Biological Physics

Biological Physics	
Offered by	Department of Applied Physics and Science Education
Language	English
Primarily interesting for	All students, but most relevant for students with background in Applied Physics and Science Education, Biomedical Engineering, Chemical Engineering,Chemistry, or Mechanical Engineering.
Prerequisites	Required courses: Recommended courses:
Contact person	dr. W.G. Ellenbroek, w.g.ellenbroek@tue.nl
Remark	Note that this coherent package is being phased out. The course Biological physics (3DBX0) is taught for the last time in 2022-2023 and assessed for the last time in 2023-2024. The other course (3FOX0) will remain, so students who pass Biological Physics in time can still complete the package.

Content and composition

Studying the mechanisms by which living species operate involves fascinating fundamental research and is of key importance for developments in healthcare. The laws of physics primarily determine the size, shape, and mechanical properties of molecular and cellular structures. The operation of cells and entire living systems involves biochemical reactions that are also intertwined with physical interaction mechanisms. In this coherent package you will obtain during the first year of your study fundamental insights in the physical processes that are at the basis of biology. In the third year you will be introduced to and get hands on experience with modelling biological systems using Monte Carlo and Brownian Dynamics simulations. By following this package, you will obtain a firm basis for a further carrier in both research and development in the life science sector.

Course code	Course name	Level classification
3DBX0	Biological physics (last taught in 2022-2023, last assessed in 2023-2024)	1
3FOX0	Modeling and simulation at the (bio)molecular scale	3

Course description

3DBX0, Biological physics (last taught in 2022-2023, last assessed in 2023-2024)
The laws of physics are inextricably linked to the existence of life. Molecular interactions and ordering processes determine self-assembly (steered by thermodynamics) and determine transport properties in living tissue. The cursory part of this course is focused on the understanding of the biological physics in terms of the thermodynamics, molecular interactions, and transport properties.
During the quartile, five research projects in the field of biophysics will be presented that are currently carried out at the TU/e by researchers from the departments of W, ST, N and BMT. Subsequently the students are challenged to define a research question themselves and write an essay describing a research project.
Topics:

- Molecular building blocks of the cell
- Understanding of the basics of Energy, Entropy and Free Energy
- Diffusion, Brownian motion / Random Walks
- Boltzmann equilibrium

- Molecular basis of viscosity
- Laws of thermodynamics
- Molecular interactions: vd Waals, electrostatic, hydrophobic interactions, depletion forces, entropic forces
- Chemical potential, reaction kinetics and equilibrium.
- Elasticity of molecules
- Molecular machines

3FOX0, Modeling and simulation at the (bio)molecular scale
Monte Carlo Sampling and Molecular Dynamics are the two most important simulation approaches for the microscopic description of phase behavior and dynamics of (bio)physical systems. As such, they are key tools for understanding e.g., mechanical properties of DNA molecules, effects of osmotic pressure, and depletion interactions in biological systems. In this course, we first introduce statistical mechanics, providing the mathematical foundation for these simulation methods. In the second part of the course the student will apply these simulation methods to study particle-based models for biophysical phenomena.
Topics:

- Background of Monte Carlo simulations: Getting statistical information out of ensemble averages, Metropolis algorithm.
- Practical: Setting up and executing a Monte Carlo simulation of a biopolymer using Mathematica or Python.
- Background of Molecular Dynamics: Verlet algorithm, calculating of forces, thermostats.
- Practical: Executing an MD simulation of a membrane using Python and LAMMPS.