Module Catalog

M.Sc. Agricultural Biosciences

Former TUM School of Life Sciences Weihenstephan

Technische Universität München

www.tum.de
www.wzw.tum.de

Module Catalog: General Information and Notes to the Reader

What is the module catalog?

One of the central components of the Bologna Process consists in the modularization of university curricula, that is, the transition of universities away from earlier seminar/lecture systems to a modular system in which thematically-related courses are bundled together into blocks, or modules.

This module catalog contains descriptions of all modules offered in the course of study.

Serving the goal of transparency in higher education, it provides students, potential students and other internal and external parties with information on the content of individual modules, the goals of academic qualification targeted in each module, as well as their qualitative and quantitative requirements.

Notes to the reader:

Updated Information

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

Non-binding Information

Module descriptions serve to increase transparency and improve student orientation with respect to course offerings. They are not legally-binding. Individual modifications of described contents may occur in praxis.

Legally-binding information on all questions concerning the study program and examinations can be found in the subject-specific academic and examination regulations (FPSO) of individual programs, as well as in the general academic and examination regulations of TUM (APSO).

Elective modules

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

Index of module handbook descriptions (SPO tree)

Alphabetical index can be found on page 98

Required Modules | Pflichtmodule

Module Description

WZ0626: Genetics and Genomics | Genetics and Genomics

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

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

Repeat Examination:
End of Semester

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

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

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

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

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

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

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

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

Learning Activity:

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

Media:
Presentations with PowerPoint, videos, black board

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

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

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

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

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

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

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

in vertebrates. Common principles (innate immunity) and specific features of plant and animal immunity are taught (e.g. adaptive and cellular immunity, systemic acquired resistance). This is not restricted to model plants, humans and mice but extends to crops and livestock animals and fills the gap between basic research and applied animal and plant sciences in breeding and biotechnology for disease resistance.

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

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

Media:
Powerpoint presentations, round table discussions

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

Review and original literature is additionally provided.

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

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

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

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

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

Module Description

WZ0623: Physiology | Physiology

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

Content:
Lecture Plant Physiology:
- Germination
- Hormone physiology of shoot growth, Hormonal control of root architecture

- Floral transition
- Fertilization, Seed and fruit development
- C-economy of plants

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

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

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

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

Reading List:
Taiz, L. and Zeiger, E. (2014): Plant Physiology and Development.
Alberts B. (2014), Molecular Biology of the Cell
Guyton and Hall Textbook of Medical Physiology, 2015 (or Brandes, Lang, Schmidt, Physiologie des Menschen, 2019)

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

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

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

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

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

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

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

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

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

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

Reading List:
To be announced

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

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

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

Module Description

MA9613:

Former TUM School of Life Sciences Weihenstephan

Version of module description: summerterm 2019

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

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

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

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Calculus and statistics on bachelor level - MA9601 (calculus) MA9614 oder WZ1868 (statistics)

Content:
- Introduction to data handling and problem solving with a statistical package (for example R)
- Exploratory data analysis including working with a graphical package (for example ggplot)
- Visualization and communication of the results of data analysis
- Design of experiments
- Multiple regression, optimization and bootstrap
- Model selection
- Special regression topics: logistic regression, survival regression, poisson regression, linear mixed models
- Clustering algorithms
- Nonparametric methods
- Principal Component Analysis and multiple correspondence analysis
- Setting up data bases for data analysis and using them
- Concepts of machine learning

Intended Learning Outcomes:
Upon successful completion of this module, students are able to apply data handling methods with a statistical package to create meaningful diagrams for visualization and communication. The students are able to select the appropriate method to prepare and analyze data by either design of experiments, machine learning and statistical methods. They understand the underlying mathematical concepts. The students are able to apply scripting methods to databases for data cleaning and analysis.
They understand sampling variability and the necessity of sampling distributions. The students can explain the concept, select the appropriate formulas and distributions and apply them to confidence intervals. The students can choose appropriate hypothesis tests and can analyze and interpret the results. The students understand the principles of the analysis of variance and are able to interpret the results. The students can apply principle component analysis and multiple correspondence analysis to data sets with a statistical package and differentiate between both methods with respect to the underlying theory. They can interpret the outputs. The students can select and apply clustering strategies and discuss the partition quality. The students can set up suitable model equations for multiple regression and analyze and interpret the results. They apply bootstrap methods to analyze the regression results. They can apply optimization functions and know the pitfalls. The students can explain multicollinearity, how it can be detected and overcome. The student can apply robust methods for hypothesis testing and their range of application. The students can explain the differences between linear mixed models, logistic, survival and poisson regression and name the situations where these models are correctly applied. The students are able to apply machine learning methods. They can do the analysis for latter methods by means of a statistical package and interpret the results.

