Universität Bremen

Faculty 02:
Biology/Chemistry

Summersemester 24

Module Guide

for the study of

Marine Microbiology

Master of Science

valid in connection with the examination regulations MPO 2023

Generated: April 8, 2024

Index by areas of study

1) Compulsory modules (90 CP)

2) Master thesis (30 CP)

3) Supplementary Courses

Module 02-BIO-MA-MarMic1: Basics in Marine Microbiology
Basics in Marine Microbiology

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Compulsory modules	College level math, chemistry and laboratory analytical chemistry skills are highly recommended.

Learning content:
The course refreshes knowledge of the bachelor education and provides an overview of prokaryotic microbiology.

- Key features are structure and function of the cell including ribosomes, cell walls, and membrane structure and their implication for the cell morphology.
- Microbial lifestyles are discussed and the importance of energy conservation is highlighted.
- Media and nutritional requirements are covered together with the limits of microbial life. Thermodynamics of microbial catabolism is taught and used in calculations.
- The curriculum continues with photosynthesis as process and discusses aerobic glucose degradation in E.coli, anaerobic respirations (nitrate, metal oxides, sulfate, CO2) as well as fermentations, syntrophy, and methanogenesis.
- Based on this overview of microbial metabolism, the kinetics of microbial enzymes are the starting point to discuss the ecology of microorganisms in the environmental habitat, natural population sizes and their dynamics.
- The microorganisms and their biochemical pathways involved in nitrogen cycling will be discussed in more detail because of their importance in the marine environment.

The practical courses involve many aspects of the isolation / cultivation of microorganisms and provide examples for their study in natural samples.
Microbial Oceanography:

- The course is an introduction into microbial oceanography and geomicrobiology.
- The interdisciplinary approach in both fields is taught by discussing main concepts and methods as well as the underlying hypotheses in a combination of the historical developments and current key papers in both fields. The aim is to provide a global overview of patterns and trends in pelagic and benthic microorganisms, their environmental function and their habitats.
- The course also includes an introduction to technologies used to assess aspects of microbial community function related to the laboratory experiments.

Learning outcomes / competencies / targeted competencies:
- Students can apply basic microbial sampling and laboratory techniques.
- They understand the underlying processes of microbial oceanography.

Calculation of student workload:
72 h Self-study
126 h SWS / presence time / working hours
72 h Exam preparation

Are there optional courses in the modules?
no

Language(s) of instruction: English	**Responsible for the module:** Dr. Tim Richter-Heitmann
Frequency: winter semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: SoSe 24 / -	**Credit points / Workload:** 9 / 270 hours

Module examinations

Module examination: Modulprüfung Basics in Marine Microbiology	
Type of examination: module exam	
Form of examination: Written examination	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / - / -	
Language(s) of instruction: Englisch	
Description: PL 1 = written exam	

Module courses

Course: Basics in Marine Physiology	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial	**Associated module examination:** Modulprüfung Basics in Marine Microbiology

Course: Marine Chemistry	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** N. N.
Language(s) of instruction: Englisch	

Teaching method(s): Lecture Tutorial Laboratory class	**Associated module examination:** Modulprüfung Basics in Marine Microbiology

Course: Field excursion to Wadden Sea	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** N. N. Prof. Dr. Jens Harder Dr. Hannah Marchant
Language(s) of instruction: Englisch	
Teaching method(s): Field trip	**Associated module examination:** Modulprüfung Basics in Marine Microbiology

Module 02-BIO-MA-MarMic2: Marine Microbial Activities
Marine Microbial Activities

Assignment to areas of study:	Content-related prior knowledge or skills:
• Compulsory modules	Basic microbial lab techniques are recommended.

Learning content:
Isolation and cultivation of aerobic and anaerobic microbes…

- Viruses:The students are introduced to general principles of viral transmission, replication and virus-host cell interactions to understand the molecular mechanisms of viral activities and host defense reactions. This knowledge gets further deepened with content about marine viruses and about the methods used to study them, their crucial role in carbon recycling in the oceans, and how they contribute to lateral gene transfer. A focus will be made on pathogenesis, host defense mechanisms, bacterial defense strategies and mechanisms (e.g. endonucleases, CRISPR-Cas, RNAi, Abi systems, TA systems) and the impact on hosts. A special consideration of bacteriophages (e.g. manipulation of gene expression, transfer of auxiliary metabolic genes, cell lysis) will be taught. The students will get exposed to lectures about viruses in archaea and marine animals to broaden up the horizon of ecological relevant virus interactions.
- Protein biochemistry: from native purification to structural analyses:
  This section of the module encompasses the basics of protein structure - function as well as the strategies for their expression, purification and characterization. The students will purify and crystallize a native soluble enzymatic complex, which has been purified from a microorganism. In parallel, they will learn how to handle a native membrane protein and characterize it by spectrophotometry. An introduction to X-ray crystallography and structural biology will teach them how protein models are built and how to extract biological information from their analysis.

