Georg-August-Universität
Göttingen

Modulverzeichnis

zu der Prüfungs- und Studienordnung für den konsekutiven Master-Studiengang "Integrated Plant and Animal Breeding" (Amtliche Mitteilungen I Nr. 7/2019 S. 60, zuletzt geändert durch Amtliche Mitteilungen I Nr. 50/2020 S. 1055)

Module

Übersicht nach Modulgruppen

I. Master-Studiengang "Integrated Plant and Animal Breeding"

1. Block A - Compulsory Modules

The following four compulsory modules worth overall 27 C must be successfully completed.

2. Block B - Elective compulsory modules A

Out of the following elective compulsory modules at least four modules worth overall at least 21 C must be successfully completed.

3. Block C - Elective compulsory modules B

Five additional modules worth overall at least 30 C must be successfully completed. Students can earn the credits through elective modules from any master study programme at the faculty of agriculture, University of Goettingen, from other institutions participating in the programme, or from other agricultural faculties or similar study programmes at other universities.

4. Block D - Key competencies

The following two compulsory modules worth overall 12 C must be successfully completed.

5. Master's thesis

Completion of the Master's thesis is worth 24 Credits.

6. Colloquium for the Master's thesis

Successful completion of the colloquium for the Master's thesis is worth 6 Credits.

II. Double-Degree Programme "European Master of Animal Breeding and Genetics" (EMABG)

Modules worth overall 120 C must be successfully completed. Modules worth 60 C must be completed following the regulations of the University of Goettingen. Another 60 C, including the Master’s thesis, must be earned and completed at one of the partner universities.

1. Block A - Compulsory modules

The following five compulsory modules worth overall 33 C must be successfully completed:

2. Block B - Elective compulsory modules

At least four modules worth overall at least 27 C must be successfully completed. From these at least two modules worth overall at least 9 C must be completed from a particular study track (letters a-c).

a. Study Track "Integrative Biology"

b. Study Track "Genomic selection"

c. Study Track "Biological and societal context of breeding"

Only one of the moduls M.SIA.E11 and E13M can be chosen.

d. Other modules

e. Alternative modules

In place of the modules listed above, it is also possible to complete other modules (alternative modules) in compliance with the following regulations. As a prerequisite for the consideration of an alternative module, the student must submit a written application addressed to the Studiendekan or Studiendekanin (dean of studies) at the faculty of agriculture. The student must submit the application before attending the respective module. The decision over the notification of acceptance or rejection will be made by the Dean of Study from the faculty of agriculture. Before reaching a decision, he or she will request a written statement from the teaching staff of the respective study programme, on the basis of which to judge the adequacy of requested

replacement of modules. The student’s application can be rejected without any explicit declaration of reasons; the student possesses no legal claim with respect to the permission of alternative modules.

Georg-August-Universität Göttingen **Modul M.Agr.0020: Genome analysis and application of markers in plantbreeding** *English title: Genome analysis and application of markers in plantbreeding*	6 C 4 SWS

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Studierende erlernen ihre Kenntnisse in klassischer Genetik auf Problemlösungen in züchterischen Situationen anzuwenden. Studierende erlernen selbständig sich Kenntnisse im Umgang mit großen Datensätzen anzueignen und sich in entsprechende Software einzuarbeiten.	Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltung: Genome analysis and application of markers in plantbreeding (Vorlesung, Übung) *Inhalte*: Überblick über verschiedene Typen von molekularen Markern. Schätzung von genetischen Distanzen. Grundlagen der klassischen Genetik zur Kopplungsanalyse. Konstruktion von Kopplungskarten. Markergestützte Rückkreuzung. Kartierung von QTL: Theorie und praktische Übungen mit großen Datensätzen aus früheren Experimenten. Grundlagen der Bioinformatik: Vergleich von DNA Sequenzen.	4 SWS
Prüfung: Klausur (90 Minuten) **Prüfungsvorleistungen:** Abgabe der Lösung von Übungsaufgaben **Prüfungsanforderungen:** Grundlagenkenntnisse in klassischen und molekularen Methoden der Kartierung von Genen. Basiskenntnisse im Einsatz molekularer Marker in der Pflanzenzüchtung.	6 C

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Englisch	**Modulverantwortliche[r]:** Prof. Dr. Timothy Mathes Beissinger
Angebotshäufigkeit: jedes Wintersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 20	

Georg-August-Universität Göttingen **Modul M.Agr.0114: Sicherheitsbewertung biotechnologischer Verfahren in der Pflanzenzüchtung** *English title: Biosafety evaluation of biotechnological approaches in plant breeding*	6 C 4 SWS

Lernziele/Kompetenzen: Vertieftes Verständnis von Sicherheitsbewertung und Sicherheitsmanagement biotechnologischer (einschließlich gentechnischer) Verfahren in der Pflanzenzüchtung; Erkennen komplexer Zusammenhänge zwischen Sicherheitsforschung, Sicherheitsbewertung und -management sowie zwischen gesetzlichen Regulierungen und wissenschaftlich-technischem Fortschritt auf nationaler und internationaler Ebene.	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltung: Anwendung und Rechtsrahmen gentechnischer Verfahren (Vorlesung, Exkursion) *Inhalte*: Sicherheitsbewertung, Beantragung und Durchführung gentechnischer Arbeiten in Labor und Gewächshaus: Rechtsrahmen, Kriterien, Voraussetzungen;Monitoring der Auswirkungen der Markteinführung gentechnisch veränderter Pflanzen: Zielsetzung, Rechtsrahmen, kritische Betrachtung (Zielstellung, Aufwand, Nutzen) ausgewählter Methoden;Gesetzliche Regelungen/Voraussetzungen für Freisetzungsversuche; Durchführung der Sicherheitsbewertung und Versuchsplanung, Beantragung, Versuchsdurchführung; Bedeutung und Notwendigkeit von Koexistenz, Situation in Deutschland/Europa, Confinement-Strategien.	
Lehrveranstaltung: Anwendung und Rechtsrahmen biotechnologischer Verfahren allgemein (Vorlesung, Exkursion) *Inhalte*: Anwendung und juristische Bewertung biotechnologischer Verfahren in der Pflanzenzüchtung; Sicherheitsforschung, -bewertung und -management; Pflanzen als Produktionsplattform - Perspektiven und Sicherheitsbewertung.	
Lehrveranstaltung: Neue Züchtungsverfahren in der Anwendung (Vorlesung, Exkursion) *Inhalte*: Gene targeting/editing, gene drive; vergleichende Auswirkung „klassischer“ und „neuer“ Züchtungsmethoden; Pflanzengenom- und Transkriptomanalyse, Datenbanken; next generation sequencing, Bioinformatik; Bewertung und Regulierung ausgewählter Züchtungsverfahren	
Prüfung: Klausur (90 Minuten) **Prüfungsanforderungen:** Anwendung und Rechtsrahmen gentechnischer Verfahren: Vertieftes Verständnis von gentechnischem Arbeiten in Labor und Freiland; Fallstudien; Monitoring und Koexistenz, Planung und Durchführung gentechnischer Versuche im Freiland; Anwendung und Rechtsrahmen biotechnologischer Verfahren allgemein:	6 C

Vertieftes Verständnis von Sicherheitsbewertung und Sicherheitsmanagement biotechnologischer Verfahren in der Pflanzenzüchtung; Fallstudien GV Pflanzen für Futter- und Nahrungsmittelanwendungen, GV Pflanzen als Produktionsplattform für industrielle & pharmazeutische Produkte sowie Energie Neue Züchtungsverfahren in der Anwendung: Vertieftes Verständnis und Sicherheitsbewertung neuer Züchtungsverfahren einschließlich Gentechnik und genome editing; Fallstudien vergleichende Sicherheitsbewertung und Bioinformatik	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch	**Modulverantwortliche[r]:** Dr. Ralf Wilhelm
Angebotshäufigkeit: jedes Sommersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 50	

Georg-August-Universität Göttingen **Modul M.Cp.0004: Plant Diseases and Pests in Temperate Climate Zones** *English title: Plant diseases and pests in temperate climate zones*	6 C 4 SWS

Lernziele/Kompetenzen: Students will be able to recognize and identify the main pests and diseases, understand the origin, distribution and dynamics of diseases and pests in the field as a basis for the development of control methods.	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltung: Plant Diseases and Pests in Temperate Climate Zones (Vorlesung, Exkursion, Übung) *Inhalte*: The main diseases and pests (fungi, viruses, bacteria, nematodes, mites, and insects) of crops (arable crops, vegetables, fruit crops) in temperate climate zones will be presented. The symptoms, diagnosis, biology and life cycles, economic importance, possible control methods will be studied in lectures, practicals and field trips. The economic damage, prognosis, possible control methods using economic thresholds will be presented.	4 SWS
Prüfung: Klausur (45 Minuten) **Prüfungsvorleistungen:** Teilnahme an Exkursionen und Übungen im Feld **Prüfungsanforderungen:** Identification and diagnosis of plant pests and diseases of crops of the temperate climate zones, knowledge of the life cycle, distribution, and population dynamics.	6 C

Zugangsvoraussetzungen: Only for students in the study programmes “Crop Protection”, EMJMD PlantHealth and “Sustainable international Agriculture”.	**Empfohlene Vorkenntnisse:** keine
Sprache: Englisch	**Modulverantwortliche[r]:** Dr. Birger Koopmann
Angebotshäufigkeit: jedes Sommersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Master: 2
Maximale Studierendenzahl: 30	

Georg-August-Universität Göttingen **Module M.Cp.0016: Practical statistics and experimental design in agriculture**	6 C 4 WLH

Learning outcome, core skills: The aim of the course is to familiarize students with the basic concepts of statistics and their application in agricultural science. The second goal is to learn the use of software packages like SAS.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Practical Statistics and Experimental Design in Agriculture (Lecture, Exercise) *Contents*: In the beginning of the course, students are introduced to the basic concepts of statistics like frequency distributions, the normal distribution and hypothesis testing. They are also introduced to software packages like SAS, that are used for the practical exercises. Regression and correlation analysis are then introduced. Different experimental designs like randomized block, latin square, and split plot are described and analyzed by one-way analysis of variance or as factorial experiments. Generalized Linear Models will be used and multivariate data will by analyzed by cluster and principal component methods. A large amount of examples and exercises constitute an important aspect of the course, enabling the students to understand and assimilate the theoretical content. Practical analyses of example data sets also provide the students with the required experience and skills for future statistical tasks in the context of Mastertheses.	4 WLH
Examination: Written examination (90 minutes) **Examination requirements:** Knowledge of the basic concepts of statistics and their application in agricultural science and in the use of software packages like SAS.	6 C

Admission requirements: none	**Recommended previous knowledge:** Mathematics, statistics
Language: English	**Person responsible for module:** Dr. Christian Kluth
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 2
Maximum number of students: 30	

Georg-August-Universität Göttingen **Module M.FES.324: Environmental Biotechnology and Forest Genetics**	6 C 4 WLH

Learning outcome, core skills: Basic principles of population genetics are introduced, factors shaping genetic diversity of tropical forest species are discussed with emphasis on the reproduction system of tropical forest plants, and genetic diversity patterns of tropical forest trees are described. Main applications of forest genetics are mentioned: provenance research and tree breeding, genetic implications of forest management, forest reproductive material, and conservation of forest genetic resources.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Tropical Forest Genetics (Lecture)	2 WLH
Course: Environmental Biotechnology (Lecture)	2 WLH
Examination: Oral examination (approx. 15 minutes)	6 C

Examination requirements: Sound knowledge of learning contents, achievement of learning outcomes and proof of aspired core skills.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Ursula Kües
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: cf. examination regulations	**Recommended semester:**
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Universität Kassel/Witzenhausen** **Module M.SIA.A02M: Epidemiology of international and tropical animal infectious diseases**	6 C 4 WLH

Learning outcome, core skills: Based on a scientific and practical up-to-date level, students know to evaluate and develop modern and effective livestock hygiene and husbandry concepts and to integrate them into complex quality management programs. Graduates are trained to be competent in implementing and communicating their knowledge in a multidisciplinary occupational setting that establishes epizootic control programs.	**Workload:** Attendance time: 84 h Self-study time: 96 h

Course: Epidemiology of international and tropical animal infectious diseases (Lecture, Exercise) *Contents*: Infectious diseases play an enormous role in international animal health control. National health and veterinary authorities, as well as international organizations (WHO, FAO) are very much involved in the surveillance of epidemics and establishment of health and hygiene monitoring programs. These efforts will increase in future, because of a further globalization of international markets, and will require well-educated experts collaborating worldwide in this multidisciplinary field. This module will give a generalized view of current epidemics together with a specialized understanding of infectious diseases and hygienic programs in subtropical and tropical countries. Characteristics of the biology of relevant infectious agents like parasites, fungi and bacteria together with their toxins, viruses, and prions will be presented in detail. Some of these germs included in this unit cause severe zoonotic diseases with a lethal danger for humans. Immunological host-defence mechanisms of wild and domestic farm animals against pathogens will be discussed together with modern strategies of active and passive immunizations. Diagnostic methods presently available and new biotechnological approaches in future assay and vaccine development will be demonstrated. The adaptation of practical health and standardized quality management processes to various animal production systems (ruminants, pigs, poultry) and the corresponding management measurements will be explained. The view will deeply focus on environmental impacts (water, soil, air hygiene), epizootiology and modern tools in epizootiological research. It will include biology and eradication of vectors (insects, ticks) transmitting pathogens of animal and zoonotic diseases, as well as biological and chemical methods for vector control. In the laboratory course, this module will also communicate well-established techniques of microbiological and parasitological diagnostics. Students will be practically trained in classical methods and in modern biochemical, immunological, biotechnological and molecular biological techniques for the detection of infectious agents, toxins and noxious substances. Tissue culture procedures for vaccine or antibody development are also used. Modification of livestock-environment interactions through human management are discussed.	4 WLH
Examination: Oral examination (approx. 90 minutes)	6 C

Examination requirements: Knowledge of current veterinary epidemic and infectious diseases inclusive emerging diseases. Background of hygiene and eradication programs. Profound knowledge in important infectious agents (parasites, fungi, bacteria, viruses) as well as toxins and prions. Skills in immunologic defense mechanisms of wildlife, zoo and domesticated animals in connection with modern active and passive vaccination strategies and biotechnological vaccine development. Knowledge in modern diagnostic tools as well as in biology and control of biological vectors (ticks, midges).	

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge (B.Sc. level) of soil, plant and animal sciences
Language: English	**Person responsible for module:** N. N.
Course frequency: each winter semester; Göttingen	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 30	

Additional notes and regulations:

Literature:

Lecture based materials.

