Module Catalog

M.Sc. Chemical Biotechnology

TUM Campus Straubing for Biotechnology and Sustainability (TUMCS)

Technische Universität München

www.tum.de/
www.cs.tum.de/

Module Catalog: General Information and Notes to the Reader

What is the module catalog?

One of the central components of the Bologna Process consists in the modularization of university curricula, that is, the transition of universities away from earlier seminar/lecture systems to a modular system in which thematically-related courses are bundled together into blocks, or modules.

This module catalog contains descriptions of all modules offered in the course of study.

Serving the goal of transparency in higher education, it provides students, potential students and other internal and external parties with information on the content of individual modules, the goals of academic qualification targeted in each module, as well as their qualitative and quantitative requirements.

Notes to the reader:

Updated Information

An updated module catalog reflecting the current status of module contents and requirements is published every semester. The date on which the module catalog was generated in TUMonline is printed in the footer.

Non-binding Information

Module descriptions serve to increase transparency and improve student orientation with respect to course offerings. They are not legally-binding. Individual modifications of described contents may occur in praxis.

Legally-binding information on all questions concerning the study program and examinations can be found in the subject-specific academic and examination regulations (FPSO) of individual programs, as well as in the general academic and examination regulations of TUM (APSO).

Elective modules

Please note that generally not all elective modules offered within the study program are listed in the module catalog.

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Compulsory Courses | Pflichtmodule

Module Description

CS0007: Applied Microbiology and Metabolic Engineering | Applied Microbiology and Metabolic Engineering [MetabEng]

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In order to check whether students have understood the principles and relevant methods and techniques of applied microbiology and metabolic engineering not only in theory, but can also apply them practically, two forms of examination are used. On the one hand, the students answer questions on fermentation strategies during a written exam (90 min) and prove that they have understood the correlations of microbial metabolism. Allowed tools are calculators. Additional resources may be approved by the lecturer if required. The written exam can be repeated each semester. On the other hand, by drawing up written protocols for the laboratory tests carried out, the students demonstrate that they can carry out a selected production process and describe it quantitatively (for each experiment about 5 pages of protocol / not graded course achievement). Guidelines for protocol preparations are discussed. Insufficient protocols can be improved once according to suggestions provided. In case still insufficient the practical course, including the protocol can be repeated the following year.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamentals of Microbiology and Molecular Biology from the Bachelor's courses

Content:
Relevant techniques of applied microbiology and metabolic engineering:
- microbial metabolism (biosynthesis and degradation pathways) - industrial microbiology: production of alcohols, amino and organic acids, vitamins, antibiotics, enzymes, etc.
- bioprocessing techniques - metabolic engineering strategies

(e.g. optimization of precursor and cofactor availability) -
quantitative biology
- Strategies to engineer microbial systems for production of chemicals and fuels based on biogenic resources, side and waste streams.

Intended Learning Outcomes:
Upon successful completion of the module, students will be familiar with the principles and relevant methods and techniques of applied microbiology and metabolic engineering. The students have gained knowledge of microbial fermentation processes and are able to develop strategies for the manipulation of cellular metabolism for selected product classes. The students have learned how to quantitatively describe fermentation processes and calculate mass balances. After completing the practical course, students will be able to cultivate a production strain, optimize process parameters, analyze biomass, substrate and product concentrations, and create a carbon balance of the process.

Teaching and Learning Methods:
The contents of the lectures during the semester are conveyed by a talk of the lecturer, based on ppt-presentations.The blackboard might additionally be used to explain more complex relationships. To a limited extent, this can be supplemented by self-study of the literature mentioned in the lecture. In the practical course during the following semester break the implementation of the theoretically learned knowledge takes place, thereby the students' laboratory skills are trained with regard to the development and optimization of fermentation processes.

Media:
PowerPoint, whiteboard

Reading List:

Responsible for Module:
Blombach, Bastian; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Applied Microbiology and Metabolic Engineering (Lecture) (Vorlesung, 2 SWS)
Blombach B [L], Blombach B, Glawischnig E

Applied Microbiology and Metabolic Engineering (Practical course) (Praktikum, 2 SWS)
Blombach B [L], Blombach B, Glawischnig E, Hädrich M, Vital S
For further information in this module, please click campus.tum.de or here.

Module Description

CS0009: Enzymatic Biotransformations | Enzymatic Biotransformations [IBT]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The students should be able to understand and describe possibilities and limitations of established industrial enzymatic processes. This understanding and its application to derive ways to improve existing processes, making them more sustainable and to establish new ones, a written examination takes place with a duration of 90 minutes (approved tool: calculator). As a voluntary mid-term effort, the students can take part in three online test within the Moodle course of the exercise. If they achieve at least 65% of the points in these tests, a bonus of 0.3 will be credited on the grade of the written examination (however, an improvement of the grade from 4.3 to 4.0 is not possible).

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
The lecture provides a broad overview about applications of enzymes in industrial processes and detailed insight into the corresponding technically important aspects by means of current examples. Essential contents are: industrially relevant properties of enzymes, essential enzyme classes and the most important enzymatic mechanisms, whole cell catalysis vs. enzyme catalysis, biocatalysis vs. classical chemical catalysis, methods of enzyme immobilization, enzymes in aqueous and non-aqueous systems, enzymatic reactions combined with chemical reactions, large-scale supply of enzymes. On the application side, biotransformations which are necessary for the conversion of biogenic ressources are treated as well as reactions for the synthesis of bulk chemicals, fine chemicals and food additives.

Intended Learning Outcomes:
After participating in the lecture the students will be able to review possible applications of enzymes in different chemical and technical processes, to understand the behaviour and limitation of enzymes in these processes and to derive ways to establish new reactions biocatalytically and to propose technically meaningful scenarios for newly developed enzymatic processes respectively.

Teaching and Learning Methods:
The lecture will be performed as ex-cathedra teaching which is interrupted by queries to familiarize students with all necessary basics and to stimulate independent, critical thinking. In the exercise, the students will deepen the knowledge they have learned and solve specific problems of varying complexity, either alone or in group work.

Media:
PowerPoint, white board, exercise sheets or online questions

Reading List:

Responsible for Module:
Sieber, Volker; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Enzymatic Biotransformations (Exercise) (Übung, 1 SWS)
Sieber V [L], Arana Pena S, Hupfeld E

Enzymatic Biotransformations (Lecture) (Vorlesung, 2 SWS)
Sieber V [L], Sieber V
For further information in this module, please click campus.tum.de or here.

Module Description

CS0011: Conceptual Design of Bioprocesses | Conceptual Design of Bioprocesses [CDBP]

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The exam performance is effected by an written exam (60 min). It is reviewed wheter the students know the fundamentals of chemical and bioprocess engineering and if they can apply this knowledge on the design and evaluation of complex processes.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Module "Bioprocess Engineering"

Content:
Basics of conceptual design of bioprocesses; Basics of computational process design including calculation of process parameters; transfer of fundamental scale-up criteria towards real problem solving; Balancing of all process streams; Deepened knowledge of engineering principles and efficient energy utilization; State-of-the-art examples for sustainable bioprocesses will be given which utilize agricultural residues, waste streams or synthesis gas, and, thus, protect the climate.

Intended Learning Outcomes:
The students are qualified to understand the fundamentals of design and calculations of biotechnological processes after the course. They will aquire knowledge of all aspects of process design.

Teaching and Learning Methods:
The module consits of lectures and tutorials. Contents of the lecture shall be imparted in speech and by presentation. In the exercises, performed as part of the module, learned theory shall directly be applied with a practical orientation by means of calculations and examples from

targeted aspects of bioprocess design. Additionally the students will be qualified by an in-depth knowledge of the design of unit operations including calculation of process parameters based on utilization of selected software tools (such as SuperPro Designer).

Media:
slides, interactive quizzes, scripts, practical exercises

Reading List:
Elmar Heinzle, Arno P. Biwer, Charles L. Cooney. Development of Sustainable Bioprocesses: Modeling and Assessment. Online ISBN:9780470058916

Responsible for Module:
Zavrel, Michael; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Conceptual Design of Bioprocesses (Exercise) (Übung, 2 SWS)
Dsouza V, Zavrel M

Conceptual Design of Bioprocesses (Lecture) (Vorlesung, 2 SWS)
Zavrel M
For further information in this module, please click campus.tum.de or here.

Module Description

CS0013: Advanced Scientific Planning Based on Current Research Topics at TUM | Advanced Scientific Planning Based on Current Research Topics at TUM [MW2473]

Advances in Biotechnology; teamwork in student groups with state-of-the-art topics in biotechnology

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students submit a report (either a high quality, collaborative, scientific report in English that is marked by the supervising professor, or a review paper). The scientific report as well as the review paper should not exceed 20 pages unless the supervisor has agreed on a lengthier document. Individual contributions of the group members are tracked in the cloud based editor and this allows an individual assessment of the submitted document. For students who chose the review paper option it is envisaged to submit their review paper to a suitable science journal (possibly with revisions) where group members and supervisors are co-authors. Students demonstrate that they are able to structure and assess current knowledge in a systematic manner and strictly follow citation integrity practices. They include graphical and tabular data and information describing the state of the art in the chosen research topic. If students chose the project plan/scientific report, an actual implementation of the proposed research work targeting the knowledge gap may be envisaged.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
This course is in English only and a reasonable to high level of written and spoken English is required. On top of the English language requirement a substantial level of soft and social skills is highly desirable, since students have to master a topic in a team over a full semester.

Content:
During the face-to-face lectures on two consective days at the beginnning of the semester it is envisaged to communicate the following content:
-fundamentals of scholarly work
-literature survey with science databases
-reference management with zotero.org
-publishing of research
-collaborating in teams: conflict management, communication, emotional intelligence, empathy
-collaborative writing with a cloud based editor and introduction to Fiduswriter.org
-registration in Moodle together with an introduction to learning material made available on Moodle
-introduction to current biotechnology topics and knowledge gaps from TUM research chairs
An agenda of the 2-day face-to-face lectures at the beginning of the semester is available for download at https://syncandshare.lrz.de/getlink/fiLZ3CULyrCVBDU38xiDce3B/agenda_advances_in_biotechnology
Online supervision and tuition on a weekly basis is provided by a postdoc/research fellow/doctoral student and is based the Fidus writer cloud based editor (https://tum.fidus.org or https://fidus.tum.de) and further communication channels in Moodle. Once the common topic has been agreed on by the group, students write up a detailed scientific text that includes summaries, illustrations and tables about the chosen topic. This document as well as the course language is in English. Based on their findings and the state of the art in their chosen biotechnology topic the group draw conclusions with an emphasis on how to bridge knowledge gaps through future research. It is envisaged to submit the the review paper/scientific document created by the group in a scientific journal. Alternatively, if students choose the project plan, the document should allow an implementation of the proposed project plan in practice.

Intended Learning Outcomes:
Students enrolling in this course gain competence in producing an overview of current knowledge in a biotechnology topic from ongoing research at the TUM. Students are free to choose either a review paper about a given biotechnology topic or a research plan. Students acquire proficiency to outline, structure and assess current knowledge from the available literature in a systematic manner. This includes compiling graphical illustrations and tables from the literature and teaches students how to correctly cite from relevant literature sources under the adoption of scientific integrity practices.

Teaching and Learning Methods:
The two-day kickoff meeting at the beginning of the semester introduces students to fundamental concepts of successful teamworking principles through a mix of lectures, teaching videos and team building exercises. The know how acquired in the kickoff meeting forms the basis for the collaboration and supervision in the subsequent virtual student teams.
Literature surveys and research on the state of the art in the chosen biotechnology topic is supervised online on a weekly basis for the remainder of the semester. Interaction between student group and supervisor/postdoc/doctoral student occurs via Moodle and over the the cloud based editor (http://fidus.tum.de or http://tum.fidus.org) which allows simultaneous editing by individual students. Moodle functionality such as chat, forum, feedback fom supervisors is made available

for all members of the group. Video conferencing can be chosen as a further communication channel between students and supervisor. The simultaneous editing of the group document allows the formation of student groups from a remote campus without the need for face-to-face meetings. Traditional, asynchronous editing makes such a collaboration between physically distant campusses hard if not impossible.

The list of scientific topics/knowledge gaps in this module are replaced every semester and students can download this list from
https://syncandshare.lrz.de/getlink/fi7HYsPPgsWNtmgr1UGLpPVH/
topics_advances_in_biotechnology
Students are encouraged to read through the topics beforehand so that they can go for a research field that suits their personal preference and where they want to gain individual expertise. This simplifies the selection of the topic and the formation of the student group during the kickoff meeting at the beginning of the semester. Once the topic has been identified the mode of study is primarily self-study with permanent exchange and interaction with fellow members of the student group. The supervisor periodically reviews the progress of the group and provides sound advice and assistance to improve the quality of the document.

Media:
Students use the cloud based editor "Fidus writer" to author a scientific document in collaborative manner. The proposed reference management tool is Zotero.org.

Reading List:
Students need to conduct a comprehensive literature survey on their chosen science topic. The tool zotero.org allows reference management in groups. Relevant literature for the kickoff meeting:

The Leader's Guide to Emotional Agility (Emotional Intelligence), Kerrie Fleming, 1st edition, FT Publishing International, 2016, 208 pages, https://www.oreilly.com/library/view/the-leaders-guide/9781292083070/?ar and
https://learning.oreilly.com/library/view/the-leaders-guide/9781292083070/

“Academic Writing for Graduate Students: Essential Tasks and Skills”, by John M. Swales and Christine B. Feak,
paperback, 3 rd edititition, 2012, ISBN-13: 978-0472034758 (several copies in TUM library)

The essentials of academic writing for international students, Stephen R. Bailey, 2015, ISBN: 9781317503729
https://opac.ub.tum.de/TouchPoint/singleHit.do?
methodToCall=showHit&curPos=1&identifier=2_SOLR_SERVER_234404024

Writing for Engineering and Science Students - Staking Your Claim, by Gerald Rau, 1st Edition, 2019, eBook ISBN
9780429425684, London, Routledge, 324 pages, https://www.taylorfrancis.com/books/writing-engineering-science-

students-gerald-rau/10.4324/9780429425684

Webster and Watson, “Analysing the past to prepare for the future: Writing a literature review”, MIS Quarterly, Vol.25, No.2, 2002, https://www.jstor.org/stable/4132319 (accessed January 2021)

“The scientific paper is obsolete, here is what is next”, The Atlantic Daily, https://www.theatlantic.com/science/archive/2018/04/the-scientific-paper-is-obsolete/556676/, last accessed 21Jan2021

Responsible for Module:
Sieber, Volker; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Electives | Wahlmodule

Technical Electives | Fachspezifische Wahlmodule

Module Description

WZ1149: Utilisation of Timber as Material | Werkstoffliche Nutzung von Holz

Version of module description: Gültig ab summerterm 2013

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Prüfungsdauer (in min.): 30 Minuten.
Die Anwendung der Lernergebnisse wird der Stoffvermittlung entsprechend in Rahmen der Vorlesung durch die Vorstellung und Besprechung von Fallbeispielen geübt. Das individuelle Beherrschen der Lernergebnisse wird in einer mündlichen Prüfung unter Beweis gestellt.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Einführung in die Grundlagen der Holzkunde und Holztechnologie

Content:
Die Vorlesung vermittelt die vielfältigen Einsatzmöglichkeiten der stofflichen Holznutzung, d.h. als Material und Werkstoff. Ausgehend von den materialtechnologischen, physikalischen und chemischen Eigenschaften werden die Anforderungen und Voraussetzungen vermittelt, um Holz in tragender, nichttragender, dekorativer, bauphysikalisch korrekter Form im Bauwesen, in der Möbel-, Transport- und Verpackungs- und Papierindustrie einzusetzen. Neben den Verarbeitungs-, Produkt- und Anwendungstechnologien werden Möglichkeiten diskutiert, um die Stoffstromlenkung im Hinblick auf eine Kaskadennutzung zu optimieren.

Intended Learning Outcomes:
Die Teilnahme an der Modulveranstaltung befähigt zur Formulierung von verwendungsspezifischen Anforderungen an die Qualität von Massivholz und Holzwerkstoffen. Die Technologien zur Verarbeitung des Holzes als Material und Werkstoff sind bekannt. Die Einsatzformen in den verschiedenen Bereichen der Zivilisationsgesellschaft sind bekannt, ein Schwerpunkt bildet die bauindustrielle Anwendung. Konzepte zur Gestaltung der Verarbeitungs- und Nutzungsformen mit dem Ziel einer besseren Umsetzung der Kaskadennutzung können entwickelt werden.

Teaching and Learning Methods:

Media:

Reading List:

Responsible for Module:
Klaus Richter (klaus.richter@wzw.tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

WZ1193: Biogas Technology | Biogastechnologie [BiGA]

Version of module description: Gültig ab summerterm 2024

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 100	**Contact Hours:** 50

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students take a written examination (90 minutes) to demonstrate their knowledge of microbial breakdown processes in the biogas process, as well as their ability to assess influencing factors. They also demonstrate their knowledge of various technologies for using biogas and can explain their respective advantages and disadvantages. Additionally, they demonstrate that they have understood the legal and economic framework conditions of biogas technology and are able to translate these to case examples. Students also show that they can develop basic concepts of biogas plants.They will answer questions on the topic in their own wording and explain case examples or work out calculations. Multiple-choice questions are also possible.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Required: basic knowledge in biology, especially microbiology, as well as general and organic chemistry, mathematics, physics and thermodynamics of cycles; of advantage: knowledge in agriculture and agricultural engineering

Content:
Microbiology of biogas processing, anaerobic substrate breakdown, factors influencing the fermentation process, process management strategies, biogas storage and purification; biogas recovery (e.g. use of a motor for power generation with or without the use of heat or feeding into the gas grid); legal-economic framework conditions; sustainability issues; competition for raw material and acceptance of biogas plants; aspects of biogas plant design.

Intended Learning Outcomes:
After successful completion of the module, students are able to develop concepts for biogas generation and recovery in a specific context. Students are aware of microbial breakdown

processes in biogas plants and can differentiate between various influencing factors. They are also aware of various processes for the use of biogas and understand their advantages and disadvantages. Students recognize the meaning of biogas technology for sustainable energy supply. Students have a good knowledge of legal and economic framework conditions in the field of biogas generation and they are able to conceptualize basic biogas plants.

Teaching and Learning Methods:
Lectures given as presentations, with the help of a blackboard and interactive elements, in particular group work on case examples; optional: excursion to a biogas plant to deepen acquired knowledge in a real-life setting

Media:
PowerPoint presentation, slide notes, exercise sheets

Reading List:
D. Deublein, A. Steinhauser, Biogas from Waste and Renewable Resources - An Introduction, Wiley-VCH, 2010, ISBN-13: 978-3-527-32798-0, ISBN-10: 3-527-32798-3

Responsible for Module:
Doris Schieder (doris.schieder@tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0003: Production of Renewable Fuels | Production of Renewable Fuels

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning results are going to be proven in form of a written exam of 90 Minutes. Along the problem set, it is checked whether the student is able to understand, improve and assess industrial processes for the production of renewable fuels. No aids permitted.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic knowledge in chemistry, Fundamentals in Thermodynamics (e.g., Grundlagen der Thermodynamik), Fundamentals in Process Engineering (e.g., Introduction to Process Engineering)

Content:
Requirements for fuels, linkage of energetic and chemical value chains, fossil fuel production as reference, balancing and assessments (Well-to-Wheel), Hydrogen and methanol economy, alternative fuels on C1-basis, fisher-tropsch fuels, OME, bio-based oil fuels, biodiesel, green diesel, HEFA, bio-based alcohols, legislation of fuels.

Intended Learning Outcomes:
This module aims at making the students familiar with the industrial processes to produce renewable fuels. They are able to set up material and energy balances of these processes and assess their sustainability. Limitations with respect of raw material supply, energetic efficiencies and market requirements are understood. The students understand the interactions of fuel market and energy market.

Teaching and Learning Methods:
The module consists of a lectures and exercises. Contents of the lecture shall be imparted in speech and by presentation. To deepen their knowledge students are encouraged to study the literature and examine with regards to content the topics. In the exercises learned theory is applied with a practical orientation by means of arithmetic examples.

Media:
Hybrid live lectures & asynchronous mini-videos allowing distance learning, lecture Script and exercises via online platform, excursions to fuel production plants

Reading List:
• Jacob A. Moulijn, Michiel Makkee, Annelies E. van Diepen: Chemical Process Technology, Wiley (2013).
• George Olah et al.: Beyond Oil and Gas: The Methanol Economy, Wiley VCH (2006)
• Volker Schindler: Kraftstoffe für morgen: Eine Analyse von Zusammenhängen und Handlungsoptionen, Springer (1997)
• Martin Kaltschmitt, Hans Hartmann, Hermann Hofbauer: Energie aus Biomasse; Grundlagen, Techniken und Verfahren,SpringerVieweg (2016)
• Jochen Lehmann, Thomas Luschtinetz: Wasserstoff und Brennstoffzellen, Springer (2014)

Responsible for Module:
Burger, Jakob; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Production of renewable fuels (Tutorial, Straubing) (Übung, 2 SWS)
Burger J [L], Burger J, Groh D, Rosen N

Production of renewable fuels (Tutorial, Garching) (Übung, 2 SWS)
Burger J [L], Burger J, Groh D, Staudt J

Production of renewable fuels (Lecture, Garching) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Staudt J

Production of renewable fuels (Lecture, Straubing) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Staudt J
For further information in this module, please click campus.tum.de or here.

Module Description

CS0008: Enzyme Engineering | Enzyme Engineering [EE]

Version of module description: Gültig ab summerterm 2022

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
To proof whether the students are able to show ways to optimize enzymes in their properties and to perform this methodically, a written examination takes place with a duration of 60 minutes and a written seminar report must be created.The total grade consists of the written exam grade (67%) and the grade of the seminar report (33%).

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
This course aims to convey molecular biology and protein chemistry approaches to optimize enzymes especially by variation of the primary structure. Essential contents are: analysis of the limitation at the molecular level, rational methods, computer-based methods, evolutionary and combined procedures, high-throughput methods, robotics. The seminar aims to convey basic bioinformatical tools used in rational enzyme design such as ligand docking, energy minimization and rational introduction of mutations. These methods will be practiced on real enzymes and used to generate improved enzyme variants for a specific engineering target.

Intended Learning Outcomes:
After participating in the lecture the students will be able to indicate options for the improvement of technically limited enzymes, to estimate the necessary effort for these improvements and they own the theoretical ability to put these improvements into practice. After having participated in the seminar the students are able to use different bioinformatical tools for rational enzyme design and are able to evaluate the results of the generated informatical predictions.

Teaching and Learning Methods:
The lecture will be performed as ex-cathedra teaching to provide the students with all necessary fundamentals. In addition, the students review single methods and procedures by themselves e.g. based on current scientific literature and present this review to each other in a presentation. In the seminar, the students will be guided through the single steps of a rational enzyme engineering approach with the help of a script. The results of these steps will be summarized in a written report to put the single steps into a larger context.

Media:
PowerPoint, lecture script, scientific publications

Reading List:
Recommendations:
"Directed Enzyme Evolution: Screening and Selection Methods" (Methods in Molecular Biology) and "Directed Evolution Library Creation: Methods and Protocols" (Methods in Molecular Biology), both Frances H. Arnold, George Georgiou (publisher), Springer, Berlin
"Protein Engineering Protocols" (Methods in Molecular Biology), Katja M. Arndt and Kristian M. Muller (publisher), Springer, Berlin.

Responsible for Module:
Sieber, Volker; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0012: Artificial Intelligence for Biotechnology | Artificial Intelligence for Biotechnology [AI]

Version of module description: Gültig ab summerterm 2024

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination takes the form of a presentation followed by discussion. The learning outcomes are verified by a group project (3-4 students per group). The presentation of the developed code and the results of the project will be done together as a group, with each group member presenting one part. The presentation should be equally divided among the group members. After the presentation, each group member is asked individual questions about the project. The final grade will be based on the presentation and results of the project (duration of presentation and questions: approx. 30 min depending on group size; approx. 8-10 minutes per student). As a voluntary mid-term effort, the students can take part in a multiple-choice test (duration: 10 minutes). If they achieve at least 65% of the points in this test, a bonus of 0.3 will be credited on the grade of the presantation (however, an improvement of the grade from 4.3 to 4.0 is not possible).

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Mathematical Skills in Linear Algebra and Statistics as well as Programming Skills in Python are expected

Content:
Technologies that generate analyses or predictions based on data can be found in almost all areas of our daily life (e.g. recommender systems, autonomous driving, and credit card fraud detection). These methods are also important for analyzing biological and biomedical data, e.g. for finding novel patterns in biological data, predicting the disease state of a patient, or the 3D structure of proteins. In this course, we will learn the fundamentals of machine learning and will apply these methods to various real-world problems.

The following contents will be treated exemplarily:
- Similarity and Distance Metrics
- Data Preprocessing and Visualization
- Dimensionality Reduction (e.g., Principal Component Analysis)
- Classification (Nearest-Neighbor, Logistic Regression, Decision Trees, Support Vector Machines (SVM))
- Model Selection and Hyperparameter Optimization (Confusion Matrix and Evaluation Measures, Cross-Validation, Hyperparameter tuning techniques, Common problems such as Over- vs. Underfitting)
- Clustering (K-Means, Hierarchical Clustering)
- Regression Models (Linear Regression, Support Vector Regression)

AI-based technologies have the potential to support many areas of biotechnology and sustainability, e.g. by guiding downstream research with data-driven predictions or supporting decision-making with demand forecasts. In this course, we will look at suitable practical examples and demonstrate their potential.

Intended Learning Outcomes:
The students know the fundamental and most important artificial intelligence, especially machine learning, methods and are able to apply them independently on various real-world problems. The students learn the basics of the programming language Python (one of the leading programming languages in the field of machine learning) and are able to implement and apply machine learning algorithms in Python. In addition, students are able to visualize and interpret different types of data and results independently. Students will understand how artificial intelligence can support areas of biotechnology and sustainability and are able to assess the potential of AI-based approaches in sustainability projects.

Teaching and Learning Methods:
Lectures to provide the students with all necessary fundamentals of artificial intelligence, especially of machine learning which they will need to independently apply these concepts to real-world data. In the exercises the students are introduced to the programming language Python, as well as to apply and implement these algorithms for specific case studies.

Media:
The lecture shall mainly be done by using PowerPoint presentations. During the exercise the students work at PCs to gain confidence in using the programming language Python. Students implement various machine learning methods in Python (e.g. using Jupyter Notebooks) and apply them on various examples. Students work on real world problems to implement learnt skills and to gain confidence in applying these different methods independently.

Reading List:
Murphy, K. P. (2012). Machine learning: a probabilistic perspective. MIT press.
Bishop, C. M. (2006). Pattern recognition and machine learning. Springer.
Raschka, S. (2017). Machine Learning mit Python. mitp Verlag.

Friedman, J., Hastie, T., & Tibshirani, R. (2001). The elements of statistical. Springer.

Responsible for Module:
Grimm, Dominik; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0017: Regulation of Microbial Metabolism | Regulation of Microbial Metabolism

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning results are to be proved in form of a written test (60 min). The students demonstrate that they know relevant mechanisms of metabolic regulation and that they have understood the basic connections of microbial metabolism and its regulation dealt with in the module and can apply and transfer the methods and techniques.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Successfully completed exams for Cell- and Microbiology (CS0256) and Molecular Biology and Genetic Engineering (CS0257) modules or equivalent modules.

Content:
Relevant topics of metabolic regulation: i.a. catabolite repression, attenuation, autogenous regulation, end product inhibition, 2-component systems, quorum sensing, regulatory RNAs, stringent control, nitrogen regulation, iron homeostasis, phosphate regulation

Intended Learning Outcomes:
Upon successful completion of the module, students will be familiar with the principles and relevant mechanisms metabolic regulation, including the ecological significance of microbial metabolism. This knowledge is the essential basis for the design of microbial systems for production of chemicals and fuels based on biogenic resources, side and waste streams. In addition, students are able to transfer the knowledge they have acquired in order to develop solutions to new problems.

Teaching and Learning Methods:
The contents of the lectures are conveyed by a talk of the lecturer, based on ppt-presentations. The blackboard might additionally be used to explain more complex relationships. To a limited extent, this can be supplemented by self-study of the literature mentioned in the lecture. Learning methods: During the follow-up of the lecture, the students intensively deal with the teaching contents of the lecture.

Media:
PowerPoint, whiteboard

Reading List:
Microbiology – an evolving science, J. L. Slonczewski, J. W. Foster, W W Norton & Co Inc, 4th edition, ISBN: 978-0-393-61403-9
Molecular Biology of the Gene, I. D. Watson, T. A. Baker, A. Gann, M. Levine, Losick, Pearson, 7th edition, ISBN-13: 978-0321762436

Responsible for Module:
Blombach, Bastian; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0018: Plant Biotechnology | Plant Biotechnology [PlBioTech]

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In a written exam (60 min) it will be evaluated to which extent the students are able to describe and assess the topics of the lecture correctly in appropriate scientific language.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successfully completed modules Cell- and Microbiology (CS0256) and Molecular Biology and Genetic Engineering (CS0257) or equivalent.

Content:
In the lecture the most important model and crop plants in biotechnology are presented, classified and their morphological and physiological properties are emphasized. Major questions, methods and solutions will be discussed with their pros and cons. Current topics will be discussed based on selected original publications. Some of the topics to be discussed: legal framework, major application of current plant genetic engineering, the Arabidopsis model system, novel concepts for yield and quality improvement. One focus is on the challenges for agriculture caused by climate change and sustainable solutions.

Intended Learning Outcomes:
The students know the most important methods and applications in plant biotechnology and are able to assess them.

Teaching and Learning Methods:
in the lecture the teaching content is communicated by a talk of the lecturer, supported by PowerPoint and skectches on the blackboard in which the latter form is chosen to derivate

complex relations. To a limited extent this can be completed for selected topics by self-study by the students.

Media:
PowerPoint, whiteboard

Reading List:

Responsible for Module:
Glawischnig, Erich; Prof. Dr. rer. nat. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Plant Biotechnology (Lecture) (Vorlesung, 2 SWS)
Glawischnig E [L], Glawischnig E
For further information in this module, please click campus.tum.de or here.

Module Description

CS0019: Chemistry of Enzymes | Chemistry of Enzymes [COE]

Version of module description: Gültig ab winterterm 2022/23

Module Level: Master	Language: English	Duration: one semester	Frequency: winter/summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
To proof whether the students are able to understand and to describe more complex enzymatic reaction mechanisms and deduce starting points for new enzymes from that, an oral examination takes place with a duration of 30 minutes.

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
The lecture first gives an insight into the kinetic processes of enzymatic reactions and their descriptions. Then the katalytic mechanisms from a chemical point of view are presented and analyzed by means of enzymes of all six enzyme classes (e.g. acid/base catalysis in hydrolases, one-electron reactions, oxygenation, radical catalysis etc), whereby here more complex mechanisms are illuminated. The different coenzymes are introduced and their interaction with the substrates and the protein backbone is explained. For selected enzymes the mechanisms are presented in relation to the applications.

Intended Learning Outcomes:
After participating in the module sessions, students will be able to understand which complex catalytic mechanisms proceed in enzymes and how they are analyzed. This enables them to assess which chemical reactions are enzymatically possible and which non-natural modifications are necessary to establish new reactions. Thus, the students can for example open up the function of newly found enzymes and develop new enzymes

Teaching and Learning Methods:
The lecture will be performed as ex-cathedra teaching to familiarize the students with all necessary basics. The lecture is interrupted by short exercises/question-answer units to stimulate independent, critical thinking. In the seminar, the students will acquire the mechanisms for selected enzyme systems in self-research, introduce them to their fellow students and solve in a group work concrete problems of varying complexity.

Media:
PowerPoint, script, task sheets

Reading List:

Responsible for Module:
Dr.-Ing. Ammar Al-Shameri

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0020: Glycomics | Glycomics

Version of module description: Gültig ab summerterm 2024

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination consists of a written exam (60 min). The students give definitions and draw or sketch the chemical structure. They answer comprehension questions about the methods covered in the lecture and explain the functional principles in words. Participation in the examination is subject to 90% attendance at the lecture and seminar.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
A prerequisite for participation in this module is the successful completion of a course on instrumental analysis. Proof (module description, transcript of records) must be sent to Broder.Ruehmann@tum.de before the module starts. If you have obtained your Bachelor's degree in Chemical Biotechnology at the TUM Campus Straubing, you do not need to send us the module description, as we are familiar with the contents of the course. If the requirements are met, you will be admitted to the module, whereby a maximum of 20 students can be admitted. An insurance which covers damages in the laboratory is necessary.

Content:
The module teaches the basics of glycomics. The following are discussed: - Complexity of carbohydrates; - Structure and function of glycosylation; - Examples of biosynthesis; - Various analytical methods; - Elucidation of EPS structures

Intended Learning Outcomes:
After attending the module courses, students will be able to describe the basics of glycomics, illustrate the chemical structure and explain its functions. Furthermore, they should be able to illustrate analytical methods.

Teaching and Learning Methods:
In the lecture, the content is taught by means of a lecture by the lecturer, supported by ppt presentations and case studies. Exercise sheets are created for the course content, which students work on in self-study. The exercises are solved and discussed during the tutorials.

Media:
Presentation, script, lab and devices, measurement data and interpretation

Reading List:
script, Sample solutions to the exercises, publications

Responsible for Module:
Broder Rühmann

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0024: Electrobiotechnology | Electrobiotechnology [EBT]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The exam performance is effected by an written exam (90 min). It is reviewed whether the students know the fundamentals of electrochemistry and if they can apply this knowledge on the design and evaluation of electrobiotechnological processes.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:

Content:
Terms and definitions of electrochemistry and bioelectrochemistry; deepened knowledge of physical-chemical fundamentals of electrochemical equilibria and electrochemical processes and reactions; fundamentals of electrochemical thermodynamics and electrochemical kinetics; fundamentals of electrochemical methods (with special focus on biological problems); bioelectrochemical processes in biological systems, especially microorganisms and enzymes; fundamentals of eletrobiotechnology especially on reactions, reactor technology and balancing. Examples of electroorganic syntheses, inter-relations with other subject areas (e.g. environmental biology); exemplarily applications in biosensoris and electrobiorefineries.

Intended Learning Outcomes:
The students are qualified to understand the fundamentals of electrochemistry and electrobiotechnology after the course. They will aquire knowledge of the different application fields of electrocchemistry as well as electroanalysis. Additionally they will be qualified by an in-depth knowledge of bioelectrochemistry especially of natural cellular bioelectrochemical processes as well as bioelectrochemistry of enzymes and microorganisms in combination how to apply them in electrobiotechnology.

Teaching and Learning Methods:
The module consits of lectures and parallel tutorials. Contents of the lecture shall be imparted in speech and by presentation. In the exercises performed as part of the module learned theory shall directly be applied with a practical orientation by means of calculations and examples from targeted aspects of electrochemistry and electrobiotechnology.

Media:
Panel, slides, scripts, exercise sheets

Reading List:

Responsible for Module:
Plumeré, Nicolas; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0025: Advanced Analytics for Biotechnology | Advanced Analytics for Biotechnology [AdInstAna]

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Examination: A 60-minute written examination in which students demonstrate their ability to solve analytical problems using a combination of experimental and theoretical methods. No aids are allowed in the examination. Participation in the examination is subject to a 90% attendance in the lecture and seminar.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Prerequisite for this module is the successful completion of a course in Instrumental Analytics including GC/MS and LC/MS. Proof (module description, transcript of grades) must be sent to corinna.urmann@tum.de before the start of the module. If you have obtained your Bachelor degree in Chemical Biotechnology at the TUM Campus Straubing, you do not need to send the module description, as we know the content of the lecture. If the requirements are met, you will be admitted to the module with a maximum of 10 students. An insurance for damages in the laboratory is necessary.

Content:
The module deals with chromatographic methods such as GC and LC (sampling, sample preparation, sample separation) in combination with different detection options such as MS, MS/MS (e.g. high resolution). In addition, different evaluation methods (practical and theoretical) for structure determination or compound identification are covered.

Intended Learning Outcomes:
After successful participation in the module, students will be able to recognise the potential applications of the methods as well as their limitations. Understand and confidently discuss

the methods and techniques presented, as well as terms and abbreviations. Apply evaluation procedures and principles of documentation and reporting correctly. Independently formulate challenging analytical questions, identify appropriate analytical techniques and combine experimental and theoretical methods to solve the problems.

Teaching and Learning Methods:
The teaching methods used are the lecture with PowerPoint support, as well as teaching videos, open source software and additional material. In the seminar, students will work on practical examples and present their results to their colleagues.

Media:

Reading List:

Responsible for Module:
Dr. Corinna Urmann

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0046: Fundamentals and Technology of Metals | Fundamentals and Technology of Metals [FUNMETAL]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The course will be evaluated in a 90 minute written exam.
In the exam, students shall answer questions freely, or based on sketches. They shall demonstrate that they are able to present production- and property profiles of metallic materials for given applications.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
The module covers the physico-chemical basics of the makeup and the resulting properties of metals. For technologically relevant metals, production routes, testing methods and applications will be shown.

Intended Learning Outcomes:
After completion of the module, students are able to name the technologically most relevant metallic materials. They can evaluate production routes based on their applicability, explain testing methods and name applications of the discussed materials. Through case studies, students are prompted to select materials for specific application scenarios and justify their choice based on manufacturing and property profiles.

Teaching and Learning Methods:
Lecture and Seminar

Media:
Blackboard, slides

Reading List:
Materials Science and Engineering: An Introduction" by William D. Callister Jr. and David G. Rethwisch
"Physical Metallurgy Principles", Fourth Edition, by Reza Abbaschian and Robert E. Reed-Hill

Responsible for Module:
Prof. Marc Ledendecker

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0101: Renewables Utilization | Renewables Utilization

Version of module description: Gültig ab winterterm 2020/21

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Assessment takes a written examination (90 minutes), with students to unterstand and to apply structure, transformation and use of different renewable resources. Students are required to answer questions using individual formulations and outline structures and reactions. In addition, sample calculations are to be worked out.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic lectures in chemistry; Basics on renewables utilization

Content:
Various types of ingredients of renewable raw materials: sugars, polysaccharides, fats and oils, amino acids, proteins, terpenes, aromatics. The following topics will be dealt with in more detail: structure, composition, occurrence, properties, analysis and type of added value or use in various examples.

Intended Learning Outcomes:
After completion of the modules, students understand the chemical composition of renewable resources as well as their production and application. Using this knowledge students are able to explain the respective advantages and disadvantages as well as analyze the underlying physical, chemical and biotechnological principles of their conversion into valuable products.

Teaching and Learning Methods:
Lecture and accompanying tutorial including individual work on specific examples.

Media:
Presentation, script, examples and solutions

Reading List:

Responsible for Module:
Rühmann, Broder; Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Renewables Utilization (Exercise) (Übung, 2 SWS)
Rühmann B

Renewables Utilization (Lecture) (Vorlesung, 2 SWS)
Sieber V [L], Rühmann B, Sieber V
For further information in this module, please click campus.tum.de or here.

Module Description

CS0104: Biogenic Polymers | Biogenic Polymers [Bioplar]

Version of module description: Gültig ab winterterm 2020/21

Module Level: Master	Language: English	Duration: one semester	Frequency: winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
During the seminar, students independently work on a topic from the field of biogenic polymers, and give an oral presentation. Group work is optional. Assessment requires an oral examination (30 minutes). Students demonstrate their knowledge of physico-chemical properties of biogenic polymers as well as possible applications. Students are able to develop options for chemical synthesis and analysis of physico-chemical properties of bioplastics. No further tools are allowed in the examination.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successful participation in "Basics in Chemistry" and knowledge of materials and chemical compounds, or comparable knowledge on chemistry and physics.