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

Media:
Scripts, overhead, exercise sheets

Reading List:
Hastie, R., Friedman, J., Tibshirani, R., The Elements of Statistical Learning: Data Mining, Inference and Prediction, Springer
Abram, B., Ledolter, J., Introduction to Regression Modeling, Thomson Brooks/Cole
Fitzmaurice, G. M., Laird, N. M., Ware, J. H., Applied longitudinal analysis, Wiley

Collett, D., Modelling Survival Data in Medical Research, Chapman & Hall CRC
Van Belle, G., Fisher, L D., Heagerty, P. J., Lumley, T., Biostatistics: a methodology for the health sciences, Wiley
Peck, R., Olsen, C., Devore, J., Introduction to Statistics and Data Analysis, Brooks/Cole Cengage Learning

Lecture notes, additional material in moodle course

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

Courses (Type of course, Weekly hours per semester), Instructor:
Statistical Computing and Data Analysis [MA9613] (Vorlesung, 2 SWS)
Ankerst D, Neumair M
For further information in this module, please click campus.tum.de or here.

Elective Modules | Wahlmodule

Lab Courses | Lab Courses

Module Description

WZ0628: Lab Course Immunology | Lab Course Immunology

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

Content:
In this module, students are introduced to planning and performing immunological experiments in order to analyze the immune system of plants and animals. Students gain knowledge about theoretical background of technologies used to analyze the immune system.
The following methods/technologies will be performed during the exercise:
- Measuring calcium signaling in plants and animal cells

- Measuring reactive oxygen species
- Transfection of plants for interference with immuno-competence
- Isolation of lymphocytes by density gradient centrifugation
- Characterization of lymphocyte populations by FACS
- in silico analyze of FACS data
- ELISA
- Stimulation of macrophages and NO measurement

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

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

Media:
PowerPoint presentations, round table discussions

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

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

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

lab course – animal immunology (Übung, 2 SWS)
Schusser B [L], Schusser B, Sid H, Vikkula H, Zehn D
For further information in this module, please click campus.tum.de or here.

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

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

Intended Learning Outcomes:
After participating in this module the students will have a fundamental understanding and the theoretical know-how for the isolation, cultivation and genetic manipulation of mammalian cells. In addition they have learned basic practical skills, methods and techniques essential to cell biology. They have learned and understood a number of techniques relevant to the manipulation of mammalian cells and are able to apply the acquired knowledge to solve problems and design necessary experiments.
The module provides the student with problem solving skills and promotes the interest in cell biology and its application.

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

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

Reading List:
To be announced

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

Courses (Type of course, Weekly hours per semester), Instructor:
Introduction to Mammalian Cell Culture (Übung, 3 SWS)
Fischer K, Flisikowska T, Rieblinger B, Schnieke A

Questions in Cell Biology and Use of Genome Editing Tools (Seminar, 2 SWS)
Fischer K, Flisikowska T, Rieblinger B, Schnieke A
For further information in this module, please click campus.tum.de or here.

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic knowledge in statistics and genetics

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

5) Exercise and practice of analysis based on a dataset from initial data to statistical analysis and writing a report with discussion about the data.

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

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

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

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

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

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

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

Module Description

WZ0627: Lab Course Physiology | Lab Course Physiology

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

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

Repeat Examination:
Next semester

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

Content:
Lab Course Plant Physiology:
- Basic technical principles of gas exchange measurements, including determination of possible pitfalls
- Separate C-fluxes in photosynthesis: Carboxylase and oxygenase activity, dark respiration
- Manipulating photosynthesis by environmental parameters: CO_2, light and water
- Comparison C3- and C4-photosyntesis
- Determination of mesophyll conductance (C3) and bundle sheath leakiness (C4) by use of stable isotopes

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

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

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

Lab Course Plant Physiology:
- Participants will a priori receive a script that informs them of the content, aims, and methods of the practical course
- The course will start with a 2-3 hour introduction during which all general aspects will be explained and discussed. This will take place in free discussions and in parts with the help of PowerPoint-assisted short presentations.
- Then the student will participate in 4 topics/units that are distributed over the 4 days. Content of the units will be discussed upfront, then the practical work will be carried out, finally there will be a discussion of results.
- The course will end with an afternoon during which all topics and aims of the course will be recapitulated.

