PHYS-752

Lecture series on Biomimetics

Invited lecturers (see below), Lingenfelder Magalí, Various lecturers

Cursus	Sem.	Type
Physics		Opt.

Language of teaching	English
Credits	2
Session	
Exam	Oral presentation
Workload	60h
Hours	**34**
Courses	26
TP	8
Number of positions	**30**

Frequency

Every year

Remark

Next time: Spring

Summary

This course gives a comprehensive view of Biomimetics, with especial focus and hierarchical structure-function relationships. We explore the physical principles of bioinspired nanostructures and biomechanics, and their application to the design of creative and sustainable materials.

Content

Nature has achieved effective hierarchical architectures and smart response to stimuli through more than four billion years of evolution. In this course, we will discuss both natural and bioinspired systems from their fundamental physical chemistry properties, the factors determining its nucleation and growth across different scales, and their applications. The course offers a broad program on structure-function of biomimetic systems with speakers from EFFL and other top universities in Switzerland, Europe and the United States (via zoom). It is intended to be interesting for physicists, chemists, and material scientists.

The lectures cover the following topics:

- Nucleation and growth from a physicist perspective
- Bioelectricity
- Biomechanics
- Biopolymers and bioinspired polymers
- Chiral nanostructures
- Self cleaning interfaces: structural hidrophobicity
- Nanophotonics and metamaterials, structural colors in Nature
- Bioinspired Antimicrobial surfaces
- Nanopores and energy flow
- Microfluidics in bioinspired drops
- Principles of Natural and artificial photosynthesis
- Self-healing systems
  - Mechanisms of pattern formation and self-assembly across different length scales
  - Bioinspired block-copolymer thin films and nano/micro particles
  - Smart nanostructured materials (responsive to light, pH, heat, etc).
  - Deciphering and tuning biomineralization

Each of the invited speakers will deliver two 45-minute presentations:

- first, a tutorial lecture on the fundamental principles of their research topic (the basics)
- followed by a talk on their current research (focusing on the highlights). Total: 2h lecture, including Q&A.

EPFL lecturers Spring 2021:
Prof. Aleksandra Radenovic (confirmed), Prof. Esther Amstad (confirmed), Prof. Harm-Anton Klok (confirmed)

For the Spring semester 2021 we have the following external invited speakers:

Prof. Nicholas Kotov (Biointerfaces Institute, University of Michigan) (confirmed)
Prof. James De Yoreo (Physical Sciences Division, Pacific Northwest National Laboratory, Washington, USA) (confirmed)
Prof. Michael Mayer (Chair Biophysics, Adolphe Merkle Institute, University of Fribourg, Switzerland) (confirmed)
Prof. Raffaele Mezzenga (Department of Health Sciences & Technology & Department of Materials, ETHZ, Switzerland) (confirmed)
Prof. Ullrich Steiner (Soft Matter Physics, Adolphe Merkle Institute, University of Fribourg, Switzerland) (confirmed)
Prof. Thomas Speck (Functional Morphology and Biomimetics, Institute for Biology II, University of Freiburg, Germany) (confirmed)
Dr. Elisabet Romero (Quantum Design of Photosynthesis, ICIQ, Spain)
https://moodle.epfl.ch/course/info.php?id=16616

Program:

- **February 25 Maggie Lingenfelder**

Welcome intro and organization of the course, distribution of study- groups

- **March 4 Jim De Yoreo**

Nucleation and Growth

- **March 11 Esther Amstad**

Bioinspired drops

- **March 18 Elisabet Romero**

Quantum design of photosynthesis

- **March 25 Nick Kotov**

Bioinspired Chiral Nanostructures

- **April 1 Ullrich Steiner**

Nanophotonics and Metamaterials

- **April 15 Thomas Speck**

Functional Morphology and Biomechanics of Plants: Inspiration for Biomimetic Materials Systems

- **April 22 Maggie Lingenfelder**

Bioinspired Antimicrobial surfaces

- **April 29 Raffaele Mezzenga**

Biological filamentous colloids

- **May 6 Harm-Anton Klok**

Bioinspired Polymers

- **May 13 Michael Mayer**

Bioelectricity

- **May 20 Aleksandra Radenovic**

Nanopores and energy flow

- **May 27 Students Practical Activity**

- **June 3 Online Oral Exam-Student Presentations**

Note

The course is intended to run only on the spring semester, the main topics remain but invited speakers might be updated from year to year.
Students from Physics, Chemistry and Materials Science can benefit from this course.

Keywords

biomimetics, biomimicry, biophysics, nanoscience, biointerfaces, chirality, bioelectricity, self-assembly

Learning Prerequisites

Required courses

Students need to have a basic background in Physics, Chemistry and Materials Science to follow this course, and be interested in multidisciplinary research.

Learning Outcomes

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

- Interpret structure-function relationships in Nature and its application to design artificial systems
- Understand the physical principles of nucleation and growth, energy transfer, symmetry and structure in different biological scenarios.
- Be inspired by nature to design sustainable artificial systems

Expected student activities

Participation in class and discussion
Bibliographic research
Group case study

Resources

Bibliography

Research papers from each group presenting during the current semester

Ressources en bibliothèque

- Institute of Physics. Bioinspiration &, Biomimetics : Learning from Nature (2006)
- B. Bhushan, Biomimetics: Bioinspired Hierarchical-Structured Surfaces for Green Science and Technology, Springer, 2018, ISBN 978-3-319-71676-3