Module Catalog

M.Sc. Horticultural Science

Study Program Division Agricultural and Horticultural Sciences

Technische Universität München

www.tum.de

www.agrar.wzw.tum.de/index.php
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).

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

WZ1671: Crop Physiology: Growth and Development of Plants

Crop Physiology: Growth and Development of Plants
Study Program Division Agricultural and Horticultural Sciences

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:
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.
Actual articles from scientific journals will be provided.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Crop Physiology: Growth and development of plants (lecture, 4 SWS)
Habegger R [L], Habegger R, 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
Study Program Division Agricultural and Horticultural Sciences

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

Description of Examination Method:
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:
B

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.

WZ1672: Crop Quality: Basics of Quality Control and Assurance
Generated on 28.11.2019
**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:**
Crop quality: Basics of quality control and assurance (lecture, 4 SWS)
Habegger R, Regos I

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or here.
Elective Courses
Module Description

WZ6428: Analytical Methods in Horticulture, Agriculture and Plant Biotechnology

Study Program Division Agricultural and Horticultural Sciences

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Credits:*  Total Hours:  Self-study Hours:  Contact Hours:
6          180            120            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; Dr. rer. nat.

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

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://here).
Module Description

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

Study Program Division Agricultural and Horticultural Sciences

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

Description of Examination Method:
There is an oral exam for each student consisting of analyzing a case study (a scientific experiment related to one crop disease) with questions (30 min.). No help is allowed during the questions. The students will need to 1) analyze the methods used in the study 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 the case study, 4) evaluate critically the management strategy used in the study, and 5) propose new better disease management strategies based on the knowledge of the pathogen genomics. Short calculations are possible.

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.
It is built in four major blocks (four topics). The last block consists of the seminar and discussion 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, 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 chiefly 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 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 is lecture and long exercise sessions to perform simulations of SIR and SEIR models.

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. This part is a short lecture and exercise sessions with R codes simulating coevolutionary dynamics. Simulations are used to exemplify the possible outcome of coevolution and effect of disease management for the use of major resistance genes.

5) Synthesis: what is an optimal disease management taking into account pathogen evolution? This is a lecture and 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:**
After successful completion of this module the students possess a profound understanding of the evolutionary mechanisms driving the changes in crop pathogen populations. For example, they can describe how the genomes of pathogens change in time due to the action of humans and disease management strategies. Furthermore, the students are able to describe and use knowledge from published full genome data analyses of crop pathogens. The students understand the principle of disease epidemiology. They can build the mathematical model and implement it in R for simulations. The students are able to describe and explain the mechanism of coevolution between hosts and their pathogens. To do so they can build a mathematical model of coevolution 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 possess basic skills in coding with the software R and are able to perform basic statistics for plant pathology.

**Teaching and Learning Methods:**
The lectures and exercise are intermixed during the sessions. Typically, a first part of lecture introduces the concepts and the mathematical models. The exercise on computer with R follow, and the students code and implement simulations of the models. Therefore, they gain a direct understanding of the mathematical model by performing simulations under different parameters, and then understand the outcome of the model. The exercise are for the whole group, and students are encouraged to discuss their results with their colleagues, before a summary is made 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 discussion follows with the lecturer and other students. The aim of the presentation is to describe, analyze and interpret population genomic data of crop pathogens, and propose new disease management strategies.

**Media:**
PowerPoint, computer program (R), published articles.

**Reading List:**

**Responsible for Module:**
Aurelien Tellier
tellier@wzw.tum.de

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

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](#).
Module Description

WZ3098: Basics of Metabolomics

Study Program Division Agricultural and Horticultural Sciences

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<td>English</td>
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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:
- verschieden Original- und Übersichtsarbeiten

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

Courses (Type of course, Weekly hours per semester), Instructor:
Lecture
Basics of Metabolism
3 SWS
Michael Witting
michael.witting@tum.de

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

WZ6429: Biotechnology in Horticulture

Study Program Division Agricultural and Horticultural Sciences

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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 prove 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:

Responsible for Module:
Tobias Sieberer
tobias.sieberer@wzw.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

WZ1673: Crop Biotechnology

Study Program Division Agricultural and Horticultural Sciences

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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 molecular biology and plant biotechnology using a case study

Media:
Slides of the lecture are available online
Reading List:

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

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

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

WZ1720: Crop Breeding  [Crop Breeding]

Crop Breeding
Study Program Division Agricultural and Horticultural Sciences

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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.) without additional material. Students demonstrate in the exam that they are capable to design field and laboratory experiments, to analyse 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:
Next 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 analyses, such as linkage analysis, tilling, transposon tagging and gene editing. Different experimental designs and their underlying randomisation 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 analyses. 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

Reading List:

Responsible for Module:
Prof. Dr. Chris-Carolin Schön
TUM, Lehrstuhl für Pflanzenzüchtung
chris.schoen@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Crop Breeding (lecture, 4 SWS)
Schön C [L], Schön C, Avramova V

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

WZ1696: Crop Genomics [WZ1696]

Crop Genomics
Study Program Division Agricultural and Horticultural Sciences

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 exam (90 min.) 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 analyse genotype-phenotype associations. The grade of the exam will be the final grade of the module.

Repeat Examination:
Next 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 analyse 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.
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 analyse 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.

Teaching and Learning Methods:
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

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:

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

Responsible for Module:
Eva
Dr. Bauer
e.bauer@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

WZ1588: Evolutionary Genetics of Plants and Microorganisms

Study Program Division Agricultural and Horticultural Sciences

<table>
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<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
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<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
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<tr>
<td>Credits:*</td>
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<td>Contact Hours:</td>
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<tr>
<td>5</td>
<td>150</td>
<td>120</td>
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Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Prüfungsdauer (in min.): 30.
There will be an oral exam consisting of questions (30 min.). No help is allowed. The students will need to show an understanding of the concepts of Evolutionary genetics. Short calculations are possible. This exam = 2/3 of the final mark. A 20 min presentation of research papers on domestication will be evaluated during the seminar part of the course. This presentation counts for 1/3 of the final mark.

Repeat Examination:

(Recommended) Prerequisites:
Basic knowledge in statistics and genetics

Content:
1) Molecular Evolution: Hardy-Weinberg equilibrium, neutral model of evolution, mutation-drift equilibrium, natural selection, speciation models, molecular clock, sexual reproduction and recombination (Red Queen hypothesis).
2) Population Genetics and application to Genomic analyses in plants and micro-organisms: coalescent models, Muller's ratchet, Genomic applications of the coalescent: tests of selection, Spatial structure of populations.
3) Population genetics and plant domestication: history of plant domestication, examples of domestication processes, genomic signatures of domestication.

Intended Learning Outcomes:
A profound understanding of the evolutionary mechanisms and the underlying theory, basic understanding of softwares for evolutionary genomics analysis, and good understanding of the origin of modern crops

Teaching and Learning Methods:
class lecture

Media:

Reading List:
**Responsible for Module:**
Aurelién Tellier (aurelien.tellier@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Evolutionary Genetics of Plant and Microorganisms (exercise, 2 SWS)
Tellier A [L], Tellier A

Evolutionary Genetics of Plant and Microorganisms (lecture, 2 SWS)
Tellier A [L], Tellier A

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

WZ6430: Genetic and Environmental Control of Vegetal Plants

Study Program Division Agricultural and Horticultural Sciences

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<th>Module Level:</th>
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<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
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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 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:
Belitz, H.D.; Grosch, W.; Schieberle, P. 2009: Food Chemistry.

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

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

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

WZ1035: Host-Parasite-Interaction

Study Program Division Agricultural and Horticultural Sciences

<table>
<thead>
<tr>
<th>Module Level: Master</th>
<th>Language: English</th>
<th>Duration: one semester</th>
<th>Frequency: winter semester</th>
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<tbody>
<tr>
<td>Credits:* 5</td>
<td>Total Hours: 150</td>
<td>Self-study Hours: 80</td>
<td>Contact Hours: 70</td>
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Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The modul is rated via written examination on the lecture staff together with the performance in the seminar including an oral presentation of original literature (Journal Club).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basics of molecular plant biology

Content:
In this module, we reach a deep understanding of plant-pathogen interaction at the molecular level. 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, we train reading and understanding of original literature (Journal Club). In the practical course, we learn real-time PCR, confocal laser scanning microscopy, 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. Deep understanding of the molecular basis of plant pathogen interactions.

Teaching and Learning Methods:
Lecture, Journal Club, practical course

Media:
Powerpoint, Skript (Download)

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

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

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

Host-Parasite-Interaction (seminar, 2 SWS)
Ranf-Zipproth S [L], Hückelhoven R, Engelhardt S, Stam R

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

WZ1545: Human Resource Management in Agriculture and Related Industries

Study Program Division Agricultural and Horticultural Sciences

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<th>Module Level:</th>
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<td>Master</td>
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<td>one semester</td>
<td>winter semester</td>
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<td>90</td>
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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:**

**Responsible for Module:**
Vera Bitsch  
bitsch@tum.de

**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

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://www.example.com).
Module Description

