Module Handbook

Master's programme
Evolutionary Biology

Faculty of Biology

This module handbook serves as a comprehensive overview of the content and organization of the entire JGU degree program in Evolutionary Biology. It encompasses a study plan and a module overview.

The handbook provides information on the following aspects:

- Essential prerequisites for completing a module
- Schedule of when a module and its courses are offered
- Contents and learning objectives of the individual modules or courses
- Type and degree of obligation associated with the modules or courses
- Contact hours (SWS; h) and workload (h) per module and course
- Certificates of achievement required for individual courses
- Type of module examinations and the composition of the module grade
- Number of credit points (LP) awarded upon successful completion of the module
- Individuals responsible for each module
- The broader applicability of a module in other degree programs

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Abbreviations:

V	=	Vorlesung / lecture
Ü	=	Übung / exercise
S	=	Seminar / seminar
Ex	=	Exkursion / excursion
Pro	=	Projekt / project
Pfl.	=	Pflichtlehrveranstaltung /compulsory course
WPf.	=	Wahlpflichtlehrveranstaltung /elective compulsory course
LP	=	Leistungspunkte / credit points
SWS	=	Semesterwochenstunde / semester hours (45 min.) per week (contact time)
SoSe	=	Sommersemester / summer semester
WiSe	=	Wintersemester / winter semester

Further Explanation of Terms:

- **Workload:** Calculated as either credit points multiplied by 30 or the sum of contact time and self-study.
- **SWS (Semester Hours per Week):** 1 SWS equals 45 minutes per week throughout the entire semester, which spans 14 weeks.
- **LP (Leistungspunkte) = CP (Credit Points):** This refers to credit points according to the ECTS system (European Credit Transfer System). ECTS is a system that enhances the international comparability of modules based on workload, contact time, learning effort, and degree of difficulty. One credit point (CP) is equivalent to approximately 30 working hours, comprising both contact time with the lecturer and time dedicated to self-study.

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Study Plan / Studienverlaufsplan

1st semester (30 LP):

- 3 compulsory modules (M1, M2, M3)

2nd semester (30 LP):

- 3 compulsory elective modules (M4).
  Approximately 7 modules are offered (M4A, B, C,....), and students can choose 3 of these

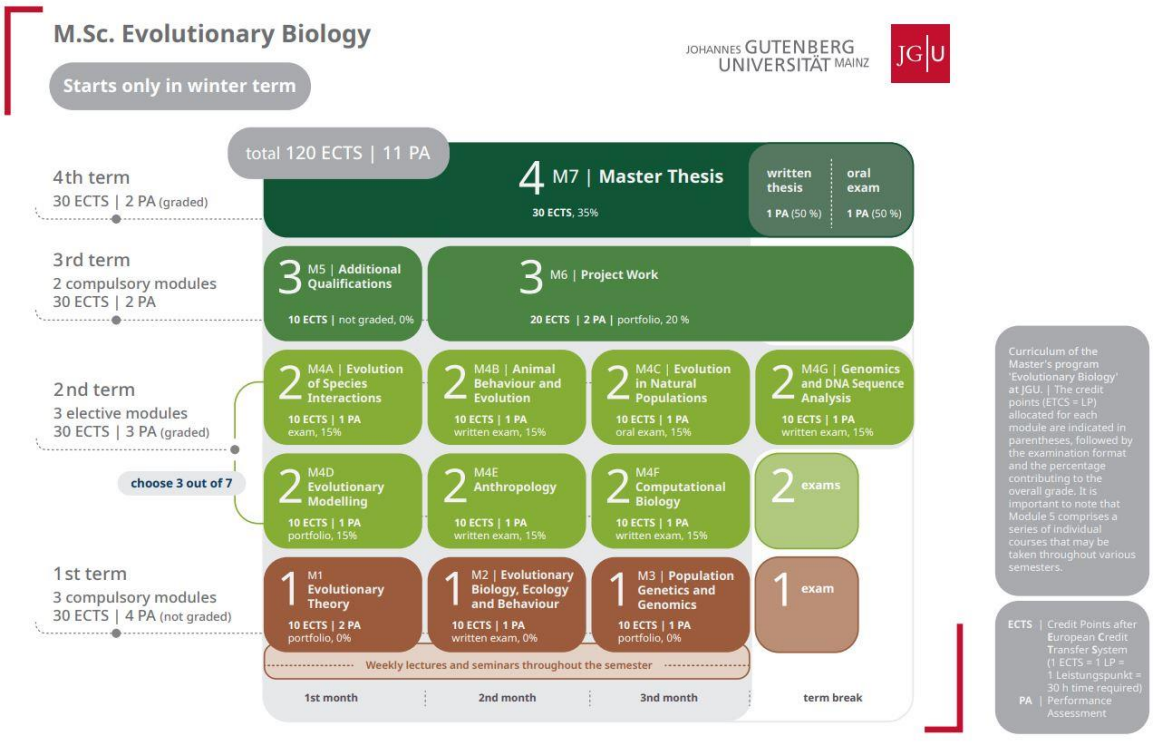
3rd semester (30 LP):

-1 compulsory module "Advanced Qualifications" (M5)
Courses within this module can be taken throughout the entire duration of the study program

-1 compulsory module "Project Work" (M6)

4th semester (30 LP):

- 1 compulsory module "Masterthesis" including the final exam (M7)



Curriculum of the Master's program 'Evolutionary Biology' at JGU. It is important to note that Module 5 comprises a series of individual courses that may be taken throughout various semesters

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

Study plan M.Sc. Evolutionary Biology at the Johannes Gutenberg-University Mainz

The M.Sc. program in Evolutionary Biology is a sequential Master's program with a pronounced emphasis on research-oriented teaching. The program commences each winter semester with three compulsory modules attended by all students. These modules consist of semester-long lectures and three accompanying exercises, presented in one-month blocks. From the outset, students have the opportunity to attend various activities that collectively constitute Module 5, providing them with additional soft skills.

The first module imparts theoretical fundamentals of evolutionary biology. The second module covers diverse aspects of general evolutionary biology, encompassing ecology, behavior, diversity, and biotic interactions of animals and plants. This module includes a corresponding laboratory practical. The third module introduces population genetics and genomics, featuring a parallel programming course. Through these three modules, all students attain uniform methodological prerequisites across theory, laboratory work, and computer skills, along with comprehensive knowledge in various facets of modern evolutionary biology.

In the second semester, students select three elective modules offered by individual research groups. These modules span general evolutionary biology, biotic interactions, ecology, behavior, theoretical biology, population biology, anthropology (including primatology), and bioinformatics. Practical exercises, supplemented by theoretical components, are the main focus during this semester.

The third semester entails a project work (Module 6), akin to an extensive lab, theory or computer course, involving independently conducted scientific experiments. Data generated in this module are analyzed and documented in the subsequent Master's thesis module (M7). Alternatively, the project work and the master's thesis can encompass two distinct scientific projects. The final examination takes place at the conclusion of M7.

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

Studienverlaufsplan Studiengang M.Sc. Evolutionary Biology (Evolutionsbiologie) an der Johannes Gutenberg-Universität Mainz

Das M.Sc.-Programm in Evolutionärer Biologie ist ein konsekutives Masterprogramm mit einem klaren Fokus auf forschungsorientierte Lehre. Das Programm beginnt jeweils im Wintersemester mit drei Pflichtmodulen, die von allen Studierenden gemeinsam belegt werden. Diese Module umfassen jeweils eine semesterlange Vorlesung und drei Übungen, die in einmonatigen Blöcken angeboten werden. Von Anfang an haben die Studierenden die Möglichkeit, eine Reihe von Kursen zu besuchen, die gemeinsam das Modul 5 bilden und den Studierenden zusätzliche Soft Skills vermitteln.

Im ersten Modul werden die theoretischen Grundlagen der evolutionären Biologie vermittelt. Im zweiten Modul werden zahlreiche Aspekte der allgemeinen evolutionären Biologie, einschließlich Ökologie, Verhalten, biotische Diversität und Interaktionen von Tieren und Pflanzen, gelehrt. Dieses Modul beinhaltet auch ein entsprechendes Laborpraktikum. Das dritte Modul führt in Populationsgenetik und Genomik ein, einschließlich eines entsprechenden Programmierkurses. Durch diese drei Module erwerben alle Studierenden einheitliche methodische Voraussetzungen in den Bereichen Theorie, Labor und Computer sowie umfassende Kenntnisse in verschiedenen Aspekten einer modernen evolutionären Biologie.

Im zweiten Semester wählen die Studierenden drei Wahlpflichtmodule, die von einzelnen Forschungsgruppen angeboten werden. Diese Module umfassen die Bereiche allgemeine evolutionäre Biologie, biotische Interaktionen, Ökologie, Verhalten, theoretische Biologie, Populationsbiologie, Anthropologie (einschließlich Primatologie) und Bioinformatik. Praktische Übungen, ergänzt durch theoretische Komponenten, stehen im Mittelpunkt dieses Semesters.

Im dritten Semester folgt eine Projektarbeit (Modul 6), die einem umfangreichen Labor-, Theorie- oder Computerkurs entspricht und selbständig durchgeführte wissenschaftliche Experimente einschließt. Die in diesem Modul generierten Daten werden im anschließenden Masterarbeit-Modul (M7) analysiert und dokumentiert. Alternativ können die Projektarbeit und die Masterarbeit zwei unabhängige wissenschaftliche Projekte umfassen. Die Abschlussprüfung findet am Ende von M7 statt.

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MODULES OVERVIEW

Modules for semester 1 (compulsory)					
Module	Title	Working groups involved	Module examination	LP	Contribution to the overall grade
M1	**Evolutionary Theory**	Kokko, NN	portfolio examination	10	0 %
M2	**Evolutionary Biology, Ecology and Behaviour**	Foitzik, Xu, Huber	written exam	10	0 %
M3	**Population Genetics and Genomics**	Burger, Huylmans, Andrade	portfolio examination	10	0 %

Modules for semester 2 (compulsory elective; three can be selected from the following)					
Module	Title	Working groups involved	Module examination	LP	Contribution to the overall grade
M4A	**Evolution of Species Interactions**	Xu, Huber	written or oral exam (graded)	10	15 %
M4B	**Social Evolution: from genes to behavior**	Foitzik, Menzel	written exam (graded)	10	15 %
M4C	**Evolution in Natural Populations**	NN	oral exam (graded)	10	15 %
M4D	**Evolutionary Modelling**	Kokko	Portfolio examination (graded)	10	15 %
M4E	**Anthropology**	Herlyn, Burger	written exam (graded)	10	15 %
M4F	**Computational Biology**	Andrade	written exam (graded)	10	15 %
M4G	**Genomics and DNA Sequence Analysis**	Hankeln	written exam (graded)	10	15 %

Modules for semester 3 (compulsory)					
Module	Title	Working groups involved	Module examination	LP	Contribution to the overall grade
M5	**Additional Qualifications**	Huber, Huylmans, Foitzik, Burger, Dreesmann, Xu, Menzel, Herlyn, Griebeler	depending on course	10	0 %
M6	**Project Work**	All working groups of the Institute of Organismic and Molecular Evolutionary (iomE) of FB10 offer project works	portfolio examination	20	20 %

Module for semester 4 (compulsory)					
Module	Title	Working groups involved	Module examination	LP	Contribution to the overall grade
M7	**Master Thesis** (6 months)	All working groups of the Institute of Organismic and Molecular Evolutionary (iomE) of FB10 offer master theses	• Master´s thesis (graded 50 %) • Oral examination (graded 50 %)	30	35 %

Module M1	Evolutionary Theory					
Compulsory or elective module	**compulsory (P)**					
Credit points (LP) and workload	**10 LP = 300 h**					
Module duration (according to study plan)	**1 semester**					
Courses/ Forms of learning	**Type**	**Standard semester at start of study WiSe**	**Commitment level**	**Contact time (SWS)**	**Self-study**	**Credit points**
Lecture series on evolutionary theory	V	1	P	2 SWS / 21 h	69 h	3 LP
Understanding models of evolutionary logic and their tests	S	1	P	1 SWS / 10 h	140 h	5 LP
Re-creating classic model	Ü	1	P	1 SWS / 10 h	50 h	2 LP