Content:
The module deals with structure and function of natural bio-macromolecules (in particular polysaccharids and proteins). Furthermore, basics of biogenic polymers will bei discussed in the view of polymers holding potential for applications in future technology. The topic of chemical synthesis and derivatization of bioplastics for use in industry is introduced (e.g. cellulose derivatives). Special focus is set on the development of options for chemical synthesis and its competent application. Physico-chemical properties of bioplastics as well as their characterization is central to the lecture.
The seminar takes the form of a journal club with students independently work on reserach papers and their presentation to fellow students.

Intended Learning Outcomes:
After participation, students are able to classify different kinds of bioplastics with respect to their possible application. They are competent to evaluate the production processes of biopolymers used in technology and can classify them according to their profile of properties. The module enables students to decide on appropriate synthesis methods to meet specific requirements in the industry. Students will also be able to use physico-chemical analysis methods in a competent way.

Teaching and Learning Methods:
Lecture (talks given by teaching staff using PowerPoint media, books and additional written document), seminar (independent work on a topic including a presentation, peer instruction and constructive criticism)

Media:
Presentations, slide notes

Reading List:
Endres, H.J., Seibert-Raths, A., Technische Biopolymere, Carl Hanser Verlag, München, 2009

Responsible for Module:
Zollfrank, Cordt; Prof. Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Biogenic Polymers (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Helberg J

Biogenic Polymers (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Zollfrank C
For further information in this module, please click campus.tum.de or here.

Module Description

CS0105: Modelling and Optimization of Energy Systems | Modelling and Optimization of Energy Systems [MOES]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	Language: German/English	Duration: one semester	Frequency: winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Assessment is done in a written examination (90 minutes). Participants of the course solve programming tasks to demonstrate that they are able to apply the methods aquired in the course. By answering questions related to case examples they show that they have learned to put things into their proper context.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Bachelor modules Mathematics, Physics, Numerical Methods;
Basic knowledge in Energy technology; basic programming experience (ideally with Matlab)

Content:
Basics of Modelling and Simulation:
- physical models
- data-based models (look-up tables, polynomials, neural networks)
- methods for generating models
Fundamental optimization methods:
- linear optimization (linear regression)
- nonlinear optimization

Intended Learning Outcomes:
After attending the course the participants understand basic methods for creating models, simulation and optimization. In addition, they are able to apply these methods by creating appropriate program code in Matlab. Furthermore, the participants acquire Matlab programming experience.

Teaching and Learning Methods:
The module consists of a lecture and an excercise. Lectures include presentations whose content is deepened by solving excercise problems autonomously. In order to improve the learning outcome, participants work at homework excercise problems. These are discussed in the next lecture.

Media:
PP presentation, whiteboard, demonstration of programs

Reading List:
S. R. Otto & J.P. Denier, An Introduction to Programming and Numerical Methods in MATLAB, Springer, London, 2005
O. Nelles, Nonlinear System Identification, Springer, Berlin, 2010

Responsible for Module:
Kainz, Josef; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Modelling and Optimization of Energy Systems (Vorlesung mit integrierten Übungen, 4 SWS)
Kainz J [L], Kainz J
For further information in this module, please click campus.tum.de or here.

Module Description

CS0108: Catalysis | Catalysis

Version of module description: Gültig ab summerterm 2022

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Results will be assessed by a written exam (90min), whereby the students explain important facts of technical catalysis chemistry, mechanistic aspects of catalysts how catalysts work, what is their typical composition and show practical applications by using examples.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic organic and inorganic chemistry

Content:
transition metal compounds, homogenous/heterogenous catalysis, mechanistic details of activation of organic and inorganic molecules at transition metal compounds, surface chemistry, characterisation of catalysts, heat/mass transfer at catalyst grains, reactor designs

Intended Learning Outcomes:
Students can show important chemical aspects of the phenomenon of catalysis with simple examples. They can show the implication of a catalyst in an overall reaction and can quantify it mathematically by using typical measurable values.

Teaching and Learning Methods:
Using lectures, basic principles of catalysts and catalysis will be transmitted.

Media:
Power point presentation, table, oral teaching, discussion

Reading List:
Dirk Steinborn, Grundlagen der metallorganischen Komplexkatalyse, Vieweg und Teubner Verlag, 2. Auflage 2009 (434 Seiten, 41 €).

Responsible for Module:
Riepl, Herbert; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Catalysis (Lecture) (Vorlesung, 3 SWS)
Riepl H [L], Riepl H
For further information in this module, please click campus.tum.de or here.

Module Description

CS0109: Sustainable Energy Materials | Sustainable Energy Materials [SEM]

From the basics to the application

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning outcomes will be checked through a written exam (90 minutes) in which the students have to reproduce essential aspects of sustainable energy materials and their applications through examples. In addition, mathematical problems will be given to show that the students are able to quantify simple examples.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge of basic electrochemistry/physical chemistry is beneficial, but not required.

Content:
Sustainable energy management is an important issue to minimize environmental impact and climate change. Electrochemical devices such as fuel cells and batteries can help use Renewable In this course, you will learn about the basics of electrochemistry and various important devices used in current and future energy systems, such as fuel cells, batteries, and electrochemical water splitting. The lectures will cover the working principles, components, materials, applications, and future potential of these devices in the energy economy.
Using catalysts in chemical reactions can increase their speed and selectivity, leading to significant energy savings. One section of the course will focus on fuel cell catalysis, and other ideas such as using catalysts in chlorine electrolysis will be introduced to demonstrate how choosing the right counter reaction can result in energy efficiency. The topic of water splitting to obtain hydrogen will be covered later in the course.
We will examine the use of different materials in energy-related devices and how their electronic and ionic properties affect their performance.

Batteries play a crucial role in electromobility by efficiently storing and releasing electrical energy. One part of the course will cover Li-ion batteries, starting with an overview of their fundamentals and the most common cell types. In addition to discussing the characteristics of typical Li-ion electrode materials and electrolytes, the course will show how key performance characteristics such as energy density, power density, and lifespan are influenced by the cell chemistry. The course will also introduce concepts for the next generation of batteries, such as all-solid-state batteries.

Intended Learning Outcomes:
Upon successful completion of this course, students will be able to:
1. Understand and Explain Key Concepts in Electrochemistry:
o Remember and describe the fundamental principles of electrochemistry, including thermodynamics, kinetics, Pourbaix diagrams, and the Butler-Volmer equation.
o Explain the significance of electrochemical processes in energy conversion and storage technologies.
2. Analyze Electrochemical Systems:
o Interpret Pourbaix diagrams to determine the stability of materials in various pH and potential conditions.
o Apply the Butler-Volmer equation to analyze the kinetics of electrochemical reactions in different energy systems.
o Evaluate the thermodynamic feasibility of electrochemical reactions in sustainable energy applications.
3. Comprehend and Apply Battery Fundamentals:
o Understand the working principles of batteries, including charge/discharge processes, energy density, and power density.
o Differentiate between various battery types (e.g., lithium-ion, sodium-ion, solid-state, flow batteries) based on their materials, design, and application potential.
o Apply knowledge of battery chemistry to assess the performance and suitability of different battery types for specific sustainable energy applications.
4. Develop and Evaluate Sustainable Battery Solutions:
o Develop strategies for improving the efficiency, lifespan, and environmental impact of existing battery technologies.
o Critically evaluate the potential of emerging battery materials and technologies for future energy storage solutions.
5. Understand and Analyze Hydrogen Fuel Cells:
o Explain the principles of hydrogen fuel cells, including the role of catalysts, membrane technology, and the overall electrochemical process.
o Analyze the efficiency and challenges associated with hydrogen fuel cells in comparison to other energy conversion technologies.
o Evaluate the environmental and economic implications of hydrogen fuel cell deployment in various sectors.
6. Comprehend and Apply Knowledge of Electrolyzers:
o Understand the operation of electrolyzers, particularly in the context of hydrogen production from renewable energy sources.

7. Integrate Knowledge to Develop Sustainable Energy Solutions:
o Synthesize knowledge from electrochemistry, battery technology, and hydrogen energy systems to propose innovative solutions for sustainable energy storage and conversion.
o Critically evaluate the trade-offs between different energy materials and technologies, considering factors such as cost, scalability, environmental impact, and performance.
These learning outcomes are designed to ensure that students not only grasp the theoretical concepts of sustainable energy materials but also apply and evaluate these concepts in practical, real-world contexts.

Teaching and Learning Methods:
The module consists of a lecture with integrated exercises. The learning content is conveyed through lectures. In the integrated exercises, students work on individual questions and present their solutions.

1) Lectures:
- Purpose: Lectures provide the essential theoretical foundation in sustainable energy materials, covering key topics like basic electrochemistry, battery fundamentals, and hydrogen fuel cells.
- Approach: Interactive and structured with clear explanations, visual aids, and real-world examples, lectures often include brief in-class exercises to reinforce understanding.
- Outcome Alignment: Lectures support learning outcomes related to understanding and explaining core concepts, while integrated exercises help students begin to apply and analyze these ideas.

2) Exercises and Problem-Solving Sessions:
- Purpose: These sessions reinforce lecture material, allowing students to practice problem-solving, apply theory to real-world scenarios, and deepen their understanding.
- Approach: A mix of individual and collaborative exercises, including problem sets, with guidance from instructors to support learning.
- Outcome Alignment: Exercises align with outcomes related to applying, analyzing, and evaluating knowledge, preparing students for advanced tasks in projects and labs.

Media:
1) Presentation Slides:
• Purpose: Presentation slides will be the primary medium for delivering content during lectures. They will be designed to visually complement the spoken content, providing clear and concise explanations of key concepts, diagrams, equations, and real-world examples.
• Usage: Slides will be used to illustrate complex ideas in electrochemistry, battery technology, and hydrogen systems, helping students to follow along and understand the material more effectively. Key points, equations (e.g., Butler-Volmer equation), and visual aids (e.g., Pourbaix diagrams) will be highlighted to enhance comprehension.
• Accessibility: All slides will be made available to students before or after the lectures via the course’s online platform, allowing for review and study at their own pace.
2) Online Learning Platform:

• Purpose: The online learning platform (e.g., Moodle, Blackboard) will serve as the central hub for course materials, communications, and assessments. It will facilitate a blended learning approach, integrating various media forms into a cohesive learning experience.
• Usage: The platform will host lecture slides, videos, reading materials, quizzes, and assignments. It will also be used for discussion forums where students can ask questions and engage in peer learning. This platform supports continuous access to resources and enables students to manage their learning effectively.
• Interactivity: Features such as quizzes, polls, and discussion boards will allow students to interact with the material and with each other, enhancing engagement and reinforcing learning.
3) Textbooks and Research Articles:
• Purpose: Textbooks and scholarly articles provide in-depth coverage of theoretical concepts and the latest research developments in the field. These resources are essential for supporting lecture content and offering additional perspectives on topics covered in the course.
• Usage: Core textbooks will be recommended for fundamental concepts, such as basic electrochemistry and battery technology. Research articles will be assigned to provide insights into recent advancements and emerging trends in sustainable energy materials. These readings will complement lecture content and form the basis for exercises and discussions.
• Depth: By engaging with these texts, students will deepen their understanding of the material and develop critical thinking skills, particularly in evaluating new research and technological developments.

Reading List:
Handbook of fuel cells, Wolf Vielstich, Hubert A. Gasteiger, Arnold Lamm, 2010
Electrochemical Systems, Karen Thomas-Alyea, John E. Newman, 2021

Responsible for Module:
Ledendecker, Marc; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0133: Mechanical Process Engineering | Mechanical Process Engineering [MVT]

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master	Language: English	Duration: one semester	Frequency: winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Assessment takes the form of a written examination (90 minutes).
The students prove that they can solve computational problems and apply methods of mechanical particles and process engineering as well as answer questions about plants and apparatuses of mechanical process engineering.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Thermodynamics, Reaction Technology, Heat Transfer, Fluid Mechanics

Content:
The module teaches the basics necessary for the description of particle systems:
Particle size and shape, distribution functions, particle motion and interactions in heaps.
Furthermore, the basic operations applied to particles are presented: Crushing, mixing, separating, agglomerating, fixed and fluid beds, filtration.
For example, reference is made to applications in material and energy systems with regard to wood chipping, conveying, fermenter stirring and biomass combustion.

Intended Learning Outcomes:
After participating in the module, the students are able to apply the mathematical fundamentals of particle technology and to interpret the basic operations of particle process technology.

Teaching and Learning Methods:
The module consists of lecture and exercise.

The content of the module is conveyed during the lecture by speech and presentations. The students are encouraged to engage actively with the topics by integrating various self-search tasks and comprehension questions.
In the exercises, which take place in alternation with the lecture, serve for a stronger comprehension of the teaching contents. Hence, the students work on various calculation exercises and conduct different lab experiments in small groups.

Media:
Presentations, scripts, exercises

Reading List:
Bohnet, M., Hg.; 2014. Mechanische Verfahrenstechnik. Weinheim: Wiley-VCH-Verl. ISBN 9783527663569
Müller, W., 2014. Mechanische Verfahrenstechnik und ihre Gesetzmäßigkeiten. 2. Aufl. München: De Gruyter. Studium. ISBN 3110343568.
Rhodes, M.J., 2008. Introduction to particle technology. 2nd ed. Chichester, England: Wiley. ISBN 047072711X.
Schubert, H., 1990. Mechanische Verfahrenstechnik. Mit 36 Tabellen. 3., erw. und durchges. Aufl. Leipzig: Dt. Verl. für Grundstoffindustrie. Verfahrenstechnik. ISBN 9783342003816.
Schwister, K., Hg., 2010. Taschenbuch der Verfahrenstechnik. Mit 49 Tabellen. 4., aktualisierte Aufl. München: Fachbuchverl. Leipzig im Carl-Hanser-Verl. ISBN 3446424350.
Stiess, M., 1997. Mechanische Verfahrenstechnik 2. Berlin, Heidelberg: Springer Berlin Heidelberg. Springer-Lehrbuch. ISBN 978-3-662-08599-8.
Stiess, M., 2009. Mechanische Verfahrenstechnik. Partikeltechnologie. 3., vollständig neu bearbeitete Aufl. Berlin, Heidelberg: Springer Berlin Heidelberg. Springer-Lehrbuch. ISBN 978-3-540-32552-9.
Zogg, M., 1993. Einführung in die mechanische Verfahrenstechnik. Mit 29 Tabellen und 32 Berechnungsbeispielen. 3., überarb. Aufl. Stuttgart: Teubner. ISBN 9783519163190.

Responsible for Module:
Gaderer, Matthias; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Mechanical process engineering (Exercise) (Übung, 2 SWS)
Gaderer M [L], Fang W, Herdzik S

Mechanical process engineering (Lecture) (Vorlesung, 2 SWS)
Gaderer M [L], Fang W, Herdzik S
For further information in this module, please click campus.tum.de or here.

Module Description

CS0134: Conceptual Process Design | Conceptual Process Design

Version of module description: Gültig ab summerterm 2024

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The exam performance is effected by an oral exam. It is reviewed whether the students know the fundamentals of conceptual design of chemical and biotechnological processes and if they can apply this knowledge on the design and evaluation of complex processes. The exam consists of two parts: (a) 30 minutes preparation through solving a given problem set (b) 30 minutes of oral examination. In the beginning of part (b) the results of part (a) are presented by the student. (total duration 60 min)

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Knowleadge of thermodynamics and apparatusses used for fluid sparations processes. It is recommended to visit at least the course "Introduction of Process Engineering" first.

Content:
Basics of cenceptual design of processes; Basics of computational process design including calculation of process parameters; transfer of fundamental scale-up criteria towards real problem solving; Balancing of all process streams; Deepened knowledge of engineering principles.

Intended Learning Outcomes:
The students are qualified to understand the fundamentals of design, calculations, and balancing of chemical processes and fluid separation courses after the course. They will aquire knowledge of different challenges of process design and how to master them.

Teaching and Learning Methods:
The module consists of lectures and parallel tutorials. Contents of the lecture shall be imparted in speech and by presentation. In the exercises performed as part of the module learned theory

shall directly be applied with a practical orientation by means of calculations and examples from targeted aspects of process design and calculation. based on a direct comparison of a chemical process with it´s biotechnical alternative they learn to apply their knowledge on reality based challenges. Additionally they will be qualified by an in-depth knowledge of the design of operation units including calculation of process parameters based on utilization of selected software tools.

Media:
Panel, slides, scripts, practical exercises

Reading List:
Moulijn et al. (2013). Chemical Process Technology. – John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom.
Biegler et al. (1997). Systematic Methods of Chemical Process Design. – Prentice Hall.
Doherty, M.F., Malone, M.F. (2001). Conceptual design of distillation systems. – Boston: McGraw-Hill.
Gmehling, J., Kolbe, B., Kleiber, M., Rarey, J. (2012). Chemical Thermodynamics for Process Simulation. 1. Auflage. Weinheim: Wiley – VCH
Grassmann, P., Widmer, F., Sinn, H. (1997). Einführung in die Thermische Verfahrenstechnik. 3. vollst. überarb. Auflage. Berlin: de Gruyter.
Stichlmair, J.G., Fair, J.R. (1998). Distillation: Principles and Practice. – New York: Wiley – VCH.

Responsible for Module:
Burger, Jakob; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Conceptual Process Design (Lecture) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Ibanez M, Staudt J

Conceptual Process Design (Exercise) (Übung, 2 SWS)
Burger J, Rosen N, Wolf A
For further information in this module, please click campus.tum.de or here.

Module Description

CS0135: Cooperative Design Project | Cooperative Design Project

Version of module description: Gültig ab winterterm 2020/21

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 120	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module concludes with the creation, presentation and positive evaluation of a final presentation. In the presentation, the students should present tasks, solutions, procedures in project management, and the project results in a concise form. The presentation should also show which contributions to teamwork have been made by the students themselves. In regular meetings with the supervisors, the individual achievements will be monitored.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
The task describes a technical problem in the field of the use of biogenic resources for which the team has to find a solution. Examples are e.g:
1. preparation of a concept and design of a biogas plant for an agricultural business
2. Feasibility Study on the conversion of high performance packaging in space application from fossil-based plastics to bio-based plastics

Intended Learning Outcomes:
After successful participation in the module, students will be able to
- organize and evaluate the cooperation in a team with heterogeneous knowledge,
- delegate tasks,
- apply the basics of process and energy technology to practical questions,
- design a project in terms of time management, balancing, interaction, objectives,
- analyse projects and to present them to outsiders,
- lead works in a hierarchical organization

Teaching and Learning Methods:
The module consists of a project work, which is carried out in a cooperative team between Bachelor and Master students. Depending on the given task, the team size is 2-6 persons. The Master students assume the role of project leaders and are responsible for formulating and achieving the project goals. The Bachelor students carry out research, analysis and calculations and are supported by the Master students if required. Progress, role identification, and individual involvement are monitored in regular meetings with the supervisor.

Media:
Will be adapted to task at the project start by the supervisor

Reading List:
Rowe, S. (2015). Project Management for Small Projects, 2nd Edition. Oakland: Berrett-Koehler Publishers.
Specific literature will be announced by the supervisor before the project starts.

Responsible for Module:
Alle prüfungsberechtigten Dozenten/innen des Studienganges Technologie biogener Rohstoffe

Courses (Type of course, Weekly hours per semester), Instructor:
(Cooperative) Design Project (Praktikum, 5 SWS)
Burger J [L], Burger J, Elfaitory H, Rosen N, Staudt J

(Cooperative) Design Project (Praktikum, 5 SWS)
Gaderer M [L], Herdzik S, Huber B, Meilinger S, Putra L, Schenker M, Veiltl P

Cooperative Design Project (Prof. Zavrel) (Praktikum, 5 SWS)
Zavrel M [L], Beerhalter D, Borger J, Dsouza V, Geisler N, Marino Jara J, Oktay I, Stegemeyer U, van der Walt H
For further information in this module, please click campus.tum.de or here.

