MSE-471

# Biomaterials (pour MX)

Bastings Maartje

| Cursus | Sem. | Type |
|---|---|---|
| Materials Science and Engineering | MA1, MA3 | Opt. |

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|---|---|
| Language of teaching | English |
| Credits | 5 |
| Withdrawal | Unauthorized |
| Session | Winter |
| Semester | Fall |
| Exam | Written |
| Workload | 150h |
| Weeks | 14 |
| **Hours** | **5 weekly** |
| Courses | 2 weekly |
| Exercises | 1 weekly |
| TP | 2 weekly |
| **Number of positions** | **32** |

**Il n'est pas autorisé de se retirer de cette matière après le délai d'inscription.**

## Summary

This course introduces the principles governing biomaterials and their interactions with biological systems. Topics include material properties, biointerfaces, mechanobiology, drug delivery, tissue engineering, and immune engineering, with emphasis on design, performance, and clinical translation.

## Content

**BLOCK 1: Foundations: Structure, Properties, and Biointeractions**
**Lecture 1. Introduction to Biomaterials**

- Historical perspective and definition of biomaterials
- Major classes of biomaterials
- Clinical needs and biomedical applications
- Overview of modern biomaterials research

**Lecture 2. Biomaterial Properties and Design Principles**

- Natural versus synthetic biomaterials
- Mechanical, chemical, and structural properties
- Degradation and stability
- Transport and diffusion
- Responsive and dynamic materials
- Design tradeoffs in biomaterials

**Lecture 3. Biointerfaces and Mechanobiology**

- Surface versus bulk properties
- Protein adsorption and biofouling
- Cell-material interactions
- Ligand presentation and receptor engagement
- Mechanotransduction and stiffness sensing
- Viscoelasticity and matrix mechanics
- Cell adhesion and force transmission

**Lecture 4. Biomaterial Platforms**

- Polymers and hydrogels
- Nanoparticles and lipid systems
- Fibrous and scaffold materials
- Bioinspired and self-assembled materials
- Emerging biomaterial platforms

**Exercise Session 1**

- Biomaterial selection and design challenge
- Analysis of literature case study
- Material property comparison exercises

**BLOCK 2 : Biomaterials in Medicine**
**Lecture 5. Biomaterials for Drug and Gene Delivery**

- Controlled release systems
- Nanomedicine and targeting
- Gene and RNA delivery
- Intracellular delivery barriers
- Bioavailability and pharmacokinetics

**Lecture 6. Biomaterials for Tissue Engineering and Regenerative Medicine**

- Extracellular matrix-inspired materials
- Cell adhesion and scaffold design
- Stem cell niches and mechanobiology
- Dynamic and adaptive matrices
- Organoids and biofabrication

**Lecture 7. Biomaterials and the Immune System**

- Foreign body response
- Inflammation and immune modulation
- Vaccine materials and adjuvants
- Biomaterials for cancer immunotherapy
- Immunoengineering strategies

**Exercise Session 2**

- Translational biomaterial case study
- Design of a biomaterial for a biomedical application
- Critical discussion of recent research papers

**BLOCK 3 : Evaluation, Translation, and Future Directions**
**Lecture 8. Characterization and Performance of Biomaterials**

- Mechanical and physicochemical characterization
- Microscopy and spectroscopy techniques
- In vitro and in vivo evaluation
- Biocompatibility assessment
- Failure mechanisms and performance analysis

**Lecture 9. Translation of Biomaterials**

- Manufacturing and scale-up

- Intellectual property and patents
- Startups and spin-offs
- Clinical needs and commercialization
- Case studies of successful biomaterial translation

**Lecture 10. Regulatory and Clinical Translation**

- Regulatory frameworks (FDA/EMA/ISO)
- Preclinical and clinical studies
- Ethics and safety considerations
- Combination products and advanced therapies

**Lecture 11. Emerging Directions and Course Synthesis**

- Personalized biomaterials
- AI-guided material discovery
- Living and adaptive biomaterials
- Sustainability in biomaterials
- Future challenges and opportunities
- Course review and integration

## Keywords

Biomaterials, biocompatibility, biofunctionality, implants, nanotechnology, tissue engineering, drug-delivery, nanoparticles.

## Learning Prerequisites

### Required courses

Introduction to materials science
Biology for engineers

### Recommended courses

Materials, metallurgy, polymer, ceramics, soft matter

## Learning Outcomes

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

- Estimate a biomaterial in function of the application
- Compare developments of new biomaterials
- Describe the interactions with biological environment
- Describe the translation of a biomaterial to commercial use
- Design a nanoparticle for targeting/drug delivery
- Compare biocompatibility of various materials
- Describe requirements to limit toxicity

## Transversal skills

- Communicate effectively with professionals from other disciplines.
- Respect relevant legal guidelines and ethical codes for the profession.
- Collect data.

- Access and evaluate appropriate sources of information.

## Teaching methods

Ex cathedra and invited speakers
Practicum at DLL laboratories: development and characterization of a soft biomaterial as scaffold for cell proliferation.

## Expected student activities

Attendance at lectures.
Presence at DLL sessions.

## Assessment methods

Written exam in exam period (75%)
Laboratory poster session (25%)
Conference style poster session will be held in het last week of the semester. 1 poster per group, with a 2-3 min pitch and 10 min presentation.

## Supervision

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| Office hours | Yes |
| Assistant.e.s | Yes |
| Forum | No |

## Resources

### Notes/Handbook

All necessary documentation will be made available in the Moodle of this course

### Moodle Link

- https://go.epfl.ch/MSE-471

### Videos

- https://tube.switch.ch/channels/e9df0a00