Learning outcomes / competencies / targeted competencies:

- Students are able to demonstrate a detailed understanding of microbial survival and life in natural marine habitats, and its mechanistic underpinning. Therefore, the students understand the core concepts of microbial metabolism and their impact on the marine environment.
- Students can use examples to illustrate microbial diversity with respect to their distribution, ecological and physiological role in the ocean.
- Students can relate structural, physiological and genetic adaptations of microbes to their diverse roles in the marine food chain.
- Students are able to interpret data arising from environmental microbiology experiments and scientific publications.

Calculation of student workload:
126 h SWS / presence time / working hours
72 h Exam preparation
72 h Self-study

Are there optional courses in the modules?
no

Language(s) of instruction:	Responsible for the module:
English	Dr. Tim Richter-Heitmann

Frequency: winter semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: SoSe 24 / -	**Credit points / Workload:** 9 / 270 hours

Module examinations

Module examination: Modulprüfung Marine Microbial Activities	
Type of examination: module exam	
Form of examination: Written examination	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / - / -	
Language(s) of instruction: Englisch	
Description: PL 1 = written exam	

Module courses

Course: Prokaryotic Microbiology	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** N. N. Prof. Dr. Michael W. Friedrich Prof. Dr. Jens Harder
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial Laboratory class	**Associated module examination:** Modulprüfung Marine Microbial Activities

Course: Marine Viruses	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** Dr. Susanne Erdmann
Language(s) of instruction: Englisch	

Teaching method(s): Lecture Tutorial Laboratory class	**Associated module examination:** Modulprüfung Marine Microbial Activities

Course: Metobolism	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial Laboratory class	**Associated module examination:** Modulprüfung Marine Microbial Activities

Course: Glycobiology	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** Dr. Jan-Hendrik Hehemann
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial Laboratory class	**Associated module examination:** Modulprüfung Marine Microbial Activities

Course: Physiology	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial Laboratory class	**Associated module examination:** Modulprüfung Marine Microbial Activities

Module 02-BIO-MA-MarMic3: Molecular Marine Microbiology
Molecular Marine Microbiology

Assignment to areas of study:	Content-related prior knowledge or skills:
• Compulsory modules	Basic biological knowledge, including some experience in molecular techniques and handling of microorganisms, basic statistics is highly recommended.

Learning content:

- Uni- and multivariate statistics for microbial ecology:

Modern biological science is primarily based on credible experimental design coupled with the appropriate handling and analysis of data. Statistical understanding is central to this entire process: it can make or break an experimental or observational study before it even begins. Further, its application to biological and ecological data has its own peculiarities which are not typically covered in traditional statistics courses. This brief sub-module will introduce students to the concepts required to bring statistical understanding into the practice of microbial ecology. It will begin by reviewing basic concepts of statistics and relating them to biological practice and proceed to address more complex approaches designed to handle the high-dimensional and unruly data which is produced by techniques from mass spectrometry and next-generation sequencing to microscopic surveys and synthetic in silico analyses. Each taught component is followed by a practical session where students will be introduced to the staistical programming language and environment, R, which has become an essential skill in the life sciences and beyond.

- Bioinformatics:

The deluge of sequence- and (meta) genome data produced in life-sciences these days demands for a thorough understanding of the basic principles and bioinformatics tools to be used for sequence data analysis and annotation. To efficiently transfer these data into biological knowledge, skills in using web-based systems as well as working on the command line are a prerequisite for a successful career as a molecular biologist.
The necessary bioinformatics skills are conciliated by a series of lectures conveying basic knowledge about currently available sequence database resources, the theory of pairwise and multiple sequence alignments and comparisons, as well as resources and systems for (meta)genome annotations.
The lectures are rounded up by hands on experiences with Unix (Linux) based operating systems, the command line interpreter, pairwise and multiple alignment tools, pattern and profile databases as well as the corresponding search tools.

Learning outcomes / competencies / targeted competencies:

- Students understand in-depth how sequence information is collected, organized and stored, managed and analysed, including the general ability to use standard bioinformatics tools to access and use biological information.

Students can

- choose appropriate methods to analyze microbial communities
- to apply the rRNA approach to microbial ecology
- identify, visualize and quantify clades of Bacteria and Archaea in communities
- make functional assignments of identified organisms/genes
- interpret diversity and metagenomic data
- use flow cytometry as a method of cell characterization, enumeration and cell sorting.
- understand the principles of computers, computing, programming languages, and computational complexities
- understand the principles of patterns and profiles for sequence analysis
- work with public databases
- work with Linux and command line interpreters
- apply scoring systems and substitution matrixes
- apply pairwise and multiple sequence alignment methods

Following the statistics sub-module, students :

- understand the core principles required to design robust experimental or observational investigations, especially with regard toreplication, balanced designs, and statistical power
- can approach and understand the role of statistical distributions in data analysis
- can use basic statistics such as the various measures of location and spread and understand their link to probability
- can correctly interpret and report “significance” and confidence intervals
- understand the logic behind common uni- and multivariate hypothesis testing approaches as well as their caveats
- understand the appropriate use of dissimilarity and distance measures in numerical ecology
- understand the the core concepts behind dimension reduction techniques based on spectral analysis and dissimilarity and how to
- correctly interpret their outputs
- can perform both uni- and multivariate techniques in the statistical programming language, R, as well as how to code and document for reproducibility

Calculation of student workload:
98 h SWS / presence time / working hours
90 h Exam preparation
82 h Self-study

Are there optional courses in the modules?
no

Language(s) of instruction:	**Responsible for the module:**
English	Dr. Tim Richter-Heitmann
Frequency:	**Duration:**
winter semester, yearly	1 semester[s]

The module is valid since / The module is valid until:	Credit points / Workload:
SoSe 24 / -	9 / 270 hours

Module examinations

Module examination: Modulprüfung Molecular Marine Microbiology	
Type of examination: module exam	
Form of examination: Written examination	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / - / -	
Language(s) of instruction: Englisch	
Description: PL 1 = written exam	

Module courses

Course: Statistics	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial Laboratory class	**Associated module examination:** Modulprüfung Molecular Marine Microbiology

Course: Linux and Bioinformatics Introductory Course	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** N.N.
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial	**Associated module examination:** Modulprüfung Molecular Marine Microbiology

Course: Next generation sequencing and Metagenomics

Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial	**Associated module examination:** Modulprüfung Molecular Marine Microbiology

Course: Research Data management	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** Prof. Dr. Frank Oliver Glöckner Dr. Ivaylo Kostadinov
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial	**Associated module examination:** Modulprüfung Molecular Marine Microbiology

Course: Microbial Oceanography	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** Prof. Dr. Antje Boetius
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial Laboratory class	**Associated module examination:** Modulprüfung Molecular Marine Microbiology

Module 02-BIO-MA-MarMic4: Marine Microbial Interactions
Marine Microbial Interactions

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Compulsory modules	Basic biological knowledge, including some experience in molecular techniques and handling of microorganisms, basic statistics are highly recommended.

Learning content:

- Molecular Ecology:

The molecular ecology lecture series covers basic and advanced methods of molecular microbial ecology including the rRNA approach to microbial evolution and ecology. The principles of prokaryotic systematics are explained together with options for reconciliating the classification of cultured and uncultured Bacteria and Archaea (species definition; 16S rRNA identity-based thresholds for taxonomic ranks; candidate taxa). The second part deals with the cultivation-independent assessment of microbial diversity and the composition of microbial communities by various methods of molecular biology (sampling; fixation, nucleic acid preservation, extraction, and amplification; comparative sequence analysis, phylogenetic reconstruction, primer and probe development; Fluorescence in situ Hybridisation (FISH) and microscopy). The third part outlines approaches for the linking of identification of populations to functional assignments (e.g. FISH & microsensor measurements, isotope uptake experiments, incubations with fluorescently labeled substrates). In this context we also touch upon so-called “functional genes” and the role of comparative genomics and metagenomics in molecular microbial ecology and systematics. Finally, principles and applications of flow cytometry are covered in the context of abundant clades of bacterioplankton.
The laboratory course is offering hands-on training in molecular microbial ecology. In particular, the assessment of the microbial diversity and the composition of microbial communities by various methods are practiced with samples obtained by the students in the October field excursion. Topics include DNA extraction methods, PCR amplification and 16S ribosomal RNA tag sequencing. Furthermore an introduction to sequence databases and ARB/SILVA will be offered followed by taxonomic classification of obtained sequences and phylogenetic tree reconstruction. Different FISH formats like CARD-FISH and HCR-FISH will be used for cell localisation and enumeration by epifluorescence microscopy. Finally specific genes will be visualised by geneFISH in combination with laser scanning microscopy. The course ends with applications of flow cytometry.
The more theoretical and computational part of the module is covering lectures dealing with various DNA sequencing technologies, sequence editing, assembly and gene prediction, metagenome analysis including binning and taxonomic classification, manual control and misinterpretation analysis.

Learning outcomes / competencies / targeted competencies:

- Students can plan and critically apply modern molecular-biological methods for field and laboratory investigation of microbial communities.
- They can interpret biodiversity and community composition data, considering potential biases.
- They can predict the environmental role of bacterial and archaeal clades, interaction of clades and the relationships of populations.
- Students have a general understanding of the importance of symbioses for the biology and evolution of marine organisms andecosystems.
- At the end of the course, students know and understand key concepts from the field of marine biogeochemistry including the role of carbon cycle.
- Students have a quantitative understanding of the concepts of rates and fluxes of key elements and compounds in the marine environment and are able to calculate these at a basic level.
- Students understand how radioactive and stable isotopes can be applied to derive quantitative insight into the cycling of biogeochemically relevant elements.

Calculation of student workload:
72 h Self-study
72 h Exam preparation
126 h SWS / presence time / working hours

Are there optional courses in the modules?
no

Language(s) of instruction: English	**Responsible for the module:** Dr. Tim Richter-Heitmann
Frequency: winter semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: SoSe 24 / -	**Credit points / Workload:** 9 / 270 hours

Module examinations

Module examination: Modulprüfung Marine Microbial Interactions	
Type of examination: module exam	
Form of examination: Written examination	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / - / -	
Language(s) of instruction: Englisch	
Description: PL 1 = written exam	

Module courses

Course: Molecular Ecology	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** N. N. Prof. Dr. Rudolf Amann N.N. Dr. Bernhard Fuchs Dr. Anke Meyerdierks
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial Laboratory class	**Associated module examination:** Modulprüfung Marine Microbial Interactions

Course: Microbial Symbiosis	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** Prof. Dr. Nicole Dubilier
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial Laboratory class	**Associated module examination:** Modulprüfung Marine Microbial Interactions

Course: Biogeochemistry	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** N. N. Dr. Gaute Lavik Prof. Dr. Marcel Kuypers
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial Laboratory class	**Associated module examination:** Modulprüfung Marine Microbial Interactions

Module 02-BIO-MA-MarMic5: Marine Microbes in their Environment
Marine Microbes in their Environment

Assignment to areas of study:	Content-related prior knowledge or skills:
• Compulsory modules	Basic understanding of oceanographic processes is highly recommended.

Learning content:
In Physical Oceanography the concepts of salinity, temperature, density pressure will be introduced. Factors shaping this distribution, such as energy balance, energy transport, and the hydrological cycle will be considered. Force balances, e.g. hydrostatic and geostrophic, Ekman layer; wind-driven upwelling and downwelling, and properties of the Coriolis effect will be introduced. How this drives patterns of large scale wind-driven and overturning circulation in the Ocean. In Marine Geology students will learn about the origin and differentiation of the Earth, including rock-forming processes and the cycling of rocks; the formation and evolution of the ocean crust and related transport of heat and matter between the crust and the oceans; the origin of plate tectonics and rock magnetism; and oceanic provinces in relation to plate tectonics. Lectures will also touch on geochemical cycles (e.g., the silicate-carbonate cycle and its implications for the Earth's climate), mapping the seafloor, sedimentation and sediment distribution, submarine volcanism and hydrothermal vents, and sea-leave change and coastal processes.

Learning outcomes / competencies / targeted competencies:
- Students have an introductory understanding of the role of the ocean in the climate system and of the forces driving the ocean, basic understanding of the distribution of temperature and salinity in the ocean (including interaction with the atmosphere) and of the force balances that are responsible for driving the circulation.
- Students have some understanding of how the large-scale physics of the ocean affects biological production.
- The students comprehend the basics of some key geological concepts relevant for marine sciences.
- They have a general understanding of the dynamic processes of marine geosystems.
- They can appreciate the interplays between plate tectonics, sedimentation, and ocean composition.

Calculation of student workload:
62 h Self-study
62 h Exam preparation
56 h SWS / presence time / working hours

Are there optional courses in the modules?
no

Language(s) of instruction:	Responsible for the module:
English	Dr. Tim Richter-Heitmann
Frequency:	**Duration:**
summer semester, yearly	1 semester[s]
The module is valid since / The module is valid until:	**Credit points / Workload:**
SoSe 24 / -	6 / 180 hours

Module examinations

Module examination: Modulprüfung Marine Microbes an their Environment	
Type of examination: module exam	
Form of examination: Written examination	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / - / -	
Language(s) of instruction: Englisch	
Description: PL 1 = written exam	

Module courses

Course: Marine Microbes in their Environment	
Frequency: winter semester, yearly	**Are there parallel courses?** yes
Contact hours: -	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial	**Associated module examination:** Modulprüfung Marine Microbes an their Environment
Associated module courses **Marine Microbes in their Environment** (Lecture)	

Module 02-BIO-MA-MarMic6: Frontiers in Marine Microbiology

Frontiers in Marine Microbiology

Assignment to areas of study:	Content-related prior knowledge or skills:
• Compulsory modules	Basic understanding of oceanographic processes is recommended.

Learning content:

The lectures of this modul comprise basic, advanced, and applicable knowledge on marine oceanography and its current major questions, marine carbon fixation and element cycles, bacterial gene regulation and how to analyze differential gene expression, how microbes form and use biofilms, and prokaryotic membrane transport processes and functions.

The learning content of this modul is broad but well focused on some of the main learning competencies for students of marine microbiology. The students learn how global processes such as carbon fixation and contributions to element cycles are maintained through differential gene expression and membrane transport processes. The students acquire in-depth knowledge about how these processes and mechanisms contribute to the life styles in form of sessile marine structures such as biofilms or mats. While current problems of prokaryotic oceanography are dealt with, cycling of carbon and other elements will be exemplarily introduced. The course focusses on microorganisms in their habitats. Based on an understanding of the major physiological processes of prokaryotic microorganisms, current intensively studied aspects of microbial activity in the ocean will be presented such as: biofilm microbiology, mixotrophy, the iron, sulphur and phosphorus cycle, extremophily, hydrocarbon and polymer degradation but also specific issues such as the Deepwater Horizon oil spill and its consequences for the chemical ecology of marine prokaryotes. The basic principles of bacterial gene expression and differential gene expression will be explained using both, knowledge from model organisms and applied aspects in marine microbes. The students learn how to analyze prokaryotic genes expression using an array of classical and modern methods (Northern blot, reporter gene analysis as well as different ‘omics techniques). Prokaryotes interact with their biotic and abiotic environment through transport processes and changes of membranes. The students will consequently be provided with an overview on structure and function of microbial membranes. Enhanced knowledge will be communicated in terms of transport processes across microbial cell envelopes, receptors and nutrient uptake. Membrane lipids as primary loci for adaptations to environmental stress will be discussed and the biomarker concept will be introduced.

Learning outcomes / competencies / targeted competencies:
Based on an ecological view, students are able to predict the microbial activity in habitats and how they are regulated at the DNA and membrane level. Students can understand and convey future developments as responses to disturbances of natural communities. Students will acquire an integrated in-depth view on microbial life in the ocean and its physiological basis with respect to differential gene expression, sessile or planktonic life styles, and membrane transport processes.
At the cellular level, students will know that a membrane is likewise a very stable lipid bilayer and a highly dynamic entity, and that it has profound effects on the localization, the structure and the activity of the embedded proteins and transported compounds alike. The comparison between diffusion processes and active transport should make clear that uptake of a substrate against a concentration gradient needs energy, which can be provided e.g. by ATP, PEP or the electrochemical gradient of H+ or Na+.
In addition, the strategy by which microorganisms deal with low iron availability under oxic conditions is an excellent example of how microorganisms cope with such a situation. Based on the different mechanisms of carbohydrate uptake the students are able to predict, which microorganisms might dominate a microbial community under special environmental conditions. In terms of marine biofilms as a major form of prokaryotic living in the ocean, students can tell how biofilms are formed, what primers are necessary for biofilm formation, what the composition of the biofilm matrix is, and how biofilms disperse microbes. Last but not least, the course participants understand how bacterial genes are expressed and regulated, what impact the alteration of sigma factors of RNA polymerase can have, why two-component regulatory systems are essential for marine prokaryotes and how we can assess and quantify bacterial gene expression. For this, students have learned how classical and modern methods in bacterial genetics are conducted. The course participants are equipped with the knowledge to choose the right method to investigate their future marine research objects at the eco-system, cellular, and molecular level.

Calculation of student workload:
56 h SWS / presence time / working hours
62 h Self-study
62 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:	**Responsible for the module:**
English	Dr. Tim Richter-Heitmann
Frequency:	**Duration:**
summer semester, yearly	1 semester[s]
The module is valid since / The module is valid until:	**Credit points / Workload:**
SoSe 24 / -	6 / 180 hours

Module examinations

Module examination: Modulprüfung Frontiers in Marine Microbiology	
Type of examination: module exam	
Form of examination:	**The examination is ungraded?**
Written examination	no

Number of graded components / ungraded components / prerequisites of the examination: 1 / - / -
Language(s) of instruction: Englisch
Description: PL 1 = written exman

Module courses

Course: Frontiers in Marine Microbiology	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 4	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Lecture	**Associated module examination:** Modulprüfung Frontiers in Marine Microbiology
Associated module courses **Frontiers in Marine Microbiology** (Lecture)	

Module 02-BIO-MA-MarMic7: Lab Rotation I

Lab Rotation I

Assignment to areas of study:	Content-related prior knowledge or skills:
• Compulsory modules	Lab experiences and knowledge of general methods in molecular biology and biogeochemistry are highly recommended.

Learning content:

The module Lab Rotation I aims at the training and individual performance of a research project under supervision of a senior scientist in the framework of inquiry-based learning.

Work on all steps of a scientific project by way of example:

1. Practical planning and outline of time schedule with supervisor
2. Initial literature review
3. Sampling of data
4. Analysis and interpretation of data
5. Writing, revision and formatting of project report

This part (steps 1-4) includes compulsory elective choices (Wahlpflicht, WP) of up to 6 weeks duration:

- WP1: Students undertake the practical work integrated in a research group at the University of Bremen.
- WP2: Students undertake the practical work as internship students integrated in an external national or international research group

Students conduct a laboratory rotation of up to 6 weeks each in research groups of the MPI, the University of Bremen, the AWI or the Jacobs University. Students work closely with a senior graduate student or postdoc on a defined project. The project teaches students to work independently and help them in their choice of a thesis subject. Students are trained in keeping a reliable and complete laboratory notebook that is regularly supervised by their project advisor. At the end of each project, students summarize their project in a written project report to gain experience in evaluating their results and putting them into context, and to become confident in scientific writing.

Learning outcomes / competencies / targeted competencies:

- Students will be able to apply modern techniques independently for culturing, identifying, and studying bacteria physiologically and molecular-biologically in the laboratory.
- They will be able to contribute elementary to work of others in the lab (teamwork).
- Students will be able to analyze biological samples by using different quantitative state-of-the-art methods in microbiology, molecular biology, bioinformatics, and biogeochemistry and will understand the limits and uses of laboratory techniques (critical data analyzing).
- This includes the ability to plan and perform experiments independently with relevance to a given topic(management of time and resources).
- They learn to communicate and critique experimental results and content of journal articles. They will be able to write lab reports at a professional level (communication skills).

Calculation of student workload:

56 h SWS / presence time / working hours
40 h Exam preparation
174 h Self-study

Are there optional courses in the modules?
yes
The module (steps 1-5) includes compulsory elective choices (Wahlpflicht, WP) of up to 6 weeks duration:

WP1: Students undertake the practical work integrated in a research group at the University of Bremen.

WP2: Students undertake the practical work as internship students integrated in an external national or international research group.

