchener Business Plan Wettbewerb: Handbuch Businessplan-Erstellung, München http://www.evobis.de/coaching/handbuch/

Malek, Miroslaw / Ibach, Peter K. (2004): Entrepreneurship, Dpunkt Verlag

Moore, Geoffrey A. (2002): Crossing the Chasm, Harpercollins

Osterwalder, Alexander / Pigneur, Yves (2010): Business Model Generation: A Handbook for

Ries, Eric (2011): The Lean Startup

Savoia, Antonio (2019): The right It

Timmons, Jeffry A. / Spinelli, Stephen (2009): New Venture Creation, 7thedition, McGraw, Hill Professional

UnternehmerTUM (2011): Handbuch Schlüsselkompetenzen, 7. Auflage

Responsible for Module:
Zimmermann, Markus; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Think.Make.Start. (Praktikum, 4 SWS)
Zimmermann M [L], Martins Pacheco N, Bandle M, Förtsch T, Reif M, Baur C, Höller B, Thies A
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2760: The Great Transformation - Approaches to and Examples of Transformational Change in Business & Society | The Great Transformation - Approaches to and Examples of Transformational Change in Business & Society

Version of module description: Gültig ab summerterm 2017

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 95	**Contact Hours:** 55

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment is based on an oral group presentation and a seminar paper.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
A basic understanding of sustainability science.

Content:
According to the WBGU a comprehensive transition is defined as “to take the → planetary guard rails into account as a Great Transformation requiring the modification of both the national and the global economy within these guard rails in order to avoid irreversible damages to the Earth system and its ecosystems, and the impact of the damages on humankind.” (Wissenschaftlicher Beirat Globale Umweltveränderungen 2011b, S. 393). In this one-week long seminar, first the students will be theoretically introduced to the topic of the Great Transformation. In this context, both the current discussion about the Great Transformation as well as the different approaches of the transformation towards sustainability will be part of the seminar. Regarding the latter, on the scientific level transformative science, and on the conceptual/practical level transformation design and the economy for the common good will be presented and critically analyzed as well as evaluated. Transferring this theoretical knowledge into practice will be achieved through field trips to regional transformation projects.
Day*
Content
1

- Introduction round (in the morning)
- Discussion round – discussion stimulus: „Do we have to preserve our world for upcoming generations?“ (Schwinn 2015) (in the morning)
- Topics: critical thinking and analyzing; Introduction to the Great Transformation; Current discussion about the Great Transformation (in the morning and in the afternoon)
2
- Topics: transformative science; Project examples for transformative science (in the morning)
- Field trip 1 (in the afternoon)
3
- Critical reflection of transformative science and field trip 1 (in the morning)
2
- Topics: transformation design; Practical examples transformation design (in the morning)
- Field trip 2 (in the afternoon)
4
- Critical reflection of transformation design and field trip 2 (in the morning)
- Topics: Economy for the common good; Practical examples economy for the common good (in the morning)
- Field trip 3 (in the afternoon)
5
- Critical reflection of the economy for the common good and field trip 3 (in the morning)
- Preparation of group presentations for the respective field trip (in the afternoon)
6
- Group presentations (in the morning)
- Reflection of the entire seminar (in the morning)
- Information regarding the seminar paper (in the morning)
*Days 1 - 5: 8:30 a.m. to 12:30 p.m. and 1:30 p.m. to 6:30 p.m.
*Day 6: 08:30 a.m. to 1:30 p.m.

Intended Learning Outcomes:
At the end of the seminar, students are able to:
1.) understand the origins of the Great Transformation
2.) understand the scope of the Great Transformation and the general approaches of the transformation towards sustainability
3.) use basic critical thinking techniques
4.) understand transformation concepts and projects and critically analyze as well as evaluate them (e.g. Common Good Balance Sheets and Reports)
5.) understand the transition of transformation concepts into practice and consequently design transformation projects
6.) suggest possible ideas of improvement

Teaching and Learning Methods:
The module will include lectures, group discussions, group work, case presentations, field trips and reading assignments (also some home reading).

Media:
PowerPoint, board, flip chart, handouts, video.

