Study program: Master Marine Microbiology „MarMic“

1) Specifications of the module	
Module Indicator	02-02-04 PM1.28
Titel of the module	***Module 1 – Marine Chemistry, Biogeochemistry I*** ***Lectures, Practical Course, and field excursion***
Allocation to study program	M.Sc. Marine Microbiology (Marmic)
Recommended prerequisites	*College level math, chemistry and laboratory analytical chemistry skills.*
Contents	*The course provides a basic introduction to marine biogeochemistry, with an emphasis on understanding the microbiological, geochemical and oceanographic processes that control the distribution and cycling of bioactive elements and compounds in the marine environment.* *The lectures and tutorials introduce the students to the basics of the marine carbon cycle and the fundamental role of photosynthesis and respiration on driving marine biogeochemistry. The role of oxygen and anaerobic terminal electron acceptor processes are discussed, as well as the controls on carbon assimilation and growth. The concepts of ecological stoichiometry and limitation, with particular emphasis on the N and P cycles are presented. Implications for changes in global biogeochemistry, such as climate-relevant trace gas emissions and oxygen minimum zones are discussed.* *The laboratory part of the course provides an introduction to biogeochemical methods commonly employed to quantify carbon, nitrogen and phosphorus cycling in the marine environment. Quantitative analytical methods and calculations for the determination of concentrations, rates and fluxes nitrogen, phosphorus or carbon compounds are applied to environmental samples. The further application of these techniques to quantitative single-cell environmental biogeochemistry methods is also introduced.* *The practical part of the course will take place in the MPI Biogeochemistry Labs.*
Learning outcome / competences	*At the end of the course, students should know and understand key concepts from the field of marine biogeochemistry including the role of carbon cycle. Students should have a quantitative understanding of the concepts of rates and fluxes of key elements and compounds in the marine environment and be able to calculate these at a basic level.*
Workload calculations	270 hrs
Medium of teaching	English
Person responsible	Timothy Ferdelman
Frequency of the course	WiSe, annually
Period per semester	1 Semester /Term
ECTS-Points	9
SWS /semester periods per week	6

2) Specifications of the examination	
Examination *Modulprüfung (MP)* *Kombinationsprüfung (KP)* *Teilprüfung (TP)*	*Part of written and oral exams (TP)*
Performance PL = *Prüfungsleistung (Bestandteil der MP/KP/TP)* SL = *Studienleistung* PVL = *Prüfungsvorleistung (Freiwillig zu Übungszwecken als Selbstkontrolle, siehe AT 2010)*	*Supervision, lab reports, discussions*
Special kind of examination	Written / *oral examination*
Duration	
3) Information on the course of this module	
Name/Titel der Lehrveranstaltung **VAK 02-02-PM1-28**	
Frequency of the course *z. Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	WiSe, annually
Parallel curricular activities	Lab course
Language	English
Lecturers	Timothy Ferdelman, Jens Harder, Dirk deBeer, Thorsten Dittmar
Teaching method	Lecture, seminar, tutorial
Literature	Original papers will be provided during the course

Study program: Master Marine Microbiology „MarMic“

1) Specifications of the module	
Module Indicator	
Titel of the module	***Module 2 - Biology of marine prokaryotic microorganisms I***
Allocation to study program	M.Sc. Marine Microbiology (Marmic)
Recommended prerequisites	B. Sc.
Contents	**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.* **Marine Prokaryotes** *The course refreshes knowledge of the bachelor eduction and provides an overview on the microbiology of prokaryotes. Key features are structure and function of cells dealing, cell size, ribosomes, cell walls, membrane structure. Lifestyles are discussed and the importance of energy conservation is explained. Microbial media and nutritional requirements are covered together with the limits of microbial activity. Thermodynamics of microbial catabolism is explained and used in calculations. Then the curriculum starts with photosynthesis as process. (internal comment : lectured by J Harder)* *Starting with glucose degradation in E.coli, aerobes as well as nitrate respirations, metal respirations, fermentations, syntrophy, sulfate reduction and methanogenesis are presented. (lectured by MW Friedrich)* *Based on this overview, the kinetics of enzymes and microorganisms are the starting point to discuss the ecology of microorganisms in the environmental habitat, natural population sizes and the dynamics of microbial populations (lectured by J Harder).* *The practical courses involve many aspects of the cultivation of microorganisms and provide examples for the study of microorganisms in natural samples.* **Marine Botany** *The part introduces the biology, taxonomy and morphological characteristics of the major groups of marine primary producers, especially of algae. This is an introductory overview on the major marine* *primary producers with emphasis on phytoplankton. Basic aspects on marine primary productivity, ecological and physiological adaptations of organisms to the environment as well as evolutionary* *and morphological characteristics will be covered.*
Learning outcome / competences	Students should be able to demonstrate a detailed understanding of microbial survival and life in natural environments, especially in marine habitats, and of the mechanisms assisting this survival. Therefore, the