Georg-August-Universität Göttingen **Universität Kassel/Witzenhausen** **Module M.SIA.A14: Organic livestock farming under temperate conditions**	6 C 4 WLH

Learning outcome, core skills: *Advances in animal nutrition and animal health:* Students get to know scientific tools for quantifying, assessing and evaluating problems within organic livestock production. *Animal welfare :* Students have a basic understanding of animal welfare, familiarize with different organic husbandry systems, practical problems and scientific concepts including how to assess animal welfare both at farm and system level. *Sustainable forage production systems:* Students are able to assess the relationships between sward management and structural (yield, botanical composition) and functional (nutrient efficiency) sward characteristics.	**Workload:** Attendance time: 60 h Self-study time: 120 h

Course: Animal Welfare (Lecture) *Contents*: • Principles of animal welfare in relation to organic farming; scientific methods of welfare assessment	1,33 WLH
Course: Advances in animal nutrition and animal health (Lecture) *Contents*: • Organic livestock production in Europe • Possibilities and limitations within organic farming to ensure a high level of animal health • Strategies within animal nutrition to increase the efficiency in the use of limited esources • System-oriented versus technical approaches	1,33 WLH
Course: Sustainable forage production systems (Lecture) *Contents*: • Design and management of a sustainable forage production • Management of forage quality and biodiversity on grassland • Minimizing nutrient losses towards water and atmosphere	1,33 WLH
Examination: Written examination (90 minutes) **Examination requirements:** Knowledge of basic terms relevant to organic livestock systems; insights into aspects of feeding, healthcare, welfare, forage production and forage quality assessment; linkages and interdependencies between the discussed fields. One written exam with all three parts**.**	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge (B.Sc. level) of animal sciences
Language: English	**Person responsible for module:** Prof. Dr. Albert Sundrum
Course frequency: each summer semester; Witzenhausen	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 35	

Additional notes and regulations:

Literature:

Advances in animal nutrition and animal health:

- Vaarst, M., Roderick, S., Lund, V., Lockeretz, W. (eds.) 2004: Animal health and welfare in organic agriculture. CABI Publishing

Animal welfare:

- Appleby, M.C., Hughes, B.O. (eds) 1997: Animal welfare. CAB International, Wallingford;
- Vaarst, M. et al. (eds.) 2004: Animal health and welfare in organic Agriculture. CAB International, Wallingford

Sustainable forage production systems:

- Hopkins, A. 2000: Grass, its production and utilization. Blackwell Science, Oxford, UK;
- Cherney J.H. 1998: Grass for dairy cattl.e CABI Publishing, Exon, UK;
- Frame, J. 1992: Improved Grassland Management. Farming Press Books, Ipswich, UK.

Georg-August-Universität Göttingen **Universität Kassel/Witzenhausen** **Module M.SIA.A15M: Scientific writing in natural sciences**	6 C 4 WLH

Learning outcome, core skills: In the course of their study programme, when compiling their MSc thesis and for their further (academic) career, students have to deliver a variety of scientific texts. Therefore, this module aims at presenting and discussing the main principles of such texts. It provides training in how to write different types of essays, abstracts, grant winning proposals and complex texts (chapters) in preparation and writing of the master thesis research. At successful completion of this module, participants will be able to: • differentiate the structure and format of various types of scientific texts; • search scientific literature, set up and manage an electronic literature database and compile reference lists; • write term papers, grant proposals, conference abstracts, and final thesis (chapters); • compile scientific tables and figures and be able to decide which type of data is best expressed in which format; • apply the rules of good scientific practice; • give and receive constructive feedback on scientific texts.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Scientific writing in natural sciences *Contents*: To provide participants with theoretical basics and practice these, the module will offer a mixture of lecture and exercises. Within the course a variety of facets and techniques of scientific writing will be imparted that graduate SIA students should be able to master. Consequently, participants are introduced to scientific literature search and analysis, good scientific practice and how to avoid plagiarism. Additionally, guidelines for creating concise tables and figures are presented. To be prepared for their master thesis work, students will be taught how to write different scientific text documents such as grant proposals and conference abstracts. By reviewing and discussing a scientific article and peer-reviewing an abstract of a fellow student by using an online tool, module participants will train how to give and receive constructive feedback. Finally, students will choose a topic for their term paper (see below) to further apply the newly acquired knowledge.	

Examination: 3 short written assignments (approx. 4 pages, 50%) are to be handed in during the semester and one major text (term paper, approx. 6 pages 50%) is to be submitted at the end of the semester.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of Word (Microsoft or Open Office) and Adobe Acrobat.
Language: English	**Person responsible for module:** Prof. Dr. Eva Schlecht

Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 3
Maximum number of students: 30	

Georg-August-Universität Göttingen **Universität Kassel/Witzenhausen** **Module M.SIA.E11: Socioeconomics of rural development and food security**	6 C 4 WLH

Learning outcome, core skills: Students learn concepts of development and problem-oriented thinking in a development policy context. The identification of interdisciplinary linkages is trained. Building on case-study analyses, course participants can pinpoint appropriate economic and social policies and assess their impacts. These qualifications can also be transferred to unfamiliar situations.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Socioeconomics of rural development and food security (Lecture) *Contents*: This module provides students with an overview of socioeconomic aspects of hunger and poverty in developing countries. Apart from more conceptual issues and development theories, policy strategies for rural development and poverty alleviation are discussed and analyzed. Special emphasis is put on problems in the small farm sector. Numerous empirical examples are used to illustrate the main topics.	4 WLH
Examination: Written examination (90 minutes) **Examination requirements:** Concepts and measurement of hunger and poverty; development theory; classification and evaluation of rural development policies	6 C

Admission requirements: none	**Recommended previous knowledge:** Prior knowledge of microeconomics at the BSc level is useful
Language: English	**Person responsible for module:** Prof. Dr. Matin Qaim
Course frequency: each winter semester; Göttingen	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 120	

Additional notes and regulations:

Literature:

Text books, research articles and lecture notes.

Georg-August-Universität Göttingen **Universität Kassel/Witzenhausen** **Module M.SIA.E13M: Microeconomic theory and quantitative methods of agricultural production**	6 C 4 WLH

Learning outcome, core skills: Microeconomic Theory of Agricultural Production Students are familiar with microeconomic approaches and can apply them to analyze issues related to agriculture and rural development. Quantitative Methods in Agricultural Business Economics Students are familiar with quantitative methods used for the analysis and planning of farms and enterprises in the agricultural sector.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Microeconomic theory of agricultural production (Lecture) *Contents*: Consumer theory, producer theory, markets, monopoly situations, risk and uncertainty, economics of technical change, farm household models, sharecropping contracts.	2 WLH
Course: Quantitative methods in agricultural business economics (Lecture) *Contents*: Budgeting, accounting, annual balance sheets, linear programming, finance, investment analysis	2 WLH
Examination: Written examination (120 minutes) **Examination requirements:** Consumer theory; producer theory; risk; technological progress; farm household models; budgeting and accounting; linear programming; finance; investment analysis	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Matin Qaim
Course frequency: each winter semester; Göttingen	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 40	

Additional notes and regulations:

Literature:

Text books, research articles and lecture notes.

After successful conclusion of M.Agr.0060 students can not complete M.SIA.E13M

Georg-August-Universität Göttingen **Universität Kassel/Witzenhausen** **Module M.SIA.I14M: GIS and remote sensing in agriculture**	6 C 4 WLH

Learning outcome, core skills: GIS: A broad overview of basic GIS functions and related background knowledge should enable students to explore GIS-Software for relevant commands and prepare functional strategies for spatial data management and analysis. Lecture and exercise examples have predominantly agricultural reference. Remote Sensing The lecture will introduce physical principles (reflectance, transmittance, and absorption), sensor techniques (passive and active sensors, satellites, field spectrometer) and methods of analysis (calibration, validation) in remote sensing applications. This technical framework is presented using agricultural examples, as e.g. the generation of maps for crop yield and protein, assessment of species composition in mixed vegetation (e.g. grassland), like legume content for a calculation of residual nitrogen and crop rotation effects.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: GIS (Lecture) *Contents*: The course gives an introduction to Geographical Information Systems (GIS). Starting from geodetical background information, a wide range of different GIS- methods and -functions are presented using agricultural examples (e.g. data import, georeferencing, aggregation, (re)classification, interpolation, overlays and image analysis). The students have the opportunity to carry out exercises on the computer themselves for some important GIS-procedures. A special focus is given on data capturing using maps and field data survey with GPS as well as the spatial analysis of site conditions. Finally a particular view on GIS in organic farm management and Precision Farming is given.	2 WLH
Course: Remote sensing in agriculture (Lecture) *Contents*: The lecture will introduce physical principles (reflectance, transmittance, and absorption), sensor techniques (passive and active sensors, satellites, field spectrometer) and methods of analysis (calibration, validation) in remote sensing applications. This technical framework is presented using agricultural examples, as e.g. the generation of maps for crop yield and protein, assessment of species composition in mixed vegetation (e.g. grassland), like legume content for a calculation of residual nitrogen and crop rotation effects.	2 WLH
Examination: Oral examination (approx. 30 minutes) **Examination requirements:**	6 C

Knowledge about basic GIS functions and the preparations of functional strategies for spatial data management. Knowledge of physical principles, methods of analysis and sensor techniques.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Dr. Thomas Möckel
Course frequency: each winter semester; Witzenhausen	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Additional notes and regulations:

Literature:

Principles of Geographical Information Systems
by Peter A. Burrough and Rachael A. McDonnell (2015)

Introduction to Remote Sensing
by James B. Campbell **a**ndRandolph H. Wynne (2011)

Georg-August-Universität Göttingen **Universität Kassel/Witzenhausen** **Module M.SIA.P13: Agrobiodiversity and plant genetic resources in the tropics**	6 C 4 WLH

Learning outcome, core skills: Students are able to understand the role of agrobiodiversity in tropical agro-ecosystems, to present approaches of functional biodiversity analysis and to discuss the needs and strategies of on-farm (in situ) and off-farm conservation of plant genetic resources.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Agrobiodiversity and plant genetic resources in the tropics (Lecture, Seminar) *Contents*: Case-study based analysis of the role of biodiversity for selected crops in different agro-ecosystems from the arid to the humid climate zones; importance of biodiversity for the stability / sustainability of smallholder (subsistence) versus commodity-oriented commercial agriculture in the Tropics, assessment and utilization of diversity, principles and practices in conservation of genetic resources, role of homegardens and indigenous wild fruit trees for in situ conservation of biodiversity, causes and consequences of genetic erosion, approaches of germplasm collection.	4 WLH
Examination: Oral exam (about 15 minutes, 60%) and presentation (about 20 minutes, 40%) **Examination requirements:** Students should be able to understand the role of agrobiodiversity in tropical agroecosystems, to present basic approaches to functionally analyse biodiversity and to discuss the need of and strategies for *in* and *ex situ* conservation of genetic resources.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge in plant and soil sciences
Language: English	**Person responsible for module:** Prof. Dr. Gunter Backes
Course frequency: each winter semester; Witzenhausen	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: not limited	

Additional notes and regulations:

Literature:

Altieri, M. 1987: Agroecology: the scientific basis of alternative agriculture. Westview Press, Boulder, Colorado, USA; Eyzaguirre, P.B., Linares, O.F. 2004: Home gardens and agrobiodiversity. Smithsonia

Books, Washington, USA; Wood, D., Lenne, J.M. 1999: Agrobiodiversity: Characterization, utilization and management. CABI Publishing, Wallingford, UK.

Georg-August-Universität Göttingen **Module M.iPAB.0001: Quantitative genetics and population genetics**	6 C 6 WLH

Learning outcome, core skills: Advanced knowledge of the basic model of quantitative genetics, genetic effects and parameters, breeding values and variances. Similarity between relatives, inbreeding, crossbreeding and heterosis. Dynamics of genetic variability in limited populations.	**Workload:** Attendance time: 84 h Self-study time: 96 h

Course: Quantitative genetics and population genetics (Lecture, Exercise) *Contents*: The genetic composition of a population in a single locus model, changes of gene and genotype frequencies, the polygenic model, components of phenotypic variance, relationship and inbreeding, heterosis and inbreeding depression, genetic drift, linkage disequilibrium, selection signatures. All contents are initially taught in theory and are consolidated in practical computer exercises (some with real data). Literature: Falconer & Mackay, Introduction to Quantitative Genetics (Prentice Hall), Lynch and Walsh, Genetics and Analysis of Quantitative Traits (Sinauer)	6 WLH
Examination: Written examination (90 minutes) **Examination requirements:** Advanced knowledge of the quantitative-genetic and population genetic basics of breeding, ability to apply appropriate methods to real data sets. Final exam with practical examination on computer.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of plant and animal breeding
Language: English	**Person responsible for module:** Prof. Dr. Henner Simianer
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.iPAB.0002: Breeding schemes and programs in plant and animal breeding**	6 C 4 WLH

Learning outcome, core skills:	**Workload:**
Students will learn the basic elements and structures of breeding programs in plant and animal breeding. They understand the relationship between biological characteristics of the crop or livestock species and the specific design of the breeding program. The students know the four breeding categories and design possibilities of breeding programs for self-pollination, cross-pollination and vegetative and clonally propagated crops. They learn breeding programs for major crops and livestock species.	Attendance time: 56 h Self-study time: 124 h

Course: Breeding schemes and programs in plant and animal breeding (Lecture, Excursion) *Contents*: Design of breeding programs. Basic elements of breeding programs: Breeding objectives and breeding planning, performance testing, selection and mate selection, use of biotechnologies, transfer of breeding progress in the production level, monitoring of the breeding progress. Breeding program structures in the most important crop species: cereals, corn, rape, sugar beet, specialty crops. Breeding program structures in the main livestock species: dairy cattle, pigs, poultry, beef cattle, small ruminants. Breeding program structures in forest genetics.	4 WLH
Examination: Written exam (45 minutes, 50%) and Presentation (about 20 minutes) with written outline (max. 10 pages) (50%) **Examination requirements:** Profound knowledge of basic breeding program structures and elements of breeding programs and their concrete implementation to various crops and livestock. Elaboration of the breeding planning for a livestock or crop species.	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Timothy Mathes Beissinger
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1
Maximum number of students: 20	

Additional notes and regulations:
Mandatory excursions to practical plant breeding and animal breeding programs.