Reading List:
Wissenschaftlicher Beirat Globale Umweltveränderungen (2011): World in transition. A social contract for sustainability; with 62 figures. Berlin: WBGU.
Felber, Christian (2015): Change Everything. Creating an economy for the common good. London: Zed Books.

Responsible for Module:
Prof. Dr. Michael Suda – Lehrstuhl für Wald- und Umweltpolitik (Arbeitsbereich Umweltgovernance) - Hans-Carl-v.-Carlowitz-Platz 2 85354 Freising

Courses (Type of course, Weekly hours per semester), Instructor:
Course
The Great Transformation - Approaches to and examples of transformational change in business & society
Lecturer
Heike Pöschl
Form of Teaching
Seminar
For further information in this module, please click campus.tum.de or here.

Module Description

WI001194: Who is responsible for food and health? Social and cultural perspective on food, health, and technology | Who is responsible for food and health? Social and cultural perspective on food, health, and technology

Version of module description: Gültig ab winterterm 2018/19

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 150	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The grading will be based on a presentation (~20 minutes) and a final paper consisting of a 2-page outline and the paper at the end of the term itself. Additionally, students get the opportunity to write comments/responses on the readings as a voluntary midterm assessment. Students will be assessed on their understanding of the course material, their application of relevant social science concepts to real-life events, and discussion of controversies raised by the readings. The topic of the final paper should relate to food and health and questions of responsibility. Students will receive feedback on their outline of their final paper in due time. This will assure students find a feasible topic, and use an appropriate key concept (or concepts) and literature from class. The final paper will be assessed on the incorporation of this key concept(s) and knowledge from the module (3000-4000 words).

Repeat Examination:
End of Semester

(Recommended) Prerequisites:

Content:
How to eat and live healthily are important topics and central values within contemporary societies, particularly in industrialized countries. Here, being healthy has become an important goal and source of personal as well as shared identity for many, which people often also define through the types of food that they eat. Health and food are also important governance issues as governments across the world face challenges like rising obesity rates, environmental pollution or the climate crisis. At the same time, techno-scientific reconfigurations of food, such as the

example of genetically modified food, are often very contentious and the source of heavily debated controversies as purported healthier and/or more sustainable solutions. Along the way, different actors, collectives and institutions claim responsibility for themselves or others over who gets to, and should decide on health and (healthy) food. This module explores social and cultural perspectives on food, health and related technologies and innovations to inquire what role the practice, normative approach, and policy of 'responsibility' takes on. We will ask: who is responsible for food and health? Is it the individual, the family, the state, medicine, the market, or all of these actors to different degrees? What is good food and health, anyways? And what role do scientific knowledge and technological innovations play in settling these types of questions? The module foregrounds critical discussions on the ways in which scientific knowledge and technological innovations play a role in how we perceive (healthy) food and our own (healthy) bodies. It traces how and why being healthy has become such a central value particularly in societies of industrialized countries. Health has turned not only into a central source of personal identity, but also into an important object of governance, with states investing in the health of their populations. The module further emphasizes the discussion on how (scientific) knowledge related to questions of food and health is produced but also contested. These issues will be discussed in relation to specific contemporary topics, such as the obesity epidemic, microplastic pollution, agricultural biotechnology, vertical farming or epigenetics. Throughout the course, students get to know relevant social science concepts, such as biopolitics, neoliberal orders and responsibilization, nutritional scientism, healthism, among others, which will enable them to think critically about the social and cultural aspects of food, health, innovation and technology.

Intended Learning Outcomes:
Students will understand and apply a range of key concepts, theoretical frameworks, and analytic tools from the domains of Science and Technology Studies (STS), Sociology, Anthropology, and related social science disciplines (biopolitics, nutritional scientism, healthism, as well as responsibilization and neoliberal orders, technological determinism). They will be able to analyze the complex interactions between food, health and questions of responsibility (e.g. food as a form of health identity; health paradigms in society, policy, research & innovation; food regulation/ labeling and notions of health and sustainability). Students will further:
• Discern how food and health relates to questions of social order (gender, religion, state, etc.)
• Gain a critical understanding of techno-scientific innovation in what comes to be understood as 'healthy,' and how this relates to wider political, economic and other social orders
• Comprehend how regulatory systems (policy, food and drug labeling, etc.) shape our understanding of what counts as "healthy" (food)
• Research interdisciplinary literature and write a paper on a health- and/or food-related issue that inquires who is considered responsible (state, industry, researchers, consumer activists, etc.)

