QBio402: Biotechnology & Synthetic Biology

Module Responsible: Prof. Dr. Matias Zubriggen	**Version:** 02/01/2021
Module Organizer: Prof. Dr. Matias Zubriggen	**Type:** Compulsory

Lecturer:
Prof. Dr. Matias Zubriggen, Prof. Dr. Julia Frunzke, Prof. Dr. Nick Wierckx, Prof. Dr. Karl-Erich Jäger, Dr. Anita Loeschcke, Dr. Stephan Thies

Total Working Time	Credit Points	Contact Time	Self Study	Duration
270 h	9 CP	120 h	150 h	1 Semester

Course Components		Group Size	Frequency
Lecture:	3 SWS	P: 40	Every Summer Semester
Exercise:	3 SWS	P: 40	
Practical:	2 SWS	P: 20	

Learning Competencies:
The students are familiarized with the principles, approaches and applications of synthetic biology and metabolic engineering, both on the theoretical and experimental side. This includes microorganisms, animal and plant systems (white, red and green). The students are introduced into the development and application of engineering approaches in biology. This includes advanced technologies like biosensors, microfluidics and optogenetics. Students learn how to work with microbial and animal/plant cell cultures, and are guided in a small project from cloning and cultivation up to biocatalyst design, bioreactor cultivation and product purification. In addition, the students are taught the practical handling of bioreactors or fermenters and how they can use various parameter measurements to infer the growth and performance of organisms. The students get an introduction into bench to business approaches.

Content:
Lecture

- Metabolic and Biochemical Engineering
  - Fundamentals of metabolism
  - History of Biotechnology: past, present, future
  - Changing/rerouting metabolism, role of transporters
  - Laws of Growth, Fermentation
  - Microfluidics
  - Physiological parameters
  - Flux balance analysis
  - Downstream processing
  - Regulatory framework.
  - Microbial platforms: photosynthetic and non-photosynthetic bacteria, yeast, algae.
  - Products: bulk and fine chemicals, polymer precursors, biopharmaceuticals

- New enzymes:
  - Metagenomics. Protein engineering function/mechanism. Directed evolution approaches.
  - Selection vs Screening: high-throughput screening (Labor) and Computational Methods (in silico), link to synthetic biology: identify/develop biocatalysts to close gaps in synthetic metabolic networks.
  - Industrial applications.
  - Combination with chemistry, biohybrid systems.

- Synthetic Biology: Design-Build-Test-Learn cycle
  - Synthetic biology engineering principles
  - Product specification – bioparts – mathematical modelling – prototyping – testing – validation
  - Synthetic molecular modules and circuits - logic gates
  - Synthetic signal and metabolic networks
  - Synthetic regulation, switches
  - Optogenetics
  - Synthetic molecular tools: biosensors, CRISPR
  - Enabling technologies: flow cytometry, microfluidics, advanced microscopy, 2D and 3D printing, AI – Machine learning algorithms, cell culture, tissue engineering and organoids

- Synthetic biology applications: white-green-red
  - Biopharmaceutical design and production. Regulatory frameworks, clinical trials.
  - Biomedicine/personalized medicine. Immuno and cell-therapies.
  - Agriculture
  - Production of fine and bulk chemicals
  - Synthetic evolution/evolutionary engineering: enhancing product tolerance, substrate utilization, growth coupling strategies to increase precursor supply/enhance production
  - Xenogenetics, synthetic organelles and cells. Bottom up vs top down approaches
  - Genome engineering/reduction. De novo engineering.
  - Reconstruction biology / concept of orthogonal systems. Applications in fundamental research.
  - Synthetic microbial communities
  - Synthetic tissues and organoids. Cybergenetics.

Practical:

- Molecular genetic basics for engineering (for bacteria): Plasmids, Genomic integration, Gene expression.
- Mini projects on specific scientific questions using one system as central, e.g. Pseudomonas for metabolite production, across several labs.
- Special emphasis on the protocol writing (industry wise). Links to “Learning scientific approach” (S.1) and project practicals in S.6-8.
- Introduction of a digital lab book for the mini-projects. Corresponding introduction to eLab Journal.

Presentation:

Development of a project dealing with the translation of scientific knowledge into marketable products (including development of new technologies/inventions, market and cost analysis, translational approaches, funding, business strategy). The students will present the project in the form of an elevator pitch as normally done for fund raising rounds with investors.

Conditions of Participation:
Passed Modules QBio201

Examination:
Learning portfolio consisting of
- Written Exam (60% of the final grade)
- Practical performance (20% of the final grade)
- Presentation (20% of the final grade)

Prerequisites for Awarding Credits for this Module:
- Passing Written Exam
- Submitted Protocol

Factor for the Overall Grade:
The grade is weighted according to the credit points (CP) in the overall grade.

Language:
English

Literature:

Further Information: