Modulhandbuch

# Microbiology - Master's Programme

im Wintersemester 2018/2019

erstellt am 26/04/24

mar500 - Physiology and diversity of microorganisms	
mar510 - Molecular Mechanisms and Interactions	
mar520 - Main Module Proteomics	5
mar530 - Main Module Ecophysiology of prokaryotes	
mar540 - Main Module Ecology of Marine Microbial communities	-
mar560 - Profile Module Fermentation	
mar570 - Profile Module Introduction to DNA-sequencing and sequence analysis	12
mar580 - Profile Module Microbial ecology of marine sediments	
mar600 - Profile Module Methods in Aquatic Microbial Ecology	-
mar610 - Profile Module Isolation and characterization of microorganisms	16
mar620 - Profile Module Marine Chemical Ecology	18
mar622 - Profile Module R programming for (meta)-genomic sequence analysis	20
mar630 - Research Project	21
mar640 - Research Project	23
mam - Master's Thesis Module	
	25

# Mastermodule

## mar500 - Physiology and diversity of microorganisms

Module label	Physiology and diversity of microorganisms
Modulkürzel	mar500
Credit points	12.0 KP
Workload	360 h
Verwendbarkeit des Moduls	Master's Programme Microbiology (Master) > Mastermodule
Zuständige Personen	<ul><li>Könneke, Martin (module responsibility)</li><li>der Mikrobiologie, Lehrende (Module counselling)</li></ul>
Prerequisites	
Skills to be acquired in this module	The students know the cells of pro- und eukaryotes and understand the basic mechanisms of microbial metabolism. Furthermore, students learn about the physiological and phylogenetic groups of prokaryotes, eukaryotic microorganisms and viruses and get an overview on applied aspects of microbiology.
Module contents	
	The module consists of 5 parts:
	1) Physiology and life modes of prokaryotes (lecture + exercises)
	Topics are cellular and subcellular organisation, assimilation and dissimilation, energy metabolism, transport, microbial growth, chemiosmotic theory, fermentation, anaerobic respiration, lithotrophy, photosynthesis, metabolism of different Archaea, Bacteria pathogenic prokaryotes, microbiological techniques.
	2) Microbial diversity (lecture + exercises)
	Topics are the eukaryotic cell, diversity, systematics and taxonomy of prokaryotes and eukaryotic microorganisms, algae, protozoa, molds, phagocytosis, symbioses, pathogenic eukaryotes, diversity of eukaryotic microbes, components of viruses, virus reproduction, bacteriophages, diversity of viruses, virus diseases.
	3) Broadening lectures, one out of the following
	<ul> <li>Biological significance of suspended matter: Lecturer: Simon; Form of study: 1 lecture a week, partially blocked for 2 lectures a week; 3 CP; summer term;</li> </ul>
	<ul> <li>Sediment Microbiology:</li> <li>Lecturer: Engelen; Form of study: 3 weeks block; 3 CP; summer term;</li> <li>This lecture presents state of the art knowledge about occurrence, life and activities of microorganisms in these environments. Physiological issues are addressed as well as evolutionary and applied aspects.</li> </ul>
	Topics are: formation, diagenesis and special features of sediments; physico- chemical conditions and geological records; interpretation of gradients; microbes and biological processes in sediments; methods for cultivation of sediment organisms; molecular methods; biogeochemical methods; quantification of prokaryotes and viruses
	- Scientific writing and presentation: Lecturer: Engelen; Form of study: weekly seminar; 3 CP; The students know the importance and structure of scientific publications. They learn to read papers critically and which require important for the different parts. Furthermore, students will train to give oral presentations as well as scientific reports and poste how to use the library and how to find relevant literature and how to use citation programs.
	Topics are: types and relevance of scientific publications; parts of scientific publications step by step: Abstract, Introduction, Results, Discussion; university facilities for literature search; oral presentation; how to prepare posters; tips for using Excel, PowerPoint, Word and Endnote
	<ul> <li>Alternative lectures of the MSc "Marine environmental sciences" or "Biology" (see current online schedule)</li> </ul>

Date 26/04/24

#### 4) Excursions into the field, to companies and scientific institutions

5) ICBM and microbiological colloquium (alternating weekly)

Literaturempfehlungen		Mardigan "Brock - Biolog	y of microorganisms"	
Links				
Language of instruction		English		
Duration (semesters)		1 Semester		
Module frequency		annual		
Module capacity		unlimited		
Type of module		Pflicht / Mandatory		
Module level		BC (Basiscurriculum / Ba	se curriculum)	
Teaching/Learning method		Lecture + Exercises: Phy Lecture + Exercises: Mici 1x broadening lecture or Microbiological + ICBM C Excursions (1 CP)	robial diversity (3 CP) seminar (3 CP)	prokaryotes (3 CP)
Examination		Prüfungszeiten	Type of examination	
Final exam of module		At the end of the lecture period. the exact date will be announced during the course	'Physiology and life mo 'Microbial Diversity'.	chable points in written tes
Lehrveranstaltungsform	Comment	SWS	Frequency	Workload of compulso attendance
Lecture		6	SoSe oder WiSe	٤
Exercises		2	WiSe	2
Study trip		1	SoSe oder WiSe	

#### mar510 - Molecular Mechanisms and Interactions

Module label	Molecular Mechanisms and Interactions		
Modulkürzel	mar510		
Credit points	12.0 KP		
Workload	360 h		
Verwendbarkeit des Moduls	<ul> <li>Master's Programme Microbiology (Master) &gt; Mastermodule</li> </ul>		
Zuständige Personen	<ul><li>Rabus, Ralf Andreas (module responsibility)</li><li>der Mikrobiologie, Lehrende (Module counselling)</li></ul>		
Prerequisites			
Skills to be acquired in this module	The students know the molecular mechanisms of metabolism, genetics and evolution. They know regulatory mechanisms on the molecular level and feedback mechanisms between organisms. They know the basics of microbial ecology and the biogeochemistry of important microbial habitats. They know molecular and chemical-analytical methods of microbiology. The have experience with the field study of microorganisms.		
Module contents			

The module consists of 5 parts:

#### 1) Molecular Microbiology (lecture + exercise)

Topic I - DNA: structure, DNA-proteins, DNA-replication, recombination, transposition, mutation, repair, plasmids and DNA-exchange Topic II - gene expression: transcription, regulation of transcription, translation Topic III - enzymes: protein structures, basic concepts and kinetics, catalytic and regulatory strategies Topic IV - regulatory networks: diauxie and catabolite repression, oxygen

regulation, chemotaxis

#### 2) Microbial Ecology (lecture + exercise)

Principles of biogeochemistry, global element cycles, mineralisation of organic substances, chemotaxis, aquatic habitats, terrestrial habitats, deep subsurface biosphere, syntrophy and symbiosis, microbes in earth history, methods in microbial ecology, isotope fractionation, applied microbiology, bioremediation

#### 3) Broadening lectures, one out of the following

- Biological significance of suspended matter:

Lecturer: Simon; Form of study: 1 lecture a week, partially blocked for 2 lectures a week; 3 CP; summer term;

- Sediment Microbiology:

Lecturer: Engelen; Form of study: 3 weeks block; 3 CP; summer term; This lecture presents state of the art knowledge about occurrence, life and activities of microorganisms in these environments. Physiological issues are addressed as well as evolutionary and applied aspects.

Topics are: formation, diagenesis and special features of sediments; physicochemical conditions and geological records; interpretation of gradients; microbes and biological processes in sediments; methods for cultivation of sediment organisms; molecular methods; biogeochemical methods; quantification of prokaryotes and viruses

- Scientific writing and presentation:

Lecturer: Engelen; Form of study: weekly seminar; 3 CP; The students know the importance and structure of scientific publications. They learn to read papers critically and which require important for the different parts. Furthermore, students will train to give oral presentations as well as scientific reports and poste how to use the library and how to find relevant literature and how to use citation programs.