Teaching and Learning Methods:
Students will receive input and benefit from the expertise of six university teachers who will individually or in teams present specific topics and key concepts. Students will also engage in extensive in-class discussions based on the reading, and do practical mini-workshops with their peers to learn how to reflect and position themselves with regard to these issues. Seminar sessions and discussions are based on assigned readings provided in the syllabus at the

beginning of the term. A key part of instruction is the close reading of weekly assigned texts and reflections of key arguments and concepts. Moreover, the course will use regular exercises to achieve learning progress and practice the application of course content to real-life cases.

Media:
Reader (literature provided in course moodle); power point presentations; flipcharts; video clips; newspaper articles

Reading List:
Clarke, A. E., Shim, J. K., Mamo, L., Fosket, J. R., & Fishman, J. R. (2003). Biomedicalization: Technoscientific Transformations of Health, Illness, and U.S. Biomedicine. American Sociological Review, 68(2), 161-194.
Crawford, R. (1980). Healthism and the Medicalization of Everyday Life. International Journal of Health Services, 10(3), 365-388.
Nettleton, S. (1997). Governing the Risky Self: How to Become Healthy, Wealthy and Wise. In A. Petersen & R. Bunton (Eds.), Foucault, Health and Medicine (pp. 207-222). London/New York: Routledge.
Rose, N. (2006). The Politics of Life Itself: Biomedicine, Power, and Subjectivity in the Twenty-first Century. Princeton, NJ: Princeton University Press.
Scrinis, G. (2008). On the Ideology of Nutritionism. Gastronomica: The Journal of Critical Food Studies, 8(1), 39.

Responsible for Module:
Penkler, Michael; Dr. phil.

Courses (Type of course, Weekly hours per semester), Instructor:
Responsibility in Environment and Health: Social and Cultural Perspectives on Environment, Health, Science, and Technology (Seminar, 2 SWS)
Breuer S [L], Breuer S, Brunet L, Clare A, Koch S, Samaras G, Sultan A
For further information in this module, please click campus.tum.de or here.

UnternehmerTUM | UnternehmerTUM

Module Description

WI000159: Business Plan - Basic Course (Business Idea and Market) | Geschäftsidee und Markt - Businessplan-Grundlagenseminar [Business Plan Basic Seminar]

Geschäftsidee & Markt

Version of module description: Gültig ab summerterm 2018

Module Level: Bachelor/Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a semester-long project work, which ends in the delivery of a business plan and in a presentation. The presentation includes a prototype-demo of the developed product or service. Through the project-work, it is assessed how well the participants can identify and implement business opportunities. In teams students recognize the needs and demands of the customers. Through customer feedback, field interviews and contextual observations they synthesize the identified needs to translate them into clear and significant customer benefits. Students develope business models to learn how to bring the idea to the market and position the business with respect to competition. They learn the systematic and iterativ approach of the Business Design for business model, team and technology development.

Specifically with the examination deliverables, the participants demonstrate to what extent they have developed the following competences:
- In their business plan participants formulate in a concise and structured way how they developed an understanding about the actual customers and markets for their business idea.
- In their pitch presentation participants present their business idea before a jury of experts. The presentation includes a demo of the prototype for the developed product or service.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
- Knowledge: No special requirements, willingness to participate

- Abilities: Identifying opportunities; team work; communication; commitment; reliability
- Skills: openness; analytical thinking; visual thinking; self-motivation

Content:
In a creative atmosphere, the participants learn to think through and present a business idea in the structured form of a business plan in order to solve a customer problem. For that purpose, fundamental chapters of a business plan are developed. Participants will network with people from the entrepreneurial environment of TUM.

The matter is developed in the following steps:
- The fundamentals of innovation
- Overview: Developing a business plan
- Consumer and consumer value
- Business model
- Assessment of business ideas
- Market & competition
- Pitching business ideas
- Presentation practice: customer, customer value, market USP
- Forming powerful business teams
- Protection of intellectual property

Intended Learning Outcomes:
At the end of the seminar the students will be able to:
- understand the difference between idea, invention, and innovation;
- understand the use of an iterative approach in the development of business opportunities;
- evaluate opportunities for business ideas and apply business concepts by prototyping, e.g. with the help of a business plan;
- evaluate business ideas and identify business opportunities;
- segment markets and analyze potential niche markets;
- evaluate own business idea with the help of customer feedback, observations from stakeholders, and interviews;
- identify a real customer problem and create customer benefit with ideas for a solution.

Teaching and Learning Methods:
Seminar-style: The lecturers are entrepreneurs, serial founders, coaches, and former managing directors.
- Interdisciplinarity: Participants form cross-disciplinary teams to ensure a balanced mix of expertise and skills in the team.
- Action-based learning: All participants are encouraged to be proactive and to learn through experience.
- Learning by doing: Each team develops a real business idea or one chosen for the seminar. Particular attention is paid to truly understanding the customer, for example, by interviews, observation, or expert discussion.

- Prototyping: Using simple prototypes, the teams develop their business idea and make them tangible.
- Online Networking: The work in the seminar is accompanied by online tools to support the team-building and generation of ideas.
- Elevator Pitch Training: Through the practice of elevator pitches, participants develop skills for short and effective presentation of their business ideas.
- Presentation Training: Each team presents and defends their business idea twice before an expert-jury and receives feedback on presentation style and content.

Media:
- Videos
- Slides
- Handouts (distributed online)
- Case studies
- Intranet
- Online Project Pool

Reading List:
- Münchener Business Plan Wettbewerb: Der optimale Businessplan, München
- UnternehmerTUM: Handbuch Schlüsselkompetenzen (erhält jeder Teilnehmer)
- Horowitz, Ben (2014): The Hard thing About Hard Things, HarperBusiness
- Kawasaki, Guy (2004): The Art of the Start, Penguin Publishing Group
- Moore, Geoffrey A. (2002).: Crossing the Chasm, HarperCollins
- Osterwalder, Alexander / Pigneur, Yves (2010): Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, John Wiley & Sons
- Ries, Eric (2011): The Lean Startup, Penguin Books Limited
- Thiel, Peter (2014): Zero to One: Notes on Startups, or How to Build the Future, Crown Business
- Timmons, Jeffry A. / Spinelli, Stephen (2009): New Venture Creation,7thedition, McGraw Hill Professional

Responsible for Module:
Bücken, Oliver; Dipl.-Kfm. (Univ.)

Courses (Type of course, Weekly hours per semester), Instructor:
Geschäftsidee und Markt - Businessplan-Grundlagenseminar (WI000159) (Seminar, 2 SWS)
Heyde F [L], Heyde F
For further information in this module, please click campus.tum.de or here.

Module Description

WI000813: Technology Entrepreneurship Lab | Technology Entrepreneurship Lab

Version of module description: Gültig ab summerterm 2018

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The grading is based on a project work.
With the project work students show their understanding of the processes associated with the recognition and development of entrepreneurial opportunities. Students show that they are able to analyze the development of entrepreneurial teams. Moreover, they show their ability to apply coaching tools.
Throughout the project work each student has to hand in regular written documentation of maximum one page in which to describe the continuous development of the entrepreneurial idea as well as the team (60%). At the end of the project work each student has to hand in a summary documentation of maximum three pages (40%) covering idea development, team development and used tools.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
First entrepreneurial experience (in any field)
First team development experience (in any filed)
Ideally already taken part in Tech Challenge (WI 001180) or Business Plan Basic Seminar (WI000159)

Content:
In cooperation with UnternehmerTUM GmbH.
The module Technology Entrepreneurship Lab offers a "hands-on-experience" for the development of entrepreneurial business ideas and opportunities with

teams. Students work full-time for three consecutive days on the development of their entrepreneurial, technological and coaching skills. The students document both, the opportunity development process and the parallel team development
process and present both processes. Subsequently, they will work on their teams' development of an opportunity assessment plan for the respective business ideas.

Intended Learning Outcomes:
After module participation students are able to understand the processes associated with the recognition and development of entrepreneurial opportunities. In addition, they are able to analyze the development of
entrepreneurial teams and to apply coaching tools for this purpose. Further, they are able to develop an opportunity assessment plan as well as guide others in this process.