Module Description

CS0140: Advances in Bioprocess Engineering | Advances in Bioprocess Engineering [ABE]

Advances in Bioprocess Engineering

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning outcomes are evaluated by a graded seminar presentation. The prsentation allows the students to assess the extent to which they can summarize a complex scientific work in the field of Bioprocess Engineering correctly and present it to an audience in a comprehensible and convincing way.

Repeat Examination:

(Recommended) Prerequisites:
Modules: Bioprocess Engineering, Downstream Processing, Conceptual Design of Bioprocesses

Content:
The technical content of the course focuses on current research results in the field of Bioprocess Engineering (Fermentation, Downstream Processing, Scale-up). This seminar focuses on particularly sustainable bioprocesses that, for example, use agricultural residues, are less harmful to the environment or protect the climate.

Intended Learning Outcomes:
The students know the current and relevant methods and applications of Bioprocess Engineering and are able to evaluate and classify them. Students can acquire, present and critically discuss relevant technical literature.

Teaching and Learning Methods:
First, a selection of current publications is made and a preliminary discussion of the respective topics with the students takes place. The students then work out a presentation which they then present and discuss in the seminar.

Media:
presentations, publications

Reading List:
will be given out at the start

Responsible for Module:
Michael Zavrel

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0149: Renewable Resources in Medicine | Renewable Resources in Medicine

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The Assessment consists of a written examination (90 minutes)

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Requirements for the successful participation is basic knowledge in chemistry, cell and microbiology, biochemistry, materials science and renewable ressources

Content:
The course provides basic knowledge on the human anatomy, cell biology on general and the cell membranes in particular. The interaction of materials with cell surfaces and tissue will be introduced. The general issues related to pharmacology and the fabrication of drugs from from renewable ressources will be discussed. The application of renwable resources as the main course topic in surgery, internal medicine, plastic and reconstructive surgery as well as wound dressings will introduced. Future tasks for the medical application of renewable resources are outlined. The legislative framework for application of medical products and fabrication will be discussed.

Intended Learning Outcomes:
The successful visit of this course enables the students to select materials from renewable ressources for relevant fields in medicine (skin, muscle, bone) and can particularly assess the valueof their applicability. They are able to apply the most important legislation in medical application and to validate the material reqeuiements for the application in humans (biocompatibility). They are able to identify and develop new concepts for sustainable materials

from renwable ressources in medicine due to their aquired medical, chemical and materials science knowledge and they can set the base for the potiental application of such materials.

Teaching and Learning Methods:
Lecture (talk by teaching staff) with media, seminar on case studies

Media:
Presentation, script, examples, case studies

Reading List:
The following literature is recommended: Buddy Ratner et al.: Biomaterials Science - An Introduction to Materials in Medicine, Elsevier

Responsible for Module:
Zollfrank, Cordt; Prof. Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0156: Material Application for Renewable Resources | Material Application for Renewable Resources

Version of module description: Gültig ab summerterm 2024

Module Level: Master	Language: English	Duration: one semester	Frequency: summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
During the seminar, students independently work on a selected topic from the field of biobased materials and give an oral presentation with PowerPoint-handout (min. 10 slides). Group work is compulsory (3 – 5 persons). The students will implement their own online survey and present the findings in the context of the relevant literature in the presentation (each student has to present 5 minutes). The oral presentation shall be assessed according to content of the PowerPoint-handout and rhetoric aspects. The PowerPoint-handout summarizes the relevant literature, data, and key findings. Weighting: PowerPoint-handout 1, oral presentation 1.
The seminar work is not part of the written exam. However, midterm bonus points can be achieved which will have an effect on the individual final grade (-0,3).

Assessment requires a written examination (90 minutes). Students demonstrate their knowledge of physico-chemical properties and possible applications of biobased materials, as well as their environmental impact. Students are able to develop options for chemical synthesis and production processes of biobased plastics. No further tools are allowed in the examination.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successful participation in "Basics in chemistry " and “Biogenic Polymers”, as well as knowledge of materials and chemical compounds, or comparable knowledge of chemistry and physics.

Content:
Lectures give an overview the applications for biogenic resources in materials industry. Starting with the chemical composition and physic-chemical properties of the raw materials, the module introduces students to production and processing of biodegradable and non-biodegradable

bioplastics, as well as of natural fibre composites. It also covers material properties, relevant fields of application, their environmental impact, as well as current market trends.
In the seminar, students independently work on research papers and based on that, give a presentation to fellow students.

Intended Learning Outcomes:
After successful participation, students are able to assess opportunities and barriers for the application of biobased plastics, as well as their environmental impact compared to conventional plastics. Above all, they are competent to select suitable feedstocks, classes and types of materials, as well as processes to meet the technical requirements of a specific target product, having lower environmental impact at the same time.

Teaching and Learning Methods:
Lecture (talks using PowerPoint slide media, books and additional written material), seminar (independent work on a selected topic with subsequent presentation, peer instruction and constructive feedback).

Media:
Presentations, slide notes

Reading List:
Endres, H.J., Seibert-Raths, A., Technische Biopolymere, Carl Hanser Verlag, München, 2009
Pickering, K. L. (Hrsg.): Properties and performance of natural-fibre composites, CRC Press, Boca Raton 2008
Lewin, M.(Hrsg.): Handbook of Fibre Chemistry, Marcel Dekker, New York, 1998

Responsible for Module:
Fink, Bettina; Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0179: Advances in Metabolic Engineering | Advances in Metabolic Engineering [AMB]

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning outcomes are tested by a graded seminar presentation. The presentation allows the students to assess the extent to which they can summarize a complex scientific work in the field of Metabolic Engineering correctly and present it to an audience in a comprehensible and convincing way.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successfully completed exams for Cell- and Microbiology (CS0256) and Molecular Biology and Genetic Engineering (CS0257) modules or equivalent modules.

Content:
The technical content of the course focuses on current research results in the field of Metabolic Engineering. Molecular biological-methodical as well as biotechnological application-oriented work is dealt with, for example:
- Genome meditation using CRISPR / multiplex gene silencing approaches using CRISPRi or sRNA binding protein Hfq
- Multiplex genome editing through natural transformation (MuGENT)
- Biological sensor/reporter systems and switches
- Chassis organisms and minimal genomes by means of genome reduction and genome assembly of synthetic DNA fragments (top-down and bottom-up approaches)
- Implementation of novel capabilities and functions in established biotechnologically used organisms (e.g. C1-fixation, N-fixation...)
- Recombineering

- Strategies for sustainable production based on waist- or side streams

Intended Learning Outcomes:
The students know the current and relevant methods and applications of Metabolic Engineering and are able to evaluate and classify them. Students can acquire, present and critically discuss relevant technical literature.

Teaching and Learning Methods:
First, a selection of current publications is made and a preliminary discussion of the respective topics with the students takes place. The students then work out a presentation which they then present and discuss in the seminar.

Media:
Powerpoint, blackboard work

Reading List:

Responsible for Module:
Blombach, Bastian; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Advances in Metabolic Engineering (Seminar, 2 SWS)
Hädrich M, Vital S
For further information in this module, please click campus.tum.de or here.

Module Description

CS0181: Advanced Electrochemistry | Advanced Electrochemistry

Version of module description: Gültig ab winterterm 2023/24

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning results are proved in form of a written test (60 min exam duration) at the end of the semester. During the semester four online test to each of the main topics of this module are offered as voluntary mid-terms. The online tests are opened in the week after a main topic was concluded and remain open for five days. Up to 10% of the total number of points of the final examination can be credited as bonus points. The results of the online tests, which are held during the semester, determine the amount of bonus points. At least 65% of the points in the online test must be achieved in order to receive bonus points. This means the online test are not graded, the points reached in the online test only determine if and how many bonus points a student gets for their final examination. It is not possible to raise the grade from 4.3 or worse to 4.0. This should encourage students to continuously participate in the lectures and exercises which are very important to them. Based on questions to electrochemical aspects the students prove that they know the corresponding technical terms, designations and contents, that they understand the basic relations and are able to apply their knowledge concerning the reactions taking place within the scope of kinetic and thermodynamic connections. For that purpose, concrete computational tasks are assigned.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Participation in the Modules “Allgemeine Chemie” and “Physikalische Chemie”, “Mathematik” und “Physik” or similar courses. In general the student should have a basic knowledge of the reaction kinetics and thermodynamics.

Content:
- Fundamentals of Electrochemistry: Thermodynamics (electrochemical potential, electrode potential, Nernst equation), transport in solution (migration, diffusion, convection), thermodynamics of interface (the electrical double layer), electrochemical kinetics.
- Stationary Electrode Voltammetry (Potential pulse, linear sweep and cyclic voltammetry at macro- and microelectrodes) for determination of thermodynamic and kinetic parameters.
- Mass transport by convection (Rotating disc electrode and rotating ring/disk electrode), thin film methodology, ultra-micro electrodes, flow-cell electrodes.
- Electrochemical Impedance Spectroscopy (general principles, data acquisition and modelling, data analysis and interpretation).
- Implementations of electrochemistry (Renewable energy conversion, green electrosynthesis, Sustainable energy harvesting and storage)

Intended Learning Outcomes:
The students acquire knowledge of advanced concepts of electrochemistry. They master the most important analytical techniques for investigating and evaluating electrochemical systems and know how to control them. In particular, they understand where and when certain measurement techniques are used and what knowledge they gain from them. Based on this, they are able to investigate the same system under different limiting conditions. Furthermore, the students are familiar with the electrochemical processes relevant in industry, such as the conversion of renewable energies, green electrosynthesis and sustainable energy generation and storage, and can apply their theoretical knowledge to these processes. Furthermore, they know concrete application examples from research and industry and how these can be designed and optimised.

Teaching and Learning Methods:
In the lecture the teaching content is imparted by speech of the lecturer using text documents, PowerPoint presentations and blackboard sketches. This enables a way of delivering the teaching content to the students in detail and answering questions as soon as they arise. PowerPoint slides and blackboard sketches create a visual assistance to understand the complex relationships in electrochemistry. Additionally, the students are provided with exercises to consolidate what they have learned in the lecture. The solutions to those exercises are later presented and discussed by the students in a practice lesson.

Media:
Presentations, Moodle course with online tests, exercise sheets, question cataloge, PowerPoint, script

Reading List:
Elektrochemie, Hamann/Vielstich, ISBN: 3527310681
Electrochemical Methods: Fundamentals and Applications; Bard/Faulkner, ISBN-13: 978-0471043720

Responsible for Module:
Plumeré, Nicolas; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Electrochemistry (Übung, 1 SWS)
Plumeré N [L], Moore Y

Advanced Electrochemistry (Vorlesung, 2 SWS)
Plumeré N [L], Plumeré N
For further information in this module, please click campus.tum.de or here.

Module Description

CS0219: Protein-based Materials for Technology | Protein-based Materials for Technology

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The performance test will be in the form of a written examination. The students should demonstrate an understanding of the lecture content and its applications to problems related to proteins-based materials in the exam. No auxiliary means are allowed in the exam. 120 min examination time.

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
This course will intend to consolidate concepts in Physics, Mechanics, Physical Chemistry, Biology, Engineering, and Chemistry having the focus on articles describing protein-based materials and their used in technological platforms. As such, knowledge in Physics, Chemistry, Mechanics, and Biology is required.

Content:
The module aims to provide in-depth knowledge to the students in physical chemistry, spectroscopy, thermodynamic, protein structure, and optoelectronics applied to protein-based materials. The module will study scientific articles that describe protein-based materials. The first focus will be on extracting information about the structure-functionally relationship of proteins and their interaction with other molecules and macromolecules and the different techniques used for that purpose. The second focus will be on studying how protein-based materials can have applications outside the typical biology range.
The course will study at least one scientific article per session to cover protein-based materials with applications in optoelectronics, medicine, and chemistry.
Each topic will be addressed, refreshing the most important physicochemical principles and more useful techniques followed by their relevance in these materials' structural and functional aspects and their application.

Intended Learning Outcomes:
At the end of the module, the students will be able i) to critically evaluate the information in scientific articles relating to novel protein-based materials for technology; ii) to analyze protein-based materials using a physicochemical perspective; iii) to describe the different ways protein interact with other molecules or macromolecules to form functional materials; iv) to describe the main role and characteristics of protein-based materials in technological platforms. They will be able to examine the structure of proteins and other molecules and macromolecules and the forces that define their functionality. They will be able to apply these concepts in bio-based and bio-inspired technologies.

Teaching and Learning Methods:
This course attendance includes lectures and seminars. For this purpose, powerpoint presentations, practical training materials, and open discussion seminars will be used.

Media:
The following forms of media apply: script, powerpoint, films, and blackboard

Reading List:
1. Physical Chemistry for the Biological Sciences, 2nd Edition Gordon G. Hammes, Sharon Hammes-Schiffer, Wiley, 2015, ISBN: 978-1-118-85900-1
2. Physical Chemistry for the Life Sciences, 2ndEdition Peter Atkins and Julio De Paula Oxford University Press ISBN: 978-0-19-956428-6
3. Introduction to Biophotonics Paras N. Prasad Wiley 2003, ISBN: 0-471-28770-9.
4. Introduction to Biomechanics Duane Knudson Springer 2007 ISBN: 978-0-387-49311-4

Responsible for Module:
Costa Riquelme, Rubén Dario; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Protein-based materials for technology (Exercise) (Übung, 2 SWS)
Costa Riquelme R [L], Costa Riquelme R, Atoini Y, Banda Vazquez J

Protein-based materials for technology (Vorlesung, 2 SWS)
Costa Riquelme R [L], Costa Riquelme R, Atoini Y, Banda Vazquez J
For further information in this module, please click campus.tum.de or here.

Module Description

CS0225: Flow Biocatalysis | Flow Biocatalysis [FCB]

Version of module description: Gültig ab winterterm 2022/23

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 75	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning results are proved in form of a presentation and a discussion (30 min per participant, 50 % of grade).A written report to the experiments has to be also submitted). Based on current developments in flow chemistry and enzymatic biotransformation the students must prove their knowledge to the corresponding state of the art and technical terms, their skill to design and conduct enzymatic cascades in flow, and their ability to evaluate obtained results and identify bottlenecks. Students must prove that they have understand the basics of flow biocatalysis and its applications in academia and industry.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Students must have been successfully completed the course “enzymatic biotranformation, CS 0009” in order to be enrolled to this course.

Content:
Principles of flow chemistry (flow reactor design, fluid dynamics, residential time)
Enzyme immobilization techniques (absorption, covalent, ligand interaction)
Introduction to PAT (process analytical technology) in flow biocatalysis
Examples of enzymatic cascades in flow (recent scientific reports and articles)
Principles of flow biocatalysis with whole cells (biofilms)
Flow biocatalysis in industry.

Intended Learning Outcomes:
After visiting the module, students know fundamentals of flow biocatalysis and first-hand experience in enzymatic purification and immobilization. They have deepend their previous knowledge of enzymatic biotransformation by performing a multi-enzymatic cascade in flow to

produce fine chemicals. They understand the interaction between the different parameters of multi-enzymatic cascades; they can determine the bottlenecks of such cascades and find solutions to overcome them. Furthermore, the students gained a border perspective about the different techniques for enzyme purification and immobilization, product extraction and quantification, and calculations of reaction efficiency. Finally, the students learned how to transfer their knowledge towards industrial processes and address the environmental and economic challenges related to them.

Teaching and Learning Methods:
The content of the module is taught theoretically in the seminar (1 SWS). The experimental part of the module will be taught in form of a practical course (2 SWS). In the lecture the content will be conveyed by speech of the lecturer using PowerPoint presentations and Whiteboard sketches. This enables a way of delivering the teaching content to the students in details and answering the arose questions straight-ahead. PowerPoint slides and sketches create a visual assistance to understand the content. Additionally, the students will be provided with the recent published literature on flow biocatalysis to bring their knowledge to edge of the current science. A Part of the literature content will be introduced into the Power point slides to assist students in understanding scientific articles. In the practical course, students will learn how to design and construct a flow reactor for enzymatic cascades. They will learn how to purify enzymes and immobilize those using different techniques. Finally, students will integrate the immobilized enzymes into the flow reactor to perform a multi-enzymatic cascade and will evaluate the final product using analytical methods.

Media:
Presentations, PowerPoint, script

Reading List:
Recent published scientific articles and reviews. It will be provided prior to the course.

Responsible for Module:
Ammar Al-Shameri (a.al-shameri@tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0235: Methods and Applications of Synthetic Biology | Methods and Applications of Synthetic Biology

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Achievement of the desired learning objectives will be verified in a written final exam (90 minutes). In the exam, the students demonstrate that they understand and can explain the methods and applications covered in the module. Students will also demonstrate that they are able to predict the functions of engineered biological systems and that they can analyse results presented in figures from scientific publications.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamental knowledge in molecular biology

Content:
- DNA synthesis and assembly
- Design of dynamic regulatory circuits
- CRISPR/Cas tools and applications
- Cell-free synthetic biology
- Bottom-up assembly of life-like systems
- Biosensor design
- Optogenetics
- High-throughput screening
- Microfluidics
- Applications of synthetic biology tools in sustainable biomanufacturing, health and environment

Intended Learning Outcomes:
After successful participation in the module, students understand important synthetic biology methods such DNA assembly, cell-free prototyping, CRISPR/Cas tools, optogenetics, automation and high-throughput screens. Students will be able to explain applications of synthetic biology in sustainable biomanufacturing, health and environment. They are also able to discuss risks and benefits of these applications and their impacts on the environment and society.
Furthermore, after completing the module, students can analyze the results of synthetic biology experiments in recent scientific publications, and hypothesize on the outcomes of further experiments.

Teaching and Learning Methods:
The contents of the lectures are conveyed by a talk of the lecturer based on slide-supported presentations. The content of the lecture with be supplemented by self-study of recent scientific publications that are provided to the students. The lecture will be supplemented with quizzes and discussions among students to promote critical reflection and active engagement with the contents.

Media:
Slides, scientific publications (provided), online quizzes

Reading List:
The material in the lecture is sufficient for learning and is provided in the lecture.

Responsible for Module:
Niederholtmeyer, Henrike; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Methods and Applications of Synthetic Biology (Vorlesung, 2 SWS)
Niederholtmeyer H [L], Niederholtmeyer H
For further information in this module, please click campus.tum.de or here.

Module Description

CS0236: Recent Topics in Cell-free and Bottom up Synthetic Biology | Recent Topics in Cell-free and Bottom up Synthetic Biology

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning outcomes will be tested by a graded seminar presentation and by active participation in the discussions. In the presentation, the students demonstrate that they are able to understand a scientific publication by extracting its key messages and by presenting its findings and methods in a comprehensible way. In their presentation, they also demonstrate that they can critically evaluate a study.

Repeat Examination:

(Recommended) Prerequisites:
Fundamental knowledge in molecular biology

Content:
The course focuses on recent research in the fields of cell-free and bottom up synthetic biology.
- Cell-free transcription and translation
- Cell-free prototyping to characterize new parts and networks for basic science and applications in sustainable production and health
- Cell-free biomanufacturing
- Cell-free biosensing
- Construction of life-like systems from the bottom up
- Self-replication of biochemical systems
- Synthetic compartments
- Microfluidic methods in cell-free and bottom up synthetic biology

Intended Learning Outcomes:
After successful participation in the module, students are able to explain current methods in cell-free and bottom up synthetic biology. They understand the goals of research in the field and can discuss recent examples from the scientific literature. Furthermore, students will be able to extract key messages from scientific publications and to present them in an engaging manner to their peers. They will be able to logically structure a presentation about a scientific publication, and to judge if its conclusions are supported by the data.

Teaching and Learning Methods:
Students select a recent publication from the field of cell-free and bottom up synthetic biology from a list of topics that is provided. The course begins with a slide-supported presentation by the lecturer to give an overview over the field and to provide instructions to the students. The students prepare a presentation about the selected publication and its methods. Individual meetings will be scheduled to support the students in their preparations. Student presentations take place in the seminar and the presented results will be discussed.

Media:
Slides, scientific publications (provided)

Reading List:
The material provided in the course is sufficient for learning.

Responsible for Module:
Henrike Niederholtmeyer

Courses (Type of course, Weekly hours per semester), Instructor:
Recent topics in cell-free and bottom up synthetic biology (Seminar, 2 SWS)
Niederholtmeyer H [L], Niederholtmeyer H
For further information in this module, please click campus.tum.de or here.

Module Description

CS0237: Project Week: Practical Enzyme Engineering | Project Week: Practical Enzyme Engineering [P-EnzEng]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** irregularly
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The results produced in the practical section will be presented in a written report of a maximum of 15 pages. The students will present the topic with a brief introduction, results section and discussion of the results as well as a brief outlook giving a suggestion of further experiments. The student will prove that they have understood the used methods and the rationale of the experiments and can apply this knowledge to plan further studies.

Repeat Examination:

(Recommended) Prerequisites:
Successful participation in the course “Enzyme engineering” (CS0008 or CS0076)

Content:
The module introduces the students to a real-life scientific project of enzyme engineering using state-of-the-art techniques. This includes advanced library cloning methods as well as medium to ultra-high-throughput screening methods. Two libraries will be cloned with different approaches yielding different numbers of variants, which will subsequently be screened with assistance of a robotic liquid handling station as well as a droplet sorting device.

Intended Learning Outcomes:
The students will gain insight into state-of-the-art enzyme engineering methods. After the course, they should be able to execute basic experiments with the demonstrated methods. They should be able to process, interpret and present data from large screening projects. Finally, they should have acquired the knowledge to choose a method for library generation based on the available possibilities and needs of the engineering project.

Teaching and Learning Methods:
Seminar presentation, active participation in experimental planning, lab-work, demonstration of advanced methods by trained scientists, guided evaluation of screening results

Media:
Seminar presentation, screening result files

Reading List:
course script and related scientific papers

Responsible for Module:
Prof. Volker Sieber

Courses (Type of course, Weekly hours per semester), Instructor:
Practical Enzyme Engineering (Praktikum, 4 SWS)
Sieber V [L], Mayer M, Romeis D, Schulz M, Siebert D
For further information in this module, please click campus.tum.de or here.

Module Description

CS0245: Advanced Electronic Spectroscopy | Advanced Electronic Spectroscopy

Version of module description: Gültig ab summerterm 2022

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The performance test will be in the form of a written examination. The students should demonstrate in the exam the understanding of the different techniques taught during the module.
No auxiliary means are allowed in the exam. 120 min examination time

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
This course will intend to consolidate concepts in Physics, Chemistry, and Instrumentation having the focus on articles utilizing the different techniques. As such, knowledge in Physics, Chemistry, and Instrumentation is required.

Content:
The module aims to provide in-depth knowledge to the students in electronic spectroscopy and its applications.
The module will critically evaluate optical spectroscopy techniques such as fluorescence, Uv-Vis absorption, Circular dichroism, photoacoustic spectroscopy, and circularly polarized luminescence focusing on their fundamental strength and weakness. Every method will be described following three main focuses: theory, material description, and applications.
Application examples will be from literature and journal articles.
The module will also continuously reinforce the theoretical background of the interaction between electromagnetic radiation and matter.

Intended Learning Outcomes:
At the end of the module, the students will have developed the ability to analyze advanced problems in electronic spectroscopy and associated phenomena. They will learn to evaluate

critically information regarding techniques such as fluorescence, Uv-Vis absorption, Circular dichroism, photoacoustic spectroscopy, and circularly polarized luminescence.

Teaching and Learning Methods:
This course attendance includes lectures and exercises. Additionally, in the module's final weeks, the student will be encouraged to create a presentation consisting of their critical analysis of a journal article. For this purpose, PowerPoint presentations, practical training materials, and open discussion seminars will be used.

Media:
The following forms of media apply Script, PowerPoint, films, and blackboards.

Reading List:
1. Physical Chemistry for the Life Sciences, 2ndEdition Peter Atkins and Julio De Paula Oxford University Press ISBN: 978-0-19-956428-6
2. Introduction to Biophotonics Paras N. Prasad Wiley 2003, ISBN: 0-471-28770-9.
3. Principles of fluorescence spectroscopy , Lakowicz, Joseph R., ed. . Springer science & business media, 2013.

Responsible for Module:
Costa Riquelme, Rubén Dario; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0255: Current Topics in Machine Learning and Bioinformatics | Current Topics in Machine Learning and Bioinformatics [CTMLBI]

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning outcomes are tested by a graded seminar presentation with a duration of approximately 45 minutes including a discussion with the audience. The seminar allows the students to assess the extent to which they can summarize a complex scientific work in the field of Machine Learning or Bioinformatics correctly and present it to an audience in a comprehensible and convincing way. Furthermore, to assess the skill to quickly understand, review and critically discuss recent research in these fields, the active participation and discussions of the other seminar presentations will be considered as well.

Repeat Examination:

(Recommended) Prerequisites:
Knowledge in Machine Learning and Bioinformatics (e.g. Bioinformatics (WZ1631) and Artificial Intelligence for Biotechnology (CS0012)) is expected

Content:
At the beginning of this course, introductory lectures about current topics in Machine Learning and Bioinformatics will be given. The following topics are treated exemplarily:
- Ensemble learners
- Neural Networks (Basic concept, Feedforward neural networks, Recurrent Neural Networks, Convolutional Neural Networks, Generative Models)
- Green Artificial Intelligence
- Genome-wide Association Studies
- Phenotype Prediction
- Protein-Protein Interaction Network Analysis
- Protein Prediction

- Data Driven Biotechnology
In this course, we will also talk about recent Machine Learning and Bioinformatics research and how it can support sustainability, e.g., by guiding downstream research with data-driven approaches. Furthermore, we will also look at Green Artificial Intelligence, a research direction that aims to make resource-intense AI development more sustainable. After introductory lectures, each student will analyze a recent scientific paper in these research areas in self-study and present it to the course. Active participation and discussions in all the other presentations is expected.

Intended Learning Outcomes:
After successful participation in this module, students will be able to understand and present recent research in Machine Learning or Bioinformatics. They are enabled to analyze recent scientific publications in one of the two fields. Based on this knowledge, they can summarize and present a scientific paper in a concise and understandable way as well as to discuss recent research in Machine Learning or Bioinformatics. Furthermore, students know about current research directions in these scientific fields and know how current Machine Learning and Bioinformatics research supports sustainability.

Teaching and Learning Methods:
At the beginning of this course, introductory lectures to current Machine Learning and Bioinformatics topics will provide additional and necessary fundamentals to understand recent scientific publications. Furthermore, each student will analyze a recent research paper in one of the two fields in self-study and present it to the course to train the ability to understand advanced concepts. Beyond that, for further training of these skills, the paper presentations will be discussed in the course.

Media:
Slide presentation, blackboard, discussion forums in e-learning platforms

Reading List:
Pattern Recognition and Machine Learning, Christopher M. Bishop
Deep Learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville

Responsible for Module:
Prof. Dr. Dominik Grimm, Florian Haselbeck

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0261: Phytopharmaceuticals and Natural Products | Phytopharmaceuticals and Natural Products [Phytopharm]

Version of module description: Gültig ab summerterm 2022

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Knowledge of the covered topics of phytopharmaceuticals and natural products compounds is assessed in a written examination (90 minutes). In addition, students are required to explain the medicinal effects of medicinal plants in the examination using examples.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Organic and anorganic chemistry, botany

Content:
Content of the lecture:
-definition of medicinal plants and phytopharmaceuticals
-position of phytopharmaceuticals in pharmacology
-compounding (tea drugs, soluble extracts, sCO2 extracts, steam destillation, pure substances)
-effect-determining components and frequent mechanisms (inflammation cascade, infections, coagulation system, neurotransmission, digestive system)
-typical medicinal plants grown in Europe
-international trade in medicinal plants
-important classes of compounds (terpenes, steroids, coumarine, alcaloids, vitamins, saccharides)
-quality determination and typical methods (chromatography)
-falsification and chemotype (chemical race)
-drug regulator affairs (authorisation, documents)
-use of medicinal plants in practice

Intended Learning Outcomes:
After their participation, students can explain the production of phytopharmaceuticals derived from typical medicinal plants (from collection to quality control). They can relate chemical compounds and medical effects of typical examples.

Teaching and Learning Methods:
The lecture takes the form of oral presentation given by teaching staff with the help of PowerPoint media, books and other written material.

Media:
PowerPoint presentation and printed handout. Laboratory equipment for experiments.

Reading List:
Deutschmann, F., Hohmann, B., Sprecher, E., Stahl, E., Pharmazeutische Biologie, 3 Bde., G. Fischer Verlag, 1992

Responsible for Module:
Riepl, Herbert; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0262: Literature Seminar: Redox Enzymes in Electrobiotechnology | Literature Seminar: Redox Enzymes in Electrobiotechnology [Literature Seminar: EBT]

Version of module description: Gültig ab summerterm 2022

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The competence to conduct a literature search with digital methods, analysis of the state of the art and frame a subject specific question is to be demonstrated in the form of a presentation. For this purpose, groups of two are formed, whereby each of these groups is given a branch in the field of bioelectrochemistry. With the help of current literature, they should evaluate the state of the art and how to further develop this field by designing a novel research project. The results are presented and defended in a 20-minute oral presentation at the end of the term.

Repeat Examination:

(Recommended) Prerequisites:
Successful participation in the module "Einführung in die Elektrochemie" or “Advanced Electrochemistry” or consolidated knowledge in the field of electrochemistry and successful participation in the module “Enzyme und ihre Reaktionen” or “Enzymatic Biotransformations”.

Content:
This course focuses on the field of enzymes useful in electrobiotechnology and biophotoelectrochemistry. In particular, the structured analysis of publications found and an efficient evaluation according to their usefulness for one's own research question will be discusses. Additionally, the course will cover,
- detailed and critical examination of published results and the pitfalls of common measurement techniques.
- the submission and reviewing processes including templates/platforms for authors and for reviewers.

- review and presentation of various recent scientific discoveries in the field of bio(photo)electrochemistry.
- examples of current research projects including research proposals.
- development of novel projects and how to find a good working hypothesis.
- the process of turning the working hypothesis into a research proposal.

Intended Learning Outcomes:
After successful participation in this module, students will be able to:
- understand and analyse the structure of a scientific publication in the topic of redox enzymes in electrobiotechnology and biophotoelectrochemistry.
- critically assess the issues in the conculsion due to the methods used to investigate a given system.
- classify the literature found according to its quality and its usefulness for their own research question.
- evaluate the state of the art of redox enzymes used in electrobiotechnological and biophotoelectrochemical applications.
- based on the literature develop a research project with a novel working hypothesis.

Teaching and Learning Methods:
In this seminar, the students are supposed to analyse and evaluate given publications in the first weeks. In the seminar the findings are debated with a special focus on the issues and pitfalls due to the used measurement methods. The objective is to teach how the same measurement results can lead to different conclusions especially if not all features of a measurement method are considered. Supplementary presentations about submission processes and research proposals should teach how to develop and secure funding for a new research project.

Media:
Presentations, case studies, discussion rounds, Moodle course with discussion forum.

Reading List:

Responsible for Module:
Prof. Dr. Nicolas Plumeré Dr. Martin Winkler Dr. Vincent Friebe

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0264: Polymer Processing | Polymer Processing [PolyProc]

Processing of polymers intro plastic parts

Version of module description: Gültig ab summerterm 2024

Module Level: Master	Language: English	Duration: one semester	Frequency: winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The content and learning objectives of the lecture are examined at the end of the semester in a written test (90 min). An oral pre-test containing safety relevant laboratory work issues must be carried out before the individual pratical course. A written report on the practical course consisting of approximately five pages must be submitted. The written report is an ungraded student achievement.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Polymer chemistry, polymer physics, rheology fluid mechanics, Biogenic Polymers

Content:
The lecture deals with unit operations, basic techniques and processes of plastic material processing, e.g. compounding, extrusion, injection molding, plastic part forming processes and also typical applications. In addition, methods for characterizing thermal and mechanical properties are presented. One focus here is the connection between the processing parameters and the end-use properties. The acquired knowledge is deepened in the accompanying practical course. Injection molding and extrusion tests are carried out and the test specimens are then characterized with regard to their thermal, optical and mechanical properties. Additional foci will be laid on the chemistry, structure and classification of polymers and plastic parts. The lecture also deals with the physical properties of polymers and plastic materials involving materials science. Characterization of the mechanical and thermal properties and their effects on processing, viscosity, viscoelastic behavio will be discussed

Intended Learning Outcomes:
In addition to the chemical-physical basics of polymeric materials, this module imparts the methodical knowledge about classic and modern innovative processing methods of polymeric materials. The students are able to sensibly classify plastic materials, their manufacture and use them for specific applications. The basics for the production technology of plastic materials are acquired. After successfully completing the module, students are able to select and use methods for processing plastic. They will be able to assess sustainability aspects of the polymer production process in terms energy consumption and materials use. Through practical work, the competence for the meaningful use of testing and characterization methods of polymer materials is acquired.

Teaching and Learning Methods:
Lecture (lecture by teaching staff with Power Point slide media, books and other written material), laboratory practical course (experimentation of the students under supervision)

Media:
Power Point slide presentations; Drawing and writing on a black board; Laboratory equipment for experimentation

Reading List:
Polymer Engineering; Technologien und Praxis; Peter Eyerer, Peter Elsner, Thomas Hirth
Polymer Extrusion; Chris Rauwendaal
Extrusion: The Definitive Processing Guide and Handbook; Harold F. Giles, Jr.
Einführung in die Kunsstoffverarbeitung; Michaeli, W.
Werkstoffkunde der Kunststoffe; Menges, G.

Responsible for Module:
Zollfrank, Cordt; Prof. Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Polymer Processing (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Helberg J

Polymer Processing (Practical) (Praktikum, 1 SWS)
Zollfrank C [L], Helberg J
For further information in this module, please click campus.tum.de or here.

Module Description

CS0265: Biorefinery | Biorefinery [BioRaff]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** German/English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students answer questions in a written examination (60 minutes) that will be graded. They thereby show that they have understood, can explain and are able to assess the various steps and processes involved in biorefinery. In an additional voluntary coursework (Mid-term), which is not part of the written exam, students individually study selected topics in the field. Here, they apply their knowledge acquired in lectures to deduce and/or evaluate processing methods. Findings are presented in a "research paper" and a short presentation (5 min). Bonus points (up 10/60 depending on the quality) will be awarded for the coursework on the written exam.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in chemistry and biology; Module "Renewables Utilization"

Content:
Contents of the module include:
comparison of biorefinery and mineral oil refinery; role of biorefineries for the development of a sustainable biobased economy; presentation and analysis of different biorefinery systems (e.g. green biorefinery, lignocellulose biorefinery);
selected procedures for the extraction of resources (focused on lignocellulose);
selected biogenic compounds for further processing (e.g. saccharides, lipids/oils, lignin);
selected pathways of their use (e.g. bioalcohols, polylactic acid, proteins, succinate and other components);
cascade use of materials and energy.

Intended Learning Outcomes:
After completion of the course, students will have understood the concept of biorefinery, analogous to and in contrast with mineral oil refinery. Students are able to describe various biorefinery concepts and methods for processing renewable resources in biorefineries. The understand the importance of biorefineries for a future sustainable biobased economy. They are able to apply their knowledge to the analysis and assessment of viable biorefinery systems, taking into account their respective advantages and disadvantages. In addition, they have trained their competences in literature research and critical evaluation as well as in the preparation of "research papers".

Teaching and Learning Methods:
Lecture: talks given by teaching staff; Exercise: more detailed studies on selected topics; students individually prepare one topic and finally present their results ("research paper").

Media:
PowerPoint presentation, blackboard

Reading List:
B. Kamm, P. R. Gruber, M. Kamm (Hrsg.), Biorefineries - Industrial Processes and Products, Vol. 1-2, Wiley-VCH, Weinheim, Germany, 2006

Responsible for Module:
Schieder, Doris; Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Biorefinery (Seminar) (Seminar, 1 SWS)
Schieder D

Biorefinery (Lecture) (Vorlesung, 2 SWS)
Schieder D
For further information in this module, please click campus.tum.de or here.

Module Description

CS0266: Sustainable Chemistry | Sustainable Chemistry

Version of module description: Gültig ab summerterm 2024

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination will take the form of a written test (60 minutes). In this examination the competence for the evaluation of chemical processes and for the derivation of optimization strategies shall be proven. No aids are permitted in the written examination. In order to additionally check whether the students are able to communicate scientific topics in front of an audience and whether they are able to critically deal with problems in individual steps, the results of the processing of the case studies are presented in the form of a 20-minute presentation alone or in a group. This presentation is ungraded study achievement.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successful participation in the module "Basics in chemistry" or comparable knowledge in chemistry.

Content:
The module teaches basic principles of sustainable chemistry. Focus is set on the evaluation of chemical processes in view of efficiency, atom economy and amount of waste. In addition, optimizsation strategies related to catalytical methods, raw material and energy efficiency are discussed. Students individually prepare current topics related to sustainable chemistry and present them in the seminar.

Intended Learning Outcomes:
By attending the module events, students are able to highlight the principles of sustainable chemistry. Students can analyze the efficiency and waste quantities of chemical reactions and evaluate various alternative processes. Furthermore, they are able to discuss further chemical aspects of the conversion of renewable raw materials into valuable products. Through the

independent development of case studies, the students master all the steps that are important in the critical examination of problems (consideration of the example, development of criteria for evaluation, assessment, presentation of the results to an audience).

Teaching and Learning Methods:
Lecture with board addresses and presentations: Basic development and derivation of technical contents; seminar with written tasks. Consolidation of the technical learning contents through learning activity of the students themselves, e.g. through independent development of case studies from the field of sustainable chemistry.

Media:
Presentation, script, examples

Reading List:
Stanley E. Manahan: Green Chemistry, ISBN: 0-9749522-4-9

Responsible for Module:
Zollfrank, Cordt; Prof. Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Sustainable Chemistry (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Helberg J, Zollfrank C
For further information in this module, please click campus.tum.de or here.

Module Description

CS0267: Biological Materials | Biological Materials

Version of module description: Gültig ab winterterm 2023/24

Module Level: Bachelor/Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 60	**Contact Hours:** 90

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Understanding of the course contents and their application will be tested in a written exam of 90 minutes duration. In detail, the students are required to describe the physical and chemical foundations of the formation, as well as relations between the hierarchical structure and properties, of typical biological materials. Further, the transfer of this knowledge to technological applications and to the design of novel biologically inspired materials, as covered in the course, is a test subject. Lecture notes are not permitted.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in geometry and chemistry

Content:
The module Biological Materials in Nature and Technology covers important biological functional materials, based on basic materials scientific knowledge. This encompasses such materials that fulfill, in their biological system, or in a technological application, either in native state, or modified, one or more specific functions. Differences and similarities to classical engineering materials are pointed out. In addition to the modules Bioinspired Materials and Instrumental Analysis, the students learn important methods for structural and property analysis. After a presentation of the classification of biological materials, students- are taught the basic correlations between hierarchical structuring and macroscopic properties. As the most important complex, the influence of hierarchical structuring on the mechanical properties of materials will be discussed. The students learn, which modes of failure can occur in biological systems and how they are influenced. In this context, modification routes for biological materials are shown and discussed.

Intended Learning Outcomes:
After successful completion of the module, the students are enabled to name criteria for a proper usage of biological materials. They can name specialized methods for the analysis of hierarchical structures and the derived material properties and explain the correlations between structure and external properties. Further, they are able to describe tailored modification routes for biological materials.

Teaching and Learning Methods:
Lecture with discussion and case studies

Media:
Presentation, slides

Reading List:
Structural Biological Materials: Design and Structure-Property Relationships. Eds Elices M, Pergamon-Elsevier Science Ltd, Oxford, (2000).
Fratzl P & Harrington MJ. Introduction to Biological Materials Science. Wiley VCH, Weinheim, Germany, (2015).