Language(s) of instruction: English	**Responsible for the module:** Dr. Tim Richter-Heitmann
Frequency: summer semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: SoSe 24 / -	**Credit points / Workload:** 9 / 270 hours

Module examinations

Module examination: Modulprüfung Lab Rotation I	
Type of examination: module exam	
Form of examination: See free text	**The examination is ungraded?** yes
Number of graded components / ungraded components / prerequisites of the examination: - / 1 / -	
Language(s) of instruction: Englisch	
Description: SL 1 = short publication manuscript	

Module courses

Course: Lab Rotation I	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 4	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Self-study unit	**Associated module examination:** Modulprüfung Lab Rotation I
Associated module courses **Lab Rotation I** (Laboratory class)	

Module 02-BIO-MA-MarMic8: Lab Rotation II

Lab Rotation II

Assignment to areas of study:	Content-related prior knowledge or skills:
• Compulsory modules	Lab experiences and knowledge of general methods in molecular biology and biogeochemistry are highly recommended.

Learning content:

The module Lab Rotation I aims at the training and individual performance of a research project under supervision of a senior scientist in the framework of inquiry-based learning.

Work on all steps of a scientific project by way of example:

1. Practical planning and outline of time schedule with supervisor
2. Initial literature review
3. Sampling of data
4. Analysis and interpretation of data
5. Writing, revision and formatting of project report

This part (steps 1-4) includes compulsory elective choices (Wahlpflicht, WP) of up to 6 weeks duration:

- WP1: Students undertake the practical work integrated in a research group at the University of Bremen.
- WP2: Students undertake the practical work as internship students integrated in an external national or international research group

Students conduct a laboratory rotation of up to 6 weeks each in research groups of the MPI, the University of Bremen, the AWI or the Jacobs University. Students work closely with a senior graduate student or postdoc on a defined project. The project teaches students to work independently and help them in their choice of a thesis subject. Students are trained in keeping a reliable and complete laboratory notebook that is regularly supervised by their project advisor. At the end of each project, students summarize their project in a written project report to gain experience in evaluating their results and putting them into context, and to become confident in scientific writing.

Learning outcomes / competencies / targeted competencies:

- Students will be able to apply modern techniques independently for culturing, identifying, and studying bacteria physiologically and molecular-biologically in the laboratory.
- They will be able to contribute elementary to work of others in the lab (teamwork).
- Students will be able to analyze biological samples by using different quantitative state-of-the-art methods in microbiology, molecular biology, bioinformatics, and biogeochemistry and will understand the limits and uses of laboratory techniques (critical data analyzing).
- This includes the ability to plan and perform experiments independently with relevance to a given topic (management of time and resources).
- They learn to communicate and critique experimental results and content of journal articles. They will be able to write lab reports at a professional level (communication skills).

Calculation of student workload:

56 h SWS / presence time / working hours
174 h Self-study
40 h Exam preparation

Are there optional courses in the modules?
yes
The module (steps 1-5) includes compulsory elective choices (Wahlpflicht, WP) of up to 6 weeks duration:

WP1: Students undertake the practical work integrated in a research group at the University of Bremen.

WP2: Students undertake the practical work as internship students integrated in an external national or international research group.

Language(s) of instruction: English	**Responsible for the module:** Dr. Tim Richter-Heitmann
Frequency: summer semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: SoSe 24 / -	**Credit points / Workload:** 9 / 270 hours

Module examinations

Module examination: Kombinationsprüfung Lab Rotation II

Type of examination: combination exam

Form of examination: See free text	**The examination is ungraded?** no

Number of graded components / ungraded components / prerequisites of the examination:
1 / 1 / -

Language(s) of instruction:
Englisch

Description:
PL 1 = oral examination
SL 1 = oral presentation

Module courses

Course: Kombinationsprüfung Lab Rotation II

Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 4	**University teacher:** N. N.

Language(s) of instruction:
Englisch

Teaching method(s): Self-study unit	**Associated module examination:** Kombinationsprüfung Lab Rotation II

Associated module courses

Lab Rotation II (Laboratory class)

Module 02-BIO-MA-MarMic9: Lab Rotation III

Lab Rotation III

Assignment to areas of study:	Content-related prior knowledge or skills:
• Compulsory modules	Lab experiences and knowledge of general methods in molecular biology and biogeochemistry are highly recommended.

Learning content:

The module Lab Rotation I aims at the training and individual performance of a research project under supervision of a senior scientist in the framework of inquiry-based learning.

Work on all steps of a scientific project by way of example:

1. Practical planning and outline of time schedule with supervisor
2. Initial literature review
3. Sampling of data
4. Analysis and interpretation of data
5. Writing, revision and formatting of project report

This part (steps 1-4) includes compulsory elective choices (Wahlpflicht, WP) of up to 6 weeks duration:

- WP1: Students undertake the practical work integrated in a research group at the University of Bremen.
- WP2: Students undertake the practical work as internship students integrated in an external national or international research group

Students conduct a laboratory rotation of up to 6 weeks each in research groups of the MPI, the University of Bremen, the AWI or the Jacobs University. Students work closely with a senior graduate student or postdoc on a defined project. The project teaches students to work independently and help them in their choice of a thesis subject. Students are trained in keeping a reliable and complete laboratory notebook that is regularly supervised by their project advisor. At the end of each project, students summarize their project in a written project report to gain experience in evaluating their results and putting them into context, and to become confident in scientific writing.