Teaching and Learning Methods:
The module consists of a three-day introductory lecture on entrepreneurial, technological and coaching skills as well as a hands-on 3 month execution phase with teams. A coach accompanies this process. The business ideas and team development processes are supervised and presented.

Media:
PowerPoint, Flipchart, online communication tool, virtual meetings, online webinars

Reading List:
Hisrich, R. D./Peters, M. P./Shepherd, D. A.: Entrepreneurship, 8th edition, McGraw-Hill, 2010

Responsible for Module:
Patzelt, Holger; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Technology Entrepreneurship Lab (WI000813) (Seminar, 4 SWS)
Heyde F [L], Heyde F
For further information in this module, please click campus.tum.de or here.

Module Description

WI001180: Tech Challenge | Tech Challenge

Version of module description: Gültig ab winterterm 2017/18

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:**
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Overview of Final Deliverables

1. Functional Prototype (in hard- and/or software): 40% of grade
2. Final Demo (7 minutes incl. video): 30% of grade
3. Technical Project Description: 15% of grade
4. Read Deck (up to 10 slides max.): 15% of grade

Details of final deliverables below.

Final Deliverable 1: Functional Prototype

- Functional prototype in hard- and/or software
- Not a final product, but should showcase at least one key aspect of your product/service
- For software, use any framework, IDE, language etc. that works
- For hardware, use MakerSpace & prototype budget (up to 250€ per team, only redeemable with invoice!)

Final Deliverable 2a: Final Demo…

- You will have exactly 7 minutes, incl. your video of up to 2 minutes; and Q&A thereafter
- Your demo (incl. video) should include: Team, Customer Need, Value Proposition, Prototype, Competition, Differentiation, Future Roadmap (Note: content is same as the read deck)
- All team members must present
- Slides should not distract from the presenter (e.g. too much text, low contrast, …)

Final Deliverable 2b: …and Video

- Cannot be longer than 2 minutes max. (and should be at least 1 minute long)
- Can be real-life video, powerpoint slides, animations, cartoons or any other video format
- Should not be silent - audio can be spoken text, real world sound, music, …
- Should cover: Customer Need, Value Proposition (Prototype optional), Differentiation
- Think of it as a marketing or sales tool

Final Deliverable 3: Technical Project Description

- Description of all hardware components and software modules/frameworks used, as well as step-by-step instructions to re-create your prototype (e.g. see project descriptions at Hackster.io)
- Link to an online code repository (e.g. GitHub, GitLab, BitBucket) is mandatory

Final Deliverable 4: Read Deck

- Needs to be understandable as stand-alone with no further explanation (assume reader has not seen demo or video!)
- Use presentation format (i.e. slides); different than the presentation used in demo!
- Cannot be more than 10 slides max. (excl. appendix)
- Your read deck should include: Team, Customer Need, Value Proposition, Prototype, Competition, Differentiation, Future Roadmap (note: content is same as final pitch)

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge: Willingness to participate; affinity with tech and entrepreneurship trends preferred
Abilities: Identifying opportunities; proactiveness; communication; teamwork; commitment
Skills: openness; analytical thinking; design thinking; self-motivation; networking

Content:
- Kick-off: Introduction to challenges, resources, objectives. “Challenge fair” at the end. Students are sensitized, inspired and stimulated to develop feasible, viable and holistic solutions to address current industrial topics as smart city, mobility, digital healthcare, Industry 4.0 and smart grid by utilizing cutting-edge technologies as cloud, IoT, AI, AR/VR.
- Challenge workshops: 1 day is reserved for each corporate to hold an interactive workshop with the batch of students interested to know more about the respective challenge (known needs, available technologies, boundary conditions, etc.).
- Interdisciplinary teams and ideas registration as pertaining to a specific challenge (choice made by teams): Team, Vision, Project Plan
- Ideation workshop: Design thinking, empathic exploration, needfinding, concept generation, evaluation, and selection
- Work-in-progress: Prototyping, testing, generating feedback, iterating, creating new insights and elaborating use cases. On demand office hours and consulting sessions with experts for ideation, technology development, product design, and team development.