Georg-August-Universität Göttingen **Module M.iPAB.0003: Statistical genetics, breeding informatics and experimental design**	6 C 4 WLH

Learning outcome, core skills: Novel biotechnological methods allow the production of very large data sets (gene sequences, genotypes, transcriptomes) at decreasing costs. Students learn about statistical and computational methods to use these records for breeding issues. Furthermore, the main experimental designs to plan, implement, and evaluate targeted and efficient experiments for data generation will be treated.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Statistical genetics, breeding informatics and experimental design (Lecture, Exercise) *Contents*: • Gene Expression Analysis • Genome-wide association analysis • QTL mapping • Statistical hypothesis testing • Regression methods • Analysis of variance • Multiple testing • Experimental designs (block designs, randomized designs, Latin squares) • Sample size estimation • Introduction to programming • Fundamentals of databases Literature: Andrea Foulkes: Applied Statistical Genetics with R; Francis O'Donnel: Statistical Experiment Design and Interpretation; An Introduction with Agricultural Examples	4 WLH
Examination: Written examination (60 minutes) **Examination requirements:** Profound knowledge of statistic and informatics methods to use them for breeding issues.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basics in statistics and genetics
Language: English	**Person responsible for module:** Prof. Dr. Armin Schmitt
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.iPAB.0004: Internship**	9 C 6 WLH

Learning outcome, core skills: Specialized knowledge of the respective field, social competences (working organization, teamwork, interdisciplinary working, flexibility), applied methodical competences.	**Workload:** Attendance time: 240 h Self-study time: 30 h

Course: Internship (Internship) *Contents*: Practical working in different areas of plant and animal breeding (industry, departmental research, consulting). Insights to working methods, areas of responsibility and the everyday professional life in plant and animal breeding. Acquisition of practical and applied knowledge and skills. Duration of Internship: 6 weeks	6 WLH
Examination: Homework (max. 20 pages, 50%) and presentation (about 20 minutes, 50%) **Examination requirements:** Practical working in different areas of plant and animal breeding, internship report and presentation.	9 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Stefan Scholten
Course frequency: each semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.iPAB.0005: Poultry breeding and genetics**	6 C 4 WLH

Learning outcome, core skills: The module teaches substantiated and application-orientated understandings of the poultry breeding sector. The main organizational and technological elements of the current breeding programs as well as their optimization to future breeding challenges will be provided. Thereby, breeding strategies of relevant economic traits will be shown concentrating on the development of selection strategies to improve functional traits (adaption to climate, disease resistance, behavior, reproduction, product quality, metabolic dysfunction). Students will learn the application of quantitative and molecular genetic technologies for the applied research in poultry breeding.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Poultry breeding and genetics (Lecture, Excursion) *Contents*: • Structure, Organization and Economics of Poultry Breeding • Breeding Strategies for primary and functional traits in poultry and water fowl (genetics and breeding in reproduction, feed conversion, growth, product quality, immune system, disease resistance, behavior and well-being, environmental adaption and metabolic stability). This includes particularly: • Methods of phenotyping and performance testing • Estimation of breeding values (conventional and genomic) • Selection index and BLUP • Genome-wide association studies (GWAS) and QTL mapping • Omics • Software application	4 WLH
Examination: Written examination (90 minutes) **Examination prerequisites:** Attendance to the mandatory excursion **Examination requirements:** Profound knowledge about applied poultry breeding.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of animal breeding
Language: English	**Person responsible for module:** Dr. sc. agr. Ahmad Reza Sharifi
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 30	

Additional notes and regulations:
Attendance to the mandatory two-day excursion.

Georg-August-Universität Göttingen **Module M.iPAB.0006: Breeding informatics**	6 C 4 WLH

Learning outcome, core skills: Students deepen their knowledge of informatics methods to evaluate large datasets for breeding issues.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Breeding informatics (Lecture, Exercise) *Contents*: • Design and implementation of databases with mySQL • Basic data structures • Programming in R and Perl • Regular expressions • Design and implementation of pipelines for data analysis • Shell scripts on Linux (gawk, sed) • Relation of genotype - phenotype • Measures to detect selection signatures • Basic concepts of bioinformatics	4 WLH
Examination: Written examination (90 minutes) **Examination requirements:** Profound knowledge of informatic methods to evaluate large datasets for breeding issues.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of molecular genetics, statistics, programing
Language: English	**Person responsible for module:** Prof. Dr. Armin Schmitt
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.iPAB.0007: Biotechnology and molecular genetics in plant and animal breeding**	6 C 4 WLH

Learning outcome, core skills: Profound knowledge of biotechnologies to decipher phenotypes and traits for plant and animal breeding. Skills to use appropriate molecular genetic tools to elucidate the genetic basis of traits. Development of creativity and independent as well as globally thinking to solve complex breeding challenges; effective communication skills (both orally and written); self-learners.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Biotechnology and molecular genetics in plant and animal breeding (Lecture, Excursion) *Contents*: Basics of genetics (Mendelian inheritance; karyograms; DNA, RNA and protein; gene structure; epigenetics), Biotechnologies for animal breeding (Artificial Insemination; Spermsexing; embryo transfer and associated techniques such as in vitro fertilization, embryo sexing, stem cells, cloning), Biotechnologies for plant breeding (in vitro cloning, induction of haploids, direct and indirect genetic transformation, interspecific sexual and somatic hybridization), Molecular genetics (PCR; qPCR; Recombinant DNA Technology; DNA markers; miRNA; Sanger sequencing; expression analysis; Next Generation Sequencing; array techniques; cytogenetics; proteomics; genome editing techniques). Literature: Clark & Pazdernik: Biotechnology (Academic Cell Publishing); Pineda & Dooley: Veterinary Endocrinology and Reproduction (Blackwell Publishing); Squires: Applied Animal Endocrinology (CABI); Krebs, Kirkpatrick, Goldstein: Lewin's Gene XI (Jones and Bartlett Publishing); Brown: Gene cloning and DNA analysis (Blackwell Science); Journal: Trends in Plant Science (Elsevier Ltd.)	4 WLH
Examination: Written examination (90 minutes) **Examination requirements:** The examinee should show the potential to solve breeding challenges applying the best biotechnologies and most accurate molecular genetic tools.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basics in animal and plant breeding
Language: English	**Person responsible for module:** Prof. Dr. Jens Tetens
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1
Maximum number of students: 20	

Additional notes and regulations:
The module includes a mandatory excursion to a DNA/Transcriptomics core facilitiy or a breeding

organisation.

Georg-August-Universität Göttingen **Module M.iPAB.0008: Molecular and biotechnological methods in plant and animal breeding**	6 C 4 WLH

Learning outcome, core skills: In addition to the theoretical background (Module M.Agr.0131 (Biotechnology and molecular genetics in plant and animal breeding)), the students should improve their basic knowledge in biotechnologies and molecular genetics by learning hand-on skills in the lab. The students should be capable to perform experiments on their own and to present them in an adequate manner.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Molecular and biotechnological methods in plant and animal breeding (Block course, Practical course) *Contents*: Sample collection; DNA and RNA isolation; Sanger Sequencing including the usage of appropriate software programs; Separation and visualization of nucleic acids; qualitative and quantitative PCR; ELISA assays to determine hormone profiles or as a pregnancy/ non pregnancy testing system; microsatellites; SNP; AFLP; storage of DNA and RNA; semen evaluation; in vitro generation and genetic analyses of embryos; direct and indirect transformation; protoplasts, in vitro propagation, androgenesis and gynogenesis; gene cloning. Literature: e.g. Current Protocols in molecular biology; A practical guide to basic laboratory endocrinology: Introduction to Plant Biotechnology	4 WLH
Examination: Protocol (max. 40 pages, 80%) and presentation (about 10 minutes, 20%) **Examination requirements:** The examinees should provide detailed information in their protocols including the biological background of the methods. The examinee should show its independent ability to conduct experiments in the lab.	6 C