- Students will work in groups >2, numbers depends on the total number of participants, not more than 5 per group

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

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

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

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

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

Research Tools | Research Tools

Module Description

WZ0630: Analysis of Epigenomic Data | Analysis of Epigenomic Data

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
End of Semester

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

Content:
Epigenetic modifications, such as DNA methylation or histone modifications, have a central role in the regulation of gene expression, particular in response to environmental and developmental cues. Next Generation Sequencing (NGS) technologies now allow us to measure the genome-wide patterns of various epigenetic modifications at unprecedented resolution. These technologies have opened up novel research avenues in basic and applied plant biology, including studies of

development, stress response and natural variation. In this module students will be familiarized with the following NGS analysis steps:
- Introduction to Linux and R.
- Downloading NGS datasets from GEO public repository.
- Importing and manipulating NGS datasets.
- Alignment, trimming and quality filtering of ChIP-seq and WGBS sequencing reads.
- WGBS: Methylation state calling and detection of differentially methylated regions (DMRs).
- ChIP-seq: peak calling and differential enrichment analysis.
- Integration of WGBS and ChIP-seq with gene expression data.

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

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

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

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

Media:
Tutorials

Reading List:
Tutorials

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

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

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: summerterm 2019

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

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

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

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
None.

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

- Protein quantification by spectrophotometry
- Analysis of plant metabolites and plant growth regulators by HPLC, GC and spectroscopy
- Analysis of plant nutrients by atomic emission spectroscopy, ion chromatography and photometry

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

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

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

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

Responsible for Module:
Rozhon, Wilfried; Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Analytical Methods in Horticulture, Agriculture and Plant Biotechnology (Übung, 4 SWS)
Poppenberger-Sieberer B [L], Rozhon W
For further information in this module, please click campus.tum.de or here.

Module Description

WZ6429: Biotechnology in Horticulture | Biotechnology in Horticulture

Former TUM School of Life Sciences Weihenstephan

Version of module description: summerterm 2019

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

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

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

Repeat Examination:
Next semester

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

Content:
This course focusses on plant biotechnology and molecular biology. Subsequently, the students have the opportunity to apply plant biotechnological methods including:
- DNA isolation;
- Restriction analysis;
- PCR genotyping;

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

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

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

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

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

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

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

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

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic knowledge of computer systems.

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

Introduction to Linux and R
- Managing data folders and datasets

- Managing the R environment and R libraries

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

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

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

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

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

Media:
Tutorials, PowerPoints, software training.

Reading List:
Tutorials

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

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

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

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2020/21

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

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

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

Repeat Examination:
Next semester

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

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

Intended Learning Outcomes:
In individual research projects, students will become familiar with computational strategies for the analysis of high dimensional data. Upon completion of this module, students are able to handle large datasets and process them with appropriate tools using programming languages like R or

Python. They will be able to analyze datasets and use suitable tests for evaluating the plausibility of the data and to do quality filtering. They will be able to apply custom pipelines for data analysis. Depending on the specific project this will include the use of public databases, text manipulation with R or Python, gene expression analysis with bioconductor R, sequence analysis with blast, vmatch, Clustalw, BWA, genome visualization with GBrowse and Next Generation Sequencing workflows. Students will be able to test the significance of the results and to interpret them in the context of current literature.

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

Media:
Case studies, computer exercises.

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

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

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

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:

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

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

presentations and will be able to contribute ideas in discussions following the presentation. They will learn how to critically evaluate their own work and those of others.

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

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

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

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

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

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

Module Description

WZ0632: Research Internship Plant Immunology | Research Internship Plant Immunology

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

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

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

Repeat Examination:
Next semester

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

Content:
In the exercise, the students are taught how to read relevant literature, extract a specific research question from that, and how to apply research methodology relevant to the research question they want to answer. They learn how to document, process, statistically evaluate and display their data.

In the research lab training, they apply learned methods on a specific research questions in a one-to-one supervised situation.