Learning outcomes / competencies / targeted competencies:

- Students will be able to apply modern techniques independently for culturing, identifying, and studying bacteria physiologically and molecular-biologically in the laboratory.
- They will be able to contribute elementary to work of others in the lab (teamwork).
- Students will be able to analyze biological samples by using different quantitative state-of-the-art methods in microbiology, molecular biology, bioinformatics, and biogeochemistry and will understand the limits and uses of laboratory techniques (critical data analyzing).
- This includes the ability to plan and perform experiments independently with relevance to a given topic (management of time and resources).
- They learn to communicate and critique experimental results and content of journal articles. They will be able to write lab reports at a professional level (communication skills).

Calculation of student workload:

56 h SWS / presence time / working hours
40 h Exam preparation
174 h Self-study

Are there optional courses in the modules?
yes
The module (steps 1-5) includes compulsory elective choices (Wahlpflicht, WP) of up to 6 weeks duration:

- WP1: Students undertake the practical work integrated in a research group at the University of Bremen.
- WP2: Students undertake the practical work as internship students integrated in an external national or international research group.

Language(s) of instruction: English	**Responsible for the module:** Dr. Tim Richter-Heitmann
Frequency: summer semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: SoSe 24 / -	**Credit points / Workload:** 9 / 270 hours

Module examinations

Module examination: Kombinationsprüfung Lab Rotation III	
Type of examination: combination exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / 1 / -	
Language(s) of instruction: Englisch	
Description: PL 1 = oral examination SL 1 = poster presentation	

Module courses

Course: Lab Rotation III	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 4	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Self-study unit	**Associated module examination:** Kombinationsprüfung Lab Rotation III

Module 02-BIO-MA-MarMic10: Transferable Skills
Transferable Skills

Assignment to areas of study:	Content-related prior knowledge or skills:
• Compulsory modules	none

Learning content:
This module focuses on the documentation of labwork, the presentation and discussion of results as well as public speaking since all of these skills are a necessity in scientific life. Students learn to find out about their personal strengths and develop their individual presentation profile. They will receive training and feedback concerning structure, orientation and personal performance to ensure improvement during their MSc phase to ensure that they become creative and credible scientist.
The students will acquire relevant tools for documentation of their experimental results with special focus on
- Good scientific practice
- How to keep a lab notebook
- How to write a lab report
- How to summarize results in a scientific paper
- How to prepare a poster
- Presentation and communication skills
- Time management

Learning outcomes / competencies / targeted competencies:
- The students will be able to present, communicate and discuss effectively with co-workers and other scientists.
- They are able to speak in front of an audience
- The students have developed presentation skills to enhance self-confidence, to present scientific results and deliver key findings to colleagues and the public. They can keep the audience engaged and stick to the given time frame.
- Students are able to plan, organize, coordinate and control their own projects with theories and principles they learnt in their classes.
- Team building is promoted; a synergistic learning environment is created, where the team can focus on to achieving a common goal, including problem solving. It also provides opportunities for personal growth and development.

Calculation of student workload:
68 h Exam preparation
42 h SWS / presence time / working hours
70 h Self-study

Are there optional courses in the modules?
no

Language(s) of instruction:	Responsible for the module:
English	Dr. Tim Richter-Heitmann
Frequency:	**Duration:**
winter semester, yearly	1 semester[s]

The module is valid since / The module is valid until:	Credit points / Workload:
SoSe 24 / -	6 / 180 hours

This module is ungraded!

Module examinations

Module examination: Modulprüfung Transferable Skills

Type of examination: module exam

Form of examination:	The examination is ungraded?
Written examination	yes

Number of graded components / ungraded components / prerequisites of the examination:
- / 1 / -

Language(s) of instruction:
Englisch

Description:
SL 1 = oral presentation

Module courses

Course: Transferable Skills

Frequency:	Are there parallel courses?
winter semester, yearly	no
Contact hours:	**University teacher:**
-	Prof. Dr. Nicole Dubilier

Language(s) of instruction:
Englisch

Teaching method(s):	Associated module examination:
Lecture Laboratory class	Modulprüfung Transferable Skills

Module 02-BIO-MA-MarMic11: Advanced Lab and Thesis Preparation Course
Advanced Lab and Thesis Preparation Course

Assignment to areas of study:	Content-related prior knowledge or skills:
• Compulsory modules	none

Learning content:
What are major tasks of a scientist, what are scientific questions or hypotheses, the right approach to answer a scientific question (primary methodology), developing different experimental techniques, calculation of (bio-)chemical data, introduction to new methods, which have not been demonstrated during the previous lab courses. Conducting studies in a chronological order.
Tips for how to read and interpret publications.
Tips how to use statistics for testing significance of results.
Tips how to write a master thesis/dissertation.

Learning outcomes / competencies / targeted competencies:
The students can
develop good hypotheses

- plan experiments in advancs
- Identify methods that are relevant to your hypothesis
- arrange and analyse data efficiently
- manage resources
- work safely and effectively in a laboratory or in the field/ on cruises
- identify gaps in the literature
- prepare a master thesis formally

Calculation of student workload:
150 h Self-study
70 h Exam preparation
70 h SWS / presence time / working hours

Are there optional courses in the modules?
no

Language(s) of instruction:	Responsible for the module:
English	Dr. Tim Richter-Heitmann
Frequency:	**Duration:**
winter semester, yearly	1 semester[s]
The module is valid since / The module is valid until:	**Credit points / Workload:**
SoSe 24 / -	9 / 270 hours

Module examinations

Module examination: Modulprüfung Advanced Lab and Thesis Preparation Course

Type of examination: module exam

Form of examination: Oral examination (single)	**The examination is ungraded?** yes
Number of graded components / ungraded components / prerequisites of the examination: - / 1 / -	
Language(s) of instruction: Englisch	
Description: SL 1 = oral presentation	

Module courses

Course: Advanced Lab and Thesis Preparation Course	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** Prof. Dr. Jens Harder
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial	**Associated module examination:** Modulprüfung Advanced Lab and Thesis Preparation Course

Module 02-BIO-MA-MarMic12: Module Master Thesis (and Colloquium)
Master Thesis (incl. Colloquium)

Assignment to areas of study:	Content-related prior knowledge or skills:
• Master thesis	At least 75 CP of the study program have to be achieved before students can register for the Master Thesis.

Learning content:
The module Master Thesis aims at the training and individual independent performance of a research project under supervision of a senior scientist in the framework of inquiry-based learning. The master thesis project is supervised and conducted under the conditions of the respective department at the University of Bremen and the examination regulations of the respective study programme.

The Module Master Thesis includes:
- Definition of an independent research theme in marine microbiology
- Planning and discussion of the contents and the time frame of the research work in lab meetings
- Realization of the research project: practical preparation, sampling, acquisition of data, statistical analysis, structuring and writing of the thesis under the guidance of supervisor(s)

The module includes compulsory elective choices (Wahlpflicht WP) of 26 weeks (or upon request 34 weeks) duration:

- WP1: The practical work is conducted in a research group at the University of Bremen
- WP2: The practical work is conducted as an internship student integrated in an external national or international research group.

Learning outcomes / competencies / targeted competencies:
The students can carry out scientific work independently, can answer scientific questions by planning appropriate experiments, are able to analyze and asses the data gained. They can communicate and critique experimental results and content of journal articles in comparison to their own findings. Students are able to work as a scientist independently.

Calculation of student workload:
320 h Self-study
900 h Exam preparation
412 h SWS / presence time / working hours

Are there optional courses in the modules?
yes
The module includes compulsory elective choices (Wahlpflicht WP) of 26 weeks (or upon request 34 weeks) duration:

- WP1: The practical work is conducted in a research group at the MPI, the University of Bremen, the Jacobs University or the AWI
- WP2: The practical work is conducted as an internship student integrated in an external national or international research group

Language(s) of instruction:	Responsible for the module:
English	Dr. Tim Richter-Heitmann

Frequency: winter semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: SoSe 24 / -	**Credit points / Workload:** 30 / 900 hours

Module examinations

Module examination: Modulprüfung Module Master Thesis (and Colloquium)	
Type of examination: module exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 2 / - / -	
Language(s) of instruction: Englisch	
Description: PL 1: Master thesis PL 2: Colloquium (public presentation and defense)	

Module courses

Course: Master Thesis (incl. Colloquium)	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: -	**University teacher:** Prof. Dr. Jens Harder
Language(s) of instruction: Englisch	
Teaching method(s): Self-study unit	**Associated module examination:** Modulprüfung Module Master Thesis (and Colloquium)

Module 02-BIO-MA-0-MarMic: Supplementary Courses in the Master Marine Microbiology

Supplementary Courses in the Master Marine Microbiology

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Supplementary Courses	none

Learning content:

Learning outcomes / competencies / targeted competencies:

Calculation of student workload:

Are there optional courses in the modules?
no

Language(s) of instruction:	**Responsible for the module:**
English	N.N.
Frequency:	**Duration:**
(depending on capacity) winter or summer semester	1 semester[s]
The module is valid since / The module is valid until:	**Credit points / Workload:**
WiSe 23/24 / -	0 / 0 hours

This module is ungraded!

Module examinations

Module examination: with examination or without examination

Type of examination: module exam

Form of examination:	**The examination is ungraded?**
See free text	yes

Number of graded components / ungraded components / prerequisites of the examination:
- / 1 / -

Language(s) of instruction:
Englisch

Module courses

Course: Lab Safety and Fire Prevention Workshop (in English)

Frequency:	**Are there parallel courses?**
(depending on capacity) winter or summer semester	no
Contact hours:	**University teacher:**
	N. N.

Language(s) of instruction:
Englisch

Teaching method(s): Lecture Tutorial	**Associated module examination:** with examination or without examination
Associated module courses **Lab Safety and Fire Prevention Workshop (in English)** (Lecture)	

Course: Introduction to an unique interdisciplinary study program	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours:	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Lecture	**Associated module examination:** with examination or without examination