Course Package

Bioengineering Technologies 1A + 1B

Name module	Bioengineering Technologies 1A + 1B
Educational programme	MSc Biomedical Engineering
Period	First semester (Quarter 1A+1B)
Study load	30 ECTS
Coordinator	J. Huttenhuis

<table>
<tr><th colspan="4">Bioengineering Technologies</th></tr>
<tr><th>block 1A</th><th>block 1B</th><th>block 2A</th><th>block 2B</th></tr>
<tr><td>Introduction to Bioengineering Technologies 201800288 (5 EC)</td><td>Applied Cell Biology 201900088 (5 EC)**</td><td></td><td></td></tr>
<tr><td>In vitro Diagnostics* 201700040 (5 EC)</td><td>Advanced Drug Delivery and Nanomedicine 202200254 (5 EC)</td><td></td><td></td></tr>
<tr><td>Electives: choose 5 EC</td><td>Electives: choose 5 EC</td><td rowspan="4"></td><td rowspan="4"></td></tr>
<tr><td>Biophysical Techniques & Molecular Imaging - 193640020 (5 EC)</td><td>Lab on a chip - 191211120 (5 EC)</td></tr>
<tr><td>Physical Biology - 202001414 (5 EC)</td><td rowspan="2">Biomedical Materials Engineering - 201400283 (5 EC)</td></tr>
<tr><td>Advanced Anatomy and Physiology - 202300081 (5 EC)</td></tr>
</table>

Required preliminary knowledge: Fundamental knowledge and concepts from Cell Biology; Biochemistry; Chemistry; Physics: - Biology/Biochemistry: Cell structure; Organelles; DNA; RNA; Proteins; Enzymes; Antibodies; - Chemistry: fundamentals of Inorganic and Organic chemistry; Standard Techniques; - Physics: Fundamentals of Optics; Thermodynamics; - Math: Statistics (basics); Basic knowledge in Biology (high school level) and Thermodynamics (BSc level) is assumed to be present; A bachelor degree in Applied Physics; Biomedical Technology or Advanced Nanotechnology; Biomedical Signal Acquisition; Micro Electro Mechanical Systems Design; Technology.

* Mandatory preliminary knowledge: Entry requirements for BME.
** Mandatory preliminary knowledge: Introduction in Bioengineering Technologies. Note: this course is compulsory for students enrolling for the course Tissue Engineering

Note: Only possible as a complete package because '*201800288 Introduction to Bioengineering Technologies (1A)*' is the mandatory introduction to '*201400330 Applied Cell Biology (1B)*'.

Block 1A

201800288 - Introduction to Bioengineering Technologies

NOTE: This course is specifically aimed at students who did not complete a bachelor in Biomedical Technology at the University of Twente. This applies to international students and students who completed a bachelor other than

Biomedical Technology. The purpose is to level background knowledge in cell biology and chemistry to the level of students who completed the bachelor in Biomedical Technology in Twente and to acquire or train lab skills.

The course consists of practicals and self-study with diagnostic exams and assignments.

During the practicals, students are familiarized with working safely in an ML-1 laboratory according to Dutch regulations. Students will be trained in essential lab skills such as pipetting, gel electrophoresis, spectrometry, microscopy, and safe and sterile working in a biological safety cabinet. Students will perform an actual cell culture experiment. Students will learn to keep a lab journal at advanced level. The practicals will be performed in small groups with ample opportunity for individual feedback. Data from the cell culture experiment will be presented during a poster presentation.

This course also enables students to search, find, and evaluate scientific literature using the digital library. This also includes proper citing and referencing. Students will receive individual feedback on the search process and search results.

A poster workshop will optimally prepare students how to make and present a scientific poster.

Potential gaps in pre-knowledge will be assessed with diagnostic tests in cell biology and organic chemistry. Starting point will be to acquire the key learning objectives derived from the bachelor BMT which will be essential to successfully complete the compulsory master courses in Applied Cell Biology, Tissue Engineering and various chemical courses. From these diagnostic tests individual study programs will be designed to bridge the knowledge gap (if necessary). New this year will be a comprehensive lecture that summarizes key concepts on organic chemistry. During the course additional diagnostic tests will be taken to monitor the progression of the students. If necessary, individual meetings with teaching staff can be arranged to provide the individual student with additional feedback. If necessary, students can take some chemistry classes form the bachelor BMT module 1 program (in English). The final test will be poster presentation of the cell culture experiment placed in a broader perspective related to one of the research theme of this master track, namely, cell material interactions. This will be representative for the required entrance level for the successful completion of the compulsory master courses.

201700040 - In vitro diagnostics

In vitro diagnostics (IVD) is the analysis of bodily fluids and tissue samples for the purpose of medical diagnostics.

Main aims of the course:

1. To understand the requirements an IVD device has to fulfil
2. To understand the processes and concepts employed in existing IVD devices
3. To apply this understanding to critically assess recent developments and proposed concepts for targeted biomarkers and/or diseases.

Lecture: After an introduction on the purpose of IVD devices and the requirements they have to fulfil, the lectures will focus on the (bio)-chemical and physical processes and technical concepts employed in these devices:

- Sample preparation techniques
  - enrichment/purification/separation
  - amplification
  - labelling
- Detection techniques:
  - label free
  - fluorescence based
  - electrochemical/electrical
- Microfluidics for IVD
- Point-of-care diagnostics

Electives: choose 5 EC

193640020 - Biophysical Techniques & Molecular Imaging

Luminscence: Fluorescence, phosphorescence, bioluminescence; advanced luminescence principles: polarization, lifetime; bulk and single molecule approaches; imaging and spectroscopy in a microscope; intrinsic and extrinsic fluorophores; protein fluorescence; genetically encodable fluorescent markers, nanoparticles

Microscopy: wide-field, dark field, confocal, phase contrast, fluorescence microscopy (FRAP, FLIP, FLIM, FRET), micro-spectroscopy, hyperspectral imaging, polarization contrast, lifetime imaging, resonance energy transfer imaging, nano-particle imaging, non-linear microscopy.

Vibrational Spectroscopy and Imaging: label-free contrast methods such as spontaneous Raman micro-spectroscopy, Infrared microscopy, CARS microscopy, non-linear fluorescence microscopy and single molecule micro-spectroscopy.

202001414 - **Physical Biology**

The complex behaviour of cells and bio-molecules cannot be fully understood without deep physical insight, triggering an increasing interest in physical biology. Generic physical concepts have given quantitative insight into how muscle cells convert the chemical energy of ATP into movement and into how DNA can replicate itself during cell division. In this course, we will discuss both the biochemistry and basic physical principles that help us understand and quantitatively describe biological phenomena and processes occurring in cells.

After an introduction into cellular and molecular biology, you will learn how the confluence of thermal, mechanical, chemical and entropic forces make the behaviour of cells and biological macromolecules so different from our everyday experience. Topics include: the central dogma in molecular biology, cellular transport mechanisms, different forms of intracellular signalling mechanisms, , diffusion, entropic forces, self-assembly, biopolymer elasticity, and molecular machines. The course consists of lectures, self-study, and 15 min presentation and peer review by students on a self-chosen subject related to the latest developments in one of the course topics.

202300081 - Advanced Anatomy and Physiology

This course will introduce anatomy and physiology by focusing on organ structure, function(s) and regulatory principles. The main organs that will be covered in this course: liver, kidney, heart, lungs, and brain that corresponds to metabolism, regulation of extracellular fluid and urine formation, circulation, respiration, and coordination of body functions, respectively. Moreover, the links between these systems and pathophysiology (physiological changes in response to disease) will be provided. Lectures on different models including 2D, 3D in vitro, in vivo preclinical models, engineered organs, and organ-on-a-chip platforms will be provided to reveal the organ complexity and challenges with the development of biomimetic organ systems to study health and diseases in the lab settings.

BLOCK 1B

201900088 - **Applied Cell Biology**

a) Theoretical and technical lectures on Applied Cell Biology;
b) In-depth analysis and oral presentation of a research paper on Applied Cell Biology
c) Design experiments based on a hypothesis, perform experiment and verbally report, including poster presentation.
d) Experimental design will be guided by computational model of cellular communication network. The students will generate dynamic models in ANIMO, a software tool developed in-house.

Learning goals:

a) Get acquainted with terminology used in Applied Cell Biology;
b) Understanding the principles of cellular communication at advanced level.
c) Use the knowledge of cell signaling for the development of typical biomedical engineering strategies for controlling cell behavior.
d) Understand how genetic information flows and how one can control it to steer cell behavior;

The modules are tentative and subject to change. Please check the website *regularly.*

e) Understand how tissues develop and are maintained throughout the life of an organism and use this knowledge for solving challenges in development of organs-on-chip;
f) Understand the road from hypothesis to conclusion and techniques used to test and confirm/discard a hypothesis;
g) Capable of selecting the most appropriate molecular and/or cell biological techniques for testing an hypothesis;
h) Perform a cell biology experiment, analyze data using a computational model and present data orally in poster format.

Note: this course is compulsory for students enrolling for the course Tissue Engineering

202200254 - Advanced Drug Delivery and Nanomedicine

Advanced Drug Delivery and Nanomedicine (ADDN) course provides both fundamental and applied knowledge on the topic of drug delivery and nanomedicine. Conventional medicines, either administered orally or systemically, are not always sufficient for achieving the desired therapeutic effects but rather exhibit adverse side effects. Therefore, novel drug delivery systems are highly crucial to develop, using which the drugs can be specially delivered at the targeted site or even to the specific cell types. Using these novel approaches, high therapeutic effects with low side effects can be achieved. A large part of the course will be devoted to different drug delivery systems including nanomedicine. Besides drug delivery systems, use of nanomedicine for imaging and diagnostics as well as theranostics (therapeutics + diagnostics), will be covered during this course. Furthermore, a genetic disorder or chronic diseases can be treated by delivering nucleic acid (DNA or RNA) to the pathological cells, inducing or suppressing a specific genetic function. Also, gene delivery technologies are crucial to develop vaccines such as mRNA vaccine against COVID-19. The ideal drug or gene delivery system should be nontoxic, biocompatible, safe, simple, and easy to fabricate as well as should provide efficient targeting. This course provides an in-depth overview of drug and gene delivery technologies including nanomedicine.

Electives: choose 5 EC

191211120 - Lab on a Chip

The Lab on a Chip course will take the student to the world of miniaturised systems used in various fields of chemistry and life sciences. A "Lab-on-a-Chip" consists of electrical, fluidic, and optical functions integrated in a microsystem, and has applications in (bio)chemical and medical fields. The core of most lab-on-a-chip system is a microfluidic channel structure, through which nanoliter amounts of liquids with dissolved molecules are propelled, separated and reacted by hydraulic, electrokinetic or surface forces. The fluidic structures are machined in materials like fused silica, borofloat glass, or polymers. The course will treat a number of aspects of such microsystems in seven problem-based learning sessions. Groups of 4 students receive the problem on Monday and try to find solutions to the problem during the week, using a.o. the material offered in a reader. They give a presentation of their solution to the other groups and the teachers on Friday, which is followed by a discussion on the subject treated. The problems offered concern the transport of liquid and dissolved molecules in microsystems, aspects of microfabrication, electrochemical and optical detection methods, the manipulation of cells in microfluidic systems and separations in microfluidic systems. The course is aimed at MSc students of Biomedical Engineering, Electrical Engineering, Nanotechnology, Chemical Engineering, Mechanical Engineering or Applied Physics.

201400283 - Biomedical Materials Engineering

This course deals with the basic principles of regulation, processing, surface modification and analysis of biomaterials as well as of tissue-biomaterial interactions in regenerative medicine.