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

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

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

Media:
PowerPoint presentations, round table discussions

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

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

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

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

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

Content:
The students work on a research project in the lab on one of the following topics:
a) plant hormone signalling
b) impact of environmental cues on plant growth and development
c) heterologous expression of plant proteins

Methods and techniques applied in the framework of the course will depend on the individual project and may include: cloning, plant transformation, PCR, qPCR, Western blot analysis, protein expression and purification, assays for enzymatic activity, EMSA, chromatin IP, fluorescence and electron microscopy, phenotypic characterisation of plants, cold or heat stress assays, ion leakage assays, dose response assays and quantification of metabolites and nutrients by chromatographic and spectroscopic techniques. Statistical methods are applied for data evaluation. Many of these techniques are applicable to other (non-plant) organisms.

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

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

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

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

Responsible for Module:
Rozhon, Wilfried; Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum Biotechnologie gartenbaulicher Kulturen (Forschungspraktikum, 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' | Research Project 'Chemical Genetics'

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

Content:
Chemical Genetics is a novel interdisciplinary approach in which small molecules are used to identify proteins responsible for the expression of a specific phenotype (forward chemical genetics) or to affect the function of a specific protein and assess the morphological, physiological and molecular consequences within the organism (reverse chemical genetics). Chemical genetic

approaches are not only useful in basic research questions, they can also directly lead to the development of drugs and agrochemicals.
This module will teach students a subset of the following techniques by participating in a research project in the lab:
- Storage and handling of a chemical library;
- Design of a chemical genetic screen;
- Set up of a chemical genetic screen in conformity with the required quality standards;
- Phenotype-based small molecule screening in Arabidopsis thaliana
- Phenotype-based small molecule screening horticulturally relevant plant species;
- Expression marker-based small molecule screens;
- Hit confirmation assays;
- Dose response assays;
- Structure/function analysis using cheminformatic methods;
- Establishment of an in vitro assay to test ligand-target interaction.

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

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

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

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

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

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum Chemische Genetik (Forschungspraktikum, 10 SWS)

Poppenberger-Sieberer B, Rozhon W, Sieberer T
For further information in this module, please click campus.tum.de or here.

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

Content:
The students work on a research project independently in the laboratory. The project will focus on quantification of primary metabolites, secondary metabolites and/or nutrients in crop plants and factors/methods for altering the metabolite composition of crops.

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

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

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

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

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

Responsible for Module:
Rozhon, Wilfried; Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum Metabolite Analyses in Crops (Forschungspraktikum, 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' | Forschungspraktikum Molekulare Pflanzenzüchtung

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:

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

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

data will be addressed, which includes e.g. statistical data analysis, mapping of genes/QTL, characterization of genes, literature work.

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

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

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

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

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

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

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum Molekulare Pflanzenzüchtung (Forschungspraktikum, 10 SWS)
Avramova V, Mayer M, Valle Torres D, Mohler V
For further information in this module, please click campus.tum.de or here.

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:

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

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

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

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

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

Reading List:
Orginal research literature and reviews.

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

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

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

Content:
As primary resource of biomass, plants grow by continuous formation of modular organs. The net growth is the result of different growth parameters including the rate of organ formation, the size of the single organs and the overall amount of formed organs. Moreover, it is strongly dependent on environmental conditions (nutrients, water, light and temperature) and the germplasm (constitution

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

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

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

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

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

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

Courses (Type of course, Weekly hours per semester), Instructor:
Forschungspraktikum Wachstumsregulation der Pflanzen (Forschungspraktikum, 10 SWS)
Poppenberger-Sieberer B, Sieberer T, Rozhon W

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

Module Description

WZ2380: Research Project Plant Systems Biology | Forschungspraktikum Pflanzensystembiologie