WZ1589: Marker-assisted Selection

Marker-assisted Selection
Study Program Division Agricultural and Horticultural Sciences

Module Level: Master
Language: English
Duration: one semester
Frequency: winter semester

Credits:*  Total Hours: Self-study Hours: Contact Hours:
5         150         90         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 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:
Next 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 datasets 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 datasets.
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:
Prof. Chris-Carolin Schön (chris.schoen(at)tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Marker-assisted selection (lecture, 4 SWS)
Schön C [L], Schön C, Mayer M (Hölker A)

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

WZ2049: Methods for Analysis of Next Generation Sequencing data

Study Program Division Agricultural and Horticultural Sciences

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<th>Module Level:</th>
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<td>Master</td>
<td>English</td>
<td>one semester</td>
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<td>90</td>
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Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The students have to hand in a written report, in which they describe their analysis of a dataset they have chosen. Three to four weeks will be given for performing the analysis and write the report with description of methods, statistical analyses and discussion of the results.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic knowledge in statistics and genetics, basic knowledge in UNIX

Content:
1) Introduction to NGS data and jargon.
2) Analysis of genomic NGS data: type of files, download NGS data from databases, barcoding, trimming, read quality control, parsing metagenomic data, 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: assemble de novo 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:
A profound understanding of the type of data generated by NGS, profound understanding of the analysis of genomic data up to SNP calling, profound understanding of analysis of gene expression data from RNAseq. Understanding of bias in SNP calling and gene expression and understanding of statistical issues with NGS data. Profound understanding of the challenges of de novo (and reference-based) genome assemblies. Profound understanding of the meanings of coverage/read depth etc. Be confident in using the classic tools for bioinformatics of NGS data.

Teaching and Learning Methods:
lecture, exercises, mutual questions and answers

Media:
Software training: R, SAMtools, Trimmomatic, bwa, trinity, velvet, Galaxy, Python, BLAST, PAGIT
Reading List:

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

WZ6431: Model Systems and Crop Quality

Study Program Division Agricultural and Horticultural Sciences

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<th>Module Level:</th>
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<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
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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 sensing) 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.

WZ6431: Model Systems and Crop Quality
Generated on 28.11.2019
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:
Journal articles

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

Courses (Type of course, Weekly hours per semester), Instructor:
Design and Performance of Model Experiments in Plant Nutrition (exercise, 3 SWS)
Schmidhalter U [L], von Tucher S ( Kunz K, Prey L, Heinemann P )

Introduction into "Model Experiments in Plant Nutrition" (lecture, 1 SWS)
Schmidhalter U [L], von Tucher S, Hu Y

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

Study Program Division Agricultural and Horticultural Sciences

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<th>Module Level:</th>
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<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
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Credits:*  Total Hours:  Self-study Hours:  Contact Hours:
6  150  90  60

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

Description of Examination Method:
The course grade is based on a learning portfolio. The portfolio submitted 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. 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 realworld companies.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Advanced course. Prior knowledge of economics 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:
Key concepts in organizational behavior, theory, and development:
- perspectives on organizations, their strengths and limitations;
- the role of the individual, the group, and the organization in a high performance environment;
- 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 agricultural, food, and related industries.

Intended Learning Outcomes:
Upon completion of the module students are able
- to select and apply suitable concepts of organizational behavior, theory, and development to meet organizational challenges and context, with a focus on sustainability;
- 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;
- structure organizational change processes, apply models of organizational change, and evaluate their potential implications;
- adapt organizational management and development practices to specific contexts in the agricultural, food, and related industries.

**Teaching and Learning Methods:**
Seminar: Case study based class discussions and presentations, group work based on cases and students' experiences, and assignments; student presentations and concept discussions; forum and group discussions based on individual document research. Through individually prepared class discussions and group work, students develop the ability to critically reflect and apply organizational behavior, theory, and development concepts; through presentations and concept discussions, students develop in-depth knowledge of exemplary theoretical concepts.

**Media:**
Reading assignments; case descriptions, presentations, and discussions, supported by flipchart and other facilitation media

**Reading List:**
Selected chapters from

**Responsible for Module:**
Vera Bitsch
bitsch@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
WZ2581: Plant Biotechnology

Study Program Division Agricultural and Horticultural Sciences

<table>
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<th>Module Level:</th>
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<td>winter/summer semester</td>
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Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the written, supervised examination (Klausur), 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 (90 mins) assesses the theoretical background (part A), whereas part B assesses knowledge obtained on more applied and up-to-date aspects of research that is currently being carried out at the TUM.

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: PowerPoint 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 contents.

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

**Responsible for Module:**
Prof. Dr. BrigittePoppenberger-Sieberer (brigitte.poppenberger@wzw.tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Biotechnology in Plants (seminar, 2 SWS)

Pflanzenbiotechnologie (lecture, 2 SWS)
Frey M [L], Frey M, Schwab W

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

WZ2480: Plant Developmental Genetics 2

Study Program Division Agricultural and Horticultural Sciences

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

Description of Examination Method:
Students are expected to attend lectures regularly and to participate actively. The examination (30 min oral, and the seminar) serves as a control of theoretical competence. Students have to be able to structure and illustrate their knowledge. They need to be able to describe, to interpret and to combine the information. They also need to be able to make connections to related issues. The seminar (20 min) serves as a practical exercise in the application of these theoretical capabilities and an opportunity to strengthen the presentation skills. The average of the examination and the seminar serves as the final evaluation of this module.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Students need to have a decent understanding of genetics as well as molecular and cell biology.

Content:
The lectures provide further and deeper knowledge about selected aspects of plant developmental genetics. The following topics are covered: photomorphogenesis, floral induction, meristem identity, floral organ identity, floral organogenesis, gametophytes, fertilization process, parental control of seed development. The journal club serves as a platform for the students to present original research articles, and to discuss central and novel aspects of plant developmental genetics.

Intended Learning Outcomes:
At the end of the module students have developed a solid understanding of basic concepts of plant development. Through the lecture and the journal club they acquired the capabilities to understand, to analyze, and to put into context developmental genetic approaches and results. Furthermore, they learned how to present the outcome of developmental research to a group of peers in a critical manner. In addition, they are able to transfer the acquired knowledge to other organisms and/or biological questions. In addition, the module serves to foster the student's interest and excitement for questions relating to developmental biology.

Teaching and Learning Methods:
Form of study/study technique: lecture, presentation. Study activities: study of the handouts, hand-written notes and literature. Processing of the podcasts. Presentation and critical evaluation of original research articles.

Media:
Lectures will be supported by power point presentations. Students will be able to download handouts and audio/video-podcasts of individual lectures.
Reading List:
No available text book covers all aspects of this module. The following texts are recommended as introductory or supplementary reading:

Responsible for Module:
Kay
Schneitz
kay.schneitz@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Journal Club Plant Developmental Genetics (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

Study Program Division Agricultural and Horticultural Sciences

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

Description of Examination Method:
The examination consists of a presentation. The presentation has two parts. The first part is an oral summary a published research article in the field of plant epigenetics and epigenomics, followed by short discussion (80%). The second part of the presentation is a short written summary of the article (20%). 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. Written summaries measure the student’s ability to summarize the major facts and the conclusion of a presentation in a clear and concise manner, both in a short abstract (150 words) and in a one-page executive summary.

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 plants

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.

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 (lecture, 3 SWS)
Johannes F

Plant epigenetics and epigenomics (practical training, 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**

Study Program Division Agricultural and Horticultural Sciences

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

**Description of Examination Method:**

The examination contains a written exam (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 Sciences 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.

**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 have gained 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 form literature and exercises for measuring plant stress and to evaluate and interpret data. This enables students for the experimental design and evaluation of plant performance 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 relevanance of plant stress and innovations in assessment and measurement of plant stress physiology. In the exercise, students practise in small groups, how to apply key methods for quantification of plant stress parameters. They document their data and discuss them with group members and supervisors. In the seminar, students are guided in groups how to critically read original research papers and present most recent findings in the field. They learn to critically interprete original work and current hypotheses in plant stress physiology.
Media:

Reading List:
Buchanan 2015: Biochemistry & Molecular Biology of Plants

Responsible for Module:
Prof. Dr. Ralph Hückelhoven
hueckelhoven@wzw.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

WZ2400: Practical Course: Computing for Highthroughput Biology

Study Program Division Agricultural and Horticultural Sciences

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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 biology research demands not only basic computational skills but also in depth knowledge of various biological data resources. During the course, students will 1) practice with some common data analysis methods of high throughput technology, such as gene expression analysis (microarray and RNA seq), next generation sequencing, proteomics, etc. 2) gain knowledge on how to utilize existing biological databases in their research.

Intended Learning Outcomes:
Common computational strategies to process and analyze high throughput data, including text manipulation with Python, gene expression analysis with bioconductor, R, sequence analysis with blast, vmatch, Clustalw, BWA, etc, genome visualization with GBrowse, Next generation sequencing workflow with Galaxy.

Teaching and Learning Methods:
Practice sessions for computers

Media:
Case studies

Reading List:
Practical Computing for Biologists by Steven Haddock and Casey Dunn, http://practicalcomputing.org/

Responsible for Module:
Chris Schön (chris.schoen@wzw.tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Practical Course: Computing for Highthroughput Biology (research lab training, 10 SWS)
Schön C [L], Avramova V (Gonzalez Segovia E)

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

WZ1578: Project Management in Molecular Plant Biotechnology  [SE ProManPlant Biotech]

Seminar Wissenschaftliches Arbeiten in der Pflanzenbiotechnologie
Study Program Division Agricultural and Horticultural Sciences

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

Description of Examination Method:
The examination consists of two presentations (20 min each) followed by a group discussion (10 min). By presenting the research project and a chosen scientific publication the student's ability is tested to summarize the scientific background to formulate the concrete research questions, to present the relevant results and to stand a discussion about the key conclusions. The quality of the two presentations will be evaluated and equally weighted.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basics in genetics, molecular biology and biochemistry. It is recommended to enroll 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 work out 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) They analyse, present and critically discuss an actual relevant publication in the field of Molecular Plant Biotechnology 2) Students will develop and present their own research project, carried out in one of the participating labs. Moreover the students will participate in other students 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, to assemble these data in a presentation and to orally present and discuss these data with teachers and colleagues.

Students are able to work out a project proposal in the area of Molecular Plant Biotechnology to structure it in specific objectives, to design a research plan based on a reasonable combination of experimental approaches and to present and discuss the proposal with peers. Students are able to discuss and evaluate other (student) researchers' proposals.

Teaching and Learning Methods:
To understand the basic principles of project management in Molecular Plant Biotechnology, each student will prepare and perform multimedia-supported presentations of their own research project 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

Responsible for Module:
Tobias Sieberer (tobias.sieberer@wzw.tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Project Management in Molecular Plant Biotechnology (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
Study Program Division Agricultural and Horticultural Sciences

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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 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:
Next semester

(Recommended) Prerequisites:

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:

Media:
PowerPoint presentations, chalkboard
Computer exercises, application training
Reading List:


Responsible for Module:
Prof. Chris-Carolin Schön
chris.schoen@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

WZ1674: Research Methods and Economic Research Project

Study Program Division Agricultural and Horticultural Sciences

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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:

Responsible for Module:
Vera Bitsch
bitsch@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Seminar
Research Methods and Economics Research Project
4 SWS
Vera Bitsch
TUM
bitsch@tum.de

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

WZ1577: Research Project 'Biotechnology of Horticultural Crops' [FP BiotechGaKu]

Forschungspraktikum 'Biotechnologie Gartenbaulicher Kulturen'
Study Program Division Agricultural and Horticultural Sciences

Module Level: Master
Language: English
Credits:* 10

Total Hours: 300
Self-study Hours: 192
Contact Hours: 108

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

Description of Examination Method:
Following the regular and active participation in a six week practical course (at least 32 hours/week) the students hand in a research report. By preparing the written report the students demonstrate the ability to summarize the key aims of the performed experiments in the field of horticultural plant biotechnology, 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 grading will be also based on the level of active participation and experimental/ intellectual skills during the lab work. The final grade is an averaged grade from the written report (60%) and the level of of in-course participation (40%).

Repeat Examination:

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

Content:
This course is offered for advanced students who have a background in plant biotechnology or plant molecular biology in general. The students work on a small current research project in the lab, which is concerned with the understanding of plant growth regulation in horticultural crops. The participants will get acquainted with one or more of the following techniques: (I) molecular cloning of plant expression constructs, (II) plant transformation methods (including tissue culture), (III) analysis of gene expression at the RNA and protein level, (IV) plant physiology (phenotypic analysis of mutants and wild-type plants under different conditions; genetic screens).

Intended Learning Outcomes:
Upon completion of this module students are able to understand and assess methods and aims of plant biotechnology, particularly in generating and/or characterizing mutants/transgenic plants to analyse molecular processes of growth regulation. They are capable of independently carrying out lab-based experiments with methods of molecular biology, biochemistry, plant physiology and/or genetics and can interpret the results. The module aims to prepare students for a master thesis in the respective research field.

Teaching and Learning Methods:
Personal supervision in experimental work, critical discussion of results, writing of a concise research report in the common publication format, oral presentation and discussion of data with lab peers.
Media:
Oral presentation, lab protocols, relevant scientific publications.

Reading List:

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

Courses (Type of course, Weekly hours per semester), Instructor:
Research Project ‘Biotechnology of Horticultural Crops’ (research lab training, 10 SWS)
Poppenberger-Sieberer B, Rozhon W, Sieberer T, Albertos Arranz P

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

WZ1575: Research Project 'Chemical Genetics' [FP ChemGen]

Forschungspraktikum Chemische Genetik
Study Program Division Agricultural and Horticultural Sciences

Module Level: Master
Language: English
Duration: one semester
Frequency: winter/summer semester

Credits:* 10
Total Hours: 300
Self-study Hours: 120
Contact Hours: 180

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

Prüfungsdauer (in min.): 30.
Regular and active participation in a six week practical course (minimum 30 hours/week), followed by independent writing of a research report. Basis for the grading will be the level of active participation in the practical part as well as the quality of the written presentation of the results.

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
Advanced knowledge in plant biology, biochemistry and cell biology is recommended. Basic techniques for working in a molecular biology laboratory, such as clean pipetting, are a must.

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 in the organism (reverse chemical genetics). In contrast to a classical genetic approach protein function is not disturbed by mutation of the corresponding gene, but by physical interaction of the small molecule. In practice, thousands of chemicals are tested in a high-through-put assay in a living system (whole organism or cell culture) to assess whether they can trigger a specific phenotype (e.g. stress resistance, enhanced regeneration capacity etc.). Compounds, which induce the desired effect, will then be exploited to identify the target proteins in the organism. In the reverse approach chemical ligands of a protein of interest with unknown function will be identified in vitro and then used for in vivo treatments to reveal the biological role of the protein.

The advantages over conventional genetics are: The severity and duration of the biological effect can be subtly adjusted by modulating the drug concentration and the time of application, which facilitates the functional characterization. Moreover, in many cases small molecules simultaneously inactivate functional homologs of the same protein family and thus allow circumvention of genetic redundancy, which can hamper genetic analysis especially in plants. Chemical genetic approaches are not only useful in basic research questions, they can also directly lead to the development of drugs and agrochemicals.

Participation in the course will teach students a subset of the following techniques by participating in a research project in the lab: 1) Storage and handling of a chemical library, (2) design and set up of a chemical genetic screen, (3) phenotype-based small molecule screen in Arabidopsis or an horticulturally relevant plant species, (4) expression marker-based small molecule screen in Arabidopsis, (5) hit confirmation and structure/function analysis using cheminformatic methods, (6) establishment of an in vitro assay to test ligand-target interaction.
Intended Learning Outcomes:
Acquiring profound skills to independently plan and carry out a research project in the area of chemical genetics. Getting qualified to assess for which scientific challenges a chemical genetic approach might be helpful. It is recommended to subscribe the course if a master thesis in one of the participating research groups is anticipated.

Teaching and Learning Methods:
Personal supervision in experimental work, critical discussion of results, writing of a concise research report in the common publication format, oral presentation and discussion of data with lab peers.

Media:
Personal supervision in experimental work, critical discussion of results, writing of a concise research report in the common publication format, oral presentation and discussion of data with lab peers.

Reading List:
Biochemistry and Molecular Biology of Plants; Buchanan, Gruissem and Jones, 2000
Teaching Tools in Plant Biology; http://www.plantcell.org/site/teachingtools/teaching.xhtml
At the bench - A laboratory navigator; Kathy Barker, 2004

Responsible for Module:
Tobias Sieberer (tobias.sieberer@wzw.tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Research Project 'Chemical Genetics' (research lab training, 10 SWS)
Poppenberger-Sieberer B, Rozhon W, Sieberer T

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

WZ1718: Research Project 'Horticultural Economics and Management'

Study Program Division Agricultural and Horticultural Sciences

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<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
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<tbody>
<tr>
<td>10 Credits:*</td>
<td>Total Hours:</td>
<td>Self-study Hours:</td>
<td>Contact Hours:</td>
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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:

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

WZ1697: 'Research Project 'Metabolite Analyses in Crops'

Study Program Division Agricultural and Horticultural Sciences

Module Level: Master
Language: Credits:* Total Hours: 10
Duration: 300
Self-study Hours: 108
Frequency: Contact Hours: 192

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

Description of Examination Method:
Following the regular and active participation in a 30 day practical course (in total 192 hours) the students hand in a research report. By preparing the written report the students demonstrate the ability to summarize the key aims of the performed experiments in the field of metabolite analyses in crops, 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. Grading will be based on the level of active participation and experimental/intellectual skills during the lab work and on the written report. The final grade is an averaged grade from the written report (50%) and the level of in-course participation (50%).

Repeat Examination:

(Recommended) Prerequisites:
Basic knowledge in plant biochemistry, physiology, genetics and analytical chemistry. Practical experience with basic lab working techniques such as pipetting, preparation of buffers and simple analytical methods. Completion and above average grading of Biotechnology in Horticulture (1 or 2 or 3) or an equivalent course.