In order to be able to complete the module, the following achievements must be made:	
Presence	S, Ü
Active participation	according § 5 Abs. 3
Course achievement(s)	carry out arithmetic tasks
Module exam	portfolio examination

Qualification goals/learning outcome/competences

Understand evolutionary theory: from basic population genetics to specific models of key questions in evolution.
Develop an understanding of how mathematical modelling can help elucidate the evolutionary logic underpinning predicted directions of evolutionary change
Develop an understanding of how theoretical expectations are pitted against empirical data, including knowledge of classic experiments and basics of the comparative analysis
Improved understanding of the scientific method, a basic ability to constructively criticise a scientific paper
Knowledge of diversity of reproductive strategies, life cycles and life histories across the tree of life

Content

The semester-long lecture series presents conceptual topics in evolutionary biology. The topics covered: levels of selection, natural selection, social evolution, origin and maintenance of sex and two (or more) mating types or sexes, sexual selection, spatial evolution, evolutionary rescue in changing environments, life history theory, evolution in settings of biotic interactions, and anthropogenic evolution. Each topic is also presented in a seminar with either a classic or a new publication, with students giving presentations on the publication, followed by a discussion of the merits and limitations of the study in question. Each topic is additionally presented with very simple models from the literature that are re-run in R.

Access requirement(s)	/
Recommended prerequisite(s) for the module or for individual courses of the module	/
Language(s) of instruction and examination(s)	English
Weight of the module grade in the overall grade	0%
Frequency in the offer	Once a year
Reasons for compulsory attendance events	Attendance is compulsory in both seminar and exercise, as practical exercises are carried out together within the group throughout the module, without which the learning objective cannot be achieved
Module offices	Prof. Hanna Kokko
Usability of the module in other degree programmes	M.Sc. Biology, M.Sc. Neuroscience, M.Sc. Applied Bioinformatics; M.Sc. Computer Science with Minor in Physics, Mathematics or Biology, M.Sc. Biomedicine
Other	/

Module M2	Evolutionary Biology, Ecology and Behaviour					
Compulsory or elective module	**compulsory (P)**					
Credit points (LP) and workload	**10 LP = 300 h**					
Module duration (according to study plan)	**1 semester**					
Courses/ Forms of learning	**Type**	**Standard semester at start of study WiSe**	**Commitment level**	**Contact time (SWS)**	**Self-study**	**Credit points**
Lecture series Evolution, Ecology, Behaviour	V	1	P	2 SWS / 21 h	69 h	3 LP
Methods Evolution, Ecology, Behaviour	Ü	1	P	5 SWS / 52 h	98 h	5 LP
Presenting and discussing scientific literature in the field	S	1	P	2 SWS / 21 h	39 h	2 LP

In order to be able to complete the module, the following achievements must be made:	
Presence	Ü
Active participation	according § 5 Abs. 3
Course achievement(s)	/
Module exam	written exam (60 min., graded)

Qualification goals/learning outcome/competences

Understanding key concepts and empirical findings in the field of evolutionary and behavioural ecology
Being able to plan and conduct an experiment in evolutionary biology including experimental design, data collection and statistical analyses
Being able to understand and critically discuss scientific publications in the field of empirical evolutionary research
Being able to use molecular, chemical, behavioural and biostatical methods to address evolutionary questions

Content

Introductory lecture into the field of evolutionary biology, ecology and behaviour, including subjects such as sexual selection, social evolution, co-evolution, biotic interactions, eco-evolutionary dynamics, community ecology, ecosystems, global change biology and conservation science, molecular ecology, chemical ecology. The exercise include experimental design, performing experiments, data collection and statistical analyses of empirical data sets using basic statistical analyses (including glm, lm), molecular and chemical techniques in the lab used in evolutionary research, including DNA / RNA extraction, qPCR, GC-MS, LC-MS etc using insects and plants as model systems. The seminar is used to introduce students to the scientific literature, by presenting and discussing empirical papers in the field, with a special focus on the methods and statistics deployed in evolutionary research.

Access requirement(s)	/
Recommended prerequisite(s) for the module or for individual courses of the module	/
Language(s) of instruction and examination(s)	English
Weight of the module grade in the overall grade	0%
Frequency in the offer	Once a year
Reasons for compulsory attendance events	/
Module offices	Prof. Susanne Foitzik; Prof. Shuqing Xu, Prof. Meret Huber
Usability of the module in other degree programmes	M.Sc. Biology, M.Sc. Neuroscience, M.Sc. Applied Bioinformatics; M.Sc. Computer Science with Minor in Physics, Mathematics or Biology, M.Sc. Biomedicine, M.Sc. Biomedical Chemistry
Other	/

Module M3	Population Genetics and Genomics					
Compulsory or elective module	**compulsory (P)**					
Credit points (LP) and workload	**10 LP = 300 h**					
Module duration (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Standard semester at start of study WiSe**	**Commitment level**	**Contact time (SWS)**	**Self-study**	**Credit points**
Introduction to Population Genetics and Statistical Genomics	V	1	P	2 SWS / 21 h	69 h	3 LP
Genome data analysis	Ü	1	P	6 SWS / 63 h	87 h	5 LP
R for population genetics	Ü	1	P	2 SWS / 21 h	39 h	2 LP

In order to be able to complete the module, the following achievements must be made:	
Presence	Ü
Active participation	according § 5 Abs. 3
Course achievement(s)	/
Module exam	portfolio examination (ungraded)

Qualification goals/learning outcome/competences

- Grasp concepts in population genetics
- Cultivate a population genetics mindset
- Compute basic statistics manually and on a computer
- Navigate the command line and compose bash scripts
- Analyze genomic data through the creation and utilization of custom scripts

Content

A semester-long lecture provides an introduction to classical and coalescent theory-based population genetics as well as an introduction to current methods in statistical genomics. The following topics are covered: Allele and genotype frequencies, Hardy-Weinberg equilibrium, effective population size and genetic drift in the Wright-Fisher model, population structure and subdivision, genetic diversity and distance measures, coalescent theory, neutrality and selection tests, summary statistics of genomic variation (PCA, structure/admixture; F and D statistics, site frequency spectrum), linkage disequilibrium, as well as , demographic modelling and simulations.
The practical part consists of a four-week hands-on bioinformatics course. Participants learn to navigate in a Linux-environment and are taught the basic principles of bash scripting. Early on these skills are applied to next generation sequencing data, where all steps from genome assembly to statistical analyses are covered. Furthermore, students will learn to visualize complex data-sets using the R-language.