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

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

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

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

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

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

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

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

Elective Modules Agricultural Biosciences | Wahlmodule Agricultural Biosciences

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

Description of Examination Method:
There is an oral exam (30 min.) for each student consisting of analyzing and discussing a case study (a scientific experiment related to one crop disease) based on questions by the lecturer. No help is allowed during the questions. The students have to prepare two studies at home before the exam, and one will be chosen at the time of examination. The students will need to 1) analyze the methods used in the study and the results, 2) explain the concepts of evolutionary genetics, which are related to the respective case study, 3) describe the theoretical models presented in the course, which have been adapted in the respective case study, 4) evaluate critically the management strategy used in the study, and 5) propose new better disease management strategies based on their acquired knowledge of pathogen genomics and pathogen evolution. 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 and their implications for disease management.
It is built in four major blocks (four topics). They are enclosed by seminar and discussion block where students mobilize their theoretical knowledge to interpret data and propose new disease management strategies for major crops (rice, wheat, barley, banana, maize, apple, tomato).
1) Introduction to evolutionary genomics: we describe the neutral theory of molecular evolution (including genetic drift, random mutation, transposable elements insertion). How is a genome organized? What is the spatial structure of pathogen populations (between fields, regions, and continents). We describe how natural selection acts at the level of major genes and of quantitative traits, and give examples of such genes in crop pathogens. This part is mainly a lecture with small exercise to compute genetic drift using R.
2) Pathogen genomics: range of genome sizes found in pathogens. What is the effect of recombination (sexual reproduction) and accumulation of deleterious mutations by Muller's ratchet. This part is mainly lecture with small exercise on a model of sexual recombination in pathogens.
3) Disease epidemiology: disease epidemiology principles, SIR models, models of disease spread in a field (SEIR), herd immunity concept, evolution of aggressiveness. This block consists of a lecture and long exercise sessions in R where simulations of SIR and SEIR models are performed.
4) Host-parasite coevolution: introduction to models of coevolution, importance of gene-for-gene interactions in plants. We study simple dynamical systems and predict the outcome of coevolution, that is occurrence of arms race or trench warfare dynamics. This part includes a short lecture and exercise sessions with R codes simulating coevolutionary dynamics. Simulations are used to exemplify and understand the possible outcome of coevolution and to understand the implications of deploying major resistance genes in disease management.
Synthesis: what is an optimal disease management taking pathogen evolution into account? This part consists of a lecture and a seminar part (paper presentation) where the students have to propose new disease management strategies for some crop pathogens based on case studies and the theory they learned during the course.

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

Teaching and Learning Methods:
The lectures and exercises are intermixed during the sessions. Typically, a first part of lecture introduces the concepts and the mathematical models. Then students will implement the model in R and perform simulations under different parameters. Thereby, they gain a direct understanding of the behavior and outcome of the mathematical model. The exercises are done by the whole group, and students are encouraged to discuss their results with their colleagues, before a summary is presented by the lecturer. There is also a seminar session, where students by groups of two will present a research paper which is a case study of population genomic data of a crop pathogen. The students perform a PowerPoint presentation of this case study and afterwards will discuss it with the lecturer and the other students. The aim of the presentation is to describe, analyze and interpret population genomic data of crop pathogens, critically evaluate the results and propose new disease management strategies.

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

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

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

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

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

Module Description

WZ1720: Crop Breeding | Crop Breeding

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

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

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

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

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

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

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

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

Module Description

WZ1696: Crop Genomics | Crop Genomics

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
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 analyze plant genomics data and to use bioinformatic/ statistical approaches for the analysis of genotype-phenotype associations. Successful students can judge which approaches are appropriate for specific situations.

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

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

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

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

Responsible for Module:

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

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

Module Description

WZ1037: Crop Physiology | Crop Physiology - Ertragsphysiologie

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

Description of Examination Method:
The assessment of this module consists of an oral exam (30 min.). Students have to demonstrate that they can apply the acquired knowledge in plant physiology to possible reactions of plants to changing environments like increasing CO2 concentrations, heat and drought stress, variable N supply etc. They have to show that they captured the basic concepts of plant physiology with emphasis on C economy. It will be assesed if students have acquired an adequate understanding of the interactions of different plant ressources like water, light, CO2 and nutrients.

Repeat Examination:
End of Semester

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

Content:
Aspects of crop physiology like C economy (photosynthesis and respiration), N economy (uptake, distribution, the concept of Ncrit), plant water relations, light interception, growth and development

Intended Learning Outcomes:
'A succesful participation enables the students to
- understand the C economy (emphasis on photosynthesis and respiration), water relations, and N economy of plants
- using this knowledge to comprehend canopy and yield development of crops and grassland, including light absorption and interception, N uptake and distribution as well as growth processes like cell division and elongation

- apply methods of plant physiology research (gas exchange measurements; stable isotopes) and evaluate and interprete the produced data.

Teaching and Learning Methods:
The basic plant physiological process are presented in lectures (2 SWS), complemented by examples of state-of-the-art research. An accompanying practical course (2 SWS) demonstrates methods of plant physiological research, which are executed by the students.

