TUM School of Life Sciences
Technische Universität München

Module Catalog

M.Sc. Horticultural Science
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.

Index of module handbook descriptions (SPO tree)

Alphabetical index can be found on page 119

Required Courses | Required Courses

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

WZ1672: Crop Quality: Basics of Quality Control and Assurance | Crop Quality: Basics of Quality Control and Assurance

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 Fernprüfung (Zoom, 30 min.) teilzunehmen (Onlineprüfung: WZ1672o). Eine schriftliche Prüfung wird zeitgleich parallel in Präsenz angeboten (WZ1672).

Students demonstrate their ability to understand quality control and assurance by applying non-destructive methods and to evaluate quality affecting factors in respect to horticultural crops by answering comprehension questions and solving sample problems in a written examination (120 min). Furthermore, students will be tested for their ability to analyze the import of secondary metabolites to the aroma of vegetable crops. The use of learning aids during the examination is not allowed. The answers to the examination questions requires writing a self-formulated text.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in plant production and biochemical composition of vegetable and fruit crops.

Content:
Definitions and regulations for food crop quality, including quality assurance systems nationally and internationally. Non-destructive methods for measuring quality characteristics. Secondary plant metabolism and quality characteristics of vegetables. Sampling methods and determinations for external quality (color, texture, firmness, etc.) and internal quality (secondary metabolites, aroma compounds, carbohydrates, organic acids). Endogenous and exogenous factors on quality parameters of horticultural crops.

Intended Learning Outcomes:
Upon successful completion of this module, students are able:
- to understand quality control and maintenance measures and technologies;
- to apply non-destructive methods for testing quality characteristics of horticultural products;
- to apply the quality assurance systems for vegetables and fruits;
- to analyze the contribution of secondary metabolites to the aroma of vegetable crops;
- to evaluate the impact of endogenous and exogenous factors on external and internal quality parameters of horticultural crops.

Teaching and Learning Methods:
The learning contents are presented as PowerPoint-supported lectures to impart the theoretical background in horticultural crop quality. In addition, class discussions of case studies from literature are used to intensify the knowledge in special topics.

Media:
Presentation slides, lecture, scriptum (Moodle), selected articles in scientific journals.

Reading List:
Scriptum, actual articles from scientific journals will be provided.

Responsible for Module:
Ruth Habegger (ruth.habegger@tum.de)

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

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

Elective Courses | Elective Courses

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:
Prof. Brigitte Poppenberger-Sieberer (brigitte.poppenberger@wzw.tum.de)

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

WZ2762: Research Project Molecular Genetics of Plant-Microbe Symbiosis 2 | Forschungspraktikum Molekulare Genetik der Pflanzen-Mikrobien Symbiose 2

Version of module description: Gültig ab winterterm 2017/18

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:
The students conduct an own small research project, which requires a minimum of 40h of laboratory and/or computer work per week. The work-schedule can be adjusted with the curriculum of the students. After the practical work, a report has to be prepared and handed in a few weeks after the laboratory work has been concluded. Furthermore, the students present their work in a 15-minute presentation in English in the frame of the lab progress report seminar. The evaluation of the research course will be based on an evaluation sheet containing several categories and designed to enhance the objectivity of the grading. For transparency, the sheet will be handed to the students prior to the start of the research course. 80% of the grade will be based on the quantity and quality of laboratory work and the quality of the report (writing and figures of publication quality). 20% of the grade will be based on the quality of the oral presentation.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamental knowledge of molecular biology, genetics and/or plant biology is required. Students should have basic competences in molecular biology lab work such as accurate pipetting and correct preparation of solutions (including all necessary calculations of molarity etc). Proficiency in basic computer software such as Word, Excel and Power Point is a must. Basic knowledge in R, ImageJ and/or Illustrator is an advantage.

Content:
In the research course the students acquire competence and knowledge in one of the following subjects: a) Plant hormone signalling in plant symbiosis, b) transcriptional regulation of plant symbiosis, c) nutrient exchange in plant symbiosis.

Techniques and methods will depend on the individual project and may include: golden gate cloning, plant transformation, quantitative real time PCR, phenotypic analysis of roots and fungal structures by microscopy, fluorescence microscopy and analysis of subcellular compartments with fluorescent fusion proteins, handling of plants and arbuscular mycorrhiza fungi, hormone physiology, transactivation assays, protein expression and purification, protein-protein interaction techniques (yeast-2-hybrid, CoIP), genetic mapping or genotyping, data analysis using R, preparation of figures in publication quality.
Many of these techniques are transferable to other (non-plant) organisms.

Intended Learning Outcomes:
After a successful completion of the course the students have acquired competence in several laboratory techniques related to plant molecular biology and general molecular biology and genetics, writing of a laboratory book and efficient time management by running several experiments in parallel. They have learned how to design experiments with all necessary controls, how to interpret results and how to perform basic statistical data analysis using R. Furthermore, they have increased their competence in scientific writing and have learned how to display scientific data and microscopy images in publication quality.

Teaching and Learning Methods:
Combination of close practical and theoretical supervision and independent work. Reading and understanding of laboratory protocols, writing of laboratory book. Time management in the laboratory. Reading of original research articles.

Media:
The students will use lab protocols to learn and conduct experiments by themselves but under close supervision. Supervised and independent use of lab instruments and software such as DNA analysis software, ImageJ and/or Illustrator.

Reading List:
Original articles and reviews for preparation of the research course will be provided prior to the start of the research course. For prior information about the main research focus of the laboratory we recommend the review: Gutjahr and Parniske, 2013, Ann. Rev. Cell Dev. Biol., which can be downloaded using the following link:
http://www.annualreviews.org/doi/full/10.1146/annurev-cellbio-101512-122413

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

Courses (Type of course, Weekly hours per semester), Instructor:
Research Project - Molecular genetics of plant-microbe symbiosis 2c (Forschungspraktikum, 10 SWS)
Gutjahr C

Research Project - Molecular genetics of plant-microbe symbiosis 2a (Forschungspraktikum, 10 SWS)
Gutjahr C [L], Torabi S

Research Project - Molecular genetics of plant-microbe symbiosis 2b (Forschungspraktikum, 10 SWS)
Gutjahr C, Torabi S
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

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

WZ1586: Research Project 'Plant Pathology' | Research Project 'Plant Pathology'

Version of module description: Gültig ab summerterm 2013

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 100	**Contact Hours:** 200

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

Description of Examination Method:
Logging and presenting of own research results

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in plant science

Content:
Insights into the problem-oriented work with modern methods of biological sciences. Obtaining a profound understanding and ability to apply research methods in Agrobio sciences. Insights into the scientific approach to issues from relevant research projects. Learning the presentation of research results.

Intended Learning Outcomes:
Learning of techniques for independent scientific analysis of research subjects in plant sciences. Participation in a current research project.

Teaching and Learning Methods:
laboratory work, presentation

Media:

Reading List:

Responsible for Module:
Ralph Hückelhoven hueckelhoven@wzw.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum Agrobiowissenschaften Pflanze/Phytopathologie (Forschungspraktikum, 10 SWS)
Hückelhoven R, Hausladen J, Engelhardt S, Ranf-Zipproth S, Schempp H, Stam R, Stegmann M
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 (Vorlesung, 3,3 SWS)
Tellier A

Applications of Evolutionary Theory in Agriculture: pathogen population genomics and disease management (Seminar, ,7 SWS)
Tellier A
For further information in this module, please click campus.tum.de or here.

Module Description

WZ3098: Basics of Metabolomics | Basics of Metabolomics

Version of module description: Gültig ab winterterm 2018/19

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** 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 examination consists of an oral presentation of 3-5 minutes (elevator pitch) (60% of final mark) and submission
of an maximum 6 page long abstract (40% of final mark) on the group work focusing on a specific problem.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
- basic knowledge of biochemistry
- basic statistical knowledge, e.g. t-test, etc.
- basic laboratory skills

Content:
Biochemical, analytical and data analytical basics of metabolomics are illustrated using relevant examples.
The following individual topics are covered:

biochemical basics
- Definition of systems biology and its disciplines (omics)
- Definition and aims of metabolomics and its role in systems biology
- relation of metabolomics to other omics-technologies

analytical basics
- basics of mass spectrometry (MS) and coupling of chromatographic methods
- application of MS in metabolomics
- basics of nuclear magnetic resonance (NMR) and its application in metabolomics

Metabolomics experiments
- experimental design
- sample preparation
- implementation of measurements
- quality control
- metabolite identification

data analytical basics
- basic statistical evaluation, e.g. HCA, PCA, PLS
- bioinformatic approaches

relevant applications
- in medicine, nutrition, food chemistry
- to model organisms
- in plant research and biotechnology

Intended Learning Outcomes:
The students are able to define the term of systems biology and to state its different disciplines.
Furthermore, they know different omics technologies and can separate them from each other.
The students are able to compare analytical methods used in metabolomics based on their advantages and
disadvantages and select a fitting method to solve a specific question. Moreover, they are able to apply basic
statistical data analysis methods on a given dataset and interpret the results in biochemical context. Additionally,
students are competent to perform problem-based literature research in relevant media.
On the basis of selected problems, students are able to question the current status of metabolomic research and
state possibilities for improvement.
They can draft plans and execution of metabolomics experiments and are able to comment on them.

Teaching and Learning Methods:
The module consists of a lecture, including expert input, single- and group work, case studies and student
presentations.

Media:
Script; slides

Reading List:
Metabolomics in Practice - Successful Strategies to Generate and Analyze Metabolic Data, 2013, 1. Auflage,

Wiley-VCH, ISBN: 9783527330898
- The Handbook of Metabonomics and Metabolomics, 2007, 1. Auflage, Elsevier, ISBN: 978-0-444-52841-4
- verschieden Original- und Übersichtsarbeiten

Responsible for Module:
Witting, Michael; Dr. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Basics of Metabolomics (Vorlesung, 3 SWS)
Witting M
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

WZ1673: Crop Biotechnology | Crop Biotechnology

Version of module description: Gültig ab summerterm 2015

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 132	**Contact Hours:** 48

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

Description of Examination Method:
In a written exam (60 min) the students document a sound knowledge of the methods of genetics, molecular biology and biotechnology that are applied in plant sciences today. They demonstrate insight in technologies, aims and applications thereof. In addition, students are required to write a protocol about the practical course part which details the methods used and results obtained, and discusses the outcome. The over-all grade is calculate from the grade on the written exame and the grade obtained for the protocol (in equal weight).

Repeat Examination:

(Recommended) Prerequisites:
Basics in Genetics, Genomics, Plant development; Biochemistry and/or Botany

Content:
This course is conceived to give students an introduction into plant molecular biology and plant biotechnology and is composed of a lecture part (2 SWS) and a practical part (2 SWS). It provides a background in plant genetics and plant molecular biology, introduces principles of tissue culture and other technologies essential to generate transgenic plants and teaches methods required for research in plant molecular biology and plant biochemistry. Moreover, an overview of horticultural biotech crops on the market is given.
In addition to the lectures students get hands-on experience in using some of the methods presented. In a case study transgenic crop material is screened for in samples collected in Germany by using methods such as DNA extractions, restriction digests, PCRs, gel electrophoresis and sequencing.

Intended Learning Outcomes:
Upon completion of this module students are able to understand and assess methods and aims of Plant Biotechnology. They are capable of carrying our first lab-based experiments with methods of molecular biology and can interpret the results.

Teaching and Learning Methods:
Lecture: presentation of the lecture contends on slides using PowerPoint. Practical Part: teaching of research techniques with relevance for plant moleular biology and plant biotechnology using a case study

Media:
Slides of the lecture are available online

Reading List:
Biochemistry and Molecular Biology of Plants. Buchanan, Gruissem and Jones, John Wiley & Sons, 2002; The Condensed Protocols: From Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press, 2006; Plant Biotechnology: The Genetic Manipulation of Plants. Adrian Slater, Nigel W. Scott und Mark R. Fowler, Oxford University Press, 2008.

Responsible for Module:
Brigitte Poppenberger (brigitte.poppenberger@wzw.tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Crop biotechnology (Vorlesung, 4 SWS)
Poppenberger-Sieberer B
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

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

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

WZ6430: Genetic and Environmental Control of Vegetal Plants | Genetic and Environmental Control of Vegetal Plants

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:
Aufgrund des Pandemiegeschehens hat der/die Studierende auch die Möglichkeit, an einer mündlichen Fernprüfung (30 min.) teilzunehmen (Onlineprüfung: WZ6430o). Diese mündliche Prüfung wird zeitgleich in Präsenz angeboten (WZ6430).

In the oral examination (30 min.) students demonstrate their ability to analyze the biochemical processes of primary and secondary plant metabolites and to analyze genetic potential, environmental and plant production factors and the role of mineral nutrition on the quality of vegetal plants. The students need to answer comprehension questions and solve sample problems. Furthermore, the ability is tested to conduct the Human Sensory evaluation on the analysis of aroma compounds of crops. Use of learning aids during the examination is not allowed.

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
Basic knowledge in plant production and crop quality.

Content:
Dependence of aroma compounds in vegetal crops on genetic potential and environmental conditions during cultivation of plants. Knowledge of special extraction and analysis methods for aroma compounds. Basics of Human Sensory analysis and application for vegetal crops. Correlation between analytical and sensory methods. The functions of mineral nutrients (N, K, P, S, Ca, Mg, trace elements) in plant metabolism and their impact on plant composition with respect to internal nutritional and processing properties. Effect of the supply of mineral nutrients on external

and internal parameters of plant quality; the influence of the physiological function of nutrients on quality defining products of primary and secondary plant metabolism.

Intended Learning Outcomes:
Upon successful completion of this module, students are able:
- to apply Human Sensory evaluation on the analysis of aroma compounds of vegetal crops;
- to analyze the effects of genetic potential and environmental and plant production factors on aroma relevant plant compounds;
- to analyze how physiological functions of nutrients can affect quality defining products of primary and secondary plant metabolism;
- to evaluate the role of the supply of mineral nutrients (fertilization) on external and internal quality parameters in relation to other exogenous factors;
- to chose appropriate instruments, measuring methods and analytical tools;
- to evaluate the differences of methods for analyzing internal quality parameters by using analytical tools and instruments and interpreting measured data.

Teaching and Learning Methods:
The knowledge will be imparted by PowerPoint-supported lectures to transfer the specialized knowledge about effect of genetic potential and environmental conditions on plant metabolites and the functions of mineral nutrients in plant metabolism. In addition, class discussion of case studies from literature are conducted to intensify the knowledge in relevant topics. In the lab exercise course students will define and solve problems in the chemical analysis of internal quality parameters. They will get practice in laboratory skills by performing experiments.

Media:
Presentation; lecture, scriptum (Moodle), demonstration and lab practical in labs.

Reading List:
Taiz, L. and Zeiger, E. 2006: Plant Physiology.
Belitz, H.D.; Grosch, W.; Schieberle, P. 2009: Food Chemistry.
Stone, H. and Sidel, J.L. 1993: Sensory Evaluation Practices.
Marschner, H. 1995: Mineral Nutrition of Higher Plants. 2nd edition.
Marschner, P. (ed.) 2012: Marschner’s Mineral Nutrition of Higher Plants. 3rd edition.

Responsible for Module:
Habegger, Ruth; Dr. rer. hort.

Courses (Type of course, Weekly hours per semester), Instructor:
Aroma compounds of vegetal plants (Vorlesung, 1,5 SWS)
Habegger R [L], Habegger R

Analysis of quality parameters (Übung, 1 SWS)
Habegger R [L], Habegger R, von Tucher S

Plant mineral nutrition and crop quality (Vorlesung, 1,5 SWS)
Habegger R, von Tucher S
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1035: Host-Parasite-Interaction | Host-Parasite-Interaction

Version of module description: Gültig ab winterterm 2018/19

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter 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 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 exam tests the ability of the students to transfer the deep knowledge of principles of molecular plant pathogen interaction on new scientific questions. Students have to show their ability to design experiments suitable to test a given hypothesis from molecular host-parasite interactions. Students have to show in how far they are able to extract scientific progress from original data or experiments presented in the exam.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of Plant Sciences and Phytopathology at the B.Sc. Level

Content:
In this modul, students reach a deep understanding of plant-pathogen interaction at the molecular level. This comprises pattern-triggered immunity, effector-triggered susceptibility, effector-triggered immunity and translational research. This is not restricted to model plants but extends to crops and fills the gap between basic research and applied plant sciences in breeding and biotechnology for disease resistance. In interactive learning structures with small groups, we train reading and understanding of original literature (Journal Club). In the practical course, we learn real time PCR, plant immune response assays, transient transformation of plants, cell biology of plant defense reactions, etc.

Intended Learning Outcomes:
Education to become a molecular plant pathologist, who is able to judge and design approaches for increasing disease resistance in model and crop plants.
Upon successful completion of the module, students are able

- to understand the molecular basis of plant pathogen interactions in depth.
- to transfer theoretical background and definitions of molecular host parasite interactions.
- to analyze plant immune responses.
- to collect new theoretical knowledge from literature and understand innovative technologies in plant immunity and susceptibility.
- to carry out key molecular methods for quantification of plant immune reactions and disease susceptibility (e.g. real time PCR, reactive oxygen measurement, transient transformation of plants, cell biology of plant defense reactions) in hands-on experience
- to generate experimental design and carry out evaluation of plant disease resistance tests in model and crop plants.

Additionally, students are able to process and present complex information from original literature.

Teaching and Learning Methods:
In the lecture students gain knowledge about theoretical background of plant parasite interactions, which is extracted and focussed by the lecturers from review literature. In the exercise, students practise in small groups key methods for quantification of plant immune reactions and disease susceptibility. They make hands-on experience, practise the use of molecular methods and devices, document their data under guidance and discuss them with group members and supervisors. In the 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.

Media:
PowerPoint

Reading List:
Buchanan 2015: Biochemistry & Molecular Biology of Plants. Review literature provided

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

Courses (Type of course, Weekly hours per semester), Instructor:
Host-Parasite-Interaction (Übung, 2 SWS)
Ranf-Zipproth S [L], Engelhardt S, Hückelhoven R, Stam R, Stegmann M

Host-Parasite-Interaction (Vorlesung, 1 SWS)
Ranf-Zipproth S [L], Hückelhoven R

Host-Parasite-Interaction (Seminar, 2 SWS)
Ranf-Zipproth S [L], Hückelhoven R, Engelhardt S, Stam R, Stegmann M
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1545: Human Resource Management in Agriculture and Related Industries | Human Resource Management in Agriculture and Related Industries

Version of module description: Gültig ab winterterm 2018/19

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:
During the written exam (90 min.) students demonstrate their ability to understand human resource management practices, to select and adapt techniques suitable to specific contexts in agriculture and life science industries, to compare and contrast techniques and practices, to evaluate and change selected practices in case applications. Example practices cover the fields of planning the workforce, recruiting, selecting, and training employees, as well as providing feedback to, and evaluating employees, as well as discipline and dismissal, compensation, incentive plans, benefits and services, and workplace diversity. Students analyze exam questions and write up answers in their own words.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
BS Degree. Prior knowledge of basic ideas of economics and management is required; knowledge in strategic management is recommended.

Content:
The course is designed to provide master level students with an understanding of pertinent human resource management practices and how to adapt practices from other industries to farms, horticultural and landscaping operations, in agribusinesses, in the food industry, and in related businesses. Practices relate to planning the workforce, recruiting, selecting, and training employees, as well as providing feedback to, and evaluating employees. Additional practices relate to discipline and dismissal, compensation, incentive plans, benefits and services, and workplace diversity. Examples of current issues as well as laws and regulations provide context for different human resource management practices.

Intended Learning Outcomes:
After successfully completing the module, students are able to accomplish the following:
- understand human resource management practices and their objectives;
- evaluate human resource management practices in use;
- develop and adapt appropriate human resource management practices for specific organizations in agriculture and the life science industries.
- determine the fit of different human resource management practices with different organizational goals and environments.

Teaching and Learning Methods:
Lectures serve to introduce human resource management practices and their objectives.
Video clips serve to illuminate HRM practices and as a basis of discussion of practices. Case descriptions and task sheets are analyzed in small groups and discussed in class to empower students to apply human resource management practices in specific constellations.

Media:
Presentation software, case descriptions and task sheets, discussion facilitation support media, video clips

Reading List:
Dessler, G. (latest edition). Human resource management, Prentice Hall: Upper Saddle River/NJ.

Responsible for Module:
Bitsch, Vera; Prof. Dr. Dr. h.c.

Courses (Type of course, Weekly hours per semester), Instructor:
Human Resource Management in Agriculture and Related Industries (Seminar, 4 SWS)
Bitsch V [L], Bitsch V, Huhn C, Wagner C
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

WZ6431: Model Systems and Crop Quality | Model Systems and Crop Quality

Version of module description: Gültig ab summerterm 2019

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 learning outcome is tested by an oral presentation (90%) at the end of the semester (duration of the presentation 30 min). During this presentation, students will give a talk (30 min) according to the scientific standard, treating one specific topic by showing and interpreting the results collected during the experiments (e.g., the effect of salinity stress on plant growth and chemical composition). Based on the background, a specific research question is to be deduced, the appropriate experimental design and suitable methods are to be selected and justified, and results are to be presented and discussed. Complex aspects are to be reduced to their key message. In a discussion (10 min) students will answer comprehension questions on the treated problems (e.g. effects of abiotic stress on plant growth) and show their general understanding. The presentation will be supplemented by a written precis about its content (3000 words; 10%).

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
Basic knowledge in plant nutrition

Content:
A scientific experiment on a current topic in plant nutrition will be planned, conducted and evaluated. Examples for possible topics are:
Plant growth and chemical composition (minerals and quality parameters) as affected by abiotic stress (drought, salinity, nutrient deficiency or toxicity), adaptation or mitigation strategies to climate change or nutrient - environmental interactions.
The content includes the theoretical background of the problems as well as theoretical and practical aspects on the design of such experiments and adequate methods for data collection (e.g. nutrient analyses in plants and soils, ecophysiological (e.g. plant water status, osmotic

adjustment) and non-destructive methods (e.g., canopy temperature, thermography, hyperspectral sensoring) to follow the plants biomass production and nutrient status.

Intended Learning Outcomes:
At the end of the module students are able to
1. basically plan and conduct experiments in the area of plant nutrition,
2. select appropriate analytical methods such as chemical analyses of soils and plants for minerals and quality parameters, ecophysiological and non-destructive methods and assess their specific strengths and weaknesses.
3. perform an adequate data documentation and evaluation
4. apply their theoretical background knowledge (e.g. the causes and consequences of abiotic stress to plants) to the specific research question
5. structure achieved knowledge and results for oral and written presentations according to scientific standards.

Teaching and Learning Methods:
The lecture presents an overview on the theoretical background of the specific topic, e.g. reactions of plants on abiotic stress. In the exercise course, students use different methods in practical analytical work to assess the specific strengths and weaknesses of the methods. In addition, in the exercise course students will be trained in the basics of scientific writing and presentation. The exercise course also includes the individual search on current literature.

Media:
Presentations, practical analyses, whiteboard work

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

Responsible for Module:
Sabine von Tucher sabine.tucher@tum.de

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

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

Module Description

WZ8128: Methods of Genome Analysis | Methoden der Genomanalyse

Version of module description: Gültig ab summerterm 2021

Module Level: Bachelor/Master	**Language:** German/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 module test involves a graded written exam.
The goal of the written exam (90 minutes) is to assess how well the students understand the basic concepts of genome analysis (like genes, regulatory sequences, operons, alternative splicing, SNPs, microRNAs, pseudogenes, repeats, orthology/paralogy) and how well they are able to reproduce them in limited time. Based on exemplary method calls, interrogation of input and output of methods, as well as the building of possible method pipelines to solve a specific bioinformatics problem, and the interpretation of method results, it is assessed how well the students are able to do bioinformatics analyses on their own, choose appropriate methods suitable to a specific problem and apply these. No electronic devices are allowed except for pocket calculators. Students are asked to write free-text answers to questions, solve algorithmic and logical problems, and to work through a limited number of multiple-choice questions by ticking the right answer.

To pass the module at least the score 4.0 is required.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Suggested pre-requisites for participation is basic knowledge of bioinformatics, for example as taught in the TUM modules „Introduction in Bioinformatics I and II“.

Content:
The following topics are core elements of the module:
- Genome structure
- Analysis of DNA sequences
- Gene prediction
- Operon structures

- Alternative splicing
- RNA structure
- microRNAs
- Repeats
- Pseudogenes

Intended Learning Outcomes:
Upon successful completion of the module the students are able to:
• Understand and reflect in-depth important concepts of genome analysis (genes, regulatory sequences, operons, alternative splicing, SNPs, microRNAs, pseudogenes, repeats, orthology/paralogy),
• Practically apply selected methods of genome analysis (e.g. gene prediction, prediction of microRNA binding sites, identification of DNA sequence motifs, prediction of RNA structures).

Teaching and Learning Methods:
The selected teaching approach Lecture course and the selected teaching method Oral talk are especially well suited for imparting basic concepts, methodological approaches as well as typical problems of genome informatics to students with basic knowledge of bioinformatics. In particular the exercise serves as a way to deepen the learning content of the lecture. The students are expected to prepare a scientific publication covering an already discussed topic from the lecture. In the exercise the algorithms and methods used in the publication are discussed. Where possible, the usage of the methods and the analysis of selected case studies from the publication is presented in class. Thus, also the application of the methods is trained. It will be announced before each exercise which scientific publication will be discussed. The students are encouraged to prepare the contents of the paper and familiarize their selves with the methods used. The lecturer discusses the procedures and methods in the exercise, and responds to questions and problems. Where possible, small selected case studies are solved together in the exercise, or are presented by students.

Media:
Scientific publications, presentation of slides, discussions during lectures, materials on the module Web page.

Reading List:
- Genomes 3, T.A. Brown, Garland Science, 2007
- Bioinformatics and Functional Genomics, Jonathan Pevsner, John Wiley, 2003
- Understanding Bioinformaics, M. Zvelebil and J.O.Baum, Garland Science 2008

Responsible for Module:
Frischmann, Dimitri; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Methoden der Genomanalyse: Vorlesung (Vorlesung, 3 SWS)
Frischmann D [L], Frischmann D

Methoden der Genomanalyse: Übung (Übung, 1 SWS)
Frischmann D [L], Parr M
For further information in this module, please click campus.tum.de or here.

Module Description

WI001205: People in Organizations: Managing Change and Sustainability in Agribusiness and the Food Industry | People in Organizations: Managing Change and Sustainability in Agribusiness and the Food Industry

Version of module description: Gültig ab winterterm 2018/19

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 assessment type for the module is a graded report (100%). The report includes memorandums addressing 9-10 of the case studies discussed in class; and a concept paper addressing an organizational concept. The concept paper is also presented by each student. Through the case memorandums, the students demonstrate the ability to discuss the assigned case questions by selecting and applying suitable theoretical concepts to agribusiness and the food industry. Building on the reflection process for each individual memorandum and the cases, which build on each other, deep-level contextual learning is achieved. In the concept paper, students demonstrate their ability to research and critically evaluate a current organizational concept. Through the presentation and discussion of the concept paper, students demonstrate their ability to communicate theoretical concepts and their application to agribusiness and the food industry.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
This is an advanced module. Prior knowledge of economic and management concepts is required. Successful completion of a management course on MSc. level is required, e.g., Human Resource Management in Agriculture and Related Industries or Agribusiness Management. Experience in desk research and scientific writing is required. Knowledge of basic concepts of human resource management and management skills is required.

Content:
The module builds on key concepts of economics and management, specifically human resource management, to provide master level students with knowledge in organizational behavior, theory, and development and build competencies in organizational analysis and change.
Topics covered include:
- metaphors of and perspectives on organizations, their strengths and limitations
- the role of the individual, the group, and the organization in a high performance environment
- organizational structures and the organization-environment fit
- corporate social responsibility, sustainability challenges, business ethics, and ethical conduct in bio-based industries
- adapting to current challenges and changes in the institutional environment of agriculture and the food industry
- understanding organizational change, facilitating change processes, and overcoming barriers in the context of agribusiness and the food industry.

Intended Learning Outcomes:
After successfully completing the module students are able to analyze, evaluate, and change organizational management and development practices in the agribusiness and food industry context. Specifically, students are able to
~ select and apply suitable theoretical concepts or models of organizational behavior, theory, and development to meet organizational challenges in agribusiness and the food industry
- contrast the strengths and limitations of different perspectives on organizations
- evaluate the potential impacts of various organizational management options on the individual, group, and organizational levels
- identify ethical challenges and options to organizations in agribusiness and the food industry
- adapt organizational practices and policies to sustainability measurement requirements and develop organizational sustainability or CSR (corporate social responsibility) policies
- structure organizational change processes, apply models of organizational change, and evaluate a model’s potential implications
- adapt organizational management and development practices to the specific context in agribusinsess and the food industry.

Teaching and Learning Methods:
The course People in Organizations: Managing Change and Sustainability in Agribusiness and the Food Industry has a seminar format based on the case study method. The seminar format is implemented based on case descriptions of problems, challenges, and innovations in agribusiness and food industry supply chains. Through individual document research and individually prepared class discussions and group work, students develop the ability to critically reflect on and apply concepts of organizational behavior, theory, and development in the context of agribusiness and the food industry. Through presentations and concept discussions, students develop in-depth knowledge of exemplary theoretical concepts. During class discussions and group presentations, students reflect on their experiences, prior knowledge, and assignments to develop their conceptual and evaluative skills and to adapt theoretical knowledge to practical challenges

Media:
Reading assignments; case descriptions; presentation software; discussion facilitation support media, such as flipcharts and discussion boards; video clips and podcasts.

Reading List:
Selected chapters from
Brown, Donald R. (latest edition). An Experiential Approach to Organization Development, Prentice Hall: Boston.
Daft, Richard L. (latest edition). Organizational Theory and Design. South-Western/Cengage Learning.
Kreitner, Robert and Kinicki, Angelo (latest edition). Organizational Behavior. McGraw-Hill Irwin.
Morgan, Gareth 2006. Images of Organization. Updated ed., Sage: Thousand Oaks/CA.

Responsible for Module:
Vera Bitsch bitsch@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
People in Organizations: Managing Change and Sustainability in Agribusiness and Food Industry (WZ1563, WI001205) (Seminar, 4 SWS)
Bitsch V [L], Bitsch V, Huhn C, Wagner C
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1060: Precision Agriculture | Precision Agriculture

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 module uses a written exam (120 min) for assessment, which mainly based on the criteria below:
- demonstrated understanding of the basic concepts of precision agriculture, and the fundamentals of the key technologies;
- know how to assess the effects precision farming technologies from a systems perspective;
- ability to analyze and interpret the biological meanings of sensor data for decision making;
- ability to apply techniques to certain problems of crop management; and
- critical thinking skills, for instance, the ability of comparing and evaluating different sensing and modeling methods, and assessing the limitations of each method in solving certain problems;

Repeat Examination:
Next semester

(Recommended) Prerequisites:
- Basic knowledge of agricultural engineering
- Basic knowledge of plant and soil sciences

Content:
The module introduces the concept, principles of precision farming technologies, and their applications and economics. Main topics include:
1. concept and technological advances of precision agriculture;
2. key supporting technologies including remote sensing, geographic information system (GIS), global positions system (GPS), navigation, robotics, automation and communication technologies, sensors and sensor-carrying platforms, and variable rate technology (VRT);
3. soil spatial variability (e.g. nutrient, water) measurement and management;
4. crop spatial variability (e.g. health, stress) and site-specific crop management;

5. yield monitoring and grain quality analysis;
6. plant phenotyping technologies and applications;
7. big data analysis in precision agriculture and plant phenotyping;
8. environmental and ecological implications of precision agriculture;
9. economics and adoption of precision farming technologies; and
10. challenges and future directions of precision agriculture.

Intended Learning Outcomes:
Upon successful completion of this module, students will be able to,
- understand the concept, technologies and principles of precision agriculture;
- apply sensing and modeling methods to analyze soil and crop spatial variability;
- analyze the problems of crop growth and health using sensing and modeling methods;
- evaluate the robustness and transferability of sensing and modelling methods;
- develop critical thinking ability for applying precision agriculture technologies for decision making;
- create strategies based on multidisciplinary knowledge and techniques to solve practical problems in precision agriculture.

Teaching and Learning Methods:
- The module will be instructed through lectures, and lectures with integrated (computer) exercises in order to enable students master the theoretical basis and practical skills of precision agriculture.
- The lecture serves as a systematical introduction of the knowledge and theoretical basis of precision agriculture. Case studies are used to deepen the understanding of knowledge and stimulate interactions.
- The exercises teach the practical applications through field visits, independent measuring and interpreting soil and crop variability using various sensors and modeling methods. The exercises also include computer exercises of analyzing and interpreting results based on several pre-collected example datasets.
- Students apply the knowledge and practical methods for exercises, conduct exercises through team work and discuss the results with the instructor and classmates.

Media:
PowerPoint, Scripts, computer exercise portfolio, TUM-Moodle, Zoom

Reading List:
Shannon, D.K., D. E. Clay, and N. R. Kitchen. 2018. Precision Agriculture Basics. ASA, CSSA and SSSA, Madison, WI, USA.
Bechar, A., 2021. Innovation in Agricultural Robotics for Precision Agriculture: A Roadmap for Integrating Robots in Precision Agriculture, 1st ed, Progress in Precision Agriculture. Springer, Cham.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Precision Agriculture (Vorlesung mit integrierten Übungen, 4 SWS)
Yu K, Oksanen T, Bernhardt H, Gandorfer M
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

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:
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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.
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Asseng S, et al. (2015) Rising temperatures reduce global wheat production. Nature Climate Change 5:143-147.
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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.

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

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

WZ1674: Research Methods and Economic Research Project | Research Methods and Economic Research Project

Version of module description: Gültig ab summerterm 2015

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:
Examination Duration (in min.): 30.
The course grade consists of two parts: 50% project report and 50% in-class grade. The in-class grade consists of equal parts each, proposal presentation, project results presentation, peer review of another student's proposal, peer review of another student's project results, and discussion of applications of economic concepts.
Justification: Students demonstrate their ability to apply economic concepts through class discussions and development of project ideas.
Students demonstrate their ability to develop an economics research projects through the stages of proposal presentation, result presentation, and project report.
Students demonstrate their ability to evaluate other researchers' proposals and results in a constructive manner through presentations of reviews.
Students demonstrate their ability to manage resources, and deadlines through timely submission of the enumerated tasks in stages throughout their research projects.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
BSc. Degree. Prior knowledge of basic ideas of economics and management recommended.

Content:
The module provides master level students with an advanced understanding of the research process, its quality criteria, and the application of economic concepts to questions of food and agriculture. Key economic ideas are applied to everyday questions in class discussions based on economic texts, podcasts, and others. The development, execution, publication, and review of

disciplinary and interdisciplinary research is explained in lectures and carried out by each student from beginning to end.
Steps include developing project ideas and research questions; using peer-reviewed literature to frame a student project; designing research plans with the appropriate methods and suitable techniques of data collection; structuring, preparing, presenting, and critically reviewing research proposals; data collection, data analysis, and data presentation; discussion and conclusions based on reflecting own empirical research in the light of the literature; disciplinary, professional, and ethical quality criteria of research in economics and management

Intended Learning Outcomes:
Students are able to apply economic ideas to questions related to food and agriculture in everyday life.
Students are able to develop and execute an economic research project in the field of agriculture, horticulture, and food.
Specifically, students are able to develop a project idea, develop a research question and objectives based on the project idea and the related scientific literature, and create a research plan, including the suitable combination of research methods and techniques; defend a research proposal based on the research plan.
Students are able to evaluate other (student) researchers' proposals and present such evaluations in a suitable form, orally.
Furthermore, students are able to apply their research plan through data collection, data analysis, and presentation of research results, in oral and written form; and are able to evaluate other (student) researchers' research process, results, and conclusions.
Students are able to manage resources and deadlines.

Teaching and Learning Methods:
Lectures, class discussions, and guided student project development and project evaluation (project proposal, proposal review, project results, results review, and research report).

Media:
Presentation slides, websites, articles and short texts, multi-media (podcasts, video clips), student presentations, and reviews.

Reading List:
Hartford, Tim (latest edition). The Undercover Economist. Random House: New York.
O'Leary, Zina (latest edition). The Essential Guide to Doing Your Research Project. Sage: Los Angeles.
Committee on Science, Engineering, and Public Policy,
National Academy of Sciences, National Academy of
Engineering, and Institute of Medicine (latest edition). On Being a Scientist: A Guide to Responsible Conduct in Research.

Responsible for Module:
Vera Bitsch bitsch@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Research Methods and Economic Research Project (WZ1559, WZ1674) (Seminar, 4 SWS)
Bitsch V [L], Bitsch V, Carlson L, Wagner C
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

WZ1718: Research Project 'Horticultural Economics and Management' | Research Project 'Horticultural Economics and Management'

Version of module description: Gültig ab summerterm 2017

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 assessment type of the module is a graded research paper (100%). The content of the research paper is also communicated in a scientific presentation. With the research paper, students demonstrate the ability to develop a horticultural economics or management research project at an advanced level. The students progress through the stages of proposal, revision of proposal, data collection and analysis, results, revision of result presentation, reflecting results in the light of the relevant scientific literature and drawing conclusions. Students show their ability to solve problems independently and seek support, when necessary.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge of basic concepts of economics and management is required, demonstrated, e.g., by successful completion of MSc level course in economics or management; experience with guided research in economics and management is required, demonstrated, e.g., by successful completion of a bachelor’s thesis in the field or a research course, such as Research Methods and Economic Research Project.

Content:
The module provides master level students with an advanced understanding of the research process in economics and management applied to the specific context of horticulture and related industries.
Steps of the project include
- developing the project idea and the corresponding research questions;
- using peer-reviewed literature to frame the project;

- designing research plans with the appropriate methods and suitable techniques of data collection;
- data collection and data analysis;
- data presentation;
- discussion and conclusions based on reflecting own empirical research in the light of the literature; as well as disciplinary, professional, and ethical quality criteria of research in economics and management applied in the specific context of biobased industries.

Intended Learning Outcomes:
After successfully completing the module, students are able to develop and execute a research project independently. Specifically, students are able to
- develop a project idea
- identify relevant scientific literature
- develop a research question and objectives based on the project idea and the related scientific literature
- create a research plan, including the suitable combination of research methods
- defend a research proposal based on the research plan
- apply their research plan through data collection, data analysis
- present research results in oral form
- write a research report.

Teaching and Learning Methods:
The course Research Project Horticultural Economics and Management has an independent study format. The supervised independent scientific work in the area of horticultural economics and management serves to allow students to hone their independent research skills in preparation of a master thesis. While the format allows students to make mistakes and learn from their mistakes, the guidance provided serves to avoid lengthy detours, which would impede timely completion of the students' study program.

Media:
Selected original papers; presentation software; flipcharts or similar for guided brainstorming and structuring.

Reading List:
O'Leary, Zina (latest edition). The Essential Guide to Doing Your Research Project. Sage: Los Angeles.