Topics are: types and relevance of scientific publications; parts of scientific publications step by step: Abstract, Introduction, Results, Discussion; university facilities for literature search; oral presentation; how to prepare posters; tips for using Excel, PowerPoint, Word and Endnote

 Alternative lectures of the MSc "Marine environmental sciences" or "Biology" (see current online schedule)

#### 4) Excursions into the field, to companies and scientific institutions

5) ICBM and microbiological colloquium (alternating weekly)

			5		
Literaturempfehlungen			Stryer – Biochemistry Voet – Biochemistry		
			Knippers – Molekulare G	enetik	
			Snyder – Molecular Gene		
			Brock - Microbiology		
Links					
Language of instruction			English		
Duration (semesters)			1 Semester		
Module frequency			annual		
Module capacity			unlimited		
Type of module			Pflicht / Mandatory		
Module level			BC (Basiscurriculum / Ba	se curriculum)	
Teaching/Learning method		Lecture + Exercises: Molecular microbiology (3 CP) Lecture + Exercises: Microbial ecology (3 CP) Broadening lecture or seminar (3 CP)		?)	
			Excursion (1 CP) Microbiological + ICBM C	Colloquium (2 CP)	
Examination		Prüfungszeiten		Type of examination	
Final exam of module		At the end of the lecture period, the exact date will be announced during the course.		Microbiology' and 'Micro	in written tests about the two
				seminars, field trips) an e.g. the delivery of exer	Active and documented I courses (labs, exercises, d courses. These include cises, writing a lab report or according to the advice of
Lehrveranstaltungsform	Comment	SV	WS	Frequency	Workload of compulsory attendance
Lecture			4	SoSe	56
Exercises		1	2	SoSe	28
Seminar		1	2	SoSe oder WiSe	28
Study trip			1		14

#### mar520 - Main Module Proteomics

Module label	Main Module Proteomics	
Modulkürzel	mar520	
Credit points	12.0 KP	
Workload	360 h	
Verwendbarkeit des Moduls	<ul> <li>Master's Programme Microbiology (Master) &gt; Mastermodule</li> </ul>	
Zuständige Personen	<ul> <li>Rabus, Ralf Andreas (module responsibility)</li> <li>Feenders, Christoph (Module counselling)</li> <li>Wöhlbrand, Lars (Module counselling)</li> </ul>	
Prerequisites		
Skills to be acquired in this module	The students are getting directly involved in actual scientific projects in the a of physiological and/or meta-proteomics (under guidance). They - get acquainted with state-of-the-art proteomic concepts and technologies, - know how to write concise scientific protocols, - know how to present/discuss their results in public.	
Module contents	<ul> <li>Daily lectures introduce the students to theory and concepts of modern proteomics:</li> <li>(i) separation of cellular compartments and protein extraction,</li> <li>(ii) gel-based and -free protein separation,</li> <li>(iii) gel-staining, protein detection and quantification by image analysis,</li> <li>(iv) integrative mass spectrometry-based protein identification,</li> <li>(v) meta-proteomics,</li> <li>vi) focused genomic analysis.</li> <li>Each student will prepare a seminar presentation on selected publications relevant for the actual scientific project. The following sequence of experime will be conducted: <ul> <li>extraction and quantification of total protein from prepared cell samples (ir separation of compartments),</li> <li>protein separation by SDS-PAGE and staining with Coomassie, silver and fluorescent dyes,</li> <li>digital image acquisition and analysis,</li> <li>manual and/or automated band excision,</li> <li>protein identification by nanoLC-ESI-MS/MS,</li> <li>nanoLC-MALDI-coupling and protein identification by MALDI-TOF-MS/MS</li> <li>physiological interpretation of predicted protein functions and relevant genomic context.</li> </ul> </li> </ul>	
Literaturempfehlungen	Lottspeich - Bioanalytik	
Links		
Language of instruction	English	
Duration (semesters)	1 Semester	
Module frequency	annual	
Module capacity	unlimited	
Reference text		
Type of module	Wahlpflicht / Elective	
Module level	AC (Aufbaucurriculum / Composition)	
Teaching/Learning method	Seminar (2 CP), practical course (10 CP)	
Previous knowledge	Lecture: Physiology and diversity of prokaryotes, lecture: Molecular Microbiology	
Examination	Prüfungszeiten Type of examination	
Final exam of module	Announced at the beginning of the course.	

**One assessments of examination:** Portfolio: Written protocol (75%) and contribution to the seminar (seminar presentation, 25%)

Active participation: Active and documented participation in practical courses (labs, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report or seminar presentations according to the advice or the course.

Lehrveranstaltungsform	Comment	SWS	Frequency	Workload of compulsory attendance
Seminar		2	SoSe	28
Practical training		8	SoSe	112
Präsenzzeit Modul insgesam	ıt			140 h

## mar530 - Main Module Ecophysiology of prokaryotes

Module label	Main Module Ecophysiology of prokaryotes
Modulkürzel	mar530
Credit points	12.0 KP
Workload	360 h
Verwendbarkeit des Moduls	<ul> <li>Master's Programme Microbiology (Master) &gt; Mastermodule</li> </ul>
Zuständige Personen	<ul> <li>Könneke, Martin (module responsibility)</li> <li>Engelen, Bert (Module counselling)</li> <li>der Mikrobiologie, Lehrende (Prüfungsberechtigt)</li> </ul>
Prerequisites	
Skills to be acquired in this module	The aim of the module "Ecophysiology of prokaryotes" is to impart in- depth knowledge on the metabolism and physiology of microorganisms and train students in practical skills to measure physiological parameters. After completion of the module, students can - contribute to current scientific projects (under guidance) - know modern analytical techniques - know and understand recent scientific literature - can write scientific reports, present their results and discuss them
Module contents	<ul> <li>"Ecophysiology of prokaryotes": Projects derived from current scientific programs are carried out, typically in groups of two students guided by a senior scientist or PhD student.</li> <li>Typical project deal with: <ul> <li>Anaerobic processes</li> <li>Molecular analysis of microbial communities</li> <li>Sediment microbiology</li> <li>Physiological experiments and activity measurements</li> <li>Impact of viruses</li> <li>Microscopic analysis of chemotaxis</li> </ul> </li> <li>In the accompanying seminar, recent scientific studies in international journals are presented by the students. The results are summarized and discussed in a protocol fulfilling scientific level requirements.</li> </ul>
Literaturempfehlungen	will be announced
Links	
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	annual
Module capacity	unlimited
Type of module	Wahlpflicht / Elective
Module level	AC (Aufbaucurriculum / Composition)
Teaching/Learning method	Block course, 4 weeks, seminar and laboratory work
Previous knowledge	Lecture: Physiology and diversity of prokaryotes; recommended: Sediment microbiology
Examination P	üfungszeiten Type of examination
Final exam of module A	nnounced during the course.
	One assessments of examination: Portfolio: Written protocol (100%) and contribution to the seminar (seminar presentation, no mark) Active participation: Active and documented participation in practical courses (labs, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report or seminar presentations according to the advice or the course supervisor.

Lehrveranstaltungsform	Comment	SWS	Frequency	Workload of compulsory attendance
Seminar		2	WiSe	28
Exercises		8	WiSe	112

Lehrveranstaltungsform	Comment	SWS	Frequency	Workload of compulsory attendance
Präsenzzeit Modul insgesa	amt			140 h

## mar540 - Main Module Ecology of Marine Microbial communities

Module label		Main	Module Ecolog	y of Marine Microbial communi	ties
Modulkürzel		mar54	10		
Credit points		12.0 k	(P		
Workload		360 h			
Verwendbarkeit des Moduls			Master's Pr	ogramme Microbiology (Master	) > Mastermodule
Zuständige Personen				ahi Lorena (module responsibil horsten Henning (Module coun	
Prerequisites					
Skills to be acquired in this	module	exper resea ongoi oxic s apply ecolog write and re to des microl exper enable other	mental and/or rchers and PhI ng research on ediments and a various state c gy and how to i protocols in the derence studie ign experimen bial ecology an ence in projec es them to obta	ow to address scientific questic field work in scientific projects of the ecology of bacterial commassociated to eukaryotic organi of the art methods and approach interpret data and results of the extructure of scientific papers a is to an audience. The students to and address specific researce d to choose appropriate metho that application of state o ain a more critical view on the ain the validity of scientific investion	guided by experienced signed in the context of unities in the water column, sms. The students learn to hes in aquatic microbial projects. They learn to ind to present own results gain competences in how h questions in aquatic ds. They obtain practical f the art methods. This upplication of these and
Module contents		out of workii resea scient stude	ongoing resea ng group. Typic rcher and/or a ific studies pub	nicrobes": The students carry o rch of PhD Thesis work and ot ally a group of two of three stu PhD student. In the accompany blished in international journals are written down and discusse ements.	her current research of the dents is guided by a senior /ing seminar, recent are presented by the
Literaturempfehlungen		will be	announced		
Links					
Languages of instruction		Englis	h, German		
Duration (semesters)		1 Sen	nester		
Module frequency		annua	I		
Module capacity		12			
Type of module		Wahlp	flicht / Elective	)	
Module level		AC (A	ufbaucurriculu	m / Composition)	
Teaching/Learning method		semin	ar + pracitical	course/exercise	
Examination		Prüfungszeiten		Type of examination	
Final exam of module		to be announced during the cour	se.		
		-		the seminar (seminar pro Active participation in e.g. specific exercises, v	ol (75%) and contribution to esentation, 25%) the course: This includes,
Lehrveranstaltungsform	Comment	SWS		Frequency	Workload of compulsory attendance
Seminar		1		SoSe	14
Exercises		9		SoSe	126
Präsenzzeit Modul insgesan	nt				140 h

#### mar560 - Profile Module Fermentation

Module label	F	Profile Module Fermentation
Modulkürzel	r	nar560
Credit points	(	5.0 KP
Workload		180 h
Verwendbarkeit des Moduls		Master's Programme Microbiology (Master) > Mastermodule
Zuständige Personen		<ul><li>Rabus, Ralf Andreas (module responsibility)</li><li>Wöhlbrand, Lars (Module counselling)</li></ul>
Prerequisites		
Skills to be acquired in this module	( 2 2	The students are getting directly involved in actual scientific projects in the area of general physiology (under guidance). They understand the scientific rational and design of the experiment(s), get acquainted with state-of-the-art concepts and technologies for growth balancing (e.g. bioreactor), know how to write concise scientific protocols, know how to present/discuss their results in public.
Module contents	) ( ( ( ( - - - - - - - - - - - - - - -	Growth balancing": Daily lectures introduce the students to theory and concepts of growth stoichiometry: (i) aerobic or anaerobic growth experiments n glass vessels and/or bioreactors, iii) experimental design, iii) design and operating laboratory fermenters, iv) HPLC, IC and GC-MS analysis. Each student will prepare a seminar presentation on selected publications elevant for the actual scientific project. The following sequence of experiments will be conducted: cultivation of bacterial pure cultures in Erlenmeyer flasks, glass bottles or controlled bioreactors determination of optical density, the live count, dry weight of cells and microscopic inspection during cultivation (dis)assembly and sterilization of fermentation devices operate process-controlled fermenters (incl. O2 and pH adjustments and sterile sampling) determine O2-consumption and CO2-production rates based on on-line GC- MS measurements quantification of substrate consumption for HPLC and IC quantitative determination and calculation growth balances and efficiencies
Literaturempfehlungen		
Links		
Language of instruction	[	English
Duration (semesters)		I Semester
Module frequency	r	not offered at the moment
Module capacity	l	unlimited
Type of module	l	Nahlpflicht / Elective
Module level	/	AC (Aufbaucurriculum / Composition)
Teaching/Learning method	Ś	Seminar; practical course
Previous knowledge		Lecture: Physiology and diversity of prokaryotes (successfully completed) Lecture: Molecular Microbiology
Examination	Prüfungszeiten	Type of examination
Final exam of module	Announced at the beginning	g of the course.
		<b>One assessment of examination:</b> Portfolio: Protocol (100 %), seminar presentation (no mark)
		Active participation: Active and documented participation in practical courses (labs, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report or seminar presentations according to the advice of the course supervisor.

Lehrveranstaltungsform

the course supervisor.

Lehrveranstaltungsform	Comment	SWS	Frequency	Workload of compulsory attendance
Seminar		1		14
Practical training		4		56
Präsenzzeit Modul insgesa	amt			70 h

## mar570 - Profile Module Introduction to DNA-sequencing and sequence analysis

Seminar 2 SoSe	Module label		Profile Module Introducti	on to DNA-sequencing and	sequence analysis
Workload       180 h         Verwendbarkeit des Moduls <ul> <li>Master's Programme Microbiology (Master) &gt; Mastermodule</li> </ul> Zuständige Personen <ul> <li>Brinkhoff, Thorsten Henning (module responsibility)</li> </ul> Prerequisites           Skills to be acquired in this module <ul> <li>sequence DNA by Sanger sequencing - sequences</li> <li>use the various facilities of the KOB diabases - use denicus for genome analysis - use denicus for denicus for various the sequencing will be tagenoric dual for various the protocol - use denicus for denicus for various for the use of various internut diabases. In sequencing will be tagenoric dual for various for various internut diabases. In sequencing will be tagenoric dual for various for the too days. Dualysis role various internut diabases for various and the protocol various internut diabases. In sequencing will be tagenoric dual for the use of various internut diabases. In sequencing will be tagenoric dual for the use of various internut diabases. In sequencing will be tagenoric dual for the use of various internut diabases. The escure dual for the use of various internut diabases. The escure dual for the use</li></ul>	Modulkürzel		mar570		
Verwendbarkeit des Moduls <ul> <li>Master's Programme Microbiology (Master) &gt; Mastermodule</li> </ul> Verwendbarkeit des Moduls <ul> <li>Brinkhoff, Thorsten Henning (module responsibility)</li> </ul> Prerequisites <ul> <li>Brinkhoff, Thorsten Henning (module responsibility)</li> <li>esquence DNA by Sanger sequencing             <ul> <li>esquence DNA by Sanger sequencing                 <ul> <li>esquence DNA by Sanger sequencing</li></ul></li></ul></li></ul>	Credit points		6.0 KP		
Zustandige Personen <ul> <li>Brinkhoff, Thorsten Henning (module responsibility)</li> <li>Prerequisites</li> <li>Skills to be acquired in this module</li> <li>Skills to be acquired in this module for the skills to the acquired in this module for the skills to the acquired in this module for the skills to the acquired in this module for the skills to the acquired in this module for the skills to the acquired in this module for the skills to the acquired in this module for the skills to the acquired in this module for the skills to the acquired in this module for the skills to the acquired in this module for the acquired in this module for the acquired in the first the acquired in this module for the acquired in the first to the acquired in the first the acquired in the first the acquired in the first the acquired in the acquired in the acquired in the acquired in th</li></ul>	Workload		180 h		
Prerequisites         Skills to be acquired in this module       The students know how to equence DNA by sequencing - essemble DNA sequences - use the various facilities of the NCEI database - analyze bacterial genomes for presence of specific genes - use denous for genome analysis - use ARB, databases and literature data to create phylogenetic trees, desi primers and probes - present and discuss scientific results - write a scientific protocol         Module contents       "introduction into DNA sequencing and sequence analysis". The course st with a lecture on the first two days. During the following days the participant will give seminar fails about different scientific toxides for which DNA sequencing was highly relevant. DNA sequencing days the participant will give seminar fails about different scientific toxides for which DNA sequencing was highly relevant. DNA sequencing will be taught in the lab to the working group. Sequence analysis, introduction into the use of various intermet databases, the sequence analysis phylogene of various intermet databases, the sequence analysis phylogene of various intermet databases, the sequence analysis phylogene of various of the institute.         Literaturempfehlungen       English         Duration (semesters)       1 Semester         Module creacity       18         Type of module       Wahlpflicht / Elective         Module level       AC (Aufbacurriculum / Composition)         Teaching reparticipation       English         Type of examination       Previous knowledge         Links       Contable Protocol (75 %), seminar presentation %)         Final exam of module<	Verwendbarkeit des Moduls		<ul> <li>Master's Progra</li> </ul>	mme Microbiology (Master	) > Mastermodule
Skills to be acquired in this module       The students know how to - sequencing - sequencing - sequences in the VA by Sanger sequencing - sequences in the VA by Gauger Sequences - use internet databases for sequence comparison - use the various facilities of the NCBI database - analyze bacterial genomes to predice genes - second sort of genes and probes - analyze bacterial genomes to probe comparison - use the various facilities of the NCBI database - analyze bacterial genomes to probe comparison - use the various facilities of the NCBI database - analyze bacterial genomes to probe comparison - use the various facilities of the NCBI database - analyze bacterial genomes and probes - present and discuss scientific results - write a scientific protector         Module contents       "Introduction into DNA-sequencing and sequence analysis". The course st with a lecture on the first two days. During the following days the participant will give seminar talks about differencing will be taught in the late of the institute.         Interaturempfehlungen       Interaturempfehlungen         Literaturempfehlungen       Interative databases, the sequence analysis protection will be taught in the late of the institute.         Module frequency       annual         Module capacity       1 Semester         Module level       AC (Authaccurriculum / Composition)         Teaching/Learning method       Seminar: practical corus         Previous knowledge       Lecture during the course         Examination       Profungszeiten       Active participation: Active and documented participation: according to the avadive of the ourse sequencing on accest, writing a lab regol	Zuständige Personen		Brinkhoff, Thors	ten Henning (module respo	onsibility)
- sequence DNA by Sanger sequences         - use interret databases for sequence comparison         - use interret databases for sequence comparison         - use interret databases for sequence comparison         - use ARB, databases and literature data to create phylogenetic trees, desi primers and probes         - use ARB, databases and literature data to create phylogenetic trees, desi primers and probes         - use ARB, databases and literature data to create phylogenetic trees, desi primers and probes         - use ARB, databases and literature data to create phylogenetic trees, desi primers and probes         - use ARB, databases and literature data to create phylogenetic trees, desi primers and probes         - present and discuss scientific results         - present and discuss scientific results         - present and discuss scientific results         - protein table scientific batcles for which DNA sequencing and highly relevant. DNA sequencing and highly introduction in the use of various interret databases, the sequence analysis program Genicus and the phylogeny program endows and the phylogeny introduction. The sequencing and highly introduction into the use of various interret databases.         Letraturempfehungen       1 Semester         Unitable sequence analysis program Genicus and the phylogeny program endows and the phylogeny program form annual         Module capacity       1 Semestr         Table flea	Prerequisites				
with a lecture on the first two days. During the following days the participant will give seminar talks about different scientific studies for winch DNA sequencing will be taught in the lab or the working group. Sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis, introduction into the use of various internet databases, the sequence analysis of the institute.       Literaturempfehlungen     English       Duration (semesters)     1 Semester       Module frequency     annual       Module level     AC (Aufbaucurriculum / Composition)       Teaching/Learning method     Seminar, practical course       Previous knowledge     Lecture during the course       Final exam of module     Announced during the course.	Skills to be acquired in this module		<ul> <li>sequence DNA by San</li> <li>assemble DNA sequen</li> <li>use internet databases</li> <li>use the various facilitie</li> <li>analyze bacterial genoi</li> <li>use Genious for genom</li> <li>use ARB, databases ar</li> <li>primers and probes</li> <li>present and discuss sc</li> </ul>	ger sequencing ces for sequence comparison s of the NCBI database mes for presence of specific ie analysis id literature data to create p ientific results	
Links       English         Duration (semesters)       1 Semester         Module frequency       annual         Module capacity       18         Type of module       Vahlpflicht / Elective         Module level       AC (Aufbaucuriculum / Composition)         Teaching/Learning method       Seminar; practical course         Previous knowledge       Lecture during the course         Examination       Prüfungszeiten         Final exam of module       Announced during the course.         One assessment of examination: %)       Portfolio: Protocol (75 %), seminar presentation %)         Active participation in practical courses.       Cheive participation in practical course seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab repor seminar presentation according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compute attender         Seminar       2       SOSE       Sose	Module contents		with a lecture on the first will give seminar talks at sequencing was highly ru the working group. Sequ internet databases, the s phylogeny programme A	two days. During the follow bout different scientific studi elevant. DNA sequencing w ence analysis, introduction equence analysis program	ving days the participants es for which DNA vill be taught in the lab of into the use of various Genious and the
Links       English         Duration (semesters)       1 Semester         Module frequency       annual         Module capacity       18         Type of module       Wahlpflicht / Elective         Module level       AC (Aufbaucurriculum / Composition)         Teaching/Learning method       Seminar; practical course         Previous knowledge       Lecture during the course         Examination       Prüfungszeiten         Final exam of module       Announced during the course.         One assessment of examination: %)       Portofolic: Protocol (75 %), seminar presentation %)         Active participation in practical courses.       Active and documented participation in practical courses; these include e.g. the delivery of exercises, writing a lab repor seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab repor seminars, field trips) and courses.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compute attended         Seminar       2       SOSE       Sose	Literaturempfehlungen				
Duration (semesters)       1 Semester         Module frequency       annual         Module capacity       18         Type of module       Wahlpflicht / Elective         Module level       AC (Aufbaucurriculum / Composition)         Teaching/Learning method       Seminar; practical course         Previous knowledge       Lecture during the course         Examination       Prüfungszeiten         Final exam of module       Announced during the course.         Portococ (75 %), seminar presentation %)       Portiopio: Protocol (75 %), seminar presentation %)         Active participation: Active and documented participation in practical courses (labs, exercise seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab repor seminar presentations according to the advice or the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compute attended to compute attended					
Module frequency       annual         Module capacity       18         Type of module       Wahlpflicht / Elective         Module level       AC (Aufbaucurriculum / Composition)         Teaching/Learning method       Seminar; practical course         Previous knowledge       Lecture during the course         Examination       Prüfungszeiten         Final exam of module       Announced during the course.         Portolici: Protocol (75 %), seminar presentation %         Active participation: Active and documented participation in practical courses (labs, exercise seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab repor seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compute attended seminar solution attended seminar presentation attended seminar presentation attended seminary field trips) and courses. These include attended seminary field trips) and courses. These include attended seminary field trips and courses.       Frequency       Workload of compute attended seminary field trips and courses.         Seminar       2       SoSe       SoSe       SoSe	Language of instruction		English		
Module capacity       18         Type of module       Wahlpflicht / Elective         Module level       AC (Aufbaucurriculum / Composition)         Teaching/Learning method       Seminar; practical course         Previous knowledge       Lecture during the course         Examination       Prüfungszeiten         Final exam of module       Announced during the course.         One assessment of examination: Portfolio: Protocol (75 %), seminar presentation %)         Active participation: Active and documented participation in practical courses.         Active participation: Active and documented participation in practical courses. These include e.g. the delivery of exercises, writing a lab repor seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of computi attende         Seminar       2       SoSe       SoSe	Duration (semesters)		1 Semester		
Type of module       Wahlpflicht / Elective         Module level       AC (Aufbaucurriculum / Composition)         Teaching/Learning method       Seminar; practical course         Previous knowledge       Lecture during the course         Examination       Prüfungszeiten         Final exam of module       Announced during the course.         Portfolio: Protocol (75 %), seminar presentation %)       Portfolio: Protocol (75 %), seminar presentation %)         Active participation: Active and documented participation in practical courses (labs, exercises seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab repor seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compute attende         Seminar       2       SoSe       SoSe	Module frequency		annual		
Module level       AC (Aufbaucurriculum / Composition)         Teaching/Learning method       Seminar; practical course         Previous knowledge       Lecture during the course         Examination       Prüfungszeiten         Final exam of module       Announced during the course.         One assessment of examination: Portfolio: Protocol (75 %), seminar presentation %)         Active participation: Active and documented participation in practical courses (labs, exercises seminar, field trips) and courses. These include e.g. the delivery of exercises, writing a lab repor seminar presentation according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compute attende         Seminar       2       SoSe       SoSe	Module capacity		18		
Teaching/Learning method       Seminar; practical course         Previous knowledge       Lecture during the course         Examination       Prüfungszeiten       Type of examination: Portfolio: Protocol (75 %), seminar presentation %)         Final exam of module       Announced during the course.       One assessment of examination: Portfolio: Protocol (75 %), seminar presentation %)         Active participation: Active and documented participation in practical courses (labs, exercises seminar, field trips) and courses. These include e.g. the delivery of exercises, writing a lab repor seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compute attended         Seminar       2       SoSe	Type of module		Wahlpflicht / Elective		
Previous knowledge       Lecture during the course         Examination       Prüfungszeiten       Type of examination         Final exam of module       Announced during the course.       One assessment of examination: Portfolio: Protocol (75 %), seminar presentation %)         Active participation: Active and documented participation in practical courses (labs, exercise: seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab repor seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compute attende         Seminar       2       SoSe	Module level		AC (Aufbaucurriculum /	Composition)	
Examination       Prüfungszeiten       Type of examination         Final exam of module       Announced during the course.       One assessment of examination: Portfolio: Protocol (75 %), seminar presentation %)         Active participation: Active and documented participation in practical courses (labs, exercise seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab repor seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compute attende         Seminar       2       SoSe	Teaching/Learning method		Seminar; practical cours	9	
Final exam of module       Announced during the course.       One assessment of examination: Portfolio: Protocol (75 %), seminar presentation %)         Active participation: Active and documented participation in practical courses (labs, exercise: seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab repor seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compute attended         Seminar       2       SoSe	Previous knowledge		Lecture during the cours	e	
Portfolio: Protocol (75 %), seminar presentation %)         Active participation: Active and documented participation in practical courses (labs, exercise: seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compute attended to compute	Examination	Prüfungszeiten		Type of examination	
participation in practical courses (labs, exercises seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab repor seminar presentations according to the advice of the course supervisor.LehrveranstaltungsformCommentSWSFrequencyWorkload of compute attendaSeminar2SoSe	Final exam of module	Announced during the co	urse.	Portfolio: Protocol (75 %	
Seminar 2 SoSe				participation in practical of seminars, field trips) and e.g. the delivery of exerciseminar presentations and	courses (labs, exercises, courses. These include ises, writing a lab report or
	Lehrveranstaltungsform Comment	SV	WS	Frequency	Workload of compulsory attendance
Exercises 4 SoSe	Seminar	2	2	SoSe	28
	Exercises		4	SoSe	56

## mar580 - Profile Module Microbial ecology of marine sediments

Module label			Profile	Module Microbial	ecology of marine sedime	ents
Modulkürzel			mar580			
Credit points			6.0 KP			
Workload			180 h			
Verwendbarkeit des Moduls			•	Master's Progra	mme Microbiology (Maste	er) > Mastermodule
Zuständige Personen			•	Könneke, Martir	(module responsibility)	
Prerequisites						
Skills to be acquired in this m	odule		those b collect of orga groups	iogeochemically a and analyse porev nisms by molecula of bacteria will be	and microbiologically. Fur water, determine total cell ar methods. Also cultivation performed. Finally, scient	ine habitats and characterise thermore, students learn to counts and quantify groups on of different physiological tific results will be presented cussed in a scientific protocol
Module contents		"SE/PR Microbial ecology of marine sediments": The physiological diversity of microorganisms and their spatial distribution within marine sediments are demonstrated according to chemical and physical parameters. Different physiological groups are analysed along a sediment column taken at the beach site of the island "Spiekeroog", which is sampled at the beginning of the course. At this high-energy beach, a submarine groundwater discharge is present, which leads to changing redox and salinity gradients. Therefore, especially anaerobic processes and the influence of seawater infiltration to the beach sediment is investigated. Thus, for example nitrate, sulfate and methane concentrations are measured in porewaters. As microbiological parameters, total cell numbers are counted and the numbers of archaea and bacteria as well as specific physiological groups are determined by using key genes targeted in quantitative PCR (qPCR). Furthermore, every group of students will specifically enrich representatives of a specific phylogenetic group and monitor growth and activity over time. During the accompanying seminar, each participant will give a short talk regarding the metabolic processes, ecology, physiology of a physiologic group. All the data and observations of the individual groups will be combined at the end of the course to provide an overall picture of microbial diversity and the occurrence of the different physiological groups corresponding to geochemical gradients.				
Literaturempfehlungen						
Links						
Language of instruction			English			
Duration (semesters)			1 Seme	ster		
Module frequency			annual			
Module capacity			16			
Type of module			Wahlpf	icht / Elective		
Module level			AC (Au	fbaucurriculum / C	Composition)	
Teaching/Learning method			Block c	ourse, 2 weeks, s	eminar and laboratory wo	ork
Previous knowledge			Lecture	: Microbial ecolog	y and Lecture: Sediment	microbiology
Examination		Prüfungszeiten			Type of examination	
Final exam of module		Announced during the co	urse.		One assessment of ex Portfolio: Protocol (100 (no mark)	xamination: %), seminar presentation
					seminars, field trips) an e.g. the delivery of exe	Active and documented I courses (labs, exercises, Id courses. These include rcises, writing a lab report or according to the advice of
Lehrveranstaltungsform	Comment	SI	NS		Frequency	Workload of compulsory attendance
Seminar			1		SoSe	14
Exercises			5		SoSe	70

#### mar600 - Profile Module Methods in Aquatic Microbial Ecology

Module label	Profile Module Methods in Aquatic Microbial Ecology	
Modulkürzel	mar600	
Credit points	6.0 KP	
Workload	180 h	
Verwendbarkeit des Moduls	Master's Programme Microbiology (Master) > Mastermodule	
Zuständige Personen	Brinkhoff, Thorsten Henning (Module counselling)	
Prerequisites		

Skills to be acquired in this module

#### Skills to be acquired in this module

The students learn to...

 analyse bacterial substrates at ambient concentrations such as dissolved amino acids and carbohydrates by high performance liquid chromatography (HPLC).

 $\cdot$  determine bacterial cell numbers by flow cytometry and epifluorescence microscopy and to analyse these data by image analysis.

- · extract bacterial DNA from water and sediment samples.
- · amplify bacterial genes by specific primers and PCR.

• assess bacterial communities by culture-independent methods such as denaturing gradient gel electrophoresis and next generation sequencing.

- · present and discuss scientific results.
- write a scientific protocol.

The students gain competences in:

 $\cdot$  Understanding how to analyse dissolved substrates of heterotrophic aquatic bacterial communities by state of the art approaches.

- How to assess the abundance of aquatic bacterial communities by state of the art approaches.

- Analysing the composition of bacterial communities by PCR-based cultureindependent approaches.

Module contents

The course starts with a lecture introducing basic issues of aquatic microbial ecology with an emphasis on methodological aspects. This lecture is completed before the practical work starts.

During the practical course of a block of two weeks the participants carry out analyses and experiments on:

determining the concentration of dissolved organic substrates (amino acids, carbohydrates),

the abundance of bacterial communities in aquatic systems

 the composition of bacterial communities in environmental samples by 16S rRNA gene fragments.

The main emphasis is on analyses and approaches of bacterial communities in the water column.

Literaturempfehlungen	Lecture notes, available on Stud.IP
Links	
Language of instruction	English

Duration (semesters)			1 Semester		
Module frequency			annual		
Module capacity			unlimited		
Type of module		Wahlpflicht / Electi	ive		
Module level		AC (Aufbaucurricu	Ilum / Composition)		
Teaching/Learning method			Block course, 2 we	eeks; practical course and semi	nar
Previous knowledge			For the practical c	ourse lecture: Methods in Aquat	tic Microbial Ecology
Examination		Prüfungszeiten		Type of examination	
Final exam of module		Will be announced durin	g the course	One assessment of e Portfolio: Protocol (100 (no mark)	xamination: ) %), seminar presentation
				participation in practica seminars, field trips) ar e.g. the delivery of exe	Active and documented al courses (labs, exercises, nd courses. These include rcises, writing a lab report or according to the advice of
Lehrveranstaltungsform	Comment	s	WS	Frequency	Workload of compulsory attendance
Seminar			1	WiSe	14
Exercises			6	WiSe	84
Präsenzzeit Modul insgesa	mt				98 h

#### mar610 - Profile Module Isolation and characterization of microorganisms

Module label	Profile Module Isolation and characterization of microorganisms
Modulkürzel	mar610
Credit points	6.0 KP
Workload	180 h
Verwendbarkeit des Moduls	<ul> <li>Master's Programme Microbiology (Master) &gt; Mastermodule</li> </ul>
Zuständige Personen	<ul><li>Könneke, Martin (module responsibility)</li><li>Engelen, Bert (Module counselling)</li></ul>
Prerequisites	
Skills to be acquired in this module	In this course the students will isolate bacteria and other microorganisms. They will learn classical microbiological techniques as enrichment culture, aseptic work, preparation of liquid and solid media, cultivation under oxic and anoxic condition, on agar plates and in deep agar dilution, description of microbes by techniques as staining, microscopy, microphotography.
Module contents	
	Prior to the laboratory work the participants shall read literature and current studies about their target group of microorganisms and develop an enrichment strategy isolation. They will present this and their enrichment strategy in the seminar. During the course and at the end, results and a possible molecular identification of isolates will be presented and discussed. Practical work: Student prepares media and agar plates required for the enrichment and isolation of the different target organisms in small groups. The enrichment cultures will be monitored over time by measuring various biological and chemical parameters. If pure cultures have been isolated, they will be analysed microscopically and identified using molecular methods.
Literaturempfehlungen	Brock "Biology of Microorganisms" Cypionka "Grundlagen der Mikrobiologie" Drews "Mikrobiologisches Praktikum" DSMZ catalogue (www.dsmz.de) yer "A field guide to the bacteria" Reddy "Methods for general and molecular Microbiology" Steinbüchel "Mikrobiologisches Praktikum" www.microbiological-garden.net
Links	www.microbiological-garden.net
Language of instruction	English
Duration (semesters)	1 Semester
Module frequency	annual
Module capacity	unlimited
Type of module	Wahlpflicht / Elective
Module level	AC (Aufbaucurriculum / Composition)
Teaching/Learning method	Seminar and laboratory work, twice per week, half a day each
Previous knowledge	Module mar500 including lectures on "Physiology and life modes of prokaryotes" and "Microbial diversity"
Examination	Prüfungszeiten Type of examination
Final exam of module	Announced during the course.

One assessment of examination: Portfolio: Protocol (100 %), seminar presentation (no mark)

Active participation: Active and documented participation in practical courses (labs, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report or seminar presentations according to the advice of the advice quantizer. the course supervisor.

Examination		Prüfungszeiten	Type of examination	
Lehrveranstaltungsform	Comment	SWS	Frequency	Workload of compulsory attendance
Seminar		1	SoSe	14
Exercises		4	SoSe	56
Präsenzzeit Modul insgesa	amt			70 h

## mar620 - Profile Module Marine Chemical Ecology

Module label			Profile Mo	lodule Marine Chemical Ecology
Modulkürzel			mar620	
Credit points			6.0 KP	
Workload			180 h	
Verwendbarkeit des Moduls			• 1	Master's Programme Microbiology (Master) > Mastermodule
Zuständige Personen			• •	Schupp, Peter (module responsibility) Kellermann, Matthias (Module counselling) Rohde, Sven (Module counselling)
Prerequisites			Lecture: C	Organic chemistry
Skills to be acquired in this i	module		secondary invertebra isolates ca assess po	will learn about the chemical properties and major ecological roles of ry metabolites, how to investigate the secondary metabolites of marine rates and algae, how to analyze secondary metabolite profiles, how to compounds of interest and how to conduct various bioassays to notential ecological roles of crude extracts and potentially isolated nds. Students will also learn how to statistically evaluate their results.
Module contents				al Ecology": The course consists of lectures, followed by laboratory ants. Students will research about various topics in marine chemical
			ecology. I invertebra assess th antimicrol test bacte report abo experiment	Laboratory work will include production of extracts from various rates and algae. Extracts will be tested in various feeding assays to he chemical properties of extracts. Extracts will also be tested for obial activity with environmental strains. This includes the culture of eria and antimicrobial assays. Final evaluation will be a laboratory yout the experiments. This will include statistical analysis of their ents and discussion of their results in the framework of the lectures and a presented during the course.
Literaturempfehlungen			Marine Cl	Chemical Ecology, McClintock, Baker
Links				
Language of instruction			English	
Duration (semesters)			1 Semest	ter
Module frequency			jährlich	
Module capacity			unlimited	1
Type of module			Wahlpflich	cht / Elective
Module level			AC (Aufba	paucurriculum / Composition)
Teaching/Learning method			Compact	t Course, Seminar, Practical
Previous knowledge			Lecture: C	Organic chemistry
Examination		Prüfungszeiten		Type of examination
Final exam of module		Will be announced during	g the course	e <b>One assessment of examination:</b> Portfolio: Seminar presentation (no mark), written protocol (100%)
				Active participation: Active and documented participation in practical courses (labs, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report or seminar presentations according to the advice of the course supervisor.
Lehrveranstaltungsform	Comment	S	WS	Frequency Workload of compulsory attendance
Seminar			1	WiSe 14
Practical training			4	WiSe 56
Präsenzzeit Modul insgesam	nt			70 h

## mar622 - Profile Module R programming for (meta)-genomic sequence analysis

	Profile Module R programming for (meta)-genomic sequence analysis
<i>l</i> odulkürzel	mar622
Credit points	6.0 KP
Vorkload	180 h (
	Präsenzzeit: 54 Stunden, Selbststudium: 126 Stunden
	)
/erwendbarkeit des Moduls	<ul> <li>Master's Programme Marine Environmental Sciences (Master) &gt; Mastermodule</li> <li>Master's Programme Microbiology (Master) &gt; Mastermodule</li> </ul>
Zuständige Personen	
Prerequisites	Participation in the course "Introduction in sequencing and sequence analysis". Previous programming experience is not required.
kills to be acquired in this module	
	DNA sequencing has become a routine method in microbiology research. Mo of the times, sequence analysis requires knowledge of a programming language. One of the programming languages most used for this purpose is R.
	After successful participation the students will have the competence to understand, interpret and carry out simple genome sequence analyses. They will acquire transferable skills in using R
Nodule contents	
	The course will cover the following topics:
	1. programming in R using an integrated development environme (RStudio)
	2. working with strings (stringr package)
	3. working with lists and data frames (readr and dplyr package)
	<ol> <li>sequence analysis (seqinr, Bioconductor packages: Biostring GenomicRanges, Decipher)</li> </ol>
	5. (meta)-genomic and data visualization (ggplot2, Gviz)
	6. Creating sequence / metadata dabases
	7. Accessing and mining sequence / metadata databases though R base web applications (Shiny, DT and Shinyjs packages)
	8. reporting in R (Rmarkdown and Knitr packages)
	9. managing code (Roxygen2 package)
	10. microbial genome annotation using R.
	A single, introductory lecture will be offered within the first day of the cours Then, the course will be structured in programming exercises which cover topics listed. The exercises are designed to exemplify the use R programmi within the framework of microbial (meta)-genome analysis.
	In addition to the teacher-student sessions, the students will work on individ projects. Each student will receive a short microbial genome (e.g. viral genome), and will analyze it by building custom, self-programmed pipelines. The output from the individual projects will consist in an analysis report prepared in Rmarkdown and Knitr packages. The report will include both the code and the genome analysis results.

Literaturempfehlungen			will be announced		
Links					
Language of instruction			English		
Duration (semesters)			1 Semester		
Module frequency	Module frequency			red	
Module capacity			15 ( Proportional allocat )	ion between Master MUWI and	Master Microbiology.
Type of module			je nach Studiengan	g Pflicht oder Wahlpflicht	
Teaching/Learning method			Blockveranstaltung SE/PR: R program	: ming for (meta)-genomic sequer	nce analysis (4 SWS, 6 KP)
Previous knowledge				454 Einführung in die DNA-Seq Basics of programming in R, bas	
Examination		Prüfungszeiten		Type of examination	
Final exam of module		Will be announced during	g the course	Written protocol (80%) a	and class participation (20%)
Lehrveranstaltungsform	Comment	S	WS	Frequency	Workload of compulsory attendance
Seminar			2	SoSe	28
Exercises			2	SoSe	28
Präsenzzeit Modul insgesam	nt				56 h

## mar630 - Research Project

Module label	Research Project			
Modulkürzel	mar630			
Credit points	12.0 KP			
Workload	360 h			
Verwendbarkeit des Moduls	Master's	Programme Microbiology (Master) > Mastermodule		
Zuständige Personen		e, Martin (module responsibility) obiologie, Lehrende (Module counselling)		
Prerequisites				
Skills to be acquired in this module	specific scientific experiments to co interpreted. The s	able to work (under guidance) on a project dealing with a question. They use appropiate methods and carry out ollect data. These data can be documented, analysed and students understand recent scientific literature and can regard ork. They can present and defend their work in the public.		
Module contents	The contents con level.	cern variable recent scientific questions on a high scientific		
Literaturempfehlungen	Project-specific, v	vill be announced		
Links				
Language of instruction	English			
Duration (semesters)	1 Semester	1 Semester		
Module frequency	semiannual	semiannual		
Module capacity	unlimited	unlimited		
Type of module	Wahlpflicht / Elec	tive		
Module level	MM (Mastermodu	II / Master module)		
Teaching/Learning method	Seminar; Practica	al work		
Previous knowledge	1 main module ar	1 main module and 1 profile module		
Examination	Prüfungszeiten	Type of examination		
Final exam of module	Announced during the course.	<ul> <li>Two assessments of examination: Written protocol / written English thesis, + presentation Quality of the scientific performance and thesis (75%), Final seminar and public defense (25%)</li> <li>Active participation: Active and documented participation in practical courses (labs, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report or seminar presentations according to the advice of</li> </ul>		
Lehrveranstaltungsform Comment	SWS	the course supervisor. Frequency Workload of compulsory attendance		
		attenuance		
Seminar	6	SoSe oder WiSe 84		
Seminar Practical training	6	SoSe oder WiSe 84		