Media:
Presentation as lectures, handout of the lecture content as pdf

Reading List:
Lecture handouts; current scientific publications

Responsible for Module:
Prof. Dr. Schnyder, Johannes

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

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

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2021/22

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

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

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

Repeat Examination:

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

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

- Basic knowledge about function of reproductive hormones.
- Application of biotechnology in reproduction.

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

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

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

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

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

Reading List:
To be announced.

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

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 | Evolutionary Genetics of Plants and Microorganisms

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
End of Semester

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

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

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

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

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

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

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

Courses (Type of course, Weekly hours per semester), Instructor:
Evolutionsgenetik der Pflanzen und Mikroorganismen (Übung, 2 SWS)
Tellier A [L], Tellier A

Evolutionsgenetik der Pflanzen und Mikroorganismen (Vorlesung, 2 SWS)
Tellier A [L], Tellier A
For further information in this module, please click campus.tum.de or here.

Module Description

WZ0635: Genetic Engineering of Livestock | Genetic Engineering of Livestock

Genetic engineering of livestock for applications in agriculture and biomedicine

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

Content:
Content includes:
- detailed information of the animal genome organization including eukaryotic gene structure.
- The function of the main structural and regulatory gene elements.
- Principles of DNA recombination, cloning vector design, usage of restriction enzymes, bacterial transformation, random transgene integration, DNA microinjection, methods for identification of a genetically modified organism,

- Generation of vectors for gene targeting, homologous recombination, tissue-specific recombination.
- Genome editing, CRISPR-Cas9 technology in livestock.
- Examples of genetically modified livestock.
- Ethical aspects of genome modification in livestock.

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

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

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

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

Reading List:
To be announced.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Genetically modified livestock- current literature overview (Seminar, 1 SWS)

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

Genetically modified livestock (Vorlesung, 2 SWS)
Fischer K, Flisikowska T, Flisikowski K, Schnieke A, Schusser B

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

Module Description

WZ0629: Genomics of Livestock Populations | Genomics of Livestock Populations

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

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

- Approaches to the identification of causal variants

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

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

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

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

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

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

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

Module Description

WZ1589: Marker-assisted Selection | Marker-assisted Selection

Former TUM School of Life Sciences Weihenstephan

Version of module description: summerterm 2021

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

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

Description of Examination Method:
In the 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 data sets for QTL- and association mapping as well as for genome wide prediction; theoretical background and experimental results for marker-assisted selection

Intended Learning Outcomes:
After successful completion of the module students are able to understand the basic concepts of marker-assisted selection, to apply statistical methods to experimental data sets and to use the respective genetic information in breeding programs. Students will be familiar with different

regression methods (e.g. single marker regression, multiple marker regression) in the analysis of quantitative trait loci through linkage or genome wide association mapping. Using regularized regression, they will be able to perform genomic prediction and selection. Based on examples from the literature they will be able to apply the above mentioned statistical methods to data. Using resampling methods, students will know how to evaluate the efficiency of marker-assisted prediction and selection and will be able to judge under which scenarios they are a useful tool for making breeding decisions.

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

Media:
PowerPoint presentations, chalkboard
Computer exercises, application training

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

Responsible for Module:

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

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

Module Description

WZ1033: Molecular Genetics of Crops | Molekulargenetik von Nutzpflanzen

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	summer 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:
Successful participation of the module is assessed by an oral examination (30 min) without additional help. Students show that they understand the different concepts of genome analysis in crops and that they can evaluate the required molecular techniques and the genetic strategies. In addition students answer questions to the use of bioinformatic methods and genome databases.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in plant breeding; basic knowledge in biology, cell biology, genetics and molecular biology

Content:
Basic concepts of plant genetics (classical and molecular)
Mapping of genes and genomes (monogenic/polygenic traits, physical mapping, genome sequencing)
Forward and reverse genetics methods (map-based cloning, characterisation of mutants, gene isolation, functional analysis)
Laboratory course (PCR, gel electrophoresis, cloning, plasmid
isolation, DNA sequencing)
Computer based exercises (handling of genome and sequence databases, analysis of sequencing data)

Intended Learning Outcomes:
After participation in the course students are able to evaluate different molecular techniques and genetic concepts for genome analysis in crops. They can explain research strategies for genome analyis and molecular genetics in crop plants and they can use common databases and online resources for the analysis of genomic sequencing data.