Responsible for Module:
Prof. Dr. Vera Bitsch

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

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

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

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

WZ1921: Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry | Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry

Version of module description: Gültig ab winterterm 2019/20

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 assessment type for the module is a graded learning portfolio (100%). The portfolio includes memorandums addressing 9-10 of the case studies discussed in class; and a learning statement addressing conceptual, scientific and personal learning. Through the case memorandums, the students show the ability to discuss the assigned case questions by selecting and applying suitable theoretical concepts to supply chain management and sustainability challenges in the specific context of agribusiness and the food industry. In the learning statement, students demonstrate the ability to reflect on the semester long learning process and summarize the insights gained.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Solid economic and management background; knowledge of basic concepts of strategic analysis, planning, and management (e.g., industry analysis, horizontal and vertical coordination, and SWOT), as well as the ability to apply these concepts; furthermore, knowledge of value chain management is required (e.g., theoretical background, supply chain dynamics, actors and partnerships, governance). Successful completion of a management course on M.Sc. level required, e.g., agribusiness management or value chain management. Medium level experience in desk research and scientific writing is required.

Content:
The module builds on key concepts of supply chain management, strategy, and sustainability to provide master level students with the competency to evaluate pertinent issues in agribusiness and food industry supply chains.
Topics covered include:

- value propositions, creating and capturing added value in agribusiness and the food industry
- management of customers, suppliers, and other stakeholders
- innovation in supply chains, sustainability as an innovation, sustainable supply chains
- CSR (corporate social responsibility) and sustainability measurement
- implementation of a sustainability strategy, as well as costs and benefits of sustainable practices in agribusiness and the food industry
- ethical issues in supply chain management.

Intended Learning Outcomes:
After successfully completing of the module, students are able to evaluate processes of supply chains management in agribusiness and the food industry.
Specifically, students are able to
- evaluate value propositions, as well as plans for creating and capturing value
- evaluate the management of customers, suppliers, and other stakeholders
- independently choose scientific models or concepts relevant to the analysis process of agricultural and food industry supply chains and justify their choice
- evaluate the implementation of a CSR concept or sustainability strategy, and monitor its effects on operations, suppliers, associates, and customers
- identify and analyze ethical issues in supply chain management and to recommend how to apply ethical practices.

Teaching and Learning Methods:
The course Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry has a seminar format based on the case study method. The seminar format is implemented based on case descriptions of problems, challenges, and innovations in agribusiness and food industry supply chains. Through individually prepared class discussions and group work, students develop the ability to critically reflect and apply concepts of strategy, supply and value chain management, and sustainability requirements in the context of agribusiness and the food industry. During class discussions and group presentations, students reflect on their experiences, prior knowledge, and assignments to develop an in-depth understanding of current challenges in supply chains and how to address the.

Media:
Reading assignments; case descriptions; presentation software; discussion facilitation support media, such as flipcharts and discussion boards; video clips and podcasts.

Reading List:
Current articles from scientific journals as appropriate.
Selected chapters from
Bouchery, Corbett, Fransoo, and Tan (2017): Sustainable Supply Chains: A Research-Based Textbook on Operations and Strategy. Springer: Berlin, Heidelberg, Germany.
Pullmann and Wu (2011): Food Supply Chain Management: Economic, Social and Environmental Perspectives. Routledge, New York, US.

Responsible for Module:
Bitsch, Vera; Prof. Dr. Dr. h.c.

Courses (Type of course, Weekly hours per semester), Instructor:
Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry (Seminar, 4 SWS)
Bitsch V [L], Bitsch V, Carlson L, Huhn C, Wagner C
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1567: Sustainability: Paradigms, Indicators, and Measurement Systems | Sustainability: Paradigms, Indicators, and Measurement Systems

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:
The assessment type for the module is a graded report (10 pages). The report includes three sections: (1) critical analysis of a published empirical sustainability study in the context of its sustainability definitions and authors' backgrounds; (2) critical analysis of a sustainability measurement system in use with regard to fulfilling requirements to be met by indicators and indicator systems; (3) critical analysis of a public sustainability claim by an organization from a consumer or citizen point of view. Each analysis is also presented by each student. Through reports, the students demonstrate the ability to understand relevant research, measurement systems and claims, as well as critically analyze and discuss these issues. Through the presentation and discussion of each analysis, students demonstrate their ability to communicate these critical issues and further reflect on each topic in the light of other students' questions and presentations.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge and understanding of economic and management concepts as well as of social science research methods is required.

Content:
The development of a differentiated understanding of sustainability requires the critical analysis and reflection of sustainability concepts on multiple levels. In the module the following levels are systematically analyzed and discussed based on guided discussions of assigned readings and materials developed by students based on literature and internet research:
- Paradigms and value judgments in research on and evaluation of sustainability;

- Economic, environmental and social aspects of sustainable production, marketing, and consumption;
- Measurement systems for sustainability on different levels (products, supply chains etc.);
- Public and private standards, sustainability certifications and communication;
- Consequences of measurement systems and their foci, e.g., on environmental aspects, such as carbon footprint, or on social aspects, such as fair trade

These topics are discussed in the context to current and controversial issues regarding sustainability in science and in society.

Intended Learning Outcomes:
After successfully completing the module students are able to
- Analyze and evaluate the consequences of different paradigms on the definition and understanding of sustainability and its use in published scientific articles;
- Analyze and evaluate sustainability measurement systems on the product, enterprise, and supply chain levels as well as their potential consequences;
- Evaluate public sustainability claims based on the research of available information sources;
- Apply a differentiated understanding of sustainability in an interrelated, globalized context with differing value systems and priorities in scientific and practical questions and issues.

Teaching and Learning Methods:
The course “Sustainability: Paradigms, Indicators, and Measurement Systems” has a seminar format based on assigned readings and student presentations on assigned topic areas.
After an introductory guided class discussion on assumptions and implicit sustainability definitions of participants, readings are assigned and discussed in class to lay the basis for later student presentations. Through individual document research and individually prepared class presentations, students develop the ability to critically reflect on sustainability research, sustainability indicators and measurement systems, as well as sustainability claims by various actors and organizations. Through presentations and concept discussions, students develop in-depth knowledge of sustainability issues and hone their critical thinking skills. A final discussion summaries students’ learning and additional findings throughout the semester in the concept of wicked problems.

Media:
Reading assignments; use of data bases for literature research; presentation software; discussion facilitation support media, such as flipcharts and discussion boards; video clips and podcasts.

Reading List:
National Resource Council 2010, Toward Sustainable Agricultural Systems in the 21st Century, Washington/D.C.: National Academies Press.
Current articles on sustainability paradigms, requirements of sustainability indicators and indicator systems, and applications.