	students have to understand the importance of microorganisms and processes influenced by microorganisms in the marine environment. *It is expected that students will use examples to illustrate microbial diversity with respect to their distribution, ecological and physiological role in the ocean.* *It is expected that students will relate structural, physiological and genetic adaptations of microbes to their diverse roles in the marine food chain.* *Students should be able to interpret data arising from environmental microbiology experiments and scientific publications.* *Goal of the course is also to provide students with a basis for the study of microorganisms in other fields of biology also and a foundation for those intending to progress courses in microbiology or biotechnology with other study degrees.*
Workload calculations	360 h
Medium of teaching	English
Person responsible	Jens Harder
Frequency of the course	Winter semester, annually
Period per semester	1 Semester / Term
ECTS-Points	12
SWS /semester periods per week	8
2) Specifications of the examination	
Examination *Modulprüfung (MP)* *Kombinationsprüfung (KP)* *Teilprüfung (TP)*	*Part of written and oral exams (TP)*
Performance PL = *Prüfungsleistung (Bestandteil der MP/KP/TP)* SL = *Studienleistung* PVL = *Prüfungsvorleistung (Freiwillig zu Übungszwecken als Selbstkontrolle, siehe AT 2010)*	1 PL , *Supervision, lab reports, discussions*
Special kind of examination	Written / *oral examination*
Duration	
Percentage of the grade to the final mark	
3) Information on the course of this module	
Name/Titel der Lehrveranstaltung/ of the course / sub-module **VAK** 02-307-T1-01 **Microbial Oceanography 2 SWS**	
Frequency of the course *z. Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	WiSe, annually
Parallel curricular activities	Lab course

z. Bsp. bei Praktika etc.	
Language	English
Lecturer	Antje Boetius, Pierre Offre
Teaching method	Lecture and Practical Course
Literature *Fakultativ*	*Madigan, Martinko, Dunlap, Clark : Brock Biology of Microorganisms 14.Ed., San Francisco, Pearson 2015*
Name/Titel der Lehrveranstaltung/ of the course / sub-module **VAK** 02-307-T1-06 **Marine Prokaryotes I 4 SWS**	
Frequency of the course *z. Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	WiSe, annually
Parallel curricular activities	Lab course
Language	English
Lecturer	Jens Harder
Teaching method	Lecture, practical lab course
Literature	*Madigan, Martinko, Dunlap, Clark : Brock Biology of Microorganisms 14.Ed., San Francisco, Pearson 2015*
Name/Titel der Lehrveranstaltung/ of the course / sub-module **VAK** 02-307-T1-07 **Marine Prokayotes II 3 SWS**	
Frequency of the course *z. Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	WiSe, annually
Parallel curricular activities	Lab course
Language	English
Lecturer	Michael W. Friedrich
Teaching method	Lecture , practical lab course
Literature	*Madigan, Martinko, Dunlap, Clark : Brock Biology of Microorganisms 14.Ed., San Francisco, Pearson 2015*
Name/Titel der Lehrveranstaltung/ of the course / sub-module **VAK** 02-307-T1-08 **Marine Botany 1 SWS**	
Frequency of the course *z. Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	WiSe, annually
Parallel curricular activities.	Lab course
Language	English
Lecturer	Kai Bischof
Teaching method	Lecture , practical lab course

Literature	*Madigan, Martinko, Dunlap, Clark : Brock Biology of Microorganisms 14.Ed., San Francisco, Pearson 2015*

Study program: Master Marine Microbiology „MarMic“

1) Specifications of the module	
Module Indicator	02-02-04 PM1.28
Titel of the module	***Module 3 - Molecular Ecology I, Bioinformatics, Uni- and multivariate statistics for microbial ecology***
Allocation to study program	M.Sc. Marine Microbiology (Marmic)
Recommended prerequisites	Molecular Ecology: Basic biological knowledge, including some experience in molecular techniques and handling of microorganisms. Bioinformatics: None Uni- and multivariate statistics for microbial ecology: None Global cycles of Biogenic Elements: None
Contents	*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 first 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). 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 and the "rRNA approach to 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, optimization of PCR amplification parameters and 16S ribosomal RNA tag sequencing. Furthermore an introduction to sequence databases and ARB/SILVA will be offered followed by taxonomic classification and phylogenetic tree reconstruction. Different Fluorescence in situ Hybridisation (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. 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, starting from Sanger sequencing, but also covering the principles of the latest*