Responsible for Module:
Van Opdenbosch, Daniel; Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0268: Applied Process Engineering | Applied Process Engineering [APE]

Applied process engineering

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination is performed in the form of a written examination (60 minutes). The students prove that they can solve arithmetic problems and apply methods of cost estimation and economic feasibility studies of process engineering processes as well as answer questions about optimization and cost reduction in writing.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Apparatus and plant construction, bioprocess engineering, chemical reaction technology, thermal process engineering

Content:
The module teaches the basics that are necessary for estimating costs and assessing the profitability and sustainability of a production process. Various methods of cost estimation are taught, as well as their suitability and accuracy in different project phases. The contents are in particular the following:

- Project/design phases (proof of principle, process development in the laboratory, piloting, demonstration, concept study, basic engineering, detail engineering, construction, commissioning, production, debottlenecking)
- Cost estimation (methods, including the Monte Carlo method, accuracy, process variants, sensitivity analyses, tornado plots)
- Assessment of Sustainability

- Investment versus CMO production
- Site selection and plant size
- permits
- Time plans
- Selected examples from industry
- (Operational) optimization and Lean Six Sigma tools
- Business Case Evaluation (Payback, Discounted Cash Flow, Net Present Value, Sales at Maturity)

Intended Learning Outcomes:
After participating in the module, the students are able to estimate operating and investment costs in the respective design phases for a production plant and to reduce production costs during the operation of a plant.

Teaching and Learning Methods:
In the lecture, the essential basics are presented and worked out. The content learned is applied to concrete practical questions in the exercise. Special software for cost estimation is learned in a computer exercise and sample calculations are carried out. Individual topics are worked on and presented in groups. After participating in the module, the students are able to apply the basics of cost estimation and to evaluate the profitability and sustainability in different project phases.

Media:
Presentations, interactive quizzes, case descriptions, computer exercises with software

Reading List:
Peters, M. S., Timmerhaus, K. D., West, R. E., 2003. Plant Design and Economics for Chemical Engineers. McGraw-Hill Education. ISBN 9780072392661

Vasudevan, P. T., Ulrich, G. D., 2004. Chemical Engineering Process Design and Economics: A Practical Guide. United States: Process Pub.. ISBN 9780970876829

Penney, W. R., Couper, J. R., Fair, PhD, J. R., 2012. Chemical Process Equipment: Selection and Design. Netherlands: Elsevier Science. ISBN 9780123969590

Towler, G., Sinnott R., 2021. Chemical Engineering Design - Principles, Practice and Economics of Plant and Process Design. Elsevier. ISBN 9780128211793

Chmiel, H. Bioprozesstechnik. (2011). Germany: Spektrum Akademischer Verlag. ISBN 9783827424761

Responsible for Module:
Zavrel, Michael; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0273: Electrochemical Modelling | Electrochemical Modelling [ECM]

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning results are demonstrated in form of a project. The students pick a topic of their interest in electrochemical modelling from a prepared selection. The students present this topic to their peers in the form of an 20 minute long oral presentation (+10 min discussion). In explaining their chosen topic, the students should utilize one or more of the methods learned in this course. After four weeks the student's work is present and evaluated. The student is graded based on his/her progress and approach presented in the oral summary.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
The student should know general chemistry, physics, and mathematics. Furthermore, a good knowledge of physical chemistry and electrochemistry is necessary. A basic knowledge of computer programming i.e., MATLAB is preferable.

Content:
- Physical models: continuum approximation, conservation laws, constitutive relationships, boundary conditions and the current distribution, microscopic models of electrode kinetics.
- Formulation and approximation: scaling and dimensional analysis, dimensionless groups.
- Steady-state systems: modelling voltammetry under steady reaction-diffusion, methods for solving linear systems, approximate/asymptotic methods for non-linear reaction kinetics.
- Transient systems: modelling transient potential step chronoamperometry and cyclic voltammetry with and without reactions.
- Numerical methods: approximations for first and second derivatives, explicit and implicit methods.

Intended Learning Outcomes:
The students understand the basic concepts of modelling electrochemical systems, focusing on a breadth of analytical and numerical methods applicable to solving a wide range of different systems. Furthermore, they are able to identify key processes and boundary conditions and translate these into mathematical expressions. Thus, they can systematically implement simplifications to model complex electrochemical phenomena. Importantly, they can formulate a problem and find an approximate solution using scaling, dimensionless groups, and dimensionality reduction. In particular, they can analyse and distinguish between various electrochemical methods and know how to model these. Overall, they succeed in planning and constructing their own mathematical models, which they can solve either analytically or numerically to find the current response, while reviewing and evaluating their assumptions for deriving the governing mathematical equations.

Teaching and Learning Methods:
The teaching content is presented with lectures, text documents, PowerPoint presentations, and blackboard sketches. This enables a way of delivering the teaching content to the students in detail and answering questions as soon as they arise. PowerPoint slides and blackboard sketches add visual assistance to understand the complex relationships in electrochemistry and how to express these relationships in terms of mathematical equations. Additionally, the students are provided with exercises to consolidate what they have learned in the lecture with hands-on modelling examples and reviewing the mathematical tools necessary to solve the equations. The exercises and solution are discussed and explained in the practical lessons.

Media:
Presentations, PDF-script, case studies and algorithms for models in MATLAB.

Reading List:
R. G Compton, E.Laborda, K. R. Ward, Understanding Voltammetry: Simulation of Electrode Processes.
J. M. Savéant, C. Costentin, Elements of Molecular and Biomolecular Electrochemistry.
A. J. Bard, L. R. Faulkner Electrochemical Methods: Fundamentals and ApplicationsElectrochemical Methods: Fundamentals and Applications.

Responsible for Module:
Plumeré, Nicolas; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Electrochemical Modelling (Vorlesung, 2 SWS)
Johnson III B [L], Höfer T, Johnson III B

Electrochemical Modelling (Übung, 2 SWS)
Johnson III B [L], Johnson III B
For further information in this module, please click campus.tum.de or here.

Module Description

CS0305: Research Excursion Master | Research Excursion Master

Version of module description: Gültig ab summerterm 2024

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** irregularly
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Passed/not passed:
The module is passed when the students deliver a learning portfolio consisting of the following elements::
1. 2 written pages or 20' presentation on preparatory work for the excursion. The form and the due date will be specified in the kick-off session.
2. At least two topical contributions to the excursion (topical input, interviews, questions on presentations and during site visits, discussion contributions;
3. 5-10 PPT slides reflecting the findings based on a case study visited during the excursion. The due date will be specified in the kick-off session;
4. Final report of case studies and results of the workshop;

All four elements of the learning portfolio have to be delivered to pass the module.

Repeat Examination:

(Recommended) Prerequisites:
Prerequisites may be defined by the professors / lecturers offering the excursion, dependent on the chosen destination / topic. They will be announced with the announcement of the excursion 1 month before the start of lectures in the semester in which the excursion is offered, at the latest.

Content:
The research excursion deals with individual topics from modules and / or the study programs for which it is designed. On an individual basis, professors and lecturerers from these modules / study programs offer the research excursion to a topic or place of their choice.

A bullet point list with typically 10-12 entries will be provided by the professors and lecturers with the announcement of the research excursion 1 month before the start of lectures in the semester in which the excursion is offered, at the latest.

After the excursion the results of the applied methodologies are presented and discussed in a workshop. Key findings and the results of the workshop are included in a final excursion report by the students.

Intended Learning Outcomes:
The excursion aims to support the scientific profile building of students and the acquisition of scientific, practical and social competencies and the application to case studies visited during the excursion. It supports the competence acquisition in other modules and / or the study programs in general. The students get practical insights into the topical field of the research excursion, deepen their comptencies in this field regarding ongoing research and apply their competencies to real case studies in practice.

In particular, the intended learning outcomes are the following:
- Select relevant scientific and practical information and recall it for for visits of organizations, cities and talks with experts and stakeholders,
- Prepare questions regarding the state-of-knowledge, open research questions and practical relevance and discuss these with fellow students,
- Discuss research and practical knowledge with stakeholders,
- Recognize the implementation of research and practical knowledge in the organisations / sites visited,
- Reflect on the state of implementation of theoretical knowledge in practice,
- Discuss with fellow students and supervisors gained insights and compare it with their expectations,
- Perform structured interviews and talks with experts and stakeholders in practice
- Apply methodologies from theoretical lectures and exercises on practical organizations

Teaching and Learning Methods:
The research excursion consists typically of the following elements (teaching, learning and application of methods):
- Kick-off session: To achieve a good get-to-know, brief the students about the module contents, course and required performance an interactive in-presence workshop will be carried out. This covers presentations, and interactive elements such as role games etc.
- Individual work and feedback: In order to prepare for the on-site visits the students carry out own literature research on the excursion topics. To document their learning progress and to be able to share the results they summarize their findings in written form. A presentation of the contents in front of the fellow students is an optional element. In this process, they are supervised, receive materials and continuous feedback.
- On-site visits: 3-5 day research trip with site-visits, presentations, discussions with stakeholders, interviews of experts etc. This part will be specified in the specific program of the research

excursion and can due to the variety of possible destinations and topics not be specified further at this point.
- Individual work: the students will reflect their learnings in written form,
- Workshop: the students will present and discuss their findings in a workshop to gain practical experience for their future working conditions and formulate a final excursion report.

Media:
Digital projector, board, flipchart, online contents, recent scientific journal publications, equipment and utilities demonstrating production processes in practice

Reading List:
Topic related reading, especially articles in international peer reviewed journals, will be provided during the course of the module.

Responsible for Module:
Prof. Cordt Zollfrank Prof. Hubert Röder Prof. Magnus Fröhling

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0316: Bioprocess Scale-Up | Bioprocess Scale-Up [BSU]

Bioprocess Scale-up

Version of module description: Gültig ab winterterm 2024/25

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning content is checked by means of a written examination on the learning outcomes of the module. The written examination lasts 60 minutes. Using questions on terms and methods of scaling up bioprocesses, the students show that they know the relevant technical terms, names and content, that they have understood the basic relationships and can apply their knowledge. Using calculations, the students also show that they can calculate the scale up.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Bioprocess Engineering
Conceptual Design of Bioprocesses

Content:
Biopharmaceuticals, enzymes, biological cell materials or food supplements are all derived from the cultivation of bacteria, yeasts, fungi, plant or animal cells in bioreactors. Regardless of what kind of bioprocess is used for, efficiencies of time and cost and other resources are major factors to consider. These bioprocesses are usually developed at small laboratory scale. Later, the established processes are stepwise transferred to larger volumes until the commercial industrial production-scale is reached. This procedure is known as scale-up.
To reach this goal different scale-up strategies can be applied. The objective of this course is to provide the students with the necessary and fundamental insight involved in scaling-up biotechnological processes from laboratory-scale to industrial-scale. Important methods, concepts, and tools are introduced which lay the basis for scaling up of biochemical processes. First, introduction into scaling laws will be given, followed by the introduction into general scale-up methods. Afterwards needs and challenges of scaling up bioprocesses will be discussed and

various strategies introduced. Finally, emerging trends and challenges will be discussed. Through a combination of theoretical concepts, practical examples, and real-world case studies, this lecture aims to enable participant to develop suitable scale-up strategies in future.
By the end of this lecture, participants will be equipped with the knowledge and insights necessary to navigate the challenges and seize the opportunities presented in the field of bioprocess scale-up.

Intended Learning Outcomes:
Upon completion of the course, the students are able to:
- Know fundamentals of scaling-laws
- Know fundamentals of scale-up strategies
- Have necessary knowledge and tool-sets for scaling-up bioprocesses
- Be aware of potential pitfalls during scale-up
- Know best practices for scale-up

Teaching and Learning Methods:
The lecture is mainly conducted as frontal teaching in order to familiarize the students with all the necessary basics that they need for the scale-up of sustainable processes in the field of biotechnology. Calculation exercises are included into the lecture.

Media:
Slides, interactive quiz, films, script, exercises

Reading List:
Marko Zlokarnik, Dimensional Analysis and Scale-up in Chemical Engineering, https://doi.org/10.1007/978-3-642-76673-2

Responsible for Module:
Zavrel, Michael; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Bioprocess Scale-Up (Vorlesung mit integrierten Übungen, 2 SWS)
Zavrel M [L], Zavrel M
For further information in this module, please click campus.tum.de or here.

Module Description

IN2346: Introduction to Deep Learning | Introduction to Deep Learning

Version of module description: Gültig ab summerterm 2018

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 120	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
- Written test of 90 minutes at the end of the course.
- After each practical session, the students will have to provide the written working code to the teaching assistant for evaluation. The students will be awarded a bonus in case they successfully complete all practical assignments.

The exam takes the form of a written test. Questions allow to assess acquaintance with the basic concepts and algorithms of deep learning concepts, in particular how to train neural networks. Students demonstrate the ability to design, train, and optimize neural network architectures, and how to apply the learning frameworks to real-world problems (e.g., in computer vision). An important aspect for the student is to understand the basic theory behind the training process, which is mainly coupled with optimization strategies involving backprop and SGD. Students can use networks in order to solve classification and regression tasks (partly motivated by visual data).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Programming knowledge is expected. At least one programming language should be known, preferably Python.

MA0902 Analysis for Informatics
MA0901 Linear Algebra for Informatics

Content:
- Introduction to the history of Deep Learning and its applications.
- Machine learning basics 1: linear classification, maximum likelihood
- Machine learning basics 2: logistic regression, perceptron

- Introduction to neural networks and their optimization
- Stochastic Gradient Descent (SGD) and Back-propagation
- Training Neural Networks Part 1:
regularization, activation functions, weight initialization, gradient flow, batch normalization, hyperparameter optimization
- Training Neural Networks Part 2: parameter updates, ensembles, dropout
- Convolutional Neural Networks, ConvLayers, Pooling, etc.
- Applications of CNNs: e.g., object detection (from MNIST to ImageNet), visualizing CNN (DeepDream)
- Overview and introduction to Recurrent networks and LSTMs
- Recent developments in deep learning in the community
- Overview of research and introduction to advanced deep learning lectures.

Intended Learning Outcomes:
Upon completion of this module, students will have acquired theoretical concepts behind neural networks, and in particular Convolutional Neural Networks, as well as experience on solving practical real-world problems with deep learning. They will be able to solve tasks such as digit recognition or image classification.

Teaching and Learning Methods:
The lectures will provide extensive theoretical aspects of neural networks and in particular deep learning architectures; e.g., used in the field of Computer Vision.
The practical sessions will be key, students shall get familiar with Deep Learning through hours of training and testing. They will get familiar with frameworks like PyTorch, so that by the end of the course they are capable of solving practical real-world problems with Deep Learning.

Media:
Projector, blackboard, PC

Reading List:
- Slides given during the course
- www.deeplearningbook.org

Responsible for Module:
Nießner, Matthias; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Introduction to Deep Learning (IN2346) (Vorlesung mit integrierten Übungen, 4 SWS)
Cremers D [L], Cremers D, Gladkova M (Chui P), Hofherr F (Qian S, Xia Y)
For further information in this module, please click campus.tum.de or here.

Module Description

MW1141: Modelling of Cellular Systems | Modellierung zellulärer Systeme

Version of module description: Gültig ab summerterm 2022

Module Level: Master	Language: German/English	Duration: one semester	Frequency: summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird in Form einer Klausur erbracht. Sie besteht aus Kurzfragen und Rechenaufgaben. Es wird geprüft in wieweit die Studierenden die grundlegenden Konzepte der mathematischen Modellierung und Modellanalyse bei zellulären (biologischen) Systemen verstehen und anwenden können. Es ist eine schriftliche Klausur mit einer Prüfungsdauer von 90 Minuten vorgesehen. Die Klausur wird in jedem Semester angeboten (im WS zeitnah am Beginn). Es sind keine Hilfsmittel zugelassen. Durch eine Studienleistung in Form einer Projektarbeit oder Präsentation kann die Modulnote um 0,3 verbessert werden (APSO, §6(5)).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Voraussetzungen für die erfolgreiche Teilnahme sind mathematische Kenntnisse, wie sie in Bachelorstudiengängen an wissenschaftlichen Hochschulen vermittelt werden.

Content:
Das Modul soll die Grundlagen der mathematischen Modellierung, der Analyse und der Simulation von zellulären Systemen vermitteln und vertiefen. Zu den wichtigen Prozessen gehören die Enzym-katalysierten Reaktionen, die Polymerisation von Makromolekülen und die zelluläre Signalübertragung.
Wesentliche Inhalte sind:
- Graphentheoretische Analysen,
- Aufstellen von Bilanzgleichungen für konzentrierte und verteilte Systeme,
- Analyse stöchiometrischer Netzwerke,
- Thermodynamik zellulärer Prozesse,
- Reaktionskinetiken (Enzyme, Polymerisationsprozesse, Signalübertragung),

- Stochastische Systeme

Intended Learning Outcomes:
Nach der Teilnahme an diesem Modul sind die Studierenden mit den biologischen und theoretischen Grundlagen von zellulären Systemen vertraut und in der Lage, Bilanzgleichungen für komplexe zelluläre Netzwerke zu erstellen und zu analysieren. Anhand der Modelle sind die Studierenden in der Lage das Verhalten der Netzwerke durch Simulation vorherzusagen und den gesamten biotechnologischen Prozesses zu bewerten (zeitliches Verhalten, Produktausbeuten).

Teaching and Learning Methods:
In der Vorlesung werden mathematische Ableitungen und Zusammenhänge an der Tafel mit Hilfe von Powerpoint-Präsentationen aufgezeigt. Wesentliche Aspekte werden dann wiederholt aufgegriffen und in den Übungen vertieft. Die Übungen sollen zum Teil am Rechner/Laptop durchgeführt werden, um komplexere Aufgaben, wie mathematische Modellierungen und/oder Simulationen bearbeiten zu können. Die Lösungsstrategien werden dann gemeinsam mit den Studenten besprochen, um ein vertieftes Verständnis von zellulären Systemen zu entwickeln.

Media:
Die in der Vorlesung verwendeten Folien werden den Studierenden in geeigneter Form zugänglich gemacht. Übungsaufgaben werden rechtzeitig verteilt und die Musterlösungen mit den Studierenden diskutiert.

Reading List:
Zur Verfügung stehen englischsprachige Lehrbücher, die Teilaspekte des genannten Stoffes abbilden. Zu nennen sind: Nielsen, Villadsen, Lieden: Bioreaction Engieneering Principles (Kluwer Academic Press, 2003), B. O. Palsson: Systems Biology: Properties of Reconstructed Networks (Cambridge University Press, 2006), Kremling: Systems Biology (CRC Press).

Responsible for Module:
Kremling, Andreas; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

MW1969: Desalination | Desalination [Desal]

Version of module description: Gültig ab summerterm 2013

Module Level: Bachelor/Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The theoretical knowlegde gained in the lecture is to be practically applied in exercise lessons by means of case studies. The exercises course also includes a laboratory course in which students carry out experiments with lab-scale desalination plants.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Physics, Thermodynamics and Heat and Mass Transfer.

Content:
Potable water is one of the most valuable ressources we have on our earth. The "blue gold" is essential for any life. Potable water ressources are limited and water scarcity is a big challenge in many parts of the world already today and will become even more urgent in the future.
Water desalination is one of the main technological answers to this challenge. Today, 80 Million Cubicmeter per day of Desalination Capacity is installed worldwide, showing exponential growth. This lecture wants to provide students with both basic theoretical and practical tools to be able to cope with engineering solutions to overcome the future lack of potable water. The focus will be on the thermodynamic and chemical properties of seawater, the wide range of different desalination technologies with a major on distillation and membrane processes, renewable energy and transient power supply in desalination, large and small scale applications and finally also on desalination-driven environmental aspects.

Intended Learning Outcomes:
Having successfully passed the Desalination lecture the young engineers are able to understand, design and optimize desalination plants on their own. Furthermore they are sensitized for future technological challenges in desalination e.g. transient power supply for membrane processes.

A deep understanding of the advantages and disadvantages of different desalination priciples empower them not only to make viable decisions during plant design and construction but also to use their knowlegde to further develop existing ideas. The students are prepared for solving engineering problems about potable water issues with a strong focus on desalination.