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Sustainability: Paradigms, Indicators, and Measurement Systems (Seminar, 4 SWS)
Bitsch V [L], Bitsch V, Carlson L
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

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

WZ1676: Sustainable Land Use and Nutrition | Sustainable Land Use and Nutrition

Version of module description: Gültig ab summerterm 2022

Module Level: Bachelor	**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:
During the participation in the lecture (usually Friday + Saturday), students give talks on given topics (10 min per student plus 5 min discussion und questions per student). Here, the students demonstrate that they have gained deeper knowledge of a given topic by using literature and are able to present their knowledge and discuss it. In the written examination (90 min) at the end of the semester students demonstrate the theoretical knowledge of the various perspectives of sustainable land use and nutrition by answering questions under time pressure and without helping material.
The final grade is a combined grade from the written examination (50 %) and from the student's talk (50 %).

Repeat Examination:
End of Semester

(Recommended) Prerequisites:

Content:
The module provides an overview on the various perspectives of sustainable land use and nutrition. An introduction establishes the structure of the module, which follows a supply chain: 1) The production of commodities addresses: Availability of soil resources; ecology and history of landscapes; terrestrial ecology; horticultural products for sustainable nutrition; integrative land-use concepts; production technology. 2) The distribution of commodities (transport, storage) is analyzed under the aspects of resource economics. 3) Sustainability of processing. 4) The distribution through trade and services is focused by sustainable marketing concepts. 5) Finally, consumer affairs are addressed by health aspects in the context of global nutrition; food safety; new designed food.

Intended Learning Outcomes:
The students know about the great variety of sustainability aspects in land use and nutrition. They understand the preconditions to understand the complexity and interconnectedness of multiple sectors. Students are able to analyze sustainability concepts and to transfer them to new problems. They understand that only a comprehensive perspective will lead to sustainable concepts for land use and nutrition.

Teaching and Learning Methods:
Lecture, discussion, students' talks

Media:
PowerPoint, research literature on moodle, Handouts

Reading List:
Each lecturer provides a list of articles regarding his/her topic on moodle and also during the lecture itself.

Responsible for Module:
Knoke, Thomas; Prof. Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Sustainable Land Use and Nutrition (Vorlesung, 4 SWS)
Windisch W [L], Abate Kassa G, Albrecht H, Bernhardt H, Bucka F, Eisner P, Hauner J, Knoke T, Langowski H, Leonhardt S, Roosen J, Schad P, Stark T, Windisch W
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1094: Research Project in Agrobiosciences | Forschungsprojekt Agrobiowissenschaften

Version of module description: Gültig ab summerterm 2002

Module Level:	Language:	Duration:	Frequency:
Credits:* 5	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**

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

Description of Examination Method:

Repeat Examination:

(Recommended) Prerequisites:

Content:

Intended Learning Outcomes:

Teaching and Learning Methods:

Media:

Reading List:

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungsprojekt Agrobiowissenschaften (Holz-Bioprozesse) (Praktikum, 4 SWS)
Benz J [L], Benz J

Forschungsprojekt Agrobiowissenschaften (Holz-Bioprozesse) (Praktikum, 4 SWS)
Benz J [L], Benz J

Forschungsprojekt Biotechnologie der Reproduktion (Projekt, 5 SWS)
Schusser B [L], Schusser B, Sid H

Forschungsprojekt Agrobiowissenschaften (Tierernährung) (Projekt, 4 SWS)
Windisch W [L], Künz S, Paulicks B, Windisch W

Forschungsprojekt Agrobiowissenschaften (Praktikum, 5 SWS)
Zehn D, Pfaffl M
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1676: Sustainable Land Use and Nutrition | Sustainable Land Use and Nutrition

Version of module description: Gültig ab summerterm 2022

Module Level: Bachelor	**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:
During the participation in the lecture (usually Friday + Saturday), students give talks on given topics (10 min per student plus 5 min discussion und questions per student). Here, the students demonstrate that they have gained deeper knowledge of a given topic by using literature and are able to present their knowledge and discuss it. In the written examination (90 min) at the end of the semester students demonstrate the theoretical knowledge of the various perspectives of sustainable land use and nutrition by answering questions under time pressure and without helping material.
The final grade is a combined grade from the written examination (50 %) and from the student's talk (50 %).

Repeat Examination:
End of Semester

(Recommended) Prerequisites:

Content:
The module provides an overview on the various perspectives of sustainable land use and nutrition. An introduction establishes the structure of the module, which follows a supply chain: 1) The production of commodities addresses: Availability of soil resources; ecology and history of landscapes; terrestrial ecology; horticultural products for sustainable nutrition; integrative land-use concepts; production technology. 2) The distribution of commodities (transport, storage) is analyzed under the aspects of resource economics. 3) Sustainability of processing. 4) The distribution through trade and services is focused by sustainable marketing concepts. 5) Finally, consumer affairs are addressed by health aspects in the context of global nutrition; food safety; new designed food.

Intended Learning Outcomes:
The students know about the great variety of sustainability aspects in land use and nutrition. They understand the preconditions to understand the complexity and interconnectedness of multiple sectors. Students are able to analyze sustainability concepts and to transfer them to new problems. They understand that only a comprehensive perspective will lead to sustainable concepts for land use and nutrition.

Teaching and Learning Methods:
Lecture, discussion, students' talks

Media:
PowerPoint, research literature on moodle, Handouts

Reading List:
Each lecturer provides a list of articles regarding his/her topic on moodle and also during the lecture itself.

Responsible for Module:
Knoke, Thomas; Prof. Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Sustainable Land Use and Nutrition (Vorlesung, 4 SWS)
Windisch W [L], Abate Kassa G, Albrecht H, Bernhardt H, Bucka F, Eisner P, Hauner J, Knoke T, Langowski H, Leonhardt S, Roosen J, Schad P, Stark T, Windisch W
For further information in this module, please click campus.tum.de or here.

Requirement Proof of Proficiency in German | Nachweis Deutschkenntnisse

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

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

SZ0322: German as a Foreign Language A2.1 plus A2.2 | Deutsch als Fremdsprache A2.1 plus A2.2

Version of module description: Gültig ab winterterm 2019/20

Module Level:	Language: German	Duration: one semester	Frequency: winter/summer semester
Credits:* 8	**Total Hours:** 240	**Self-study Hours:** 150	**Contact Hours:** 90

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 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. They learn and practice classifying and using an extended spectrum of main and subordinate clauses (final clause, indirect questions, temporal subordinate clause, causal sentence). They learn to employ the preterit (modal verbs) and perfect, how to use the comparative and the superlative, as well as the declination of the adjective (in the nominative, accusative and dative case). They also reinforce and expand the usage of 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 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 have the ability 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:

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

Alphabetical Index

G

H

I

L

M

P

Q

R

S

T