Access requirement(s)	/
Recommended prerequisite(s) for the module or for individual courses of the module	/
Language(s) of instruction and examination(s)	English
Weight of the module grade in the overall grade	0%
Frequency in the offer	Once a year
Reasons for compulsory attendance events	/
Module offices	Dr. Jens Blöcher; Profs. Burger, Huylmans, Andrade, Dr. Pablo Duchén Bocángel
Usability of the module in other degree programmes	M.Sc. Biology, M.Sc. Neuroscience, M.Sc. Applied Bioinformatics; M.Sc. Computer Science with Minor in Physics, Mathematics or Biology
Other	Rasmus Nielsen & Montgomery Slatkin, An Introduction to Population Genetics: Theory and Applications. Sinauer.

Module M4A	*Evolution of Species Interactions*					
Compulsory or elective module	**compulsory elective (WP)**					
Credit points (LP) and workload	**10 LP = 300 h**					
Module duration (according to study plan)	**1 semester**					
Courses/ Forms of learning	**Type**	**Standard semester at start of study WiSe**	**Commitment level**	**Contact time (SWS)**	**Self-study**	**Credit points**
Species interactions - concepts	V	2	P	2 SWS / 21 h	39 h	2 LP
Methods and practices	Ü	2	P	7 SWS / 73 h	137 h	7 LP
Presenting and discussing scientific literature in the field	S	2	P	1 SWS / 11 h	19 h	1 LP

In order to be able to complete the module, the following achievements must be made:	
Presence	Ü
Active participation	according § 5 Abs. 3
Course achievement(s)	/
Module exam	written or oral exam (graded)

Qualification goals/learning outcome/competences

- Gain an overview of the principles and concepts in the evolution of species interactions
- Learn state-of-the-art methods for studying species-interactions and evolutionary biology
- Develop key skills in designing experiments and analyse data
- Be able to present and critically discuss scientific literature
- Understand how human affect plant evolution and ecosystem functioning

Content

The lecture series will cover plant-herbivore, plant-pollinator, plant-microbe and plant-people interactions. In addition, multitrophic interactions will also be introduced. We will introduce both evolutionary principles that shape species interactions and molecular mechanisms involved in plant-animal interactions. In the practical part, students will either join researchers to participate in ongoing research projects, or develop his/her own projects. In addition to gaining basic skills in designing and conducting scientific experiments, students can also learn methods and techniques including: analytic chemistry (LC-MS/MS), evolutionary genetics and genomics, experimental evolution or molecular biology (e.g., genetic manipulations).

Access requirement(s)	/
Recommended prerequisite(s) for the module or for individual courses of the module	completed M2
Language(s) of instruction and examination(s)	English
Weight of the module grade in the overall grade	15%
Frequency in the offer	Once a year
Reasons for compulsory attendance events	/
Module offices	Prof. Shuqing Xu
Usability of the module in other degree programmes	M.Sc. Biology, M.Sc. Neuroscience, M.Sc. Applied Bioinformatics; M.Sc. Computer Science with Minor in Physics, Mathematics or Biology, M.Sc. Biomedicine, M.Sc. Biomedical Chemistry
Other	/

Module M4B	Social Evolution: from genes to behavior					
Compulsory or elective module	**compulsory elective (WP)**					
Credit points (LP) and workload	**10 LP = 300 h**					
Module duration (according to study plan)	**1 semester**					
Courses/ Forms of learning	**Type**	**Standard semester at start of study WiSe**	**Commitment level**	**Contact time (SWS)**	**Self-study**	**Credit points**
Animal Behavior and Evolution	V	2	P	2 SWS / 21 h	69 h	3 LP
Methods in Behavioral Ecology und Genomics	Ü	2	P	5 SWS / 52 h	98 h	5 LP
Behavioural Ecology and Genomics	S	2	P	2 SWS / 26 h	34 h	2 LP

In order to be able to complete the module, the following achievements must be made:	
Presence	Ü
Active participation	according § 5 Abs. 3
Course achievement(s)	/
Module exam	written exam (60 min, graded)

Qualification goals/learning outcome/competences

- Understanding advanced concepts and empirical findings in the field of animal behaviour and evolution
- Being able to independently plan and conduct an experiment in animal behaviour and evolution including experimental design, data collection and advanced statistical analyses and critically reflect on the scientific outcomes
- Being able to understand and apply molecular, chemical, behavioural, biostatical and bioinformatic methods to address evolutionary questions

Content

The lecture series will contain advanced classes on animal behaviour and communication, behavioural genomics, insect evolution, speciation, social evolution, phenotypic plasticity, molecular ecology, sex and caste determination, and biodiversity. The exercise will include field-based and lab-based biodiversity exercises, behavioural experiments and advanced methods of documenting and analysing behaviour, chemical analyses of animal metabolites to gain insights into physiological and communication aspects of behaviour, analysis of genomic and transcriptomic data to understand the evolution of animal behaviour.