	next-generation sequencing technologies, sequence editing, assembly and gene prediction, metagenome analysis including binning and taxonomic classification, manual control and misinterpretation analysis. *<u>Bioinformatics:</u>* *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.* *<u>Uni- and multivariate statistics for microbial ecology:</u>* *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 statistical programming language and environment, R, which has become an essential skill in the life sciences and beyond.*
Learning outcome / competences	** Planning and critical application of modern molecular-biological methods for field and laboratory investigation of microbial communities. Interpreting biodiversity and community composition data, considering potential biases. Prediction of the function of bacterial and archaeal clade, interaction of clades and the relationships of populations.* ** In-depth understanding 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 should be able* - *to choose between different methods to analyze microbial communities* - *to apply the rRNA approach to microbial ecology* - *to identify, visualize and quantify clades of Bacteria and Archaea in communities* - *to make functional assignments of identified organisms/genes* - *to interpret diversity and metagenomic data* - *to use flow cytometry as a method of cell sorting and analyzing.* - *to understand the principles of computers, computing, programming languages, and computational complexities* - *to understand the principles of patterns and profiles for sequence analysis* - *to work with public databases* - *to work with Linux and command line interpreters* - *to apply scoring systems and substitution matrixes* - *to apply pairwise and multiple sequence alignment methods* *Following the statistics sub-module, students would have learned:* • *The core principles required to design robust experimental or observational investigations, especially with regard to replication, balanced designs, and statistical power* • *How to approach and understand the role of statistical distributions in data analysis* • *How and when to use basic statistics such as the various measures of location and spread and understand their link to probability* • *How to correctly interpret and report "significance" and confidence intervals* • *The logic behind common hypothesis testing approaches as well as their caveats* • *The appropriate use of dissimilarity and distance measures in numerical ecology* • *The core concepts behind dimension reduction techniques based on spectral analysis and dissimilarity and how to correctly interpret their outputs* • *How to perform both uni- and multivariate techniques in the statistical programming language, R, as well as how to code and document for reproducibility*
Workload calculations	360 hrs
Medium of teaching	English
Person responsible	Rudolf Amann
Frequency of the course	WiSe, SoSe, annually
Period per semester	1 Semester /Term

ECTS-Points	12
SWS /semester periods per week	8
2) Specifications of the examination	
Examination *Modulprüfung (MP)* *Kombinationsprüfung (KP)* *Teilprüfung (TP)*	*Part of written and oral exams,presentations*
Performance PL = *Prüfungsleistung (Bestandteil der MP/KP/TP)* SL = *Studienleistung* PVL = *Prüfungsvorleistung (Freiwillig zu Übungszwecken als Selbstkontrolle, siehe AT 2010)*	1 PL , *Supervision, lab reports, discussions*
Special kind of examination	Written / *oral examination*
Duration	
3) Information on the course of this module	

Name/Titel der Lehrveranstaltung/ of the course VAK 02-02-PM1-28 Molecular Ecology I (sub-module)	
Frequency of the course	WiSe, regulary
Parallel curricular activities	Lecture, Tutorial, Lab course
Language	English
Lecturer	Rudolf Amann, Bernhard Fuchs, Katrin Knittel, Anke Meyerdierks, Hanno Teeling
Teaching method	Lecture, seminar tutorial, practical excises
Literature	*Madigan, Martinko, Dunlap, Clark : Brock Biology of Microorganisms 14.Ed., San Francisco, Pearson 2015*

Name/Titel der Lehrveranstaltung/ of the course VAK 02-02-PM1-28 Bioinformatics (sub-module)	
Language	English
Lecturer	Frank-Oliver Glöckner, Otthein Herzog, Uta Bohnebeck
Teaching method	Lecture, seminar practical excersises

Literature	Arthur M. Lesk, Introduction to Bioinformatics, Oxford University Press, 2013 S Choudhuri, Bioinformatics for Beginners: Genes, Genomes, Molecular Evolution, Databases and Analytical Tools. Academic Press, 2014
Name/Titel der Lehrveranstaltung/ of the course VAK 02-02-PM1-28 Uni- and multivariate statistics for microbial ecology (sub-module)	
Language	English
Lecturer	Pier Luigi Buttigieg
Teaching method	Lecture, seminar, practical excersises
Literature	Caldwell S. Statistics Unplugged. 3rd ed. Belmont, CA: Cengage Learning, 2009. ISBN:978-0495602187. Freedman D, Pisani R, Purves R. Statistics. 4th ed. New York, NY: W. W. Norton & Company, 2007. ISBN:978-0-393-92972-0. Zuur, A. F., Ieno, E. N., & Elphick, C. S. (2010). A protocol for data exploration to avoid common statistical problems. Methods Ecol Evol, 1(1), 3–14. http://doi.org/10.1111/j.2041-210X.2009.00001.x Borcard, D., Legendre, P., & Gillet, F. (2011). Numerical Ecology with R. (R. Gentleman, K. Hornik, & G. G. Parmigiani, Eds.). New York: Springer. http://doi.org/10.1007/978-1-4419-7976-6_1, Legendre, P., & Legendre, L. (2012). Numerical Ecology (3rd ed.). Amsterdam: Elsevier. Buttigieg, P. L., & Ramette, A. (2014). A Guide to Statistical Analysis in Microbial Ecology: a community-focused, living review of multivariate data analyses. FEMS Microbiol Ecol, 90, 543–550. http://doi.org/10.1111/1574-6941.12437

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1) Specifications of the module	
Module Indicator	02-02-04 PM1.28
Titel of the module	***Module 4 - Marine Physics and Geology; Biogeochemistry II and Global Cycles of Biogenic Elements***
Allocation to study program	M.Sc. Marine Microbiology (Marmic)
Recommended prerequisites	B.Sc.
Contents	*Salinity, temperature, density, pressure: Distribution in the ocean and the factors shaping it* *Energy balance, energy transport, hydrological cycle* *Forces in the ocean, properties of the Coriolis force* *Force balances: hydrostatic and geostrophic, Ekman layer; wind-driven upwelling and downwelling* *Pattern of large-scale circulation in the Ocean; separation into wind-driven and overturning circulation* *Driving forces for mid-latitude ocean gyres* *Origin and differentiation of the Earth, including rock-forming processes and the cycling of rocks* *Formation and evolution of the ocean crust and related transport of heat and matter between the crust and the oceans* *Origin of plate tectonics and rock magnetism; Oceanic provinces in relation to plate tectonics* *Geochemical cycles, with focus on the silicate-carbonate cycle and its implications for the Earth's climate* *Mapping the ocean floor: echo-sounding and seismics* *Sedimentation and sediment distribution in marine settings* *Submarine volcanism and hydrothermal vents* *Sea-level change and coastal processes* *Benthic boundary layer* *The carbon and nutrient cycles* *Introduction to marine organic geochemistry* *TEAPs: Terminal Electron Accepting Processes* *Mass transport , early diagenesis, and mass balances* *Microbial biomineralization* *Stable isotopes in biogeochemistry* <u>*Global Cycles of Biogenic Elements:*</u> *This sub-module includes an introduction of global cycles of biogenic elements (C, N, P, O, Ca, Si, Fe); global marine distributions of nutrients; the marine carbonate system; biological and physical carbon pumps: stoichiometry of phyto- and zooplankton (´Redfield ratios´ and deviations from Redfield); detailed discussion of the box model of the global carbon cycle by Sarmiento and Toggweiler (1984)*
Learning outcome / competences	*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. Some understanding of how the large-scale physics of the ocean affects biological production. *The students should develop a basic comprehension of some key geological concepts relevant for marine sciences. They should gain a general understanding of the dynamic processes of marine geosystems. They should develop an appreciation of the interplays between plate tectonics, sedimentation, and ocean composition.* *Students learn basic biogeochemical concepts, in particular reactivity and mass transport. The elemental cycles with a particular emphasis on the organic carbon cycle, terminal electron accepting processes and their manifestation in aquatic environments are emphasized. The use of stable isotope systematics to understand biogeochemical processes is introduced. General goal, understanding biogeochemical concepts.* *For modeling important element cycles students should* *- get an idea of the global carbon cycle and especially the role of the oceans* *- be able to interpret distributions (horizontal, vertical sections) of nutrients, DIC & TA* *- understand the basic principles for simulations of biogenic elements and derived quantities* *- (especially the conservation principle for elements and isotopes)* *- be able to construct and code simple box models*
Workload calculations	180 hrs
Medium of teaching	English
Person responsible	Dieter Wolf-Gladrow
Frequency of the course	WiSe, annually
Period per semester	1 Semester /Term
ECTS-Points	6
SWS /semester periods per week	6
2) Specifications of the examination	
Examination *Modulprüfung (MP)* *Kombinationsprüfung (KP)* *Teilprüfung (TP)*	*Part of written and oral exams (TP)*
Performance PL = *Prüfungsleistung (Bestandteil der MP/KP/TP)* SL = *Studienleistung* PVL = *Prüfungsvorleistung (Freiwillig zu Übungszwecken als Selbstkontrolle, siehe AT 2010)*	1 PL , *Supervision, lab reports, discussions*

Special kind of examination	Written / *oral examination*
Duration	
3) Information on the course of this module	
Name/Titel der Lehrveranstaltung/ of the course /sub-module **VAK 02-02-PM1-28 Marine Physics**	
Frequency of the course *z. Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	WiSe, unregelmäßig
Parallel curricular activities	none
Language	English
Lecturer	Christoph Völker
Teaching method	Lecture, tutorial
Literature	*Open university oceanography course team (1989, 2nd ed. 1991): Ocean Circulation. Pergamon Press, Oxford* *Trujillo and Thurman, Essentials of Oceanography, Pearson Prentice Hall, 9th edition, 2010* *Madigan, Martinko, Dunlap, Clark : Brock Biology of Microorganisms 14.Ed., San Francisco, Pearson 2015*
Name/Titel der Lehrveranstaltung/ of the course/ sub-module **VAK 02-02-PM1-28 Marine Geology**	
Language	English
Lecturer	Wolfgang Bach
Teaching method	Lecture, tutorial
Name/Titel der Lehrveranstaltung/ of the course / sub-module **VAK 02-02-PM1-28 Biogeochemistry II**	
Language	English
Lecturer	Tim Ferdelman, Wiebke Mohr, Arhzang Khalili
Teaching method	Lecture, tutorial, lab course
Name/Titel der Lehrveranstaltung/ of the course /sub-module **VAK 02-02-PM1-28 Global Cycles of Biogenic Elements**	
Language	English
Lecturer	Dieter Wolf - Gladrow
Teaching method	Lecture, tutorial, practical exercises

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1) Specifications of the module	
Module Indicator	
Titel of the module	***Module 5 - Biology of Marine Communities***
Allocation to study program	M.Sc. in Marine Microbiology (Marmic)
Recommended prerequisites	B. Sc.
Contents	**Eukaryotic Microorganisms** *The first part focusses developing a working knowledge of the dominant organisms in the marine plankton as well as the evolutionary ecology of planktonic phytoplankton and proto-zooplankton. Light and nutrient limitation of growth, community structure and its effect on global climate via cycles of biogenic elements, in particular carbon. Mixotrophy as a core process structuring evolution, community structure and elemental fluxes. The interaction of organisms with their physical environment and with each other via processes such as mixing, sinking and aggregation, and zooplankton feeding, including an understanding of the fundamental governing equations.* *Understanding the role of species interaction for functioning of natural relationships is studied on chemically mediated interactions among marine microalgae, with a focus on the ecological and evolutionary implications. Particular attention will be directed towards toxic and/or allelopathic species involved in Harmful Algal Blooms, in terms of the effects on marine food webs and population dynamics. The latest approaches in molecular genetics and applications of stable isotope labelling to the elucidation of biosynthetic pathways for bioactive compounds produced by eukaryotic microalgae (and comparative examples from cyanobacteria) will be addressed in the lectures. Students will be expected to conduct bibliographic research on current controversial topics in chemical ecology of marine microalgae for seminar presentations. Since this course is part of a larger module on marine algae it will not be comprehensive in the general subject area.* **Marine Prokaryotes II** *Lectures provide first an overview on structure and function of microbial membranes. This is a prerequisite for the following lectures on transport processes across microbial cell envelopes.* *In the first lectures the basic components of a membrane, phospholipids and proteins, are introduced. The terms “hydrophobic effect”, “lipid polymorphism”, “fluidity”, “curvature”, “membrane strain”, “mismatch” and the “raft” concept are covered. Special adaptations in membrane composition due to environmental changes, like low pH, low and high temperature, and high salt are also discussed. The outer membrane and the periplasmic space of Gram-negative bacteria are introduced followed by the introduction of porins, channels and receptors for phages and viruses.* *In the next lectures the permeability of and the diffusion processes across membranes are introduced followed by the term “active transport”. Here the emphasis is on primary and secondary transport processes and on ABC transporters. Another aspect is the acquisition of iron by microorganisms with the help of chelating agents and the uptake of carbohydrates into the cell.*