Content:
This course is offered for advanced students who have a background in biochemistry, biotechnology or molecular biology. The students work on a small current research project in the lab, which will focus on analysis of primary and/or secondary metabolites and minerals in horticultural crops and substrates. The participants will get acquainted with one or more of the following techniques: UV/VIS spectroscopy, fluorimetry, HPLC, ion chromatography, gas chromatography, mass spectrometry, IR spectroscopy, atomic emission spectroscopy, electrophoresis, protein analysis, enzymatic assays, DNA isolation, in vitro cultivation of plants and cell cultures.

Intended Learning Outcomes:
Upon completion of this module students are able to apply analytical methods for identification and quantification of plant metabolites and minerals. They are capable of independently carrying out lab-based experiments with methods of analytical chemistry, analytical biochemistry and molecular biology are able to calculate can interpret the results. The module aims to prepare students for a master thesis in the respective research field.

Teaching and Learning Methods:
Personal supervision in experimental work, critical discussion of results, writing of a concise research report in the common publication format, oral presentation and discussion of data with lab peers.

Media:
Oral presentation, lab protocols, relevant scientific publications.
Reading List:

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

Courses (Type of course, Weekly hours per semester), Instructor:
Research Project "Metabolite Analyses in Crops" (research lab training, 10 SWS)
Poppenberger-Sieberer B, Rozhon W, Sieberer T

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

WZ2401: Research Project 'Molecular Plant Breeding'

Study Program Division Agricultural and Horticultural Sciences

<table>
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<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
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<tbody>
<tr>
<td>Master</td>
<td>German/English</td>
<td>one semester</td>
<td>winter/summer semester</td>
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Credits:*  
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:
The scientific problem, the applied methods, the results and the interpretation and discussion of the results will be documented in a scientific report which will be graded.

Repeat Examination:
Next semester

(Recommended) Prerequisites:  
Lectures in molecular plant breeding and/or molecular genetics and/or plant breeding.

Content:
The projects, that students will work on, highlight current topics of plant breeding and address a part of ongoing research projects. They cover the acquisition of scientific methods. This may comprise molecular genetic laboratory and modern phenotyping methods for agronomic traits. Depending on the project different molecular techniques are applied (DNA extraction from plant material, PCR, cloning, sequencing, analysis of molecular markers, gene expression). Additionally, the scientific interpretation of the results (statistical analysis, mapping of genes / QTL, characterisation of genes, literature work) will be addressed. We also offer topics related to drought stress in field or greenhouse experiments with a strong focus on application in crop plants. 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, to conduct these experiments, to scientifically analyse, interpret, discuss and present the obtained results.

Teaching and Learning Methods:
Hands on lab practicals; hands on phenotyping methods; preparation and presentation of talks

Media:
Case studies

Reading List:
Project-specific current literature.
General:
T.A. Brown: Genome und Gene - Lehrbuch der molekularen Genetik; Spektrum Akademischer Verlag GmbH;
Responsible for Module:
Eva
Dr. Bauer
e.bauer@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Research Project Molecular Plant Breeding (research lab training, 10 SWS)
Avramova V, Eggels S, Mohler V, Mayer M

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

WZ1576: Research Project 'Plant Growth Regulation' [FP WaPfla]

Forschungspraktikum 'Wachstumsregulation der Pflanzen'
Study Program Division Agricultural and Horticultural Sciences

Module Level: Master
Language: English
Credits:* 10
Total Hours: 300
Self-study Hours: 120
Contact Hours: 180
Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Prüfungsdauer (in min.): 30.
Regular and active participation in a six week practical course (minimum 30 hours/week), followed by independent writting of a research report. Basis for the grading will be the level of active participation in the practical part as well as the quality of the written presentation of the results.

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
Advanced knowledge in plant biology, biochemistry and cell biology is recommended. Basic techniques for working in a molecular biology laboratory, such as clean pipetting, are a must.

Content:
As primary resource of biomass plants grow by continuous formation of modular organs. The organs are generated by the activity of stem cell centers, so called meristems. 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 multifactorially conditioned process and strongly dependent on the specific utilization of the crop. The present research project deals with the molecular identification of genetic factors which act limiting on the different growth parameters mentioned above. Using modern genetic, chemical genetic and molecular biological approaches new important loci should be identified and positioned in the current regulatory network. The generated knowledge can than be used to develop targeted strategies to improve crop breeding.

Intended Learning Outcomes:
Acquiring profound skills to independently plan and carry out a research project in the area of chemical genetics. Getting qualified to assess for which scientific challenges a chemical genetic approach might be helpful. It is recommended to subscribe the course if a master thesis in one of the participating research groups is anticipated.

Teaching and Learning Methods:
Personal supervision in experimental work, critical discussion of results, writing of a consciece research report in the common publication format, oral presentation and discussion of data with lab peers.

Media:
Personal supervision in experimental work, critical discussion of results, writing of a consciece research report in the common publication format, oral presentation and discussion of data with lab peers.
Reading List:
Biochemistry and Molecular Biology of Plants; Buchanan, Gruissem and Jones, 2000
Teaching Tools in Plant Biology; http://www.plantcell.org/site/teachingtools/teaching.xhtml
At the bench - A laboratory navigator; Kathy Barker, 2004

Responsible for Module:
Tobias Sieberer (tobias.sieberer@wzw.tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Research Project 'Plant Growth Regulation' (research lab training, 10 SWS)
Poppenberger-Sieberer B, Sieberer T, Rozhon W

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

WZ1549: Research Project 'Plant Nutrition'

Study Program Division Agricultural and Horticultural Sciences

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<th>Module Level:</th>
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<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter/summer semester</td>
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<tr>
<td>10</td>
<td>300</td>
<td>150</td>
<td>150</td>
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Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the oral presentation students are expected to present and discuss their research results according to the scientific practice. They will be asked to discuss and critically evaluate the achieved results with respect to the applied methods and compared to current literature.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in plant nutrition

Content:
Current research topics in plant nutrition e.g., plant responses to abiotic stress (nutrients, drought, salinity, heat) in cooperation with active research groups.
Studies focus on specific experimental and methodological skills in current plant nutrition in order to investigate yield development, nutrient acquisition and soil nutrient or water status. These methods include destructive and non-destructive measurements, plant and soil sensor techniques, digital imaging, chemical analysis and data analysis by statistical methods and specific algorithms.

Intended Learning Outcomes:
At the end of the module students will be able to
- to apply the theoretical background knowledge on the selected research area (e.g. the causes and consequences of abiotic stress to plants)
- to utilize specific and appropriate methods for data collection and evaluation of the achieved results
- to apply specific techniques of data analysis

Teaching and Learning Methods:
Practicals, projects

Media:
presentations, prescripts, instruction manuals

Reading List:
Original papers
Responsible for Module:
Urs Schmidhalter
urs.schmidhalter@mytum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Researchn Project Plant Nutrition (practical training, 10 SWS)
von Tucher S

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 Food Industry

Study Program Division Agricultural and Horticultural Sciences

<table>
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<th>Module Level:</th>
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<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
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Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The course grade is based on the learning portfolio. The portfolio submitted 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 agricultural, food, and related industries. 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; and 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, organizational behavior, or value chain management. Medium level experience in desk research and scientific writing is required.

Content:
Key concepts of supply chain management, strategy, and sustainability: processes of supply chain management (e.g., creating added value, management of customers and suppliers); innovation, sustainability as innovation; sustainable supply chains; CSR and sustainability measurement; implementation of a sustainability strategy, costs and benefits of sustainable practices in the context of agricultural, food and related industries; ethical issues in supply chain management.

Intended Learning Outcomes:
Upon completion of the module students are able to evaluate processes of agricultural supply chains management, e.g., creating and capturing value, management of customers, suppliers, and other stakeholders; for the areas strategy, supply chain management, and sustainability students can independently choose scientific models or concepts relevant to the analysis process and justify their evaluation; students are able to evaluate the implementation a CSR concept or sustainability strategy, and to monitor its effects on operations, suppliers, associates, and customers; Students are able identify and analyze ethical issues in supply chain management and to recommend how to apply ethical practices.
Teaching and Learning Methods:
Seminar: Case study based class discussions and presentations, group work based on cases, students' experiences and assignments. 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 in the context of sustainability.

Media:
Reading assignments; case descriptions, presentations, and discussions, supported by Metaplan, flipchart and other facilitation media.

Reading List:
Current articles from scientific journals as appropriate.
Selected chapters from
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:

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

WZ2763: Transcriptional and Posttranscriptional Regulation in Eukaryotes

Study Program Division Agricultural and Horticultural Sciences

<table>
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<th>Module Level:</th>
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<th>Duration:</th>
<th>Frequency:</th>
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<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
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<td>90</td>
<td>60</td>
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Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the written examination (60 mins) 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.
The students participate regularly and actively at the seminar. 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 power point 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 power point 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 power point 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.

**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:**
Prof. Dr. Caroline Gutjahr,
caroline.gutjahr@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
Prof. Dr. Caroline Gutjahr,
caroline.gutjahr@tum.de
For further information in this module, please click campus.tum.de or here.
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