- Customer Value Proposition, Market and Positioning with respect to competition, Unique Selling Proposition, Business Model, Value Chain, Market Entry
- Business Plan, pitch training
- Pre-Demo Day Meetup: User Acceptance Testing with respective challenge owners. Teams present, respective corporate provides feedback.
- Feedback integration to finalize project results
- Demo Day: Teams showcase their final concepts by means of their prototypes, videos, posters, and short business plans

Intended Learning Outcomes:
Upon successful completion of this module, students are able to:

- identify latest technology trends related to topics such as smart city, mobility, digital healthcare, Industry 4.0 and smart grid
- understand opportunities and challenges in applying cutting-edge technology (e.g., cloud, IoT, AI, AR/VR) to address a specific industrial challenge
- conduct project-based interdisciplinary teamwork
- carry out an individualized learning process by utilizing referenced online resources as well as on demand expert coaching regarding team development, technology development and product design
- evaluate own ideas, prototypes and project findings with experts, users, and customers, and work closely with their feedback
- recognize and utilize contemporary web platforms for digital project creation and sharing
- operate in a high-tech prototyping workshop equipped with latest technology and devices
- create functional prototypes to demonstrate own proposed solution to a specific industrial challenge
- devise a showcase of own project results to a broad audience of peers, academics and practitioners
- create short business plans to effectively communicate business value of own project results

Thus, students get familiarized with the many facets of entrepreneurship. In doing that, they are enabled to see, realize, and experience the multiplicity in the everyday life of an entrepreneur, entrepreneurial personalities, as well as entrepreneurial skills and motivations.

Teaching and Learning Methods:
Innovatively addressing complex themes as smart city and Industry 4.0 often requires the use of cutting-edge technologies within an entrepreneurial process. Based on this premise and to get the students understand and apply such a process, the module deploys hands-on project-based learning and interdisciplinary teamwork.

Each semester several industrial challenges are spotlighted as proposed by the participating corporates, who provide access to their proprietary technologies, resources, experts and coaches specific to their respective challenge. An industrial challenge is formulated to be broad, with the

potential of breeding many specific projects in return. Students are encouraged to propose which challenge to address in which way (i.e., project idea) and within which team.

Through interactive team exercises and a semester-long project, the students experience peer-learning while gaining practice in assessing and optimizing usage of their team resources. They are also provided with team coaching sessions, individual mentoring, tutorials as necessary (challenge-dependent), and hands-on courses to operate machines and devices (3D printer, laser cutter, waterjet cutter, sensors etc.) at the high-tech prototyping workshop (team- and challenge-dependent).

Media:
- Online access to slides, hand-outs, materials through dedicated e-Learning account
- Online discussion forum connecting students and involved experts
- Accounts on contemporary web platforms for digital project creation and sharing (e.g., hackster, kaggle, datacamp)

Reading List:
A maintained list of references to relevant online course materials (e.g., UnternehmerTUM MOOC videos, Coursera, Udacity, edX, Udemy) to support an individualized learning process suited to students' various levels of expertise

Responsible for Module:
Patzelt, Holger; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Tech Challenge (WI001180) (Seminar, 4 SWS)
Schutz C [L], Schutz C
For further information in this module, please click campus.tum.de or here.

Carl-von-Linde-Academy | Carl-von-Linde-Academy

Module Description

CLA11216: Agile project management hands-on | Agile project management hands-on

Version of module description: Gültig ab winterterm 2014/15

Module Level: Bachelor/Master	**Language:** English	**Duration:** one semester	**Frequency:** irregularly
Credits:* 1	**Total Hours:** 30	**Self-study Hours:** 15	**Contact Hours:** 15

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students are able to create an offer for a project and subsequently present their ideas (10-15 min). They are able to understand the basics of an offer preparation.

Repeat Examination:

(Recommended) Prerequisites:

Content:
The workshop teaches all the necessary skills for the early stages of a project. Starting with the basics of B2B sales, you will learn how to communicate the specifics of your company at the best or service the potential customer. Then you will learn how to properly create a functional specification document and convince the potential customer with a good concept and an attractive offer.
How does a company become a potential customer? Which sales skills are to be considered especially in B2B? What is important in professional communication to a company? What is important to consider in the requirements analysis? How do I define the milestones and goals of the project? How do I turn this into a concrete offer?
These and many other questions will be addressed in the two-day workshop by sales and project managers from Motius. Due to the interdisciplinary focus of Motius on projects in the fields of electrical engineering, computer science and mechanical engineering, we are able to react flexibly to unusual situations. This practical knowledge we pass on to you. Being founders as students ourselves, we are sensitive to the subtleties of communication.

Intended Learning Outcomes:
After successful participation in this module, students are able to understand the basics of technical project sales and are able to work with techniques of professional communication. Furthermore, participants have the knowledge of preparing project plans and quotations and applying basics of practical project management in the context of a proposal preparation.

Teaching and Learning Methods:
(1) First, the theoretical basics are taught. You will learn what is required for an offer and professional acquisition. You will be able to apply the knowledge directly using examples from everyday life at Motius. At the end of the day, you will be given a real-life example to work on. Within one week you will write an offer for the project in small teams.
(2) After the teams have presented their proposal, they will get detailed feedback. Then the basics of the project setup (project plan, distribution of tasks and roles, project management) are taught. The workshop concludes with the evaluation of the results and with the "assignment" of one or more teams.

Media:

Reading List:

Responsible for Module:
Slanitz, Alfred; Dr. phil.

Courses (Type of course, Weekly hours per semester), Instructor:
Agile Project Management Hands-on (Workshop, 1 SWS)
Kipfer C
For further information in this module, please click campus.tum.de or here.

Module Description

CLA10555: Communication and Facilitation in Project Teams | Communication and Facilitation in Project Teams

Version of module description: Gültig ab winterterm 2013/14

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 1	**Total Hours:** 30	**Self-study Hours:** 22	**Contact Hours:** 8

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students will write a short exam which proves that they understand various aspects of project management and are able to handle team conflicts successfully. Furthermore they are able to apply communication and facilitation skills (exam achievement).

Repeat Examination:

(Recommended) Prerequisites:
Students require adequate English skills to achieve the expected level of participation.

Content:
Team roles and team development stages (team development clock, team triangle)
How to create a good and well-structured work environment and enhance collaboration
Motivating a team with constructive feedback
How to handle conflicts successfully
Creative problem solving tools

Intended Learning Outcomes:
Here you will gain new insights into your own role within your team and gain appreciation of other roles that may appear during conflicts. By learning better ways of looking at team dynamics you will improve your ability to create a good and well-structured work environment and enhance team collaboration. After completing this workshop you will have an expanded set of useful communication and facilitation skills that will enable you to build good work relationships and deal with conflicts in a constructive manner.

Teaching and Learning Methods:
Trainer input, demonstrations, exercises, role-playing games, group discussions, feedback, etc. Each participant is encouraged to explore his/her style and thus expand their individual set of communication, dialogue facilitation and project team collaboration skills.

Media:

Reading List:
Belbin RM (1993) Team Roles At Work. Butterworth-Heinemann, Oxford

Hanlan M (2004) High-Performance Teams – How to Make Them Work. Praeger, Westport CT.

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"

Responsible for Module:
Monika Thiel

Courses (Type of course, Weekly hours per semester), Instructor:
Communication and Facilitation in Project Teams (Workshop, ,5 SWS)
Thiel M
For further information in this module, please click campus.tum.de or here.

Module Description

CLA11317: Interdisciplinary Lecture Series Environment: Politics and Society | Ringvorlesung Umwelt: Politik und Gesellschaft

Version of module description: Gültig ab summerterm 2015

Module Level: Bachelor/Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 1	**Total Hours:** 30	**Self-study Hours:** 15	**Contact Hours:** 15

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
A successful accomplishment of 9 academic performances is mandatory for the examination! The examination consists of a short PowerPoint presentation at the end of the semester. The presentation can be created alone or in groups of two. Everyone has to speak one minute. The examination is ungraded.

Repeat Examination:

(Recommended) Prerequisites:

Content:
The lecture series Umwelt (environment) is an interdisciplinary, public lecture organised by the Environmental Department of the Studentische Vertretung (Student Representatives) of the TU Munich. Experts speak e.g. on technical environmental protection, health, consumer and climate protection. In the summer semester, it offers students the opportunity to learn about the political and social dimensions of current ecological topics and research results at a scientific level.