	The course focusses on microorganisms in their habitat. Based on an understanding of the major physiological processes of prokaryotic microorganisms actually intensively studied aspects of microbial activity in the ocean are presented. In recent years, themes involved biofilm microbiology, mixotrophy of microorganisms, transport processes, microbes mediating the iron, sulphur or phosphorus cycle, extremophily, physics of microbes in the ocean, hydrocarbon degradation and the Deepwater Horizon oil spill, polymer degradation, secondary metabolites and chemical ecology.
Learning outcome / competences	*Based on an ecological view students should be able to predict the microbial activity in habitats and convey future developments as response to disturbancies of natural communities. An integrated view on microbial life in the ocean and its physiological basis should be present.* *On a cellular level students should learn that a membrane is on a large scale a very stable lipid bilayer, but on a small scale a highly dynamic entity, which has a profound effect on the localization, the structure and the activity of the proteins embedded.* *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. Furthermore, based on the different mechanisms of carbohydrate uptake the students will learn, which microorganisms might dominate a microbial community under special environmental conditions.*
Workload calculations	180 hrs
Medium of teaching	English
Person responsible	Jens Harder
Frequency of the course	Winter semester, annually
Period per semester	1 Semester / Term
ECTS-Points	6
SWS /semester periods per week	6
2) Specifications of the examination	
Examination *Modulprüfung (MP)* *Kombinationsprüfung (KP)* *Teilprüfung (TP)*	*Part of written and oral exams (TP)*
Performance PL = *Prüfungsleistung (Bestandteil der MP/KP/TP)* SL = *Studienleistung* PVL = *Prüfungsvorleistung (Freiwillig zu Übungszwecken als Selbstkontrolle, siehe AT 2010)*	presentations, *discussions*
Special kind of examination	Written / *oral examination*
Duration	

3) Information on the course of this module	
Name/Titel der Lehrveranstaltung/ of the course / sub-module **VAK** 02-307-T2-06 **Eukaryotic Microbiology I 1,5 SWS**	
Frequency of the course *z. Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	SoSe, annually
Parallel curricular activities	Lab rotation
Language	English
Lecturer	Anya Waite
Teaching method	Lecture, seminar, tutorial
Literature	*Madigan, Martinko, Dunlap, Clark : Brock Biology of Microorganisms 14.Ed., San Francisco, Pearson 2015*
Name/Titel der Lehrveranstaltung/ of the course / sub-module **VAK** 02-307-T2-07 **Eukaryotic Microbiology II 1,5 SWS**	
Frequency of the course *z. Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	SoSe, annually
Parallel curricular activities *z. Bsp. bei Praktika etc.*	Lab rotation
Language	English
Lecturer	Allan Cembella
Teaching method	Lecture, seminar, tutorial
Literature	*Madigan, Martinko, Dunlap, Clark : Brock Biology of Microorganisms 14.Ed., San Francisco, Pearson 2015*
Name/Titel der Lehrveranstaltung/ of the course / sub-module **VAK** 02-307-T1-10 **Marine Prokayotes II 3 SWS**	
Frequency of the course *z. Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	SoSe, annually
Parallel curricular activities	Lab rotation
Language	English
Lecturer	Michael W. Friedrich, Jens Harder, Karlheinz Altendorf
Teaching method *Praktikum etc.*	Lecture ,tutorial, seminar
Literature	*Madigan, Martinko, Dunlap, Clark : Brock Biology of Microorganisms 14.Ed., San Francisco, Pearson 2015*

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1) Specifications of the module	
Module Indicator	02-02-04 PM1.28
Titel of the module	***Module 6 – Virology, Marine Viruses, and Microbial Symbiosis; Molecular Ecology II***
Allocation to study program	M.Sc. Marine Microbiology (Marmic)
Recommended prerequisites	None
Contents	*A series of lectures within this module covers the field of general virology, marine viruses and symbioses. The students are introduced to principles of viral transmission, replication and virus-host cell interactions to understand the molecular mechanisms of viral activities and host defence reactions and then to marine viruses and learn about the methods used to study them, their crucial role in carbon recycling in the oceans, and how they contribute to lateral gene transfer.* *The following lectures are about symbioses. One focuses on endosymbiosis theory and explains the origin of plastids and mitochondria in eukaryotes. Subsequent lectures describe the general principles of the biology, ecology, and evolution of marine symbioses and focus on specific well-studied symbioses such as those between luminescent bacteria and squid as well as those found at hydrothermal vents to show students in detail how these symbioses are studied and what the current questions are in this field. All lectures are supplemented by tutorials with questions that are developed immediately after the lecture to ensure that the students can work up all the topics covered during the lecture and questions raised during the lecture.* *The sub-module Molecular Ecology II deals with molecular microbiology (transcriptional regulation of bacterial genes; methods for transcriptional analysis; quorum sensing, biofilm formation, and chemotaxis). Students will learn how to analyse bacterial gene expression, how bacteria communicate, sense chemical stimuli, and attach to surfaces. Special emphasis is given to molecular methods.*
Learning outcome / competences	*Knowledge about:* *Gene expression and regulation in bacteria* *Methods (Northern blot, proteomics, reporter gene assays)* *Quorum sensing in bacteria* *Chemotaxis and motility in bacteria* *Biofilm formation by bacteria* *General understanding of the role of viruses for marine ecology, of the complex interactions between viruses and their hosts and of pathogenetic processes that are associated with viral infections.* *General understanding of the importance of symbioses for the biology and evolution of marine organisms and ecosystems.*
Workload calculations	180 hrs
Medium of teaching	English
Person responsible	Nicole Dubilier
Frequency of the course	WiSe, annually

