GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2024-2025

Bio-imaging and Image Informatics (I002617)

Course size *(nominal values; actual values may depend on programme)*

Credits 4.0 **Study time 120 h**

Course offerings in academic year 2024-2025

A (semester 1)	English	Gent

Lecturers in academic year 2024-2025

Skirtach, Andre	LA25	lecturer-in-charge
Parakhonskiy, Bogdan	LA25	co-lecturer

Offered in the following programmes in 2024-2025	crdts	offering
Master of Science in Bioinformatics(main subject Bioscience Engineering)	4	A
Master of Science in Bioscience Engineering: Cell and Gene Biotechnology	4	A
Exchange Programme in Bioinformatics (master's level)	4	A
Exchange Programme in Bioscience Engineering: Cell and Gene Biotechnology (master's level)	4	A

Teaching languages

English

Keywords

Bio-imaging, Microscopy, Image Processing, Image Analysis

Position of the course

The goal of this course is to provide a broad overview of different modalities for acquiring images and analyzing image data sets from biological material at the *nano-, micro- and macroscopic level*, with an eye on extracting qualitative as well as quantitative information.

Contents

We start off with a module explaining the basic concepts in microscopy-based image formation to define the possibilities and limitations of the available imaging technologies. In this module, standard fluorescence- and transmission light- as well as more advanced electron- and label-free Raman/IR (infrared), AFM (Atomic Force Microscopy) technologies are discussed. Their application ranges, recent developments in research as well as industrial applications (e.g. holographic microscopy) are also considered. The increase in throughput and variability in human interpretation calls for objective, automated image analyses, which will be treated in a second module. Finally, a third module will focus on the state-of-the-art of multimode microscopy integration methods and applications, emphasizing their multidisciplinary character and integration with bio- and nano- technologies.

Breakdown

Chapter I. Imaging modalities
• Light Microscopy
- Basics of Optical Microscopy (bright-field, phase contrast, fluorescence)
- Advanced Light Microscopy Techniques (confocal, live-cell, non-linear)
- Fluorophores
- Single molecule imaging and Superresolution
• Label-free imaging
- Atomic Force Microscopy (AFM)
- Raman scattering and IR (infrared) Microscopy
• (cryo)-Electron Microscopy
- Scanning Electron Microscopy
- Transmission Electron Microscopy

Chapter II. Image Analysis
• Image Properties and Image Processing
- Raster versus Vector Images
- Pixel, Neighbourhood, Morphological Operations. Kernel
- Frequency Domain and Image Reconstruction
• Image Analysis
- Feature Extraction and Elements of Machine Learning Algorithms

Chapter III. Interaction and integration
• Medical Imaging and Photo-manipulation (optical tweezers)
• Correlative, Multimodal (for example, Light and Electron) Microscopy
• High-throughput and lab-on-chip technologies

Initial competences

Basics of cell biology, optics and informatics

Final competences

1 Understand the basic principles of modern imaging technologies, their components and methods, their advantages and disadvantages.
2 Apply imaging methods including selecting appropriate imaging techniques and sample preparation methods for a biological problem.
3 Apply basic image processing in ImageJ, analysis tools, and workflows for image analyses.
4 Know bio-chemical and biomolecular principles of fluorescence of molecules.
5 Be familiar with modern and recent developments in the area of instrumentation used for biological image formation.
6 Know and apply optical ray tracing and propagation in a lens system and a microscope.
7 Know the resolution limits of optical, label-free and electron microscopy in regard with applicaiton to cells and biological objects.
8 Understand the atomic structure, molecular mechanisms and the principles of vibrations of atoms in bio-molecules and thier effect on the scattering of light and electrons.
9 Be able to choose appropriate operation conditions and perform alignment of a microscope.
10 Know complementarity and applicability of label-free methods versus fluorescence microscopy in biological image formation.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Lecture, Practical, Independent work

Extra information on the teaching methods

The course consists of theoretical lectures, which are accompanied by practical sessions/demonstrations (including PC). Hand-out and references contain comprehensive information about all subjects.
A number of practicum sessions are planned. In one of them students build their own microscope based on their calculations. Other practicums involve either direct hands-on work or demos with commercially available instruments.
There are also presentations by groups of students on a chosen subject, which is covered in the course. Some other groups are expected to ask a question or questions related to the subject of the presentation.

Study material

None

References

Most references are in the handout material

Course content-related study coaching

Assessment moments

end-of-term and continuous assessment

Examination methods in case of periodic assessment during the first examination period

Written assessment

Examination methods in case of periodic assessment during the second examination period

Written assessment

Examination methods in case of permanent assessment

Participation, Assignment

Possibilities of retake in case of permanent assessment

examination during the second examination period is possible

Calculation of the examination mark

end-of-term evaluation (95 %) continuous assessment (5 %)