The lecture series Umwelt (environment) is offered in the winter semester in the module CLA11200 Ringvorlesung Umwelt: Ökologie und Technik (Lecture series on the environment: ecology and technology). It is only possible to gain given credits twice for the lecture series within each study program.

Intended Learning Outcomes:
Students are able to follow expert presentations on political and social dimensions of environmental problems and identify core theses and central facts.

Teaching and Learning Methods:
Lectures, presentations, discussions

Media:

Reading List:

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Will Technology Save Us All? A Glimpse into a Sustainable Future (Ringvorlesung Umwelt) (Vorlesung mit integrierten Übungen, 1,5 SWS)
Biller B, Dörringer L, Kopp-Gebauer B, Recknagel F, Slanitz A

Responsibility in Times of (Climate) Change (Ringvorlesung Umwelt) (Vorlesung mit integrierten Übungen, 1,5 SWS)
Dörringer L, Kopp-Gebauer B, Recknagel F, Slanitz A, Trentmann L
For further information in this module, please click campus.tum.de or here.

Module Description

CLA31900: Lecture Series Environment - TUM | Vortragsreihe Umwelt - TUM

Version of module description: Gültig ab winterterm 2019/20

Module Level: Bachelor/Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 67	**Contact Hours:** 23

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a poster created in a group of 2-3 people connecting topics from at least two lectures. In order to collect material for the poster, participants have to organize themselves in discussion groups with 5-6 people.
Each discussion group will split into two groupes for the poster. At the end of the semester the poster has to be presented. Every member of the poster group has to speak one minute,
The grade will consist of the poster and its presentation.
Mandatory requirements for the examination
For the 3-ECTS course a successful accomplishment of 16 academic performances is mandatory for the examination!

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
The systematic integration of education for sustainable development at the university is an extremely complex challenge that can only be addressed through a plural and multi-perspective approach. Within the framework of the UNESCO World Programme of Action "Bildung für Nachhaltige Entwicklung“ (BNE; =Education for Sustainable Development), the interdisciplinary lecture series Umwelt - TUM takes place at the TUM Campus Garching, which deals with changing topics in the field of environmental sustainability.

It is organized by the newly founded branch of the environmental department AStA TUM at the Garching campus to promote sustainability awareness at TUM and to offer interested students the opportunity to deal with the topic in more detail.

Intended Learning Outcomes:
After successful participation in this module, students are able to understand lectures at a high scientific level and reproduce central statements. Students are able to comprehend analyses of sustainable development and are familiar with formulating their own positions and justifying them in discussions. Furthermore, they know where they can explore the topic of sustainability in more detail on campus, whether in the form of course offerings, internships, projects or thesis.

Teaching and Learning Methods:
It consists of six lectures and an organizational meeting at the beginning. Each lecture includes two 40-minute presentations, a 15-minute break and a subsequent 45-minute discussion with the speakers, which is realized in cooperation with the Zentrum for Schlüsselkompetenzen (Center for Key Competencies) of the Faculty of Mechanical Engineering.
The lectures and presentation slides will be uploaded to the online learning platform Moodle.
As homework, students will prepare a short report of the lectures and the discussion session. In addition, introductory and further literature will be addressed to enhance more detailed discussions of the lectures.

Media:

Reading List:

Responsible for Module:
Dr. phil. Alfred Slanitz (WTG@MCTS)

Courses (Type of course, Weekly hours per semester), Instructor:
Will Technology Save Us All? A Glimpse into a Sustainable Future (Ringvorlesung Umwelt) (Vorlesung mit integrierten Übungen, 1,5 SWS)
Biller B, Dörringer L, Kopp-Gebauer B, Recknagel F, Slanitz A

Responsibility in Times of (Climate) Change (Ringvorlesung Umwelt) (Vorlesung mit integrierten Übungen, 1,5 SWS)
Dörringer L, Kopp-Gebauer B, Recknagel F, Slanitz A, Trentmann L
For further information in this module, please click campus.tum.de or here.

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