Admission requirements: M.Agr.0131	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Jens Tetens
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 2
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.iPAB.0009: Genetic resources**	6 C 4 WLH

Learning outcome, core skills:	**Workload:**
Students learn the value of genetic resources for crop and livestock. They know different methods to describe the genetic diversity and for prioritization of measures for conservation and can apply them to a practical example. They know how to collect, evaluate and conserve genetic resources. They know different technological approaches (in vivo, in vitro) for the conservation and management of genetic resources. The students know methods for the utilization of genetic resources for breeding programs. The students know the history, political meaning and the institutions of the global system for the conservation of plant and animal genetic resources.	Attendance time: 56 h Self-study time: 124 h

Course: Genetic resources (Lecture, Seminar) *Contents*: Definition of genetic resources. Primary, secondary and tertiary gene pool. Crossability and adaptation of genetic resources. Genetic distances. Multivariate methods for DNA markers and phenotypic traits. Cluster analysis, principal component analysis. Implementation of analytical methods with appropriate software. Utilization of genetic resources for breeding. Starting points for the expansion of breeding pools with genetic resources. Monitoring of diversity and performance in the expansion of breeding pools. Excursion to the gene bank in Gatersleben Literature: FAO (2015) The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture	4 WLH
Examination: Written exam (45 minutes, 50%) and presentation (about 20 minutes, 50%) **Examination requirements:** Overview of genetic resources and their use in a livestock or crop species. Profound knowledge of utilization and conservation of genetic resources.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basics of plant and animal breeding
Language: English	**Person responsible for module:** Prof. Dr. Nils Stein
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.iPAB.0010: Legal issues in plant and animal breeding**	3 C 2 WLH

Learning outcome, core skills: The students know the relevant laws, regulations and procedures for plant and animal breeding in the areas of patent law, plant variety rights, plant variety protection, animal breeding, animal protection. Students know the legal basis for genetically modified organisms in the EU and globally. The students gain a deeper understanding of the importance of legal issues in breeding.	**Workload:** Attendance time: 26 h Self-study time: 64 h

Course: Legal issues in plant and animal breeding (Lecture, Seminar) *Contents*: Legal issues in plant and animal breeding (Lecture and Seminar) Contents: International intellectual property rights, biological patents, agreements on genetic resources, GMO laws and regulations incl. The preparatory phase of European legislation for modern biological breeding tools for genome editing. In terms of plant breeding, the module covers the following topics: plant breeders 'rights, European and German breeders' rights and marketing rights for seeds including procedures for testing and acceptance of varieties and operating license obtained seed. Regarding the animal breeding, the module covers the following topics: German animal breeding law, European legal framework, animal breeding related aspects of animal welfare legislation, legal regulations on animal testing, legal regulations of international trade with breeding animals and breeding products. Literature: Plant Variety Protection Law, Animal Breeding Law, Patent Law, regulation on genetically modified food and feed	2 WLH
Examination: Written examination (45 minutes) **Examination requirements:** Profound knowledge of all aspects of the legal basis of plant and animal breeding. Preparation of a case study on legal issues.	3 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Henner Simianer
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.iPAB.0011: Seed marketing**	6 C 4 WLH

Learning outcome, core skills: Students can apply the tools of marketing to the specifics of the researchintensive seed market. They will be able to apply modern research methods in order to collect information on agricultural procurement processes and public settings. On this basis they can develop targeted strategies for national and international markets. They know customized concepts and methods of distribution.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Seed marketing (Seminar) *Contents*: The marketing of seed is a hitherto largely unexplored field of research. In the research-oriented master's degree program, the students will learn the basics of the business-to-business marketing (positioning, market segmentation, competitive strategies, international marketing, marketing tools, sales management) and its application to the purchasing behavior of farmers. Since the seed market is a socially critical debated topic, fundamentals of public relations and the corporate social responsibility are taught. In a project report in the second part of the seminar, students will elaborate their own studies on current aspects of the seed marketing and present it in a presentation.	4 WLH
Examination: Written exam (60 minutes, 50%) and presentation (about 30 minutes, 50%) **Examination requirements:** Students show in the exam that they know the basics of seed marketing. In a scientific presentation they can demonstrate that they can apply this knowledge to current problems of the subject and are able to transfer their knowledge.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of marketing and market research (incl. statistics)
Language: English	**Person responsible for module:** Prof. Dr. Achim Spiller
Course frequency: every 4th semesterEvery 2 years. Start SoSe 2017	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 2 - 4
Maximum number of students: 30	

Georg-August-Universität Göttingen **Module M.iPAB.0012: Journal Club: Key papers in animal and plant breeding**	6 C 4 WLH

Learning outcome, core skills: Students gain competences in the opening and discussion of a scientific topic by using the literature in the field of plant and animal breeding. They also obtain skills in oral and written presentation of their investigation.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Journal Club: Key papers in animal and plant breeding (Lecture, Seminar) *Contents*: Teaching of methods for collecting and using of scientific contents and papers for a specific topic. Ability to discuss scientific texts in a deepened substantive way on the basis of a comprehensive literature review.	4 WLH
Examination: Presentation (about 20 minutes) with written outline (max. 10 pages) **Examination prerequisites:** Regular participation in 10 seminars **Examination requirements:** Preparation of a literature based seminar presentation including discussion and a short draft, Preparation of a co-moderation and discussion leading, attendance to seminars.	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Jens Tetens
Course frequency: each semester	**Duration:** 2 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.iPAB.0013: Selection theory, design and optimisation of breeding programs**	6 C 4 WLH

Learning outcome, core skills: Students are familiar with the theoretical basics of the selection theory even for complex cases (direct and correlated breeding progress, single- and multiple trait selection, multiple-path selection, gene flow method, optimum genetic contribution theory). Students are able to estimate the expected breeding progress for specific cases. They know the basic designs of breeding programs in plant and animal breeding and are able to model, calculate and optimize practical breeding programs by using suitable software programs.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Selection theory, design and optimisation of breeding programs (Lecture and Exercises) *Contents*: Introduction to the selection theory, direct and correlated breeding progress , single- and multiple trait selection , multi - path models , multiplepath selection, gene flow method, optimum genetic contribution theory; Explanation of typical breeding program structures in plant and animal breeding, principles of experimental design and optimal allocation of resources, introduction to breeding planning software (ZPLAN+, Genecont etc.), impact of selection on allele frequencies (Wright-model) and genetic variance (Bulmer effect), optimization of breeding programs under constraints (eg. conservation of genetic diversity). Literature: Walsh&Lynch: Evolution and Selection of Quantitative Traits	4 WLH
Examination: Written exam (45 minuntes, 50%) and presentation (about 20 minutes, 50%) **Examination requirements:** Profound knowledge of all aspects of the selection theory, application of methods for estimating the breeding progress, assessing the impact of different selection strategies to progress in breeding, inbreeding development and preservation of genetic variance. Modeling and optimization of a given breeding program with appropriate software.	6 C

Admission requirements: none	**Recommended previous knowledge:** Good knowledge of quantitative genetics and statistics
Language: English	**Person responsible for module:** Prof. Dr. Timothy Mathes Beissinger
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.iPAB.0014: Data Analysis with R**	3 C 2 WLH

Learning outcome, core skills: The students will be able to use methods provided by the statistical package R to perform the analysis of data sets that are typical in the life sciences. A core skill is the identification, usage and evaluation of online resources (e.g. packages and data sets).	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Data Analysis with R (Block course, Lecture, Exercise) *Contents*: The fundamental concepts of the programming package R will be presented and deepened during practical exercises. Statistical methods will be recapitulated if necessary. Special emphasis is put on visualization methods. Literature: Wiki-book "R programming" https://en.wikibooks.org/wiki/R_Programming "R for Beginners" by Emanuel Paradis https://cran.r-project.org/doc/contrib/Paradis-rdebuts_en.pdf "R tips" by Paul E. Johnson http://pj.freefaculty.org/R/Rtips.pdf	2 WLH
Examination: Oral examination (approx. 20 minutes) **Examination requirements:** Ability to analyze typical data sets with the statistical package R and interpretation of the results.	3 C

Admission requirements: none	**Recommended previous knowledge:** Knowledge of basic statistics concepts
Language: English	**Person responsible for module:** Dr. Mehmet Gültas
Course frequency: each semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 4
Maximum number of students: 24	

Georg-August-Universität Göttingen **Module M.iPAB.0015: Applied Machine Learning in Agriculture with R**	6 C 4 WLH

Learning outcome, core skills: Modern agricultural research involves more and more the analysis of large datasets comprising mesaurements of several variables. This module aims to teach interested students fundamental analysis skills that permit them to cope with such data sets. In more detail, the techniques that will be treated include: • clustering • artificial neural networks • support vector machine • decision trees • random forests • feature selection Involved mathematical formalism will be avoided. The focus is rather on: • gaining an intuitive understanding of the techniques • to develop an understanding about which type of problem can be treated with which technique • the application of the techniques using machine learning-functions under R • the graphical visualisation of the results • and the interpretation of the results The teaching will be based on the analysis of published real data sets from agricultural research projects as far as possible.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Applied Machine Learning in Agriculture with R (Block course) *Contents*: The course consists of lectures, exercises and project work. After the lectures and the exercises the students will have to carry out a project work that must be finished within eight weeks after the end of the lectures. The students as well as the other research groups are welcome to suggest topics, possibly questions related to their master thesis can be treated. The project work should be a concise written report of about ten pages in which one or several of the techniques that were treated in the course are applied.	4 WLH
Examination: Oral examination (approx. 20 minutes, 60%) and term paper (max. 10 pages, 40%) **Examination requirements:** • Knowledge about the analysis of big-data sets with the statistical package R and interpretation of the results. • Knowledge about different clustering algorithms • Analysis of real agricultural data sets by applying different machine learning-functions under R • Knowledge about feature selection approaches	6 C

Admission requirements: Recommended previous knowledge: Basic knowledge of R	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Dr. Mehmet Gültas
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 25	

Georg-August-Universität Göttingen **Module M.iPAB.0016: Applied effective R programming in animal breeding and genetics**	3 C 2 WLH

Learning outcome, core skills: The students will be able to efficiently use the programing language R on big animal datasets and to implement automated workflows for animal data analysis. They also will be enabled to distribute their implementations to end users.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Applied effective R programming in animal breeding and genetics (Lecture, Exercise) *Contents*: Effective usage of the programming language R applied to animal breeding and genetics examples. This includes detailed knowledge about the use of different data types and objects in R, automation and optimization of workflows, connection to third party software. • Data input/ output • Matrix algebra in R • Effective data management • Profiling/ Benchmarking • String modifications • Parallelization • Running self-executable R scripts via the command line	2 WLH
Examination: Term paper (max. 30 pages) (max. 30 pages) **Examination prerequisites:** Regular attendance of course **Examination requirements:** The term paper must include the code; self-executable application for a predefined task with focus on efficiency and usability, short description on how the task was solved.	3 C

Admission requirements: Basic knowledge of the programming language R, for example proven by the successful participation in the modules • M.Agr.0141: Data Analysis with R • B.Agr.0375: Bioinformatik • B.Agr.0308: Biometrie or comparable modules or proofs of knowledge.	**Recommended previous knowledge:** Basic command of R
Language: English	**Person responsible for module:** Prof. Dr. Henner Simianer
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**

twice	Master: 2
Maximum number of students: 30	

Additional notes and regulations:
EMABG students will be taken preferred before all others. iPAB and M.Agr. Animal Science before others.

Georg-August-Universität Göttingen **Module M.iPAB.0017: Applied Bioinformatics with R**	6 C 4 WLH

Learning outcome, core skills: This module will cover the fundamental concepts of bioinformatics. Topics will include usage of relevant/modern biological databases and tools that are required to perform different analyses. Further, an introduction to multi-omics-data will be given, including genome, trancriptome and proteome analysis. This module aims to teach interested students fundamental analysis skills to evaluate biological data using bioinformatic techniques, and to become proficient in performing such analyses. In more detail, following topics will be treated: • Analysis of multi-omics data • Standard databases in bioinformatics • DNA sequence and genome analysis • Variant calling techniques • Sequence alignment • Gene regulatory network analysis • Clustering The lecture will be based on the analysis of real data sets from agricultural research projects as far as possible.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Applied Bioinformatics with R (Lecture, Exercise) *Contents*: The course consists of lectures, exercises and a project work. After the lectures and the exercises the students will have to carry out a project work that must be finished within ten weeks after the end of the lectures. The students as well as the other research groups are welcome to suggest topics, possibly questions related to their master thesis can be treated. The project work should be a concise written report of about ten pages in which one or several of the techniques that were treated in the course are applied.	4 WLH
Examination: Oral examination (approx. 20 minutes, 75%) and term paper (max. 10 pages, 25%) **Examination requirements:** • Knowledge about the fundamental concepts of bioinformatics • Knowledge about different databases in bioinformatics • Analysis of biological data, interpretation and modeling og biological information and applying this to the solution of biological problems in any area involving molecular data.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of R
Language: English	**Person responsible for module:** Dr. Mehmet Gültas
Course frequency: each winter semester	**Duration:** 1 semester[s]

Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 30	

Georg-August-Universität Göttingen **Module M.iPAB.0018: Introduction to the molecular genetic analysis of plant genetic resources**	6 C 4 WLH

Learning outcome, core skills: Students apply knowledge acquired in Module M.Agr.0133: Genetic Resources (GenRes). They have a broad overview of available molecular marker technologies for characterisation and quality management of GenRes. They familiarize by own hands-on experience with next-generation-sequencing based characterization of plant genetic resources. They apply computational tools for raw data acquisition and perform basic analytical steps in population characterization, genetic diversity analysis and/or genetic mapping.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Introduction to the molecular genetic analysis of plant genetic resources (Block course, Excursion, Seminar) *Contents*: Introduction into Molecular Marker and Next Generation Sequencing Technologies: principle of methodology, sample preparation requirements, infrastructure requirements for data storage and analysis. Wet lab experiments (performed in teams of two at IPK): NGS library preparation, NGS sequencing and data acquisition. Data analysis experiments 1. individually and as a team, at IPK: existing training datasets will be used for performing basic steps of raw data processing and downstream data analysis (read mapping, SNV calling, allele frequency test, mapping, GWAS, PCA) 2. group work/homework: NGS samples processed during the practical course will be analysed in team work by the participants based on the acquired knowledge. Results will be presented and discussed during the literature seminar day at GAU. Literature seminar: every participant will select an original paper on the topic during the course and present a seminar to the group at a later timepoint during the same semester. Excursion to IPK Genebank: this excursion to IPK will give insights into in field collection management during replication cycles for self-, cross-pollinating crops or vegetatively propagated species including practices of acquisition of legacy data. *Literature:* FAO (2015) The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture;	4 WLH
Examination: Written report (max. 10 pages, 50%) and presentation (approx. 20 minutes; 50 %) **Examination requirements:** Submission of written reports (lab protocols and analysis results); knowledge of molecular marker and NGS technology for collection characterisation and management	6 C