Period per semester	1 Semester /Term
ECTS-Points	6
SWS /semester periods per week	6
2) Specifications of the examination	
Examination *Modulprüfung (MP)* *Kombinationsprüfung (KP)* *Teilprüfung (TP)*	*Part of written and oral exams (TP)*
Performance PL = *Prüfungsleistung (Bestandteil der MP/KP/TP)* SL = *Studienleistung* PVL = *Prüfungsvorleistung (Freiwillig zu Übungszwecken als Selbstkontrolle, siehe AT 2010)*	1 PL , *Supervision, lab reports, discussions*
Special kind of examination	Written exam (TP)
Duration	
3) Information on the course of this module	
Name/Titel der Lehrveranstaltung/ of the course / sub-module **VAK 02-02-PM1-28 Molecular Ecology II**	
Frequency of the course *z. Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	WiSe, annually
Parallel curricular activities *z. Bsp. bei Praktika etc.*	Lab rotation
Language	English
Lecturer	Matthias Ullrich
Teaching method	Lecture, tutorial
Literature	*Madigan, Martinko, Dunlap, Clark : Brock Biology of Microorganisms 14.Ed., San Francisco, Pearson 2015*
Name/Titel der Lehrveranstaltung/ of the course / sub-module **VAK 02-02-PM1-28 Virology , Marine Viruses and Microbial Symbiosis**	
Language	English
Lecturers	Andreas Dotzauer, Nicole Dubilier
Teaching method	Lecture, tutorial
Literature	Paper handouts

Study program: Master Marine Microbiology „MarMic“

1) Specifications of the module	
Module Indicator	02-02-04 PM1.28
Titel of the module	***Modules 7 – 9: Lab Rotations I - III***
Allocation to study program	M.Sc. Marine Microbiology (Marmic)
Recommended prerequisites	Lab experiences and knowledge of general methods in molecular biology and biogeochemistry; B.Sc.
Contents	*After learning general techniques and methods in the first period of practical courses, students work actively at the bench during 3 laboratory rotations up to 6 weeks each in research groups of the MPI, the University of Bremen, the AWI and the Jacobs University. Students work closely with a senior graduate student or postdoc on a defined project. The rotations teach 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 rotation advisor. At the end of each rotation, students summarize their project in an oral presentation and written paper to gain experience in evaluating their results and putting them into context, and to become confident in scientific speaking and writing.*
Learning outcome / competences	*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).*
Workload calculations	3x 270 hrs
Medium of teaching	English
Person responsible	All lecturers and professors of Marmic course
Frequency of the course	WiSe, annually
Period per semester	1 Semester /Term
ECTS-Points	3x 9 = 27
SWS /semester periods per week	3x 4 = 12
2) Specifications of the examination	
Examination *Modulprüfung (MP)* *Kombinationsprüfung (KP)* *Teilprüfung (TP)*	*Part of written and oral exams*

Performance PL = *Prüfungsleistung (Bestandteil der MP/KP/TP)* SL = *Studienleistung* PVL = *Prüfungsvorleistung (Freiwillig zu Übungszwecken als Selbstkontrolle, siehe AT 2010)*	*Supervision, lab reports, discussions*
Special kind of examination	Written lab reports, presentations
Duration	
3) Information on the course of this module	
Name/Titel der Lehrveranstaltung/ of the course **VAK 02-02-PM1-28**	
Frequency of the course *z. Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	WiSe, annually
Parallel curricular activities *z. Bsp. bei Praktika etc.*	Seminars
Language	English
Lecturer	
Teaching method *z. Bsp. Vorlesung, Übung, Seminar, Praktikum etc.*	Lab course
Literature	*Provided by the supervisors according to the relevant research field.*

