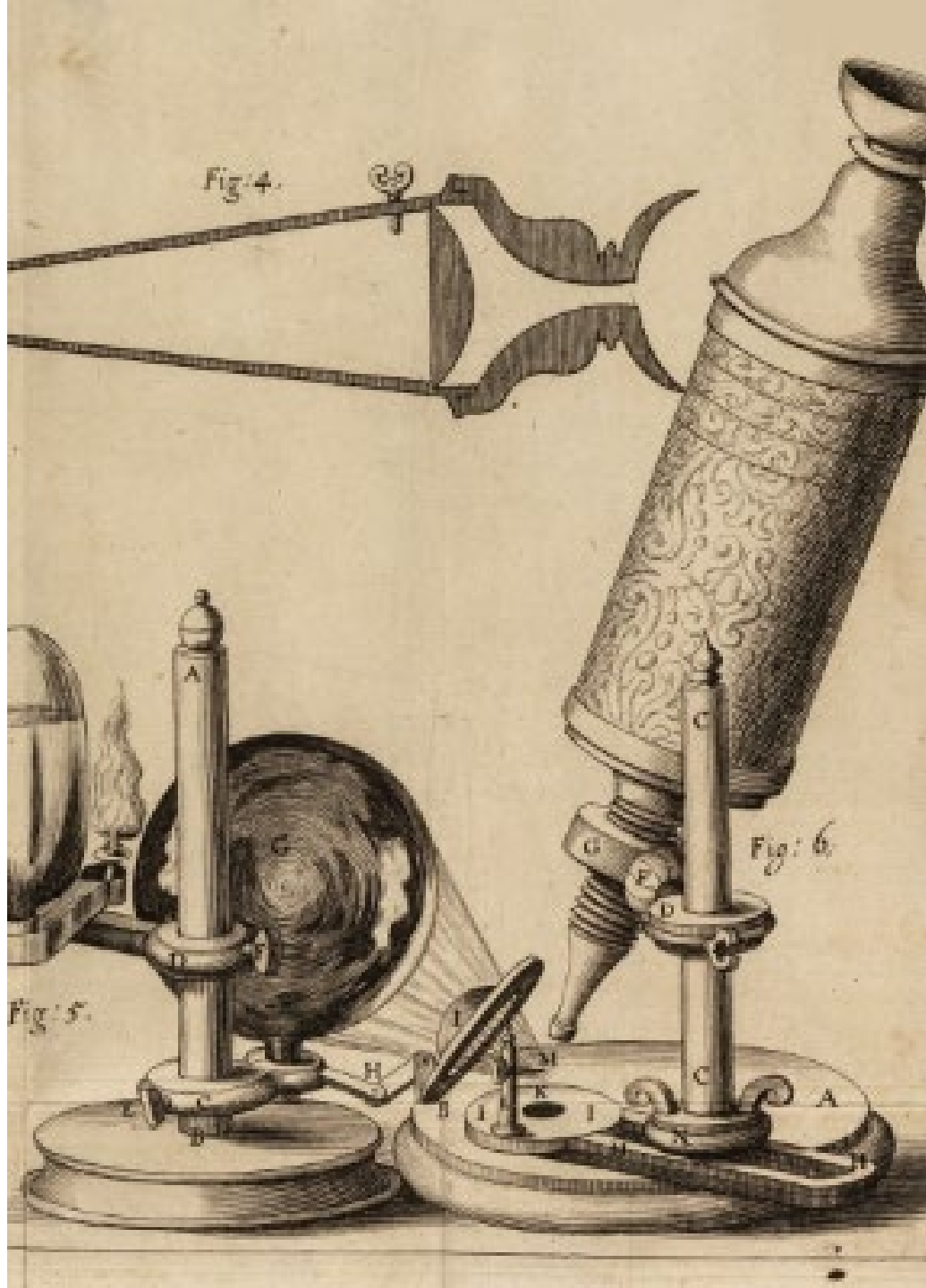




Biomicroscopy I

MICRO-561

R. Hooke, Micrographia, 1665
<https://royalsociety.org/blog/2020/07/micrographia-online/>



Biomicroscopy I MICRO-561

Organisation & Logistics

Biomicroscopy I

MICRO-561

■ Instructor

- Prof. Hatice Altug
Head of BioNanoPhotonics
System Laboratory
STI-IBI-BIOS

■ Teaching assistants

- Daniil Riabov
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- Jiayi Tan
jiayi.tan@epfl.ch

Biomicroscopy I

Logistics

- | | | | |
|------------|--------|----------------|----------------------------|
| ■ Lecture | When: | Tuesday | 15:15-16:00
16:15-17:00 |
| | Where: | DIA005 | |
| ■ Exercise | When: | Tuesdsay | 17:00-19:00 |
| | Where: | DIA005 | |
| ■ Website | | moodle.epfl.ch | |

Biomicroscopy I

Course Summary

- Understand the principles of optical microscopes, their limitations and advantages by using geometrical and wave optics.
- Introduce commonly used biomicroscopy methods such as wide-field and fluorescence.
- Cover basic microscopy components for investigating biological samples.

Biomicroscopy I

Learning outcomes

- Sketch basic optical systems
- Characterize the elements of a microscope
- Estimate the resolution of an imaging system
- Understand principles of wide-field microscopy and fluorescence microscopy
- Propose a suitable microscopy configuration for imaging a biological sample

Biomicroscopy I

Content

- Ray (geometrical) optics
- Matrix (ABCD) optics
- Wave optics
- Fourier optics
- Magnification and optical design
- Resolution in microscopy point-spread function (PSF)
- Contrast in microscopy
- Aberrations in microscopy
- Principles