Access requirement(s)	completed M2
Recommended prerequisite(s) for the module or for individual courses of the module	/
Language(s) of instruction and examination(s)	English
Weight of the module grade in the overall grade	15%
Frequency in the offer	Once a year
Reasons for compulsory attendance events	/
Module offices	Prof. Susanne Foitzik
Usability of the module in other degree programmes	M.Sc. Biology, M.Sc. Neuroscience, M.Sc. Applied Bioinformatics; M.Sc. Computer Science with Minor in Physics, Mathematics or Biology, M.Sc. Biomedicine, M.Sc. Biomedical Chemistry
Other	/

Module M4C	***Evolution in Natural Populations***					
Compulsory or elective module	**compulsory elective (WP)**					
Credit points (LP) and workload	**10 LP = 300 h**					
Module duration (according to study plan)	**1 semester**					
Courses/ Forms of learning	**Type**	**Standard semester at start of study WiSe**	**Commitment level**	**Contact time (SWS)**	**Self-study**	**Credit points**
Evolution in Natural Populations	V	2	P	2 SWS / 21 h	69 h	3 LP
Method course	Ü	2	P	50 h	100 h	5 LP
Literatur seminar	S	2	P	2 SWS / 21 h	39 h	2 LP

In order to be able to complete the module, the following achievements must be made:	
Presence	Ü
Active participation	according § 5 Abs. 3
Course achievement(s)	/
Module exam	oral examination (60 min., graded)

Qualification goals/learning outcome/competences

- Understand the key concepts of evolutionary theory, including natural selection, genetic drift, gene flow, and mutation, and how they apply to natural populations.
- Develop critical thinking and problem-solving skills by applying evolutionary theory to real-world scenarios, such as the impact of environmental change on populations, and the conservation of endangered species.

Content

Analyse and interpret empirical data on the evolution of natural populations, including measures of genetic diversity, patterns of genetic differentiation, and the role of natural selection in shaping phenotypic variation
Communicate scientific findings and ideas effectively through written assignments, oral presentations, and scientific discussions, using appropriate terminology and citing relevant literature in the field of evolutionary biology.

Access requirement(s)	/
Recommended prerequisite(s) for the module or for individual courses of the module	/
Language(s) of instruction and examination(s)	English
Weight of the module grade in the overall grade	15%
Frequency in the offer	Once a year
Reasons for compulsory attendance events	/
Module offices	Prof. Joachim Burger
Usability of the module in other degree programmes	M.Sc. Biology, M.Sc. Neuroscience, M.Sc. Applied Bioinformatics; M.Sc. Computer Science with Minor in Physics, Mathematics or Biology, M.Sc. Biomedicine, M.Sc. Biomedical Chemistry
Other	/

Module M4D	Evolutionary modelling					
Compulsory or elective module	**compulsory elective (WP)**					
Credit points (LP) and workload	**10 LP = 300 h**					
Module duration (according to study plan)	**1 semester**					
Courses/ Forms of learning	**Type**	**Standard semester at start of study WiSe**	**Commitment level**	**Contact time (SWS)**	**Self-study**	**Credit points**
Mathematical tools for theoretical biology	V	2	P	1 SWS / 11 h	19 h	1 LP
Key questions in eco-evolutionary modelling	Ü	2	P	3 SWS / 32 h	208 h	8 LP
Current Topics in Modelling Evolution	S	2	P	1 SWS / 11 h	19 h	1 LP

In order to be able to complete the module, the following achievements must be made:	
Presence	Ü
Active participation	according § 5 Abs. 3
Course achievement(s)	/
Module exam	portfolio examination

Qualification goals/learning outcome/competences

- A diversity of tools in the mathematical analysis of evolutionary scenarios: continuous and discrete time models of evolutionary change and equilibria
- Understanding how mathematical models have informed the study of evolution
- Ability to modify models to examine the robustness of conclusions

Content

The model builds on M1 by providing a more extensive look at the modelling methods available to eco-evolutionary modellers: population genetics, quantitative genetics, optimization methods, game-theoretical models, continuous-time models of dynamics using differential equations, the use of matrix algebra in evolutionary stage-dependent models, and individual/agent-based simulations. The use of these approaches will be shown in the context of life history theory, sexual selection and sex ratios, evolution of sociality (including eusociality), sexual and parent-offspring conflict, dispersal evolution, evolutionary rescue and evolution in global change contexts. Each exercise involves the goal of witnessing the published results being reproduced (in R and/or Matlab), after which additional scenarios will be run with alternative parameter values, to investigate the generality of the results and lessons learned. For a subset of models, structural robustness checks will be shown to see how the conclusions depend on the assumptions made.

Access requirement(s)	completed M1
Recommended prerequisite(s) for the module or for individual courses of the module	/
Language(s) of instruction and examination(s)	English
Weight of the module grade in the overall grade	15%
Frequency in the offer	once a year
Reasons for compulsory attendance events	/
Module offices	Prof. Hanna Kokko
Usability of the module in other degree programmes	M.Sc. Biology, M.Sc. Neuroscience, M.Sc. Applied Bioinformatics; M.Sc. Computer Science with Minor in Physics, Mathematics or Biology, M.Sc. Biomedicine, M.Sc. Biomedical Chemistry
Other	/

Module M4E	*Anthropology*					
Compulsory or elective module	**compulsory elective (WP)**					
Credit points (LP) and workload	**10 LP = 300 h**					
Module duration (according to study plan)	**1 semester**					
Courses/ Forms of learning	**Type**	**Standard semester at start of study WiSe**	**Commitment level**	**Contact time (SWS)**	**Self-study**	**Credit points**
Primate Evolution and Prehistoric Anthropology	V	2	P	3 SWS / 32 h	88 h	4 LP
Methods in Primatology and Anthropology	Ü	2	P	6 SWS / 63 h	117 h	6 LP

In order to be able to complete the module, the following achievements must be made:	
Presence	Ü
Active participation	according § 5 Abs. 3
Course achievement(s)	/
Module exam	written exam (60 min, graded)

Qualification goals/learning outcome/competences

- knows the anatomy and chemical structure of the human skeleton (osteology)
- masters scientific methods for the analysis of prehistoric skeletons and their biomolecules
- can produce genomes from a diverse set of forensic and archaeological tissues using the latest next generation sequencing techniques
- knows and understands the important geological and climatological epochs of the last 65 million years
- understands concepts and methods of climate reconstruction

- understands concepts of evolutionary analysis and phylogenetics
- comprehends human biology and hominization
- can assign individuals to larger primate groups
- is firm in collecting and processing anatomical and molecular data
- can analyse molecular evolution and reconstruct phylogenetic relationships

Content

The first part of the lecture (Prehistoric Anthropology) discusses various scientific methods used to reconstruct human history, environment, and evolution. Topics include climate and environmental reconstruction methods, physical dating techniques, isotope analyses for prehistoric diet reconstruction, and the anatomy and biochemistry of human skeletons, particularly focusing on the analysis of prehistoric biomolecules like proteins, ancient DNA, and lipids. The corresponding practical course involves osteological analysis of human skeletons, applying anatomical knowledge to fragmented archaeological remains to infer demographic parameters such as sex, age at death, and pathologies. The course then moves to the wet lab, where students learn how to produce genomes from various tissues, including forensic traces and archaeological bone remains, by extracting DNA, preparing Next Generation Sequencing libraries, performing in-solution hybridization capture, purifying and quantifying DNA.

The second part of the module (Primate Phylogeny) aims to help students understand the evolution, phylogeny, and diversity of recent and extinct primates. This involves considering morphological and anatomical features, life history traits, behavioral observations, and genetic data. Amongst others, the following topics will be covered: fundamentals of phylogenetic systematics; rare genomic changes as phylogenetic markers; ecology; social and mating systems; distribution ranges and diversity of living primates; organisation, function and evolution of the skeleton, sensory organs and digestive system; trends in human evolution including cultural achievements; links between anatomically modern humans and extinct human forms; fossils including localities and dating and what they reveal about primate evolution and hominization. In the corresponding part of the practical course, computer-based phylogenetic analyses will be conducted using anatomical and molecular data. Amongst others, students will be trained in different approaches to phylogenetic reconstruction and according software. Furthermore, the evolution of protein-coding genes will be studied. In this way, students deepen their understanding of concepts such as natural and sexual evolution, neutral evolution, and positive and negative selection.

Access requirement(s)	/
Recommended prerequisite(s) for the module or for individual courses of the module	completed M1 and M3; Lecture " Human Biology and Anthropology" by the same lecturers or comparable knowledge on the phylogeny of primates including humans.
Language(s) of instruction and examination(s)	English
Weight of the module grade in the overall grade	15%
Frequency in the offer	once a year

Reasons for compulsory attendance events	/
Module offices	Profs. Holger Herlyn; Joachim Burger
Usability of the module in other degree programmes	M.Sc. Biology, M.Sc. Neuroscience, M.Sc. Applied Bioinformatics; M.Sc. Computer Science with Minor in Physics, Mathematics or Biology
Other	/

Module M4F	**Computational Biology**					
Compulsory or elective module	**compulsory elective (WP)**					
Credit points (LP) and workload	**10 LP = 300 h**					
Module duration (according to study plan)	**1 semester**					
Courses/ Forms of learning	**Type**	**Standard semester at start of study WiSe**	**Commitment level**	**Contact time (SWS)**	**Self-study**	**Credit points**
Introduction to Computational Biology	V	2	P	2 SWS / 21 h	39 h	2
Protein analysis with bioinformatics	Ü	2	P	6 SWS / 63 h	117 h	6
Current topics in Computational Biology	S	2	P	1 SWS / 11 h	49 h	2

In order to be able to complete the module, the following achievements must be made:	
Presence	Ü
Active participation	according § 5 Abs. 3
Course achievement(s)	/
Module exam	written exam (60 min., graded)

Qualification goals/learning outcome/competences

The students will (i) receive advanced training on a programming language of wide use in Bioinformatics and (ii) learn a logically ordered series of topics describing the computational analysis, data types and databases used in diverse aspects of the study of genes, genomes, gene expression, DNA-protein interactions, protein sequence and structure, and protein-protein interactions. Special emphasis will be put in explaining how evolutionary analysis can be applied to these topics, and how these methods and databases can be used to predict protein function and mechanisms of disease.

Content

Advance programming, sequence analysis and homology, multiple sequence alignment, phylogenetic analyses, protein structure and representation, secondary structure prediction, homology modelling of protein structure, disordered proteins, database annotations and data mining, gene enrichment analysis, high-throughput data analysis (ChIP-seq, gene expression), protein interaction networks and Cytoscape.

Access requirement(s)	completed M3
Recommended prerequisite(s) for the module or for individual courses of the module	/
Language(s) of instruction and examination(s)	English
Weight of the module grade in the overall grade	15%
Frequency in the offer	Once a year
Reasons for compulsory attendance events	/
Module offices	Prof. Miguel Andrade
Usability of the module in other degree programmes	M.Sc. Biology, M.Sc. Neuroscience, M.Sc. Applied Bioinformatics; M.Sc. Computer Science with Minor in Physics, Mathematics or Biology, M.Sc. Biomedicine, M.Sc. Biomedical Chemistry
Other	/

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Module M4G	Genomics and DNA Sequence Analysis					
Compulsory or elective module	**compulsory elective (WP)**					
Credit points (LP) and workload	**10 LP = 300 h**					
Module duration (according to study plan)	**1 semester**					
Courses/ Forms of learning	**Type**	**Standard semester at start of study WiSe**	**Commitment level**	**Contact time (SWS)**	**Self-study**	**Credit points**
Genomics & DNA sequence analysis: an introduction	V	2	P	2 SWS / 21 h	69 h	3 LP
Bioinformatical methods in genomics	Ü	2	P	5 SWS / 52 h	128 h	6 LP
Current topics in genomics	S	2	P	1 SWS / 11 h	19 h	1 LP

In order to be able to complete the module, the following achievements must be made:	
Presence	Ü
Active participation	According to § 5 Abs. 3
Course achievement(s)	/
Module exam	written exam (60 min., graded)

Qualification goals/learning outcome/competences

Students acquire in-depth knowledge in the overlapping area of molecular genetics, genomics and bioinformatics. In the intensive study of methods for computer-assisted processing of DNA and protein sequences, students acquire specialised knowledge and skills that represent an essential foundation of contemporary molecular biology, genomics and bioinformatics work. They learn to critically interpret the results of computer-assisted sequence processing and to design research approaches for molecular laboratory work from such data.

