LUND UNIVERSITY

Department of Earth and Enironmental Sciences

BERN06, Computational Science: Systems Biology - Models and Computations, 7.5 credits

Beräkningsvetenskap: Systembiologi - modeller och beräkningar, 7,5 högskolepoäng

Second Cycle / Avancerad nivå

Details of approval

The syllabus was approved by Study programmes board, Faculty of Science on 2023-05-31. The syllabus comes into effect 2023-05-31 and is valid from the spring semester 2024.

General information

The course is an elective course at second cycle level for a degree of Master of Science (120 credits) in Computational Science or Applied Computational Science

The course may be included as optional course in a bachelor's or master's degree in Science(120 credits).

Language of instruction: English

Main field of study	*Specialisation*
Applied Computational Science	A1F, Second cycle, has second-cycle course/s as entry requirements
Computational Science	A1F, Second cycle, has second-cycle course/s as entry requirements

Learning outcomes

The aim of the course is that the student should have acquired basic knowledge of the most common calculation methods in system biology on completion of the course. The student shall be given experience in implementing and applying the methods on relevant biological problems.

Knowledge and understanding

On completion of the course, the students shall be able to:

• on a general level give an account of how the chemical processes of the cell can be described with equations based on basic biochemical concepts,

• describe pros and cons for stochastic or deterministic simulation of a biological system,

• in detail explain how spatial dimensions and other distributions can be incorporated in simulations.

Competence and skills

On completion of the course, the students shall be able to:

• design mathematical models of appropriate complexity in relation to available information for system at population- or cell level,

• independently conduct deterministic and stochastic simulations of single cell simple mathematical models and expand such to several interacting cells,

• systematically optimise model parameters from experimental data and estimate errors estimates using simulations.

Judgement and approach

On completion of the course, the students shall be able to:

• critically evaluate whether availble information and experimental data is sufficient to answer issues in system biology.

Course content

The course deals with:

- translation between biology and mathematics: Formulation of equations that describe transcription and translation inside cells based on various assumptions,
- population models and spatial models: Formulation of equations that describe how cell populations evolve,
- simulations: Deterministic versus stochastic simulations of mathematical models; weaknesses, strengths and applicability,
- The Gillespie algorithm for stochastic simulations: Naive implementation and possible optimisations for large systems,
- cost functions: Different strategies to compare simulations with experimental data,
- optimization methods: Overview of methods for fit models to data. Local optimisation, thermodynamic methods, particle-swarm optimisation and genetic algorithms,
- sensitivity analysis: Estimation of the uncertainty of determined parameter values. Strategies to achieve robustness.

Course design

The teaching consists of lectures and programming projects.

Assessment

Examination takes place in the form of written hand-in assignments during the course as well as orally in the form of an exam at the end of the course. The project presentations are include an individual oral presentation, uploading of digital material and active participation in presentations by other students.

For students who have not passed the regular examination, an additional examination in close connection to this is offered. The same applies to presentations of the programming projects.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Grades

Grading scale includes the grades: Fail, Pass, Pass with distinction
A Pass grade for the entire course requires a Pass grade for individual oral examination and Pass grade for all individual project presentations.

The grading scale for written examination and project report is Fail, Pass, Pass with distinction.

The final grade is decided through a weighing of the results of the oral examination (50%) and the project presentations (50%).

Entry requirements

Admission to the course requires 90 credits Sciencestudies, including knowledge equivalent to BERN01 Modelling in Computational Science, 7.5 credits or FYTN03 Computational physics, 7.5 credits and English 6/B.

Admission to the course also requires knowledge in programming in Python equivalent to NUMA01, 7.5 credits or similar knowledge in Matlab, C++ or the like programming language.

Further information

This course replaces FYTN12 Systems BIology - Models and Computations, 7,5 credits,and cannot be included in a degree together with this course.

The course is offered at the Centre for Environmental an Climate Science, Lund University