Study program: Master Marine Microbiology „MarMic“

1) Specifications of the module	
Module Indicator	02-02-04 PM1.28
Titel of the module	***Module 10: Soft and Transferable Skills***
Allocation to study program	M.Sc.
Recommended prerequisites	B.Sc.
Contents	*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 outcome / competences	*Ability to present, communicate and discuss effectively with co-workers and other scientists. Learning how to speak in front of an audience* *Development of presentation skills to enhance self-confidence, to present scientific results and delivering key findings to colleagues and to the public. Keeping the audience engaged. Sticking to the given time frame.* *Students learn how 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 focused to achieve a common goal, including problem solving. It also provides opportunities for*

	personal growth and development.
Workload calculations	Präsenzzeit 90 h, Selbststudium 90 h
Medium of teaching	English
Person responsible	Christiane Glöckner
Frequency of the course	annually
Period per semester	Mainly WS
ECTS-Points	6
SWS /semester periods per week	4
2) Specifications of the examination	
Examination *Modulprüfung (MP)* *Kombinationsprüfung (KP)* *Teilprüfung (TP)*	*none*
Performance PL = *Prüfungsleistung (Bestandteil der MP/KP/TP)* SL = *Studienleistung* PVL = *Prüfungsvorleistung (Freiwillig zu Übungszwecken als Selbstkontrolle, siehe AT 2010)*	Talks, poster presentation, discussions, literature analysis, reports including correction circles for optimization , teamwork training
Special kind of examination.	none
Duration	
3) Information on the course of this module	
Name/Titel der Lehrveranstaltung/ of the course **VAK 02-02-PM1-28**	
Frequency of the course*z.* *Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	*annually*
Parallel curricular activities *z. Bsp. bei Praktika etc.*	none

Language	English
Lecturer	Faculty members and external coaches
Teaching method *z. Bsp. Vorlesung, Übung, Seminar, Praktikum etc.*	Seminars
Literature *Fakultativ*	*Handouts*

Study program: Master Marine Microbiology „MarMic“

1) Specifications of the module	
Module Indicator	02-02-04 PM1.28
Titel of the module	***Module 11: Advanced lab and thesis preparation course***
Allocation to study program	M.Sc. Marine Microbiolgy (Marmic)
Recommended prerequisites	B.Sc.
Contents	*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 outcome / competences	- *Learning to develop good hypothesis.* - *Planning experiments in advance.* - *Identify methods that could be relevant to your hypothesis.* - *Learning how to arrange and analyse data efficiently.* - *Learning how to manage resources.* - *Working safely and effectively in a laboratory or in the field/ on cruises.* - *Identify gaps in the literature* - *Learning how to prepare a master thesis formally*
Workload calculations	180
Medium of teaching	English
Person responsible	Rudolf Amann
Frequency of the course	annually
Period per semester	1
ECTS-Points	6
SWS /semester periods per week	4
2) Specifications of the examination	
Examination *Modulprüfung (MP)* *Kombinationsprüfung (KP)* *Teilprüfung (TP)*	*none*
Performance PL = *Prüfungsleistung (Bestandteil der MP/KP/TP)* SL = *Studienleistung* PVL = *Prüfungsvorleistung (Freiwillig zu Übungszwecken als Selbstkontrolle, siehe AT 2010)*	
Special kind of examination	none

Duration	
3) Information on the course of this module	
Name/Titel der Lehrveranstaltung/ of the course / sub-module **VAK 02-02-PM1-28**	
Frequency of the course *z. Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	annually
Parallel curricular activities *z. Bsp. bei Praktika etc.*	none
Language	English
Lecturer	Faculty members
Teaching method *z. Bsp. Vorlesung, Übung, Seminar, Praktikum etc.*	Seminar
Literature	*Handouts, journal papers*

Study program: Master Marine Microbiology „MarMic“

1) Specifications of the module 12 – Master thesis	
Module Indicator	
Titel of the module	***Module 12: Master thesis and defense***
Allocation to study program	M.Sc. Marine Microbiology (Marmic)
Recommended prerequisites	All written and oral exams of the study program must be passed
Contents	*Depends on the chosen research field*
Learning outcome / competences	*To carry out scientific work independently, to answer scientific questions by planning appropriate experiments, to analyze and asses the data gained. They learn to communicate and critique experimental results and content of journal articles in comparison to their own findings. Learn to act as a scientist independently.*
Workload calculations	900 hrs
Medium of teaching	English
Person responsible	Supervisor of the thesis, Marmic faculty member
Frequency of the course	annually
Period per semester	---------
ECTS-Points	30
SWS /semester periods per week	
2) Specifications of the examination	
Examination *Modulprüfung (MP)* *Kombinationsprüfung (KP)* *Teilprüfung (TP)*	Written thesis, public presentation and defense
Performance	_____

Duration	26 weeks; extension of 8 weeks possible on well-founded reasons
3) Information on the course of this module	
Frequency of the course *z. Bsp.: WS, jährl. oder SoSe, jährl. oder WS und SoSe etc.*	
Language	English
Literature	Actually published papers, handouts from the supervisor