Content

In-depth theoretical as well as practical (computer-assisted) analysis of genetic data. In the lecture, an overview of methods and results of genome research and bioinformatics working techniques required for this purpose are provided. In the exercises, research-oriented bioinformatics tools are used, covering a wide range of applications (Sanger and Illumina DNA sequencing, de novo assembly; production and processing of next-generation sequencing data; databases and search tools; gene prediction and genome annotation; molecular evolution of genes; phylogenetics and phylogenomics; quantification of differential gene activity). If needed, molecular biology laboratory experiments complement the computer portion (e.g., nucleic acid isolation, purification and library production, NGS techniques, cDNA generation, quantitative PCR).

Access requirement(s)	completed M3
Recommended prerequisite(s) for the module or for individual courses of the module	/
Language(s) of instruction and examination(s)	English
Weight of the module grade in the overall grade	15%
Frequency in the offer	once a year
Reasons for compulsory attendance events	/
Module offices	Prof. Tom Hankeln, Prof. Markus Pfenninger
Usability of the module in other degree programmes	M.Sc. Biology, M.Sc. Applied Bioinformatics; M.Sc. Computer Science with Minor in Physics, Mathematics or Biology, M.Sc. Biomedicine, M.Sc. Biomedical Chemistry
Other	Lit.: Marketa Zvelebil & Jeremy O. Baum: Understanding bioinformatics. Garland Science

Module M5	Additional qualifications					
Compulsory or elective module	**mandatory (P)**					
Credit points (LP) and workload	**10 LP = 300 h**					
Module duration (according to study plan)	**4 semesters**					
Courses/ Forms of learning	**Type**	**Standard semester at start of study WiSe**	**Commitment level**	**Contact time**	**Self-study**	**Credit points**
Transferable skills	Lecture / workshop	3	WPfl	20 h	40 h	2 LP
Project planning and grant writing	Lecture / exercise	3	WPfl	8 h	82 h	3 LP
Discussing evolution with the public	seminar	3	WPfl	20 h	40 h	2 LP
Anthropological excursion	excursion	3	WPfl	16 h	44 h	2 LP
Scientific project in a nutshell	exercise	3	WPfl	48 h	132 h	6 LP
Project leader gene technology §15b GenTSV (ext.)	seminar	3	WPfl	15 h	15 h	1 LP
Advanced scientific English (ext.)	Lecture / exercise	3	WPfl	31 h	59 h	3 LP
Internship in a partner university or industry (ext.)	lecture/ exercise/ excursion	3	WPfl	/	180 h	6 LP
Surveying arthropod and avian biodiversity in natural habitats	excursion/ exercise	2	WPfl	10 h	20 h	1 LP
Climate change, biodiversity crisis and courses of action	lectures/w orkshop	3	WPfl	8 h	22 h	1 LP
Archaeological excavation (ext.)	excursion	3	WPfl	/	120 h	4 LP
Park and garden tour	excursion	2	WPfl	8 h	22 h	1 LP
The cast collection at the anthropology: Drawing of osteological objects	exercise	3	WPfl	3 h	27 h	1 LP
Phylogeny-informed statistics	exercise	3	WPfl	8 h	22 h	1 LP
Modelling evolution of traits	exercise	3	WPfl.	8 h	22 h	1 LP
Literature search and academic integrity (ext.)	Lecture/ excercise	1	WPfl.	4 h	50	2 LP
Personal Development Skills (ext.)	Lecture/ excercise	1	WPfl.	12 h	16	1 LP

In order to be able to complete the module, the following achievements must be made:	
Presence	/
Active participation	according § 5 Abs. 3
Course achievement(s)	According to the courses attended in accordance with the module handbook
Module exam	According to the courses attended in accordance with the module handbook

Qualification goals/learning outcome/competences
The students acquire interdisciplinary competence beyond a specific research field. Modules include science theory and communication, as well as applicable qualifications that will improve the student's ability to conduct scientific projects. Modules can be freely combined to allow students to follow their interests and set priorities.

Content (M5)
Transferable skills (Xu): Participants will learn multiple transferable skills in research, such as project management, time management, self-management, presentation etc. **Project planning and grant writing:** (Foitzik) Lectures include literature search, hypothesis generation, experimental design, grant writing. The students will develop an idea and a concept for a scientific project by reading scientific literature and discussing this among themselves and the lecturer, they develop an experimental design including a data recording and analysis concept, they will write this project up in a grant proposal and receive comments for improvement, which they have to use to revise the proposal. They will present and defend the proposal in front of the class. As they need not to conduct the project, they are free to choose a potential project from all areas of evolutionary biology. **Discussing Evolution with the Public:** (Dreesmann): The seminar uses historical and modern examples and the case study approach to illustrate how the topic of "evolution" has been (un)successfully communicated. Working on a small project, students acquire knowledge and skills to reduce complex research to a level that is accessible to the general public. **Anthropological Excursions** (Blöcher, Winkelbach, Burger): Excursions to important anthropological sites, such as the Palaeolithic caves of the Swabian Alb and/or to corresponding research institutes, such as the CEZA in Mannheim. The usual excursion duration is two days with one overnight stay. **Scientific project in a Nutshell** (Huylmans, Huber): During a 4-6-day practical course on a field site, participants learn to carry out their own scientific project, from experimental design, data collection, data analysis and documentation. **Project leader in gene technology:** Participants acquire knowledge in biological safety measurements. The relevant regulations (§15 Abs. 2 of the gene technology regulations) will be taught. The certificate acquired in this module is a prerequisite to become a gene technology project leader. (in German). **Advanced Scientific English (ISSK).** The course is offered once a year for biologists and natural scientists at the B1/B2 level. It consists of weekly lessons plus preparation and follow-up**.** https://www.issk.uni-mainz.de **Internship in a Partner University or Industry:** Participants organise and carry-out an internship in a partner university or industry **Surveying arthropod and avian biodiversity in natural habitats (Menzel):** The participants use different methods to catch arthropods in natural habitats. They learn to identify them and calculate and visualise various biodiversity metrics, e.g. to compare biodiversity among habitats. The course is complemented by an ornithological excursion. **Climate change, biodiversity crisis and courses of action** (Menzel / Zukunftsmodul): Workshop and lectures where the participants learn about causes and consequences of climate change, its relations to the biodiversity crisis and potential for action. In collaboration with the Zukunftsmodul. **Archaeological excavation:** Students can use existing contacts in the state heritage offices and with archaeologists to take part in an archaeological excavation. This event is recommended for students majoring in anthropology. **Park and Garden Tour** (Burger)**:** This one-day excursion introduces students to concepts of how botany, architecture and art were linked in the garden architecture of the Baroque and Romantic periods. Students each give a presentation on site. **The Cast Collection at the Anthropology: Drawing of Three Osteological Objects** (Herlyn): After an introduction into the cast collection, participants will select three osteological objects to draw. **Phylogeny-informed statistics** (Griebeler): This one-day course introduces students to phylogeny-informed regression analysis in R. **Modelling trait evolution** (Griebeler): This one-day course introduces students to standard models on the evolution of continuous and discrete traits in R. **Literature search and academic integrity**: Participants will learn how to use information services such as library catalogs and databases competently so that they are able to conduct a systematic search for their Master's topic, cite the sources found correctly and use a literature management system of their choice. Participants will also learn about the basic rules and values of responsible conduct, how to avoid conflicts in scientific working and how to prevent scientific misconduct such as plagiarism or data manipulation. **Personal Development Skills:** Students choose different courses from the JGU programme on topics such as self-control, learning techniques, psychosocial stress coaching, etc.