Admission requirements:	**Recommended previous knowledge:**

M.Agr.0133	Basics of plant and animal breeding, Molecular Genetics
Language: English	**Person responsible for module:** Prof. Dr. Nils Stein
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 10	

Georg-August-Universität Göttingen **Module M.iPAB.0019: Scientific Project: scientific methods, procedures and practical skills in animal and plant breeding**	9 C 6 WLH

Learning outcome, core skills: Advanced knowledge of scientific methods, procedures and practical skills in the field of animal as well as plant breeding acquired by the active participation in a research project. Students also gain key competencies such as team working, interdisciplinary working, and self-organization.	**Workload:** Attendance time: 60 h Self-study time: 210 h

Course: Scientific Project: scientific methods, procedures and practical skills in animal and plant breeding *Contents*: Working on a scientific project in the different fields of breeding research. Testing of scientific hypotheses, experimental design, analysis of genotyping data, data analysis, interpretation and presentation of the research results.	6 WLH

Examination: Term paper (max. 20 pages) **Examination requirements:** Active and independent working on a plant or animal breeding related scientific issue.	9 C

Admission requirements: The students, who are enrolled in the “Integrated plant and animal breeding (IPAB)” program, must get an approval from the program coordinator at least one month prior to the desired start date of the project.	**Recommended previous knowledge:** Basics of plant and animal breeding, statistics, and scientific writing
Language: English	**Person responsible for module:** Dr. Mehmet Gültas
Course frequency: each semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 25	

Georg-August-Universität Göttingen **Module M.iPAB.0020: Breeding Lab Internship**	9 C

Learning outcome, core skills: Students acquire professional and social skills to successfully execute a team project in complex international animal breeding business conditions. Students gather, select, and analyze information and integrate it into a viable R&D proposition, aimed at value creation. Students attain the ability to systematically evaluate information following a systematic structure, as well as take complexity (such as cultural and social awareness) into account during decision making. Furthermore, students practice professional behavior and habitus in a competitive international environment. They are able to discuss and defend their viewpoints and conclusions in a professional and academically correct way before industry representatives.	**Workload:** Attendance time: 160 h Self-study time: 110 h

Course: Breeding Lab Internship (Internship, Seminar) *Contents*: Management structures, communication and collaboration techniques when working in diverse groups, conflict management, product concept development, industry methods and practices, as well as insights into areas of responsibility and the everyday professional life of an animal breeder. Students experience a specialized animal breeding working environment outside of a university setting. Placement in non-university setting approx.4 weeks	

Examination: Presentation (approx. 15 minutes, 50%) with written report (max. 15 pages, 50%) **Examination prerequisites:** Practical work in non-university animal breeding field. Regular attendance during the four weeks. **Examination requirements:** Reflection on learning outcomes and personal experiences, as well as problem-solving capabilities and working in a diverse group outside of a university setting.	9 C

Admission requirements: Only EMABG Students	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Henner Simianer
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** from 1
Maximum number of students: 20	

Additional notes and regulations:

Students are present approx. 4 weeks at an associated partner (non-university organization) to gain insights and establish contact regarding R&D proposition. The students have extended time (approx. 4 weeks) to work on their project upon leaving the associated partner. Whenever possible, the result will be presented to and co-graded by a representative from the associated partner.

Georg-August-Universität Göttingen **Module M.iPAB.0021: Plant in vitro Cultures and Somatic Cell Genetics**	6 C 4 WLH

Learning outcome, core skills: The students are able to plan and perform plant bio- and gene-technological procedures independently and to assess their suitability for breeding related questions considering scientific and economic issues.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Plant in vitro Cultures and Somatic Cell Genetics (Block course, Lecture, Exercise)

Contents:

Lecture Contents

- Overview on bio- and gene-technological methods
- Theoretical basis, genetics and epigenetics of plant tissue culture methods
- Focus on Somatic Hybridization-, Doubled-Haploid- and Genome Editing-related plant tissue culture technology
- Methodology and strategies in genome editing and its verification
- Applications in applied breeding and plant research
- Scientific standards of lab work documentation

Practical Contents

- Design and cloning of gene specific guide-RNA
- Protoplast fusion and transformation
- Mutation detection and analysis
- Biolistic Transformation
- Embryo rescue and germination

Basics and context of biotechnological practical work by means of discrete, consecutive project work on CRISPR/Cas9 based genome editing including vector design, cloning and activity validation. The project sequence includes:

- *In silico* design of gene specific guide RNA
- Cloning of CRISPR/Cas9 vectors
- Transient transformation of the vectors in protoplasts
- Determination of the mutation efficiency by endonuclease assays

Examination: Protocol (max. 25 pages, 70%) and oral examination (approx. 15 min., 30%). **Examination requirements:** Regular attendance of practical (minimum of 90%). Formal protocol with scientifically sound lab work documentation including introduction, methods, results and discussion.	6 C

Knowledge on practical implementation, execution and applicability of molecular and cell culture methods in research and breeding	

Admission requirements: none	**Recommended previous knowledge:** Units of applied molecular biology and its conversion
Language: English	**Person responsible for module:** Prof. Dr. Stefan Scholten
Course frequency: each summer semester	**Duration:**
Number of repeat examinations permitted: twice	**Recommended semester:** until 3
Maximum number of students: 12	

Georg-August-Universität Göttingen **Module M.iPAB.0022: Molecular Genetics and Genomics**	6 C 4 WLH

Learning outcome, core skills: The students are able to plan and perform complex molecular techniques independently and to assess their suitability for breeding related questions considering scientific and economic factors.	**Workload:** Attendance time: 80 h Self-study time: 100 h

Course: Molecular Genetics and Genomics (Block course, Lecture, Exercise) *Contents*: *Lecture Contents* • Overview on molecular methods in gene and genome analysis • Theoretical basis of classical and new marker technologies • Methodology, areas of use, and automation of sequencing technologies • Applications in applied breeding and breeding research *Practical Contents* Basics of molecular biology practical work with nucleic acids by means of discrete performing polymerase chain reactions (PCR), short sequence repeats (SSR) and single nucleotide polymorphism (SNP) marker protocols. Robotics for high-throughput and miniaturization of molecular biology methods by means of using pipetting robots for single steps of the custom procedures. Custom procedures for genome and transcriptome analysis: • Production of sequencing libraries for genotyping DNA by sequencing (GBS). • Production of sequencing libraries for strand specific 3’ targeted gene expression analysis by Digital Gene Expression RNA sequencing (3’ DGE RNA-seq).	

Examination: Protocol (max. 25 pages, 70%) and oral examination (approx. 15 min., 30%) **Examination requirements:** Regular attendance of practical (minimum of 90%). Formal protocol with scientifically sound lab work documentation including introduction, methods, results and discussion. Knowledge on practical implementation, execution and applicability of molecular marker and sequencing technology in research and breeding	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Stefan Scholten
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**

twice	
Maximum number of students: 12	