QBio202: Deterministic processes in Biology

Module Responsible: Prof. Dr. Oliver Ebenhöh	**Version:** 02/01/2021
Module Organizer: Prof. Dr. Oliver Ebenhöh	**Type:** Compulsory
Lecturer: Prof. Dr. Oliver Ebenhöh	

Total Working Time	**Credit Points**	**Contact Time**	**Self Study**	**Duration**
180 h	6 CP	60 h	120 h	1 Semester

Course Components		**Group Size**	**Frequency**
Lecture:	3 SWS	P: 40	Every Summer Semester
Exercise:	1 SWS	P: 20	

Learning Competencies:

The students have basic knowledge how to describe, simulate and analyse various biological systems with differential equations. They understand how to translate biological processes into dynamic equations. They can independently develop and simulate simple mathematical models, and critically interpret their simulation results in context of available experimental data.

After completing the module, the students are able to

- translate biological systems into sets of differential equations
- implement and numerically integrate differential equation systems using the programming language Python
- understand the basic principles in model building and improvement
- interpret experimental observations using mathematical models as theoretical frameworks

Content:

This module builds upon the mathematical foundations taught in “Mathematical Fundamentals” to introduce the students into principles of mathematical modelling using differential equation systems. For this, in particular the calculus and linear algebra skills are required, and as a consequence, will be revised and covered in more depth. The module also builds on the programming skills acquired in the first semester module “Programming”.

A main focus of this module is the construction and derivation of deterministic mathematical models. Approaches will be discussed how a biological system can be abstracted, simplified, and thus translated into mathematical equations. An equally important focus is the analysis of differential equations, the computational simulation of models, and the interpretation of the results.

- Ordinary differential equations (ODEs)
    - Stationary states
    - Linearised systems
        - Eigenvalues, eigenvectors, characteristic polynomial, complex numbers
        - Jacobian

- Bistability
- Oscillations
- Bifurcations
- Limit cycles
- Non-autonomous systems

- Application of ODEs to biological systems
  - Chemical and biochemical reactions
  - Metabolic networks
  - Signalling networks
  - Gene expression networks
  - Microbial growth
  - Ecosystem dynamics
- Partial differential equations
  - Space, time, mass, density
  - Diffusion, heat conductivity
  - Reaction-diffusion systems
  - Pattern formation

Conditions of Participation:
Passed Module QBio103

Examination:
Learning portfolio consisting of

- Written exams based on the content of the lectures (50% of the final grade)
- Exercises (50% of the final grade)

Prerequisites for Awarding Credits for this Module:

- Passing Exercises (50 % of Exercise Sheets)
- Passing Written Exam

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

Language:
English

Literature:

Further Information: