

BIOENG-455

**Computational cell biology**

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Cursus	Sem.	Type
Computational biology minor	H	Opt.
Life Sciences Engineering	MA1, MA3	Opt.
Minor in life sciences engineering	H	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	During the semester
Workload	120h
Weeks	14
<b>Hours</b>	<b>4 weekly</b>
Courses	2 weekly
Exercises	2 weekly
<b>Number of positions</b>	

**Summary**

Computer modelling is increasingly used to study dynamic phenomena in cell biology. This course shows how to identify common mathematical features in cell biological mechanisms, and become proficient in selecting numerical algorithms to model them and predict their behaviour.

**Content**

- Characteristics of a cell, scales of life
- Macromolecules in the mammalian cell
- Intermolecular forces and cellular compartments
- Diffusion and entropic forces in the cell
- Thermodynamics at human and cellular scales
- Phases and phase transitions in cells
- Computer simulations of cellular dynamics
- Coarse-Grained simulations because the world is more than atoms
- Dissipative Particle Dynamics
- Membraneless organelles - a new phase of cellular material

**Keywords**

Cell Biology, Soft Matter, Thermodynamics, Diffusion, Random walks, Self-Assembly, Differential equations, Numerical algorithms, Computer simulations, Dissipative Particle Dynamics, Protein Aggregation, Biomolecular Condensates

**Learning Prerequisites****Required courses**

Phys-101  
Math-106  
Bio-205

**Recommended courses**

CS-111

**Important concepts to start the course**

Students should have a basic knowledge of cellular anatomy, calculus and ordinary differential equations, probability and statistics, mechanics and thermodynamics. They will be required to write short programmes using a programming language of their choice (python, matlab, C, C++, etc) to solve mathematical problems relevant to the topics in the course. A Dissipative Particle Dynamics simulation code is provided (<https://github.com/Osprey-DPD/osprey-dpd>), which forms the basis of the project, and students should be familiar with running programmes from the command line. A laptop or access to a computer on which the student can execute their own programmes is mandatory for this course.

## Learning Outcomes

By the end of the course, the student must be able to:

- Describe selected cellular structures and dynamical mechanisms
- Choose a numerical technique for simulating models of cellular dynamics
- Create a programme to solve numerical problems
- Justify applying a simulation technique to a problem
- Explore consequences of parameter changes on model results
- Estimate the accuracy of a numerical routine
- Explain the common elements in different simulation types
- Perform a series of DPD simulations of a complex fluid
- Organize the data produced by a series of simulations

## Transversal skills

- Demonstrate a capacity for creativity.
- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Write a scientific or technical report.

## Teaching methods

Lectures  
Exercises  
Tests  
Journal club  
Semester Project

## Expected student activities

Attending lectures, completing in-class tests, writing short programmes to solve mathematical models, selecting and working on a simulation-based semester project, presenting a paper in a journal club, writing a scientific report summarising the semester project

## Assessment methods

DPD simulation project and report - 50%  
2 x Homework exercises on numerical modelling / simulations - 15%  
3 x in class / take home tests - 30%  
Journal club presentation - 5%

## Resources

### Bibliography

Biological Physics, Philip Nelson, W. H. Freeman and Co. New York, USA, 2014  
Molecular Biology of the Cell, Bruce Alberts, et al., 2nd ed., Garland Publ. Inc. New York and London, 1989

### **Ressources en bibliothèque**

- [Biological Physics, Philip Nelson](#)
- [Molecular Biology of the Cell, Bruce Alberts,](#)

### **Notes/Handbook**

User Guide to the Dissipative Particle Dynamics simulation code is provided

### **Moodle Link**

- <https://go.epfl.ch/BIOENG-455>