Teaching and Learning Methods:
In the lecture, the subject matter is explained in an oral presentation. The exercises include both presentation and experimental investigations of the students themselves. The excerises put the main focus on deepening the understanding of the therotical aspects taught in the lecture. Difficulties will be explained in detail and problems of understanding will be solved. The exercises are not obligatory but highly recommended also in view of the exam.

Media:
Oral presentations, Tablet-PC support, lab-scale desalination plants (solar stills) in laboratory courses, excercises as preperation for the final exam.

Reading List:
Lecture notes and transkript incl. references.

Responsible for Module:
Wen, Dongsheng; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Tutorial Desalination (Übung, 1 SWS)
Wen D [L], Ma X (Albrecht N)

Desalination (Vorlesung, 2 SWS)
Wen D [L], Ma X (Albrecht N)
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1174: Molecular Biology of Biotechnologically Relevant Fungi | Molekulare Biologie Biotechnologisch Relevanter Pilze

Version of module description: Gültig ab winterterm 2022/23

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination takes the form of a written exam (60 minutes) and a presentation (60 minutes; pass/fail credit requirement).
Regular, active participation in the courses is expected. A written exam (60 min, graded) serves to test the theoretical skills learned in lectures and seminars. In the written exam, the students show whether they are able to structure the knowledge they have acquired and present the essential aspects of the topics discussed. In addition, they should also show that they are able to combine the interrelationships of the molecular biology of fungi in a meaningful way and transfer them to similar topics (e.g. a current but not discussed topic of fungal biotechnology). The presentation (in English) with subsequent discussion is designed to teach independent scientific research and to demonstrate the ability to present complicated scientific relationships in a structured and logical way. The module grade is determined by the grade of the written examination. The module is passed if a grade better than 4.1 is achieved and the course work (lecture) is successfully completed.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
For better understanding, basic knowledge of microbiology is advantageous.

Content:
The course is to teach basic knowledge about the diversity and physiology of fungi, and in addition covers more in-depth information on fungal biotechnological applicabilities. A focus will be the unique capability of fungi to degrade and convert plant biomass. Exemplary contents that will be discussed are: gene technology (bio-engineering), plant cell walls as substrate and their

degradation, signaling pathways of substrate perception, biotechnological applications of enzyme and small-molecule production, as well as application of fungi in the agricultural industry.
In the practical/seminar part of the course, selected topics will be discussed in more detail by student presentations and with the help of practical examples. In addition, an excursion to the Clariant Sunliquid demonstration plant in Straubing is planned, where bioethanol is being produced from fungal conversion of biomass.

Intended Learning Outcomes:
After successful participation in the module, the students will have advanced knowledge of the biotechnological applications of fungi for the production and development of natural and artificial biocompounds.
They will be able to:
• recapitulate the fungal metabolic capabilities
• comprehend and name the fundamental signaling pathways for metabolic adaptation
• using selected examples, classify the respective enzyme systems and their functions in anabolic/catabolic reactions
• understand the molecular techniques for genome manipulation and strain development and discuss them
• critically assess the pros and cons of the presented production systems.
Moreover, the module is intended to help develop problem-solving skills as well as to foster the interest for eukaryotic microbiology, it's advantages and disadvantages, and the importance particularly of filamentous fungi for environment and industry.

Teaching and Learning Methods:
Teaching technique: Lecture - teaching method: presentation; development of general concepts on the chalkboard
In the demonstration: teaching method: talk, demonstration; learning activity: research of relevant literature, prepare and give a talk, contructive discussion of the contents

Media:
PowerPoint presentation; chalkboard work; original research papers; lab demonstrations

Reading List:
Unfortunately no text book is available that covers all the contents of the course, but the following sources are good for basics and as additional reading:
- Money, Nick, 2007, “Triumph of the Fungi: A Rotten History”, Oxford Univ. Press
- Hudler, G.W., 1998, “Magical mushrooms, mischievous molds”, Princeton University Press
- Kendrick, Bryce, 2000, “The Fifth Kingdom”, 3rd ed., Focus Pub/R Pullins Co
- Kavanagh, Kevin, 2011, „Fungi – Biology and Applications”, Wiley-VCH
- Arora, D.K., 2004, “Fungal Biotechnology in Agricultural, Food, and Environmental Applications – Mycology Series; Vol. 21”, Marcel Dekker, Inc.
- Kück, U. et al., 2009, “Schimmelpilze – Lebensweise, Nutzen, Schaden, Bekämpfung“, Springer
- Kubicek, C.P., 2013, “Fungi and Lignocellulosic Biomass“, Wiley-Blackwell

Responsible for Module:
Benz, Johan Philipp; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Molekulare Biologie biotechnologisch relevanter Pilze (Vorlesung mit integrierten Übungen, 4 SWS)
Benz J [L], Benz J, Tamayo Martinez E
For further information in this module, please click campus.tum.de or here.

Module Description

WZ1259: Experiment Design and Planning in Chemistry | Projektierung in der Chemie

Version of module description: Gültig ab winterterm 2016/17

Module Level: Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The first part of the assessment takes the form of project work, including e.g. planning, laboratory work and a written evaluation of the project. This is to demonstrate that students can practically apply the acquired methods (e.g. literature research or pipetting) in order to design and work on small projects independently. The second part of the assessment includes a ten-minute presentation, in which the results are briefly introduced to the class and lecturers. This serves the assessment of students’ communicative proficiency in discussing scientific topics in front of an audience. Project work accounts for two-thirds of the grade, the presentation makes up the remaining one-third.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge and experience of laboratory work, such as introduced in the modules WZ 1680 (LV3641) and WZ1681 (LV968 and LV981)

Content:
The module covers various methods that are required for independent project work. The lecture first outlines the content and time requirements of chemistry projects as well as the main sources of error. It covers everything from literature research to writing reports. Finally, practical methods (pipetting, weighing, preparation of solutions and dilutions) are introduced by exercises to deepen the students' theoretical knowledge and allow them to plan and perform projects independently (starting from literature research until experiments realized in a laboratory).

Intended Learning Outcomes:
At the end of the module, students are able to complete basic work (e.g. pipetting, weighing, preparation of solutions and dilutions) in the laboratory. In addition, they can develop small projects, fulfill a project plan, as well as verify and analyse the results.

Teaching and Learning Methods:
The module consists of lectures, practical tutorials and project work. The lectures deal with the theoretical background of the topic, which is required for independent project planning. Tutorials build on these lectures and help consolidating students' knowledge in practice. In addition, students choose a project in consultation with their lecturer, which they then plan and carry out independently. Finally, students prepare a written report.

Media:
Power-Point, laboratory

Reading List:
Organikum, Lehrbuch der analytischen und präparativen anorganischen Chemie (ISBN 978-3527339686) ; 1x1 der Laborpraxis (ISBN 978-3527316571)

Responsible for Module:
Corinna Urmann (corinna.urmann@tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Research Internship (max. 20 ECTS) | Research Internship (max. 20 ECTS)

Module Description

CS0014: Research Internship Master Chemical Biotechnology | Research Internship Master Chemical Biotechnology

Version of module description: Gültig ab winterterm 2023/24

Module Level: Master	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 15	**Total Hours:** 450	**Self-study Hours:** 90	**Contact Hours:** 360

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Exam achievement consists of a graded practical course report (15-25 pages) about contents and results of the practical course containing at least an overview of the level of knowledge relating to the project subject as well as representation of used working methods and a representation of the results including interpretation. In a final grade quality of familiarisation with the topic of experimental work, interpretation of results and written elaboration shall be evaluated.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
no

Content:
Research-related works at the chairs and working groups of the TUM Campus Straubing/Garching/Freising (area of biotechnology). The students shall each get tasks from the research field of the mentoring examiner. They shall work on these tasks under supervision in form of projects. Topics have to be allocated with regard to content and expertise to one of the core themes (cultivation, economy, material use, energetic use). The students shall largely independently plan project works under supervision of the mentors.
The project work includes 360 working hours, which are set in consultation with the supervisors, usually as a block internship on consecutive weeks, which can be deviated from in consultation with the supervisors. Project works shall be documented and evaluated in form of an internship report. Optionally a completing presentation of work progress may be done in form of oral

presentations. Project works can also be done in cooperation with external institutions, e.g. companies.

Intended Learning Outcomes:
After having participated in the module the students especially understand principles of approach to (research) projects, planning of project works and critical evaluation of project results beside subject-specific knowledge and working methods each imparted in the practical course in scientific working. The students will be able to apply these principles to new project tasks. Besides they are able to document, to interpret and summarise project works and results in a meaningful way in written form.

Teaching and Learning Methods:
According to the core theme and topic, e.g. experimental equipment (laboratory), databases, libraries, subject-specific software, project and experiment design software

Media:
dependent on focus and topic e.g. experimental equipment (lab), databases, libraries,subject-specific software, project/ experiment planning software

Reading List:
Technical literature

Responsible for Module:
Sieber, Volker; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Research Internship Master Chemical Biotechnology (Blombach) (Praktikum, 15 SWS)
Blombach B [L], Blombach B, Glawischnig E, Hädrich M, Vital S

Research Internship Master Chemical Biotechnology (Costa) (Forschungspraktikum, 15 SWS)
Costa Riquelme R [L], Costa Riquelme R

Research Internship Master Chemical Biotechnology (Sieber) (Praktikum, 15 SWS)
Sieber V [L], Abbas Nia A, Al-Shameri A, Arana Pena S, Dsouza Z, Fornoni E, Friedrichs J, Fuchs A, Giustino A, Grundheber J, Hofer N, Hörnschemeyer K, Hupfeld E, Kampl L, Köllen T, Liu Y, Malubhoy Z, Marosevic M, Matena F, Mayer M, Ostertag T, Raga Carbajal E, Rau M, Romeis D, Rühmann B, Scheerer J, Schieder D, Schulz M, Sieber V, Siebert D, Skopp A

Research Internship Master Chemical Biotechnology (Prof. Zavrel) (Forschungspraktikum, 15 SWS)
Zavrel M [L], Beerhalter D, Borger J, Dsouza V, Geisler N, Marino Jara J, Oktay I, Stegemeyer U, van der Walt H, Zavrel M
For further information in this module, please click campus.tum.de or here.

Module Description

CS0294: Research Internship Master 5 ECTS | Research Internship Master 5 ECTS

Version of module description: Gültig ab summerterm 2024

Module Level: Master	Language: English	Duration: one semester	Frequency: winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 30	**Contact Hours:** 120

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a graded internship report (15-30 pages, depending on the topic) on the contents and contents of the internship results containing at least an overview of the state of knowledge on the project topic as well as the presentation of the working methods used and a presentation of the results with interpretation. In an overall grade, the quality of the familiarisation with the topic, the experimental work, the interpretation of the results and the written elaboration are evaluated.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Background knowledge of the respective focus to which the project topics of the research internships are assigned. In this case, having a background in Python or SuperPro Designer and experience in the laboratory is often recommended.

Content:
Research-related work at the chairs and working groups of the TUM Campus Straubing. The students receive tasks from the research area of the supervising examiner, which they work on under guidance in the form of projects. The subject areas must be able to be assigned to the technical content of the study program. The students plan the project work largely independently under the guidance of the supervisors. The project work consists of 120 working hours, fixed in consultation with the supervisors, usually as a block internship on consecutive weeks, which can be deviated from in consultation. The project work is documented and evaluated in the form of an internship report. In addition, a supplementary presentation of the work progress takes place. The project work can also be done with external institutions, such as companies.

Intended Learning Outcomes:
After participation in the module, students understand the principles of approach to (research)projects in addition to the subject-specific knowledge and working methods taught in the research internship projects, the planning of project work and the critical evaluation of the project results and can apply them to new project tasks. Furthermore, they are able to document, interpret and summarise project work and results in written form.

Teaching and Learning Methods:
Depending on the focus and topic, for example, experiments in laboratories, guided or independent literature and data research, concept studies, simulations, methods for project and experimental design or test evaluation

Media:
Depending on the focus and topic, e.g., experimental equipment (laboratory), databases, libraries, specialized software, programming software, simulation software, project and experimental design software

Reading List:
technical literature;
Davies, M. B. (2007): Doing a successful research project. Using qualitative or quantitative methods. Basingstoke: Palgrave

Responsible for Module:
Zollfrank, Cordt; Prof. Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Research Internship Master 5 ECTS (Praktikum, 5 SWS)
Blombach B, Glawischnig E, Hädrich M, Vital S

Research Internship Master 5 ECTS (Forschungspraktikum, 5 SWS)
Costa Riquelme R [L], Costa Riquelme R

Research Internship Master 5 ECTS (Forschungspraktikum, 5 SWS)
Sieber V [L], Abbas Nia A, Al-Shameri A, Arana Pena S, Dsouza Z, Fornoni E, Friedrichs J, Fuchs A, Giustino A, Grundheber J, Hofer N, Hörnschemeyer K, Hupfeld E, Kampl L, Köllen T, Liu Y, Malubhoy Z, Marosevic M, Matena F, Mayer M, Ostertag T, Raga Carbajal E, Rau M, Romeis D, Rühmann B, Scheerer J, Schieder D, Schulz M, Sieber V, Siebert D, Skopp A

Research Internship Master 5 ECTS (Forschungspraktikum, 5 SWS)
Zavrel M [L], Beerhalter D, Borger J, Dsouza V, Geisler N, Marino Jara J, Oktay I, Stegemeyer U, van der Walt H, Zavrel M
For further information in this module, please click campus.tum.de or here.

Module Description

CS0297: Research Internship Master 10 ECTS | Research Internship Master 10 ECTS

Version of module description: Gültig ab summerterm 2024

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 60	**Contact Hours:** 240

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a graded internship report (15-30 pages, depending on the topic) on the contents and contents of the internship results containing at least an overview of the state of knowledge on the project topic as well as the presentation of the working methods used and a presentation of the results with interpretation. In an overall grade, the quality of the familiarisation with the topic, the experimental work, the interpretation of the results and the written elaboration are evaluated.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Background knowledge of the respective focus to which the project topics of the research internships are assigned. In this case, having a background in Python or SuperPro Designer and experience in the laboratory is often recommended.

Content:
Research-related work at the chairs and working groups of the TUM Campus Straubing. The students receive tasks from the research area of the supervising examiner, which they work on under guidance in the form of projects. The subject areas must be able to be assigned to the technical content of the study program. The students plan the project work largely independently under the guidance of the supervisors. The project work consists of 360 working hours, fixed in consultation with the supervisors, usually as a block internship on consecutive weeks, which can be deviated from in consultation. The project work is documented and evaluated in the form of an internship report. In addition, a supplementary presentation of the work progress takes place. The project work can also be done with external institutions, such as companies.

Intended Learning Outcomes:
After participation in the module, students understand the principles of approach to (research)projects in addition to the subject-specific knowledge and working methods taught in the research internship projects, the planning of project work and the critical evaluation of the project results and can apply them to new project tasks. Furthermore, they are able to document, interpret and summarise project work and results in written form.

Teaching and Learning Methods:
Depending on the focus and topic, for example, experiments in laboratories, guided or independent literature and data research, concept studies, simulations, methods for project and experimental design or test evaluation

Media:
Depending on the focus and topic, e.g., experimental equipment (laboratory), databases, libraries, specialized software, programming software, simulation software, project and experimental design software

Reading List:
technical literature;
Davies, M. B. (2007): Doing a successful research project. Using qualitative or quantitative methods. Basingstoke: Palgrave

Responsible for Module:
Zollfrank, Cordt; Prof. Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Research Internship Master 10 ECTS (Forschungspraktikum, 10 SWS)
Banlaki I, Crean E, Gaizauskaite A, Kalkowski J, Li Y, Niederholtmeyer H

Research Internship Master 10 ECTS (RES) (Praktikum, 10 SWS)
Gaderer M [L], Huber B, Putra L

Research Internship Master 10 ECTS (Sieber) (Forschungspraktikum, 10 SWS)
Sieber V [L], Abbas Nia A, Al-Shameri A, Arana Pena S, Dsouza Z, Fornoni E, Friedrichs J, Fuchs A, Giustino A, Grundheber J, Hofer N, Hörnschemeyer K, Hupfeld E, Kampl L, Köllen T, Liu Y, Malubhoy Z, Marosevic M, Matena F, Mayer M, Ostertag T, Raga Carbajal E, Romeis D, Rühmann B, Scheerer J, Schulz M, Sieber V, Siebert D, Skopp A
For further information in this module, please click campus.tum.de or here.

Interdisciplinary Electives | Allgemeinbildende/Fachübergreifende Wahlmodule

Module Description

WZ1120: Medicinal and Spice Plants | Heil- und Gewürzpflanzen

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In a written examination (60 minutes), students demonstrate their ability to identify important medicinal and aromatic plants, as well as outline methods of cultivation, harvesting and drying. In addition, they have a limited time frame to classify medical effects and chemical compounds. During the course of the module, students give a detailed presentation on certain medicinal and aromatic plants, which also informs the assessment.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Organic and anorganic chemistry, botany, plant cultivation or Introduction to biology (WZ1110), chemistry (WZ1106), cultivation systems (WZ1107).

Content:
History of medicinal plants, identification of medicinal plants, special aspects of cultivation of aromatic plants, plant protection and harvesting. Drying methods used for herbs. Different classes of active substances, such as terpenes, coumarin, flavonoids and certain effect-determining ingredients. Several extraction and analysis methods of isolation of the active substance, e.g. Soxhlet extraction, thin-layer chromatography or infrared spectroscopy. Frequent mechanisms of action, e.g. inflammation cascade, infections, neurotransmission or digestion system. Current cultivation systems and use of medicinal and aromatic plants.

Intended Learning Outcomes:
After participation in the module, students know how to characterize medicinal and aromatic plants, inclucing basics of cultivation systems in herb gardens and fields. They are aware of different techniques such as drying and harvesting of various medicinal and aromatic plants. Examples are used to demonstrate the students' ability to classify medical effects and chemical compounds. Participating in tutorials on laboratorial work, students learn how to perform analytical-chemical analyses on medicinal and aromatic plants as well as deducing the respective classes of active substance.

Teaching and Learning Methods:
Lecture (talks given by teaching staff using PowerPoint media, books and other written material), excursion to process engineering company. Tutorials (e.g. students perform supervised experiments)

Media:
PowerPoint presentation and lecture notes.
Laboratory equipment for experiments, exercises about analysis

Reading List:
Deutschmann, F., Hohmann, B., Sprecher, E., Stahl, E., Pharmazeutische Biologie, 3 Bde., G. Fischer Verlag, 1992
Wendelberger, E., Heilpflanzen: Erkennen | Sammeln | Anwenden Broschiert – BLV Buchverlag Januar 2013
Dingermann, Hiller, Schneider, Zündorf 2011, Arzneidrogen Spektrum akademischer Verlag

Responsible for Module:
Alexander Höldrich (alexander.hoeldrich@tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CH0136: Principles of Patent Law | Grundlagen des Patentrechts

Version of module description: Gültig ab winterterm 2024/25

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird in Form einer 120-minütigen schriftlichen Klausur erbracht. In dieser soll nachgewiesen werden, dass in begrenzter Zeit eine Fragestellung des Patentrechts richtig erkannt wird und Wege zu einer Lösung gefunden werden können. Beispielsweise können dies Fragen zum Ablauf einer korrekten Patentanmeldung oder die Bewertung von Erfindungen in patentrechtlichen Prüfungsverfahren sein. Die Antworten erfordern gegebenenfalls eigene Formulierungen.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Keine fachlichen Voraussetzungen notwendig. Gute Deutschkenntnisse erforderlich. Englischkenntnisse sind nicht erforderlich, aber hilfreich.

Content:
Einführung in den gewerblichen Rechtsschutz und insbesondere das EPÜ-Patentsystem (Europäisches Patent). Das Modul vermittelt Grundkenntnisse im Hinblick auf Anmeldeerfordernisse, Patentierungsvoraussetzungen, Priorität, Prüfungsverfahren, Einspruch und Nichtigkeit, Beschwerde, Durchsetzung und Wirkungen von Patenten.

Intended Learning Outcomes:
Nach der Teilnahme am Modul "Grundlagen des Patentrechts" kennen die Studierenden die Abläufe im Patentsystem des EPÜ. Sie sind in der Lage, die patentrechtlichen Aspekte von Erfindungen zu bewerten und wissen, wie die patentrechtlich richtige Vorgehensweise bei der Anmeldung von Patenten ist.

Teaching and Learning Methods:
Die Inhalte des Moduls werden in einer Vorlesung (2 SWS) durch Vortrag und Präsentation vermittelt. Ferner werden gemeinsam konkrete Fragestellungen beantwortet und ausgesuchte Beispiele bearbeitet, wodurch die Studierenden zur inhaltlichen Auseinandersetzung mit den Themen angeregt werden.

Media:
Präsentationen, Skript, Übungsaufgaben

Reading List:
-EPÜ in Auszügen
-Skript
-Broschüre "Der Weg zum Europäischen Patent" des Europäischen Patentamts

Responsible for Module:
School of Natural Sciences, Department Chemie

Courses (Type of course, Weekly hours per semester), Instructor:
Grundlagen des Patentrechts (CH0136) (Vorlesung, 2 SWS)
Parchmann S (Steinberger I)
For further information in this module, please click campus.tum.de or here.

Module Description

CS0258: Nawaro in Communication and Didactics | Nawaro in Kommunikation und Didaktik

Version of module description: Gültig ab summerterm 2022

Module Level: Master	Language: German	Duration: one semester	Frequency: summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Im Laufe des Semesters wird von den Studierenden als Studienleistung die Ausarbeitung von Präsentationen, Teilnahme an Rollenspielen und Fallbearbeitungen in der Gruppe mit Videoanalysen erwartet (unbenotet). Die benotete Prüfungsleistung wird in zwei Teilen erbracht. Der erste Teil ist eine bewertete Lehrveranstaltung (Präsentation: 20 min) in Gymnasien und anderen weiterführdenen Schulen, bei der die erworbenen didaktischen Fähigkeiten angewendet werden sollen (80 % der Note). Der zweite Teil der Prüfung besteht aus einem schriftlichen Bericht (ca. 10 Seiten) bezüglich der durchgeführten Lehrveranstaltung am Gymnasium (20 % der Note).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
keine

Content:
Vermittelt werden Grundlagen der Kommunikation und Didaktik, Kommunikationsmethodik, Kommunikationsregeln und deren Anwendung im Berufsalltag sowie zielorientierte Gesprächsführung. Außerdem werden Ausdruck und Sprache, Darstellung des Studienganges, Darstellung der Inhalte und deren praktische Vermittlung, die Organisation von Unterrichtseinheiten an den involvierten Schulen, die Charakterisierung des Unterrichtsbedarfs und Belange der Öffentlichkeitsarbeit behandelt.

Intended Learning Outcomes:
Nach der Teilnahme am Modul können die Studierenden grundlegende Beratungs- und Kommunikationsmodelle analysieren und die dahinterliegende Theorie den Modellen entsprechend zuordnen.

Des Weiteren können die Studierenden anhand von Fallbeispielen Beratungs- und Kommunikationsmodelle anwenden.
Darüberhinaus überprüfen sie ihre eigene Grundhaltung und reflektieren ihr eigenes Beratungs- und Kommunikationsverhalten. Die Studierenden können Lernziele passend zur jeweiligen Zielgruppe und zu den jeweils zu vermittelnden Inhalten formulieren und definieren.
Sie können entlang der Lernziele eine Unterrichtseinheit zeitlich in eine sinnvolle Reihenfolge bringen und können entsprechende Unterrichtsmethoden passend zu den Zielen auswählen.
Sie können einen Lehrplan für Ihre Unterrichtseinheit gestalten und auch umsetzen. Des weitern können die Studierenden ihre inhaltlichen Themen verbindlich erläutern und sie in Verbindung setzen mit den Arbeitsfeldern des Wissenschaftszentrums.Sie können den inhaltlichen Bedarf der Schule analysieren und den Unterrichtsumfang planen und sie sind befähigt Presse- und Öffentlichkeitsarbeit mit Inhalten und Intention aus dem Bereich Nachwachsender Rohstoffe zu koordinieren.

Teaching and Learning Methods:
Neben der Vorlesung werden Übungen, Rollenspiele, Fallstudien und Exkursionen und in Videoanalysen werden Einzel- und Gruppenpräsentationen durchgeführt und ananlysiert.
Außerdem findet eine Lehrprobe vor einer Schulklasse eines Gymnasiums der Region statt.

Media:
Präsentationen, Skriptum, Video, Übungsblätter, Flipchart,
Powerpoint, Filme zeigen, Anschauungsobjekte (nachwachsende Rohstoffe), Fallbeschreibungen, Schultafel, Powerpoint

Reading List:
Schulz von Thun, F. (2019). Miteinander reden 1-4: Störungen und Klärungen. Stile, Werte und Persönlichkeitsentwicklung. Das "Innere Team" und situationsgerechte Kommunikation. Fragen und Antworten. Hamburg: Rowohlt Verlag.

Lippitt, G. & Lippitt, R. (2015). Beratung als Prozess: Was Berater und ihre Kunden wissen sollten. Leonberg: Rosenberger Fachverlag.

Weisbach, C.-R., Sonne-Neubacher, P. & Praetorius, I. (2015). Professionelle Gesprächsführung: Ein praxisnahes Lese- und Übungsbuch. München: Deutscher Taschenbuch Verlag.

Berger, F. (2012). Personenzentrierte Beratung. In J. Eckert, E.-M. Biermann-Ratjen & D. Höger (Hrsg.). Gesprächspsychotherapie. Lehrbuch für die Praxis (S. 279-309). Berlin: Springer."

Responsible for Module:
Claudia Martin

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

CS0298: Applied Ethics for Renewable Resources | Applied Ethics for Renewable Resources

Version of module description: Gültig ab winterterm 2024/25

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In a written examination (60 minutes), students relate on fundamental approaches to bioethics. Social issues will translate into students' tasks. Students thereby demonstrate the connections between risks and injustice. Drawing on special scenarios, students will identify areas of conflict and propose possible solutions.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
Definition of ethics terminology, main schools of thought in approaches to bioethics such as Kantian ethics / deontological ethics
Utilitarianism (theory of consequentialism), liberal individualism (rights-based theory), communitarianism (community-based theory); how bioethical issues are perceived in society, such as
-red gene technology
-green gene technology
-Areas of conflict based on the use of renewable resources: "food before fuel" slogan, exploitation of agricultural land for chemical products or for re-use as energy in light of the world's hunger epidemic. This module will also discuss food waste along the value chain from field to fork.
Legislation laid down in the Convention on Biomedicine (Council of Europe); selected areas of contention such as bioethics for all living creatures; human bioethics; definition of life; definition of death; medical ethics; research; exploitation of resources (production); resource waste (efficiency)

Intended Learning Outcomes:
After completion of the module, students will understand the fundamentals of bioethics. They will be able to gather information on the main schools of thought in approaches to bioethics. Students will have formed their own opinions on aspects of the social issues covered. They will be able to identify issues arising from the production of renewable resources and propose possible solutions using methods learnt in class.

Teaching and Learning Methods:
Lectures teach basic knowledge, presentations, tutorials on practical approches in bioethics, expert lectures on selected topics related to the ethical evaluation of using renewable resources

Media:
script, PowerPoint presentation, documentaries, group work

Reading List:
"Günter Altner: Naturvergessenheit. Grundlagen einer umfassenden Bioethik. WBG, Darmstadt 1991 ISBN 3534800435;
Suhrkamp Taschenbuch Wissenschaft Nr. 1597: Bioethik - Eine Einführung Taschenbuch – 2003 von Marcus Düwell (Herausgeber, Vorwort), Klaus Steigleder (Herausgeber, Vorwort)
European Union, 2014, Health and Consumers. Food. Stop Food Waste. European Commission. Http://ec.europa.eu/food/food/sustainability/index-en.htm [acessed June 6, 2014]
Agrarethik: Landwirtschaft mit Zukunft Gebundene Ausgabe – Juli 2012
von Uwe Meier (Herausgeber)
Energie aus Biomasse - ein ethisches Diskussionsmodell - Michael Zichy, Christian Duernberger, Beate Formowitz, Anne Uhl, Maendy Fritz, Edgar Remmele, Stephan Schleissing, Bernhard Widmann (2011): ""Energie aus Biomasse - ein ethisches Diskussionsmodell"". Darmstadt, Vieweg +Teubner, ISBN: 978-3-8348-1733-4"

Responsible for Module:
Andrea Potzler

Courses (Type of course, Weekly hours per semester), Instructor:
Applied Ethics for Renewable Resources (Lecture) (Vorlesung, 1 SWS)
Potzler A

Applied Ethics for Renewable Resources (Exercise) (Übung, 1 SWS)
Potzler A
For further information in this module, please click campus.tum.de or here.

Master's Thesis | Master's Thesis

Module Description

CS0115: Master's Thesis | Master's Thesis

Version of module description: Gültig ab summerterm 2023

Module Level: Master	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 30	**Total Hours:** 900	**Self-study Hours:** 850	**Contact Hours:** 50

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination consists of the preparation and positive evaluation of the Master's Thesis (approximately 25 to 100 pages, depending on the topic). The overall grade is determined by the grade of the Master's Thesis.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
70 credits including all compulsory modules of the Master's program

Content:
Deepening the knowledge of current academic literature on a specific topic, which can be freely chosen from the program in consultation with the supervisor. Deepening the knowledge of appropriate research methods, as well as gaining experience in their application.

Intended Learning Outcomes:
After completing the module, students are able to derive complex scientific questions and to work on them independently using adequate scientific methods. In doing so, they demonstrate their ability to think analytically on their own. They are able to present their results conclusively, discuss them, and draw final conclusions.

Teaching and Learning Methods:
First, together with the supervisor, the topic is
the topic is narrowed down and a research question is developed. Within the framework of the Master's Thesis, the students work on this scientific question. Among other things, literature

research, theoretical models and/or empirical methods are applied. The actual teaching and learning methods depend on the respective research question and are decided jointly with the supervisor in each individual case.

Media:
Academic literature, software, etc.

Reading List:
in consultation with the supervisor

Responsible for Module:
Alle prüfungsberechtigten Dozenten/innen des Studienganges

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Obligations | Auflagen

Requirement Proof of Proficiency in German | Nachweis Deutschkenntnisse

Module Description

SZ0321: German as a Foreign Language A1.1 plus A1.2 | Deutsch als Fremdsprache A1.1 plus A1.2

Version of module description: Gültig ab summerterm 2022

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 8	**Total Hours:** 270	**Self-study Hours:** 180	**Contact Hours:** 90

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In den Prüfungsleistungen werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Die Prüfungsleistungen werden in Form von kompetenz- und handlungsorientierten (Portfolio-) Prüfungsaufgaben erbracht.
Hilfsmittel sind erlaubt.
Die Prüfungsleistungen sind in ihrer Gesamtheit so konzipiert, dass die Anwendung von Wortschatz und Grammatik, das Lese- und/oder Hörverstehen sowie die freie Textproduktion geprüft werden.
Mündliche Kommunikationsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft und/oder in Form einer Audio-/Videodatei. Hierzu beachten wir die Datenschutzgrundverordnung (DSGVO, Art. 12 -21).

Repeat Examination:

(Recommended) Prerequisites:
keine

Content:
In diesem Modul werden Grundkenntnisse in Deutsch als Fremdsprache unter Berücksichtigung interkultureller und landeskundlicher Aspekte vermittelt, die es den Studierenden ermöglichen, sich

trotz geringer Sprachkenntnisse z.B. beim Einkaufen, im Restaurant, im öffentlichen Verkehr etc. zurechtzufinden.

Sie lernen/üben grundlegendes Vokabular zu Themen wie Familie, Beruf, Freizeit, Einkaufen, Wohnen, Reisen und Gesundheit, einfache Gespräche in alltäglichen Situationen zu führen und in Hauptsätzen Alltägliches im Präsens und Perfekt zu berichten, unter Verwendung von Nomen, Verben, Pronomen und Possessivartikeln, Modalverben, Imperativ und grundlegender lokaler und temporaler Präpositionen.
Es werden Möglichkeiten aufgezeigt, den Lernprozess in der Fremdsprache eigenverantwortlich und effektiv zu gestalten. Die Studierenden üben Teamkompetenz durch kooperatives Handeln in multinational gemischten Gruppen.

Intended Learning Outcomes:
Das Modul orientiert sich am Niveau A1 des GER.
Nach Abschluss dieses Moduls sind die Studierenden in der Lage alltägliche Ausdrücke und einfache Sätze zu verwenden, die auf die Befriedigung konkreter, in der Bewältigung des Alltags wesentlicher Bedürfnisse zielen:
Sie können einfache Fragen in alltäglichen Situationen stellen und beantworten, Tagesabläufe in Vergangenheit und Gegenwart beschreiben und einfache schriftliche Mitteilungen zur Person machen, Verabredungen treffen und in grundlegenden alltäglichen Situationen beispielsweise beim Einkauf oder im Restaurant ihre Wünsche erfolgreich kommunizieren, wenn die Gesprächspartner langsam und deutlich sprechen und bereit sind zu helfen.

Teaching and Learning Methods:
Das Modul besteht aus einem Seminar, in dem die angestrebten Lerninhalte mit gezielten Hör-, Lese-, Schreib- und Sprechübungen erarbeitet werden. Durch die Kombination dieser Übungen in Einzel-, Partner- und Gruppenarbeit wird der kommunikative und handlungsorientierte Ansatz umgesetzt. Durch kontrolliertes Selbstlernen grundlegender grammatischer Phänomene und Kommunikationsmuster in der Fremdsprache mit vorgegebenen (online-) Materialien werden die im Seminar vermittelten Grundlagen vertieft.
Freiwillige Hausaufgaben (zur Vor- und Nacharbeitung) festigen das Gelernte.

Media:
Lehrbuch; multimedial gestütztes Lehr- und Lernmaterial, auch online

Reading List:
Lehrbuch: wird im Kurs bekannt gegeben

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.

Module Description

SZ0337: German as a Foreign Language A1.1 | Deutsch als Fremdsprache A1.1

Version of module description: Gültig ab summerterm 2022

Module Level: Bachelor/Master	**Language:** Language taught	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 4	**Total Hours:** 135	**Self-study Hours:** 90	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Performance, testing the learning outcomes specified in the module description, is examined by a cumulative portfolio of competence and action-oriented tasks. Aids are permitted.
The examination performances are designed in their entirety to test the use of vocabulary and grammar, reading and/or listening comprehension, and free text production.
Oral communication skills will be tested via the use of appropriate idioms in written dialogue examples and/or in the form of an audio/video file. For this purpose, we observe the Basic Data Protection Regulation (DSGVO, Art. 12 -21).

Repeat Examination:

(Recommended) Prerequisites:
none

Content:
This module teaches basic knowledge of German as a Foreign Language, taking into account intercultural and cultural aspects of the country, which will enable students to find their way around despite their limited knowledge of the language, e.g. when shopping, in restaurants, on public transport, etc.
They will learn/practice basic vocabulary on topics such as family, work, leisure and food, ask and answer simple personal/family questions, understand and use numbers, prices and times and report everyday activities in simple structured main sentences in the present tense, using verbs, nouns, personal pronouns, possessive articles and negation forms.
Students practice teamwork skills by collaborating on tasks in multinational groups.

Intended Learning Outcomes:
The module is oriented towards level A1 of the CEFR. After completing this module, students will be able to use everyday expressions and very simple sentences aimed at meeting specific needs of everyday life: They can introduce themselves and others and ask other people questions about themselves and give answers to questions of this kind. They can describe daily routines in basic structures and give basic information about themselves in writing. They can communicate their needs if interlocutors speak clearly and slowly and are supportive. Students learn how to organize their own learning process of the foreign language independently and effectively.

Teaching and Learning Methods:
The module consists of a seminar in which students study the learning content with targeted listening, reading, writing and speaking exercises. The communicative and action-oriented approach is implemented by combining these exercises in individual, partner and group exercises. Online material for controlled self-study of basic grammatical phenomena and communication patterns is provided to deepen and intensify the content taught during the course. Voluntary homework (for preparation and revision) consolidates what has been learned.

Media:
Textbook, multimedia-supported teaching and learning material, also online

Reading List:
Textbook: will be announced in the course

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Deutsch als Fremdsprache A1.1 (Seminar, 3 SWS)
Bakker S, Burmasova S, Endraß E, Grgic T, Hanke C, Huber D, Keza I, Koch H, Kraut-Schindlbeck S, Lechle K, Pinskaia I, Pletschacher T, Schmidt-Bender S, Selent D, von Caprivi Caprara de Montecucculi A, von Egloffstein A, Witzig B

Deutsch als Fremdsprache A1.1 - EuroTeq Programm (Seminar, 3 SWS)
Lechle K

Blockkurs Deutsch als Fremdsprache A1.1 (Seminar, 3 SWS)
Schlüter J, von Egloffstein A, Zerfass A
For further information in this module, please click campus.tum.de or here.

Module Description

CS0257: Molecular Biology and Genetics | Molekularbiologie und Gentechnik [MolBio]

Version of module description: Gültig ab summerterm 2023

Module Level: Bachelor	**Language:** German	**Duration:** one semester	**Frequency:** winter semester
Credits:* 8	**Total Hours:** 240	**Self-study Hours:** 150	**Contact Hours:** 90

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The performance of the exam consists of a written test (90 min) in which the students show that they are able to call up and structure their theoretical and practical knowledge and use it on problems. By creating written protocols of the executed laboratory experiments (for each experiment about 5 pages of protocol), the students prove that they can documentate and illustrate theoretical principles as well as the results and the corresponding analysis and assessment of the experiments (not graded course achievement).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successfully completed exam for the Cell- and Microbiology module (CS0256) or an equivalent module. As a prerequisite for participation in the practical course, the written examination for the lecture must be successfully passed.

Content:
molecular structure of DNA, plasmids, bacteriophages, mutagenesis strategies, bacterial genomes, prokarotic gene regulation, transformation of organisms, genetic engineering, genetic engineering regulation, genome editing, cloning of DNA fragments, heterologous gene expression, analysis methods for DNA, RNA and proteins

Intended Learning Outcomes:
After completion of the modul the students possess knowledge about the most important molecular biological methods. They know how to isolate, analyse and manipulate nucleic acids and possess knowledge about the transformation of microorganisms. They understand what a genetically engineered organism is and can assess the risks and benefits of genetic engineering experiments,

including the benefits of new transgenic strains for sustainable production processes. The students can perform and analyse molecular biological experiments and name possible sources of error.

Teaching and Learning Methods:
The theoretical basics of the experiments conducted in the practical course will be delivered in the lecture part via ppt-presentations, movies and white board. In the practical course, the students will self-reliantly perform, document and analyse their experiments.

Media:
PowerPoint, blackboard work, practical course script

Reading List:
Molekularbiologische Methoden 2.0, T. Reinard, Utb, 2. Auflage, ISBN: 978-3-8252-8742-9
Mikrobiologie, J. L. Slonczewski, J. W. Foster, Springer Spektrum, 2. Auflage, ISBN: 978-3-8274-2909-4
Genome und Gene, T. A. Brown, Spektrum, 3. Auflage, ISBN: 978-3-8274-1843-2
Gentechnische Methoden, M. Jansohn, S. Rothhämel, Springer Spektrum, 2. Auflage, ISBN: 978-3-8274-2429-7
An Intro to Genetic Engineering, Desmond S. T. Nicholl, 3ed., Cambridge University Press, ISBN: 978-0521615211

Responsible for Module:
Prof. Dr. Bastian Blombach

Courses (Type of course, Weekly hours per semester), Instructor:
Molekularbiologie und Gentechnik (Vorlesung) (Vorlesung, 2 SWS)
Blombach B [L], Blombach B

Molekularbiologie und Gentechnik (Praktikum) (Praktikum, 4 SWS)
Blombach B [L], Blombach B, Glawischnig E, Hädrich M, Vital S
For further information in this module, please click campus.tum.de or here.

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