IMPRS Course Catalogue

Title Content Responsible IMPRS faculty member	Duration & Frequency
Chemical Ecology Theory (Mini lecture series)	
Chemical ecology theory Overview about theoretical concepts and historical aspects of chemical ecology. **Prof. Nicole van Dam**	6x 2h Biannually
Herbivore resistance to plant defenses Overview about the mechanisms that herbivores employ to avoid being poisoned by plant defenses. Much attention will be devoted to detoxification processes involving the metabolic transformation of defenses by enzymes such as cytochrome P450s and glutathione-S-transferases. However, we will also consider the roles of excretion and sequestration, and how herbivores can sometimes make the intended molecular target of a defense insensitive to its action. In addition to the mechanisms themselves, we will also compare the costs and benefits of circumventing plant defenses and how these might explain herbivore host ranges and the evolutionary radiation of herbivore species. Mention will also be made of the methods used in studying herbivore avoidance of defenses, including the benefits of modern chemical and gene sequencing technologies. **Prof. Jonathan Gershenzon & Dr. Daniel Vassao**	4x 2h Biannually
Biochemistry of plant secondary metabolites Overview of major groups of natural products in plants and their chemical structures, occurrence, ecological activities and biosynthesis. **Prof. Jonathan Gershenzon**	5x 2h Biannually
Patterns of plant defense Overview about physical and chemical defenses employed by plants in defense against arthropod and mammalian herbivores in different situations. Comparisons will be made of defense strategies between herbaceous and woody plants, roots and shoots, vegetative and reproductive organs. Additional topics will include the role of tolerance in helping plants resist herbivores, ontogenetic changes in defense profiles during plant lifetimes, and defenses directed against chewing herbivores vs. phloem-feeders and other guilds. Mention will also be made of how genomic, genetic and metabolomic methods have been applied to this research area. **Prof. Jonathan Gershenzon, Dr. Sybille Unsicker, Dr. Grit Kunert**	4x 2h Biannually
Ecological Immunology Parasites (broadly defined to include viruses, bacteria, protozoans, helminths and arthropods) pose major threats to the fitness of their hosts, and are comparable to other biotic interactions such as predation and competition. Parasites shape the ecology and evolution of animal behaviors, and natural selection should favor hosts	4x 2h Biannually

that can effectively protect themselves against their parasites. Despite this, no animal has 'perfect immunity'. The principal aim of ecological immunology course is to understand the causes and consequences of variation in parasite resistance and immune responses. **Dr. Hannah Rowland**	
Neurobiology Training	
From odor detection to insect behavior This course will demonstrate what chemical analytics together with electrophysiology and simple behavioral assays can tell about the strategy of insects to locate a food source. Odor emissions from fruit or flowers and their detection by an insect antenna will be analyzed in gas-chromatography-coupled electro-antennogram recordings. Odors to which the antenna turns out to be extremely sensitive will be tested for the behavioral relevance in simple choice assays. **Prof. Bill Hansson and Dr. Markus Knaden**	4 days On demand
Functional imaging of neuronal activity Different aspects of neuroethology and how odor information can affect arthropod behavior are presented. **Dr. Silke Sachse**	3 days On demand
Neurophysiology: the basics about electro- and optophysiological techniques Practical introduction into 1) patch clamp techniques to measure ion currents across biological membranes (voltage clamp) or to record the membrane potential (current clamp), and 2) to calcium imaging of insect brains to visualize neuronal activity in the brain during sensory stimulation. **PD Dr. Wicher, Prof. Bill Hansson**	2 days On demand
Insect chemical ecology workshop Impact of semiochemicals on insect behavior - rom neuronal input to behavioral output to novel applications With special focus on: plant-plant, plant-insect, plant-insect-microbe, and insect-animal interactions, pheromones, olfactory receptors, odor processing, evolution, physiological and chemical methods, insects and diseases, new and upcoming applications. **Annually varying instructors in Chemical Ecology, Prof. Bill Hansson**	2 weeks Annually alternating between SLU (Sweden) Penn State (USA), MPICE (Germany), and ICIPE (Kenya)
Microscopy Training	
The basics of light and fluorescence microscopy Basic light microscopy, contrasting methods in light microscopy, basic fluorescence microscopy, special applications in fluorescence microscopy. Practical light microscopy (contrasting methods & macroscopy). Practical fluorescence microscopy (Light sheet & confocal microscopy) **Dr. Veit Grabe**	2 days theory, 2 half days practical exercises Once or twice annually
Correlative light- and electron-microscopy - Digital neuroanatomy This course provides a theoretical overview of light and electron microscopic techniques with emphasis on the design of experiments which aims to investigate	3 days On demand

structure-function relationships across several orders of optical resolution. A practical part includes exercises in confocal microscopy (e.g. autofluorescence of cuticular structures in insects), and demos on up-to-date automated electron microscopy (e.g. Focused Ion Beam-Scanning Electron Microscopy, or FIB-SEM). Finally, students will be introduced to the computer-assisted evaluation of microscopic image stacks. **Dr. Jürgen Rybak**	
High resolution fluorescence microscopy Fluorescence CLSM at high resolution (Elyra) with bacterial and fungal cells. **Prof. Erika Kothe/Dr. Katrin Krause**	2 weeks half-day On demand
Analytical Chemistry Training	
Analysis of low molecular weight metabolites involved in signaling and defense The course will cover theoretical and practical aspects of small molecule extraction, volatile collection, and separation & identification via liquid chromatography-mass spectrometry, gas chromatography-mass spectrometry, and HPLC with various detectors. **Dr. Michael Reichelt, Dr. Tobias Köllner , Prof. Jonathan Gershenzon**	2 days On demand
Analysis of plant volatiles Lectures on theoretical aspects and hands-on elements are mixed in this course to teach participants how to sample plant volatiles and analyze the samples on the GC-MS. They will also learn how to process and statistically analyze the resulting datasets, including aspects of compound identification. **Prof. Nicole Van Dam and coworkers (offered through yDiv)**	2 days On demand
Basic training in mass spectrometry Detection of low-molecular-weight signal compounds and markers: Combination of an overview of modern MS methods and instrumentation with practical sessions on three instruments available in the MS group (GC-MS, LC-MS and MALDI-TOF). **Dr. A. Svatos & Dr. A. Attygalle** **(to be covered by Prof. O'Connor from 2021)**	4 days Biannually
Basic training in NMR NMR in chemical ecology, NMR applications, structure elucidation, sample preparation, basic introduction to information to be gained by applications of the following methods: 1D NMR (^{1}H, ^{13}C), Homocorrelation NMR (COSY, TOCSY, NOE), Heterocorrelation NMR (HSQC, HMBC, …). Lectures, demonstrations, exercises **Dr. Christian Paetz & coworkers**	4 days Biannually
Advanced training in mass spectrometry The identification of ecologically important classes of compounds (except peptides and proteins) will be demonstrated. A broad repertoire of chemical derivatization on the micro-scale will be reviewed and the utility for particular compound classes will be explained. Basic principles of metabolomics are introduced and practical training using the MarkerLynx software (Waters) are provided. **Dr. A. Svatos & Dr. A. Attygalle,** **(to be covered by Prof. O'Connor from 2021)**	4 days Biannually
Computational tools for small compound mass spectrometry Computational methods development for small compound mass spectrometry has prospered during the last decade; numerous approaches such as molecular networks and tools based on machine learning have entered the routine data analysis. This	1,5 days On demand

course will give an overview over the landscape of available approaches, and try to show which approach is right for which question. This is to avoid "blackboxing" where the last and essential step of the analysis pipeline - namely, the data analysis - is performed by tools which are not understood by the user. **Prof. Sebastian Böcker and coworkers**	
SIRIUS and CSI:FingerID for small compound identification This is a hands-on course on compound identification using tandem mass spectrometry data. The course will also cover some methodological details behind SIRIUS and CSI:FingerID, best-of-class computational tools for this purpose. It will be demonstrated how to get data into SIRIUS, how to get it analyzed, and how to interpret the results: For example, how does element auto-detection work, what is a "reasonable" fragmentation tree and what a "reasonable" predicted fingerprint. Participants can bring their own data to the course to have it analyzed. **Prof. Sebastian Böcker**	3 days On demand
Structure elucidation of secondary metabolites The course will provide a guide to structure elucidation of unknown metabolites. The application of MS, NMR, UV, IR and chiroptic methods in combination to gain insight into chemical structures will be presented. Issues of sample preparation and strategies for the selection of different spectroscopic methods will be discussed. Later, examples will be introduced of how sets of spectra can be assembled to give a structure. Problems will be assigned for solution by students working in small groups. **Prof. Georg Pohnert**	2 days
Metabolomics for ecologists The course will provide a basic overview about the application of metabolomics in ecological and biodiversity research. Tools and approaches that are used to obtain, process and analyze metabolomics data will be explored. Participants learn about the design of a metabolomic experiment, how to extract the metabolites and how to process and interpret the MS Data. They will also critically discuss the metabolomics datasets and typical pitfalls of this method. The course is a combination of theory and hands-on data analysis. **Dr. Henriette Uthe, Prof. Nicole van Dam and coworkers (EcoMetEoR Platform)**	1 week Annually (Summer course)
Data analysis for metabolomics As in proteomics, the computational analysis of the data is becoming an integral part of the analysis pipeline in LC-MS-based metabolomics. Numerous computational tools are available for processing MS1 (XCMS, mzmine2, OpenMS) and MS2 (CSI:FingerID, CFM-ID, MetFrag) data. These basic tools will be explained in detail and participants can bring own data for analysis. **Prof. Sebastian Böcker and coworkers**	2 days On demand
Statistics Training	
Basic training in statistics and the statistical program R Basic training in the most important statistical methods for comparing groups (t-test, Anova and their non-parametric relatives), regressions, ANCOVA. Combination of lecture and practical with the program “R”. **Dr. Grit Kunert**	5 days part-time Annually
Experimental design in the life sciences Experimental design basics addressing the need for good design, problems of confounding, phylogenetic relatedness, pseudoreplication, lack of replicates (low	2 days On demand