Access requirement(s)	/
Recommended prerequisite(s) for the module or for individual courses of the module	/
Language(s) of instruction and examination(s)	English, Deutsch
Weight of the module grade in the overall grade	0%
Frequency in the offer	depending on the individual course programmes
Reasons for compulsory attendance events	/
Module offices	Profs. Meret Huber, Ann Kathrin Huylmans
Usability of the module in other degree programmes	/
Other	Alternative courses with general education content not listed here can be recognised as equivalent on application; courses must be chosen in such a way that they do not collide with other modules

Module M6	Project work					
Compulsory or elective module	**P**					
Credit points (LP) and workload)	**20 LP = 600 h**					
Module duration (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Standard semester at start of study WiSe**	**Commitment level**	**Contact time (SWS)**	**Self-study**	**Credit points**
Project Work	Pro	3	P	14	344 h	18 LP
Instructions for scientific work	S	3	P	2 SWS / 21 h	39 h	2 LP

In order to be able to complete the module, the following achievements must be made:	
Presence	Ü, S
Active participation	according § 5 Abs. 3
Course achievement(s)	Production and analysis of data; development of conceptual approaches
Module exam	Portfolio examination (concept paper, scripts, protocols, presentation)

Qualification goals/learning outcome/competences

- The student can independently identify and understand scientific questions
- Obtains a sufficient overview of a scientific field of research
- Reads and understands the relevant literature
- Can plan and implement an appropriate experiment
- Can develop problem-solving strategies.
- Develops routine in experimentation and problem solving
- Recognises experimental and conceptual errors and corrects them

Content

In this module, data is collected or analyses are conducted that represent a meaningful, completed scientific experiment. The data can serve as a basis for the subsequent Master's thesis (M7). Data collection can take place in the laboratory, in the field or on the computer. It can alternatively be a purely theoretical-conceptual work with or without existing data. The exact topics vary depending on the research focus of the participating working groups and are based on a population biology or evolutionary biology question.

Access requirement(s)	M1, 2, 3 + 3 M4 modules
Recommended prerequisite(s) for the module or for individual courses of the module	/
Language(s) of instruction and examination(s)	English
Weight of the module grade in the overall grade	20 %
Frequency in the offer	/
Reasons for compulsory attendance events	Attendance at the seminar is obligatory in addition to the exercise, as here the approaches to practical work are developed together in the group, which are necessary to achieve the teaching objective. The presentation in the seminar will be graded.
Module offices	Prof. Miguel Andrade
Usability of the module in other degree programmes	/
Other	/

Module M7	Master Thesis					
Compulsory or elective module	**mandatory**					
Credit points (LP) and workload	**30 LP = 900 h**					
Module duration (according to study plan)	**1 Semester**					
Courses/ Forms of learning	**Type**	**Standard semester at start of study WiSe**	**Commitment level**	**Contact time (SWS)**	**Self-study**	**Credit points**
Master thesis	-	4	P	/	750h	25
Oral exam	-	4	P	/	150h	5

In order to be able to complete the module, the following achievements must be made:	
Presence	/
Active participation	according § 5 Abs. 3
Course achievement(s)	Analysing data and writing the Master's thesis
Module exam	Master´s thesis (graded 50%) Oral examination (graded 50%)

Qualification goals/learning outcome/competences

- Students learn to competently survey a scientific field
- They can document data and analyses in writing
- They master scientifically correct citation methods
- They can write scientific texts in an understandable and formally correct manner
- They are proficient in the subject-specific standards of data analysis and can use statistics sensibly and appropriately.
- They are able to give an overview of the state of research in a scientific style, to describe and document their results and to interpret and discuss them in the light of the relevant literature in a written Master's thesis.
- They are able to present and defend their Master's thesis, answering questions on the specific scientific topic of their thesis as well as on related fields.

Content

This module deals with various topics from the field of evolutionary biology and is completed with a written Master's thesis and its oral defence. The exact topics vary according to research foci as they exist in the scientific working groups. The module can be a continuation of the research project started in the project thesis (M6). Both empirical and theoretical topics can be addressed, or those that combine both areas. The resulting written thesis first provides a general, introductory overview of the topic before documenting materials and methods as well as results, which are then discussed against the background of the current state of scientific research. Before handing in the written work, an oral presentation must be given to the working group.

Access requirement(s)	completed M1-M6
Recommended prerequisite(s) for the module or for individual courses of the module	/
Language(s) of instruction and examination(s)	English
Weight of the module grade in the overall grade	35%
Frequency in the offer	Once a year
Reasons for compulsory attendance events	/
Module offices	Prof. Shuqing Xu
Usability of the module in other degree programmes	/
Other	Final examination (60 min). The candidate gives a presentation on his/her work (20 minutes). Half of the content of the remaining oral examination relates to the discussion of the Master's thesis (20 minutes) and the other half to previously agreed topics from the wider context of research area of the thesis (20 minutes).