Modules of Evolution and Biodiversity

http://ieb.uni-muenster.de/General/SSP.html#research_modules

Overview of advanced modules (timetable)*

WINTER (WiSe):

block	I	II	III	IV	all semester
module	Freshwater Invertebrates	Host-Parasite Coevolution	Biocomputing	Molecular Phylogenetics	Mathematical Models in Biology
module					The Growth of the Evolutionary Thought

SUMMER (SoSe):

block	I	II	III	IV	all semester
module	Evolutionary Genetics	Statistics in Ecology, Experimental Design, and Statistical Models	Ecology and Evolution of Freshwater Organisms	Summer School	
module		Evolutionary Medicine			

* for up-to-date course information, you may *also* refer to the [module handbook](#)
or [course directory (Vorlesungsverzeichnis)](#).

Course details

Title:	**Freshwater Invertebrates**
People:	Prof. Dr. E. I. Meyer (coordinator), Dr. N. Kaschek
Date:	block I, Winter
Website:	Limnology Group

Please note: some lectures are currently taught in German!

Freshwater ecosystems are immensely complex co-evolved systems, where each species reveals a particular ecological function, yet also interacts with other species. Studying organisms in their natural habitat and experimentally testing their life performances allows for understanding and modeling of freshwater biodiversity.

Goals:

- Knowledge of aquatic biodiversity, insights into the systematics of invertebrates, usage of an identification key, morphological terminology, and dissection, preparation, and mounting techniques
- the practical application will be the determination of the water quality (calculation of the saprobic index)

Contents:

- A complete overview of the invertebrate freshwater fauna will be given. Associated aspects of systematics, morphology, taxonomy, biology, and ecology will be conveyed.
- The seminar will cover current research on the biology and ecology of selected species.

Methods:

- morphological traits, terminology, nomenclature, microscopy, identification key,
- colection, dissection, preparation, and mounting methods,
- field trips

Title:	**Host-Parasite Coevolution**
People:	Prof. Joachim Kurtz (coordinator)
Date:	block II, Winter
Website:	[Host - Parasite Coevolution](#)

The interplay between parasites and their hosts is thought to be one of the major driving forces of evolutionary innovation. Parasites and pathogens constantly have to evolve new ways of infection, while their hosts need to counter these attacks with efficient immune defense. Students will learn about coevolution and conduct their own lab projects.

Goals:

- Understanding of evolutionary processes, especially of co-evolution.
- Knowledge of underlying concepts and current research mostly in the area of host-parasite co-evolution, but also in the areas of evolutionary biology, immunology, and parasitology.
- Ability to plan, conduct, and present the results of small research projects.

Contents:

- experimental research project in host-parasite co-evolution
- lectures and seminars on current topics in co-evolution and related topics
- literature research and seminar

Methods:

- molecular techniques of population genetics
- experimental design
- microbiological and immunological techniques

Title:	**Biocomputing**
People:	Prof. Erich Bornberg-Bauer (coordinator), N.N.
Date	block III, Winter
Website:	[Evolutionary Bioinformatics Group](#)

Modern biological research produces vast amounts of digital information, such as DNA sequences and gene expression data. Managing and analysing this information has become a major component of many biologists' daily routine. Students will learn to analyse biological data using the Python scripting language.

Goals:

- Learn how to use a scripting language to efficiently handle any biological data.
- Be able to work in a Linux environment.

Contents:

- Practical course: Introduction to programming in Python

Methods:

- Python programming
- Linux operation system and command line interface

Title:	**Molecular Phylogenetics**
People:	Prof. Kai Müller (coordinator), Prof. Erich Bornberg-Bauer, and NN.
Date:	block IV, Winter
Website:	Evolution and Biodiversity of Plants Group

The evolutionary history of life on Earth is best studied by comparing the molecules that encode the blueprints of life: DNA, RNA, and protein. With the help of sophisticated statistical methods and computers it becomes increasingly possible to reconstruct the tree of life. Students will learn about the background theory and how to use phylogenetic methods.

Goals:

- Understanding of how the traces of evolution can be detected in molecular data.
- Learn the basic methods used in molecular phylogeny.

Contents:

- phylogenetic reconstruction
- DNA substitution models
- likelihood and Bayesian methods

Methods:

- statistical methods
- simple programming exercises in R (and/or other scripting languages)
- database search

Title:	**Evolutionary Genetics**
People:	Prof. Juliette de Meaux (coordinator), Prof. J. Kurtz, Prof. C. Acquisti, Dr. M. Diddens-de Buhr
Date:	block I, Summer
Website:	Plant Molecular Evolution Group

This module examines the footprints of natural selection on the genetics of environmentally relevant traits. Students are initiated to the methods of population genetics and molecular evolution. Simulation tools are being used to investigate the evolution of complex traits in population settings thought to be ecologically realistic.

Goals:

- Understanding the theoretical background and methods used in evolutionary genetics.

Contents:

- the evolution of: DNA sequences, genomes, splicing, transposons, immune system, parasites
- traces of natural selection in the genetics of environmentally relevant traits
- population genetics

Methods:

- molecular methods of population genetics: sequence analysis, quantitative genetics, ...
- simulation tools

Title:	**Statistics in Ecology, Experimental Design, and Statistical Models**
People:	Dr. Wolfgang Riss (coordinator), Prof. Dr. E. I. Meyer, and NN
Date:	block II, Summer
Website:	Limnology Group

Statistics and experimental design are two key qualifications when working in ecology and evolutionary biology. Science is the process of formulating hypotheses, testing them experimentally, and drawing conclusions from the result. If this process is flawed, no reliable knowledge can be gained. Students will use statistical software during practical exercises.

Goals:

- Knowing the background and premises for statistical surveys and inference on data from ecological surveys and experiments. Basic ability in the use of R as a working tool.
- Overview and application of modern (uni- and multivariate) exploration techniques and tests procedures.
- Practical approach to the mathematical description and performance of simple model analyses.

Contents:

- The basics of the statistical analysis, explorative methods, the nature of hypotheses, and the adequate use of tests will be exposed in lectures and practical exercises, with reference to to common problems of field and laboratory studies in ecology and evolutionary biology. In the practical part, scripting will be trained in R, a versatile and platform-independent statistical software.
- The design of experiments, the generation and test of hypotheses, and the breakdown of complex data sets will be trained in the context of the premises and constraints circumscribed by the study goal and information properties. During the practice, participants are invited to enter their own data analysis problems.
- Exploration of the application of mathematical approaches to ecology and evolutionary biology via the study of classic frameworks.

Methods:

- computer programming exercises using the statistical software package R

Title:	**Evolutionary Medicine**
People:	Prof. J. Kurtz (coordinator), Dr. Francesco Catania, PD Dr. A. Mellmann, PD Dr. J. Schmitz, Prof. Dr. M. Stoll
Date:	block II, Summer
Website:	[Animal Evolutionary Ecology Group](#)

Evolutionary medicine applies modern evolutionary theory to understand health and disease. Evolution helps to explain, for example, the evolution of pathogens causing infectious diseases, the rapid evolution of resistance to antibiotics, and the preservation of disease genes in the human population. Considering evolution may help predicting and controlling those diseases.

Goals:

- A basic understanding of why evolution is relevant for the medical sciences.

Contents:

- different aspects of applying evolutionary theory to the medical sciences
- evolution of resistance
- evolution of disease-related genes
- genome-wide association studies
- evolution of transposons

Methods:

- molecular methods of evolutionary genetics
- PCR
- sequencing; next generation sequencing
- genomics; transcriptomics, bioinformatics

Title:	**Ecology and Evolution of Freshwater Organisms**
People:	Prof. Elisabeth Meyer (coordinator), Prof. Dr. Joachim Kurz, Dr. Norbert Kaschek, Dr. Wolfgang Riss, Dr. Joern Scharsack
Date:	block III, Summer
Website:	[Limnology Group](#)

Freshwater ecosystems are immensely complex co-evolved systems, where each species reveals a particular ecological function, yet also interacts with other species. Studying organisms in their natural habitat and experimentally testing their life performances allows for understanding and modeling of freshwater biodiversity.

Goals:

- Improving knowledge on freshwater biodiversity, ecology, evolutionary theory, field and laboratory methods, experimental design, and data evaluation.

Contents:

- ecological adaptations leading to evolutionary change in freshwater organisms.
- differences between types of freshwater habitats, on their associated biodiversity, and on adaptation.
- Lectures will comprise the following topics: Phylogeny and systematics, morphological adaptations, functional role of key taxa, life history evolution, metapopulation structure and theory, dispersal biology, evolution, invasion biology, host-parasite-interactions, and development of hypotheses, which can be tested in experiments.
- Lectures will be complemented by student seminars. Depending on interest the students choose, prepare and perform experiments, which are related to the theoretical lessons and the research fields followed in the institute. Group work and own responsability is desired.

Methods:

- collection of material in the field
- sorting and enumeration techniques
- taxonomic identification
- behavioural studies
- preparation techniques
- experimental work / molecular lab
- data analysis / computer work

Title:	**Bernhard Rensch Summer-School on Evolutionary Biology**
People:	Prof. E. Bornberg-Bauer (coordinator), NN
Date:	block IV, Summer
Website:	Either at IEB Münster or at LMU Munich

The Summer School is a collaborative effort between the IEB Münster and the LMU Munich. Each year, students and distinguished scientists from all over the world come together in a relaxed and productive atmosphere at a beautiful location in Lake Chiemsee to discuss and study contemporary topics in evolutionary biology.

Title:	**Mathematical Models in Biology**
People:	Prof. Arndt Telschow (coordinator)
Date:	all semester, Winter
Website:	[Genome Evolution Group](#)

Since many processes in nature are too complex to be understood intuitively, mathematics provides the language and the tools to describe and analyse these processes with theoretical models. Students will learn to understand these models and create their own models.

Goals:

- learning the language of mathematics (e.g. how to read differential equations)
- learning how to develop a mathematical model for any particular biological question
- learning how to analyse mathematical models (e.g. how to solve differential equations)

Contents:

- difference equations / differential equations (e.g. Lotka-Volterra equations, SIR models in epidemiology)
- game theory (e.g. prisoner's dilemma, hawk-dove game)

Methods:

- difference / differential equations: fix points, bistability, stability analysis
- game theory: Nash equilibrium, evolutionary stable strategies, mixed strategies, repeated games

Title:	**The Growth of the Evolutionary Thought**
People:	Dr. Francesco Catania and Prof. Joachim Kurtz
Date:	whole winter semester (Tuesdays, literature review:18:00-19:00 at IEB seminar room; Wednesday, seminar: 9:00-10:00 at IEB Lecture hall)
Website:	[Journal Club](#) [Lecture series](#)

This module focuses on the interdisciplinary study of evolution. Evolution, broadly defined as a gradual development that may lead to a more advanced or complex form, is the most widely applicable scientific concept to understand processes at all scales, from the formation of Earth to human societies.

Goals:

- Learning basic evolutionary patterns and processes.
- Understanding evidence in support and application of the evolutionary theory.
- Developing skills in thinking across disciplines.

Contents:

- Pre-Darwinian theories and Darwin.
- History of life on Earth and evidence in support of the evolutionary theory.
- History of evolution, basic evolutionary mechanisms, and tools for studying molecular evolution.

Methods:

- Seminars
- Interdisciplinary literature review.
- Writing and presentation of research articles.

Research Modules

The Research Modules are small projects lasting 6-8 weeks and carried out in a research group under supervision of a senior researcher, post-doc or professor. Students are expected to follow one Research Module in each of the two semesters during the 1st year of the Msc curriculum. To count for the SSP, at least one of the two modules should be taken in a group of the IEB :

- Limnology and Aquatic Ecology
- Evolutionary Bioinformatics
- Evolution and Biodiversity of Plants
- Animal Evolutionary Ecology
- Plant Molecular Evolution
- Evolutionary Functional Genomics
- Genome Evolution