power), lack of randomization, negative and positive controls, blinding, blocking, design types (blocked, within-subjects, repeated measures, split unit), calibration, within and between researcher variability, and strategies for missing values and imperfect data. **Dr. Andrew Davis**	
Variance decomposition using mixed models in R Parameter interpretation in linear models, introduction to R functions, mixed models (random intercepts), variance components and ratios of variances, multi-response mixed models and Bayesian mixed model fitting, generalized linear mixed models, link functions and random-slope models, continuous random effects and animal models **Prof. Holger Schielzeth and coworkers**	5 days On demand
Genetics Training	
Inferring phylogeny based on sequence information We use different (predominantly web-based) bioinformatics tools to search for orthologous gene and protein sequences, create multiple sequence alignments, retranslate aligned protein sequences into codon-alignments and reconstruct the phylogenetic relationship of the examined sequences. Additional exercises are performed to elucidate the principle of phylogeny inference and to train the correct interpretation of phylogentic trees and related issues. **Prof. Günter Theißen and coworkers**	2 days Annually
QTL mapping of complex ecological traits TB The course covers the complete processes of QTL mapping from the generation of the mapping population to the recording of phenotype data and QTL analysis. The following topics will be addressed: crossing designs for mapping populations; targeted and untargeted metabolomics using GC- and LC-MS, basics in chromatography and mass spectrometry; design of field screening experiments (sentinel insects, herbivory and pollinator interactions); data analysis using QTL analysis pipelines and strategies for functional verification of candidate loci. **Dr. Rayko Halitschke, Prof. Ian Baldwin**	2 days On demand
Reverse genetics approach to the analysis of ecological traits The course will provide an overview about the goals of plant transformation and introduce available methods (biolistic vs. Agrobacterium, stable vs. transient, over-expression vs. RNA interference, design of vectors, choice of sequence). CRISPR-Cas9 will also be covered. A practical session is included. **Dr. Axel Schmidt & coworkers from O'Connor department**	2 days On demand
Fungal genetics This course will give an overview about mating types and pathogenicity, pheromone recognition, basidiomycete transformation and signal transduction, cytoskeleton RNA isolation, reverse transcription and Real Time PCR. **Prof. Erika Kothe**	3 days On demand
RNA Analysis Training	
Comparison of different RNA extraction methods from soil and roots This hands-on lab course will compare different RNA extraction methods for soil and root samples. Participants can extract RNA from own samples using a standard kit for RNA extraction. The kit protocol can be adjusted to the different samples. Results and troubleshooting measures will be discussed.	3 days On demand

Prof. Erika Kothe	
Transcriptome sequencing approaches in chemical ecology Overview of state-of the art transcriptome sequencing approaches: technical and strategic aspects **Dr. Heiko Vogel**	2 days On demand
Specific Topics	
Functional Assays are Not "Just-So" Stories This workshop is aimed at introducing the functional level of analysis in biological experiments; elucidate logical pitfalls in hypothesis testing, and how to successfully overcome these pitfalls to answer functional 'why' questions in a given system. The workshop will help students recognize hypotheses posed at different levels of analysis and avoid the often-repeated mistakes of contrasting hypotheses posed at different levels. The workshop will also help students to design and conduct rigorous tests of function, and how to interpret results in light of organismal-level functional considerations. In brief the workshop will cover: (1) Why focus on 'why' questions in biological research? (2) How to bring "why" questions into your own research? (3) How to test these questions? We will focus on the theory of functional analysis and its application. The workshop requires participants' active engagement. Participation in a series of exercises that include critical evaluations of claims of function from the recent literature and engagement in hypothetical scenarios regarding the participants' study systems will be essential. **Dr. Rayko Halitschke, Prof. Ian Baldwin**	On demand
Ca-signaling in plant-microbe interactions Techniques for the analysis of plant/microbe interactions will be presented with special reference to fungi interacting with roots. Students will learn the techniques of cytoplasmic calcium measurements in living *Arabidopsis* root cells, to determine whether the elicitor-induced calcium elevation leads to defense responses or a beneficial interaction, and to characterize mutants defective in specific calcium responses. **Prof. Ralf Oelmüller**	3 days On demand
Signaling in aquatic biofilms 1) What is known – overview and background; 2) Methods to elucidate signalling in aquatic biofilms 3) Course work: Lateral resolved monitoring of infochemicals **Prof. Georg Pohnert**	2 days On demand
Basic bioinformatics How to find your favorite gene/protein sequence? Theory on sequence databases and blast programs. Introduction to NCBI tools, blast servers. Introduction to protein databases, Phi-blast and tertiary structure analysis with PyMol. **Dr. Klaus Gase, Prof. Ian Baldwin**	4 days part-time On demand
Machine learning Machine learning is currently becoming an indispensable part of science, just as it has become a part of everyday life. To understand what machine learning is and what it is not, what it can do and what it cannot, how it can be applied to a scientific questions and what pitfalls have to be avoided at all costs, it is necessary that every scientist gets a basic understanding of the underlying techniques. This course is meant to provide a first glimpse into the quickly evolving field of machine learning.	1 day On demand

Prof. Sebastian Böcker and coworkers	
Training in Mathematical Modelling	
Evolutionary game theory Providing insight into the fundamental ecological and evolutionary concepts of ecological interactions, as well as introduce game-theoretical modelling as a tool to formalize ecological interactions and predict their evolutionary outcome. The following topics are covered: Levels of selection, synecology, community ecology, various typical games relevant in biology: Prisoner's Dilemma, snowdrift game, coordination game, rock-scissors-paper game; application of evolutionary game theory in biology. **Prof. Stefan Schuster**	5 days On demand
Modelling of metabolic networks Basic concepts of mathematical modelling and computer simulation of metabolic networks; the theoretical knowledge is applied to several concrete biochemical examples. **Prof. Stefan Schuster**	3 days part-time On demand
Training in Good Scientific Practise	
Good scientific practise in the doctoral training phase The major objective this workshop is to know and understand the basic rules and values of responsible conduct of research in all its stages, according to local, national and international regulations and guidelines. The participants will explore the differences and grey areas between good scientific practice, questionable research practice and scientific misconduct. All researchers working at the Max Planck Society and the Friedrich Schiller University are required to comply with the fundamental principles for safeguarding good scientific practice. What does this mean for you? Is it enough to know how to cite correctly? The workshop will give you an introduction into potential areas of conflict in research, dishonest scientific behavior, and possible consequences. The MPI-CE ombudsperson will introduce herself and her role with respect to following good scientific practice principles. The MPI-CE librarian will discuss authorship issues and rules of open access publishing. **Dr. Dorit Schmidt, Dr. Grit Kunert, Kirsten Heinrich**	1 day Annually
Open science Current trends in promoting open, transparent and reproducible research with a special focus on pre-registered projects and platforms for code and data sharing. **Prof. Schielzeth**	2 days On demand
FSU Courses of Interest	
MSc course chemical and molecular ecology Weekly lectures, iDiv excursion, seminar presentation **Prof. Nicole van Dam**	Winter semester
Master of Molecular Life Sciences Lecture course "Molecular genetics" **Prof. Günter Theissen** Lecture course "Developmental genetics" **Prof. Günter Theissen** Lecture course "Gene regulatory networks" **Prof. Günter Theissen** Lecture course "Molecular evolution"	Winter semester

Prof. Günter Theissen, Prof. David Heckel	
Master of Molecular Life Sciences MMLS.A1 “Molecular developmental biology of model organisms” Practical course and seminar **Prof. Dr. Christoph Englert** MMLS.A2 “Evolutionary developmental biology” Practical course and seminar **Prof. Günter Theissen** MMLS.A3 “Developmental control genes” Practical course and seminar **Prof. Günter Theissen**	Summer semester