#### mar640 - Research Project

Todu points       12.0 KP         Workload       360 h         Verwendbarkeit des Moduls       • Master's Programme Microbiology (Master) > Mastermodule         Zuständige Personen       • Könneke, Martin (module responsibility) • der Mikrobiologie, Lehrende (Module counseiling)         Prerequisites       The students are able to work (under guidance) on a project dealing with a specific scientific question. They use appropiate methods and carry out experiments to collect data. These data can be downenetd, analysed and interpreted. The students understand their work in the public.         Module contents       The contents concern variable recent scientific questions on a high scientific level.         Links       The contents concern variable recent scientific questions on a high scientific level.         Uniks       1 Semester         Module capacity       unlimited         Top of mainurula       Unitient of the work in the public.         Module level       MM (Mastermodule)         TachtingLearning method       Seminar. Practical work         Provious knowledge       1 main module and 1 profile module         Examination       Profungszeiten         Final exam of module       Module frequency         Seminar, Practical work       Witten profus and courses, final scientific peromance and thesis + presentation         Quelty of the scientific performance and thesis + presentation       Quelty of the scinentific recorese	Module label			Researc	h Project		
Workdoad       360 h         Verwendbarkeit des Moduls       • Master's Programme Microbiology (Mester) > Mastermodule         Zuständige Personen       • Könneke, Martin (module responsibility)         Prerequisites       - See Microbiology, Lehrende (Module counselling)         Skills to be acquired in this module       specific scientific question. They use appropriate methods and carry ou any experiment. The studentes are able to work (under guidance) on a project dealing with a specific scientific question. They use appropriate methods and carry ou any experiment. The studentes are able to work (under guidance) on a high scientific question on a high scientific question on a high scientific question on a high scientific fuerature and carn scientific questions on a high scientific question or an adjust recent scientific question or an adjust recent scientific question or an adjust recent scientific question or a high scientific fuerature and carn scientific questions on a high scientific question or any adjust recent scientific question or a high scientific fuerature and carn scientific questions on a high scientific fuerature and carn scientific questions on a high scientific fuerature and carn scientific questions on a high scientific fuerature and carn scientific question or any adjust recent scientific question or a high scientific question or any adjust recent scientific question or any adjust recent scientific question or adjust recent scientific questin or adjust recent scientific questin or adjus	Modulkürzel			mar640			
Verwandbarkeit des Moduls       • Master's Programme Microbiology (Master) > Mastermodule         Zuständige Personen       • Könneke, Martin (module responsibility)         Prerequisites       The students are able to work (under guidance) on a project dealing with a specific scientific question. They use approjent methods and carry out experiments to collect data. They use approjent methods and carry out experiments to collect data. They use approjent scientific questions on a high scientific questions understand recent scientific interview and carr goant it for their own work. They can present and defend their work in the public.         Module contents       The contents concern variable recent scientific questions on a high scientific questions on a high scientific question is understand recent scientific questions on a high scientific question so an a high scientific question so an a high scientific question.         Module contents       English         Duration (semesters)       1 Semester         Module frequency       semiannual         Module capacity       unlimited         Type of module       MM (Mastermodul / Master module)         TeachingLearning method       Seminar: Practical work         Previous knowledge       1 main module and 1 profile module         Examination       Profungazeiten       Type of examination: Written application: Active and documented participation: Active and documented participation: Active and documented participation: Active and documented participation in practical courses, writing a lab preperidentes to asserting a sensinder of a seminaran	Credit points		12.0 KP				
Zustaindige Personen       • Könneke, Martin (module responsibility)         • der Mikrobiologie, Lehrende (Module counselling)         Prerequisites         Skills to be acquired in this module         Skills to be acquired in this module         Wodule contents         The students are able to work (under guidance) on a project dealing with a specific scientific question. They use appropriate methods and carry out experiments to collect data. These data can analysed and interpreted. These data can defend their work in the public.         Module contents       The contents concern variable recent scientific literature and can regar it for their own work. They can present and defend their work in the public.         Links       The contents concern variable recent scientific questions on a high scientific level.         Links       English         Module fequency       semiannual         Module level       MM (Mastermodul / Master module)         TeachingLearning method       Seminar; Practical work         Fried exam of module       Announced during the course.         Final exam of module       Announced during the course.         Linveranstaltungsform       Comment         Final exam of module       SWS         Previous knowledge       1 main module and 1 profile module cernse.         Linveranstaltungsform       Comment         Final exam of module       SWS	Workload			360 h			
	Verwendbarkeit des Moduls	5		•	Master's Program	nme Microbiology (Maste	r) > Mastermodule
Skills to be acquired in this module     The students are able to work (under guidance) on a project dealing with a specific scientific question. They use appropriate methods and carry out appriments to collect data. These data can be documented, analysed and interpreted. The students understand recent scientific titerature and can regare if to their own work. They can present and defend their work in the public to their own work. They can present and defend their work in the public level.       Module contents     The contents concern variable recent scientific questions on a high scientific level.       Literaturempfehungen     Project-specific, will be announced       Links     English       Duration (semesters)     1 Semester       Module capacity     unlimited       Type of module     Wahlpflicht/ Elective       Module level     M (Mastermodu/ / Master module)       Teaching/Learning method     Seminar, Practical work       Previous knowledge     1 main module and 1 profile module       Final exam of module     Announced during the course.     Written protocol / written English thesis + presentation       Comment     SWS     Frequency     Quality of the scientific performance and thesis (75%), Final seminar, and public defense (25%)       Lehrveranstaltungsform     Comment     SWS     Frequency       Seminar     Frequency     Workload of compulsor active and ocourses. These include e.g. the delivery of sexrices, written a babe sexrices, sexrice	Zuständige Personen			•	,		selling)
specific scientific question. They use appropriate methods and carry out experiments to collect data. These data can be downented, analysed and interpreted. The students dream takentific literature and carre gan it for their own work. They can present and defend their work in the public.       Module contents     The contents concern variable recent scientific questions on a high scientific level.       Literaturempfehlungen     Project-specific, will be announced       Links     English       Duration (semesters)     1 Semester       Module capacity     unlimited       Type of module     Wahlpflicht / Elective       Module gapacity     1 Seminar; Practical work       Previous knowledge     1 main module and 1 profile module       Final exam of module     Prúfungszeiten       Final exam of module     Announced during the course.       Module dreams     View services, services	Prerequisites						
laval.       laval.       Project-specific, will be announced         Links       English       English         Duration (semesters)       1 Semester       Module frequency         Module capacity       unlimited       Image: Comparison of the c	Skills to be acquired in this	module		specific experim interpret	scientific questior ents to collect dat ed. The students	<ul> <li>They use appropriate magnetic and the second se second second sec</li></ul>	ethods and carry out cumented, analysed and fic literature and can regard
Links       English         Duration (semesters)       1 Semester         Module frequency       semiannual         Module capacity       unlimited         Type of module       Wahlpflicht / Elective         Module level       MM (Master module)         Teaching/Learning method       Seminar; Practical work         Previous knowledge       1 main module and 1 profile module         Examination       Prüfungszeiten         Final exam of module       Type of examination: Written protocol / written English thesis + presentation Quality of the scientific performance and thesis (75%), Final seminar and public defense (25%)         Active participation: Active and documented participation: Active and docurses (has), seercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report on seminarre sentation Seminarr       Frequency       Workload of compulson attendance         Seminar       6       SoSe oder WiSe       8/ Practical training       12	Module contents				tents concern var	iable recent scientific que	stions on a high scientific
Language of instruction       English         Duration (semesters)       1 Semester         Module frequency       semiannual         Module capacity       unlimited         Type of module       Wahlpflicht / Elective         Module level       MM (Master module)         Teaching/Learning method       Seminar; Practical work         Previous knowledge       1 main module and 1 profile module         Examination       Prüfungszeiten         Final exam of module       Announced during the course.         Krive participation: Active and documented participation in practical courses (labe, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, seminary field trips) and courses. These include e.g. the delivery of exercises, seminary field trips) and courses. These include e.g. the delivery of exercises, seminary field trips) and courses. These include e.g. the delivery of exercises, seminary field trips) and courses. These include e.g. the delivery of exercises, seminary field trips) and courses. These include e.g. the delivery of exercises, seminary field trips) and courses. These include e.g. the delivery of exercises, seminary field trips) and courses. These include e.g. the delivery of exercises, seminary field trips) and courses. These include e.g. the delivery of exercises, seminary field trips) and courses. These include e.g. the delivery of exercises, seminary field trips) and courses. These include e.g. the delivery of exercises, seminary field trips) and courses. These include e.g. the delivery of exercises, seminary field trips) and coursesese the advice of the course supervisor.	Literaturempfehlungen		Project-specific, will be announced				
Duration (semesters)       1 Semester         Module frequency       semiannual         Module capacity       unlimited         Type of module       Wahlpflicht / Elective         Module level       MM (Master module)         Teaching/Learning method       Seminar; Practical work         Previous knowledge       1 main module and 1 profile module         Examination       Prüfungszeiten         Final exam of module       Announced during the course.         Kritten protocol / written English thesis + presentation         Quality of the scientific performance and thesis (75%), Final seminar and public defense (25%)         Active participation: Active and documented participation in practical courses. (Ibes, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, seminars according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compulsor attendance         Seminar       6       SoSe oder WiSe       8e         Practical training       12       SoSe	Links						
Module frequency       semiannual         Module capacity       unlimited         Type of module       Wahlpflicht / Elective         Module level       MM (Master module)         Teaching/Learning method       Seminar; Practical work         Previous knowledge       1 main module and 1 profile module         Examination       Prüfungszeiten         Final exam of module       Type of examination: Written protocol / written English thesis + presentation of Quality of the scientific performance and thesis (75%), Final seminar and public defense (25%)         Active participation: Active and documented participation in practical courses (labs, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report or seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compulsor attendance         Seminar       6       SoSe oder WiSe       6         Practical training       12       SoSe oder WiSe       16	Language of instruction			English			
Module capacity       unlimited         Type of module       Wahipflicht / Elective         Module level       MM (Master modul/ Master module)         Teaching/Learning method       Seminar; Practical work         Previous knowledge       1 main module and 1 profile module         Examination       Prüfungszeiten         Final exam of module       Type of examination:         Final exam of module       Announced during the course.         Kerter participation: Active and documented participation: Active and documented participation in practical courses (labs, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report or seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compulsor attendance         Seminar       6       SoSe oder WiSe       6       Prectical training       16	Duration (semesters)			1 Semes	ster		
Type of module       Wahlpflicht / Elective         Module level       MM (Mastermodul / Master module)         Teaching/Learning method       Seminar, Practical work         Previous knowledge       1 main module and 1 profile module         Examination       Prüfungszeiten         Final exam of module       Announced during the course.         Written protocol / written English thesis + presentation       Written protocol / written English thesis + presentation         Quality of the scientific performance and thesis (75%), Final seminar and public defense (25%)       Active participation: Active and documented participation in practical courses. Itals and courses. These include e.g. the delivery of exercises, writing a lab report or seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compulsor attendance         Seminar       6       SoSe oder WiSe       8         Practical training       12       SoSe oder WiSe       16	Module frequency			semianr	nual		
Module level       MM (Master module / Master module)         Teaching/Learning method       Seminar; Practical work         Previous knowledge       1 main module and 1 profile module         Examination       Prüfungszeiten         Final exam of module       Announced during the course.         Final exam of module       Announced during the course.         Vertice protocol / written English thesis + presentation         Quality of the scientific performance and thesis (75%), Final seminar and public defense (25%)         Active participation: Active and documented participation in practical courses (tabs, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report or seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compulsor attendance         Seminar       6       SoSe oder WiSe       8         Practical training       12       SoSe oder WiSe       16	Module capacity			unlimited	d		
Teaching/Learning method         Seminar; Practical work           Previous knowledge         1 main module and 1 profile module           Examination         Prüfungszeiten         Type of examination           Final exam of module         Announced during the course.         Two assessments of examination: Written protocol / written English thesis + presentation Quality of the scientific performance and thesis (75%), Final seminar and public defense (25%)           Active participation: Active and documented participation in practical courses (labs, exercises, seminary field trips) and courses. These include e.g. the delivery of exercises, writing a lab report or seminar presentations according to the advice of the course supervisor.           Lehrveranstaltungsform         Comment         SWS         Frequency         Workload of compulsor attendance           Seminar         6         SoSe oder WiSe         8/           Practical training         12         SoSe oder WiSe         16/	Type of module			Wahlpfli	cht / Elective		
Previous knowledge       1 main module and 1 profile module         Examination       Prüfungszeiten       Type of examination         Final exam of module       Announced during the course.       Two assessments of examination: Written protocol / written English thesis + presentation Quality of the scientific performance and thesis (75%), Final seminar and public defense (25%)         Active participation: Active and documented participation in practical courses (labs, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compulson attendance         Seminar       6       SoSe oder WiSe       8/         Practical training       12       SoSe oder WiSe       16/	Module level		MM (Mastermodul / Master module)				
Examination       Prüfungszeiten       Type of examination         Final exam of module       Announced during the course.       Two assessments of examination: Written protocol / written English thesis + presentation Quality of the scientific performance and thesis (75%), Final seminar and public defense (25%)         Active participation: Active and documented participation in practical courses. (labs, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report of seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compulsor attendance         Seminar       6       SoSe oder WiSe       84         Practical training       12       SoSe oder WiSe       16	Teaching/Learning method		Seminar; Practical work				
Final exam of module       Announced during the course.       Two assessments of examination: Written protocol / written English thesis + presentation Quality of the scientific performance and thesis (75%), Final seminar and public defense (25%)         Active participation:       Active and documented participation in practical courses (labs, exercises, seminar, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report or seminar presentations according to the advice of the course supervisor.         Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compulsor attendance         Seminar       6       SoSe oder WiSe       84         Practical training       12       SoSe oder WiSe       16	Previous knowledge			1 main r	module and 1 prof	ile module	
Written protocol / written English thesis + presentation Quality of the scientific performance and thesis (75%), Final seminar and public defense (25%)Active participation: Active and documented participation in practical courses (labs, exercises, seminars, field trips) and courses. These include e.g. the delivery of exercises, writing a lab report or seminar presentations according to the advice of the course supervisor.LehrveranstaltungsformCommentSWSFrequencyWorkload of compulsor attendanceSeminar6SoSe oder WiSe84Practical training12SoSe oder WiSe164	Examination		Prüfungszeiten			Type of examination	
Lehrveranstaltungsform       Comment       SWS       Frequency       Workload of compulsor attendance         Seminar       6       SoSe oder WiSe       8         Practical training       12       SoSe oder WiSe       16	Final exam of module		Announced during the co	urse.		Written protocol / written presentation Quality of the scientific µ (75%), Final seminar an <b>Active participation:</b> A participation in practical seminars, field trips) and e.g. the delivery of exer seminar presentations a	n English thesis + performance and thesis d public defense (25%) ctive and documented courses (labs, exercises, d courses. These include cises, writing a lab report or
Practical training 12 SoSe oder WiSe 16	Lehrveranstaltungsform	Comment	S	WS			Workload of compulsory attendance
5	Seminar			6		SoSe oder WiSe	84
Präsenzzeit Modul insgesamt 252 l	Practical training		· · · · · · · · · · · · · · · · · · ·	12		SoSe oder WiSe	168
	Präsenzzeit Modul insgesar	nt					252 h

# Abschlussmodul

## mam - Master's Thesis Module

Module label		Master's Thesis Module		
Modulkürzel		mam		
Credit points		30.0 KP		
Workload		900 h		
Verwendbarkeit des Moduls		Master's Programme Microbiology (Master) > Abschlussmodul		
Zuständige Personen		<ul> <li>Könneke, Martin (module responsibility)</li> <li>der Mikrobiologie, Lehrende (Module counselling)</li> <li>Haller, Melanie (Prüfungsberechtigt)</li> </ul>		
Prerequisites		1 research project		
Skills to be acquired in this module		The students are able to work (under guidance) on an extended research project. They understand recent scientific literature and can regard it for their own work. They can prepare, carry out, write down, present and defend their work in the public.		
Module contents		The contents concern variable recent scientific questions on a high scientific level		
Literaturempfehlungen		project-specific, will be announced		
Links				
Language of instruction		English		
Duration (semesters)		1 Semester		
Module frequency		semi-annual		
Module capacity		unlimited		
Type of module		Pflicht / Mandatory		
Module level		Abschlussmodul (Abschlussmodul / Conclude)		
Teaching/Learning method		Seminar (2 SPPW); Practical work (28 SPPW)		
Examination	Prüfungszeiten	Type of examination		
Final exam of module		Written English thesis, seminar with public discussion in English According to the examination regulations; quality of the scientific performance and thesis (83.3 %), final seminar and public defense (16.7 %)		
Lehrveranstaltungsform	Seminar			
sws	2			
Frequency	SoSe und WiSe			
Workload Präsenzzeit	28 h			