Teaching and Learning Methods:
The lecture (3 SWS) provides the basic theory and concepts. The computer exercise (1 SWS) provides knowledge on how to use genome and sequence databases and how to perform simple sequence analyses. In teams of 2-3 students they develop a research concept on the basis of current literature and show that they can apply the acquired methods and concepts to specific research questions.

Media:
PowerPoint, chalkboard, script, current literature

Reading List:
T.A. Brown, Genomes Taylor & Francis Ltd, 4th edition 2017; Griffiths et al.: An Introduction to Genetic Analysis. (2011, international edition); Current literature will be announced during the course.

Responsible for Module:
Bauer, Eva; Dr. rer. nat.

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

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

Module Description

WZ2581: Plant Biotechnology | Pflanzenbiotechnologie

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

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

In the seminar part different speakers from the TUM, which are active in research in plant biotechnology or plant molecular biology, introduce cutting-edge research projects that take place on campus. The seminar part is conceived to highlight the exciting research that currently takes place and advertise opportunities for master thesis projects.

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

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

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

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

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

Courses (Type of course, Weekly hours per semester), Instructor:
Pflanzenbiotechnologie (Seminar, 2 SWS)
Frey M [L], Benz J, Frey M, Hammes U, Lindermayr C, Ranf-Zipproth S, Rozhon W, Schneitz K, Schwechheimer C, Stam R, Stegmann M

Pflanzenbiotechnologie (Vorlesung, 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 | Plant Developmental Genetics 2

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

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

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

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

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

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

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

Courses (Type of course, Weekly hours per semester), Instructor:
Journal Club Entwicklungsgenetik der Pflanzen (Seminar, 2 SWS)
Schneitz K, Torres Ruiz R
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1185: Plant Epigenetics and Epigenomics | Plant Epigenetics and Epigenomics

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
End of Semester

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

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

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

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

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

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

Media:
PowerPoint presentations, software practicals

Reading List:
Hand-outs

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

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

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

Module Description

WZ0047: Plant Stress Physiology | Plant Stress Physiology

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

Content:
Definition, symptoms and physiology of stress in crop and model plants (e.g. barley, Arabidopsis thaliana). Influence of diverse biotic and some abiotic stress factors on development, hormone homeostasis, physiology and yield parameters of plants. Relevance of diverse plant stresses for plant performance in agroecological context. Methods of measuring and quantification of stress responses in plants (e.g. marker gene expression, calcium influx). Stress resistance, tolerance of plants and its experimental assessment. Measuring stress parameters such as chlorophyll fluorescence, lipid peroxidation, enzyme activities, reactive oxygen species formation.

Intended Learning Outcomes:
Upon completion of the module, students are able to remember theoretical background and definitions of plant stress physiology. They are able to understand and analyze plant stress

parameters. Students gain the ability to collect new theoretical knowledge and understand innovative technologies in plant stress physiology. They are able to self-sufficiently select and apply suitable methods from literature and exercises for measuring plant stress and to evaluate and interpret data. This enables students for the experimental design 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 relevance of plant stress and innovations in assessment and measurement of plant stress physiology. In the exercise, students practice in small groups, how to apply key methods for quantification of plant stress parameters. They document their data and discuss it with group members and tutors. In the seminar, students are guided … to critically read original research papers and present most recent findings in the field. They learn to critically interpret original work and current hypotheses in plant stress physiology.

Media:
PowerPoint

Reading List:
Reviews and original research papers are provided

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

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

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

Module Description

WZ1584: Quantitative Genetics and Selection | Quantitative Genetics and Selection

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2020/21

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

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

Description of Examination Method:
In the 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:
Successful Bachelor courses in applied statistics (e.g. module Statistische Methoden)

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

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

quantify resemblance between relatives. They are able to apply these concepts to selection theory for the optimization of breeding programs.

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

Media:
PowerPoint presentations, chalkboard
Computer exercises, application training

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

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

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

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

Module Description

WZ0638: Research Internship Agricultural Biosciences | Research Internship Agricultural Biosciences

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:

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

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

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

of their research project, analyze the acquired data and interpret these results in relation to current literature. They are able to explain their project in short oral presentations.

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

Media:

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

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

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

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

Module Description

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

Former TUM School of Life Sciences Weihenstephan

Version of module description: winterterm 2019/20

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

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

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

Repeat Examination:
Next semester

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

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

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

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

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

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

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

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

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

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

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

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

Alphabetical Index

A

B

C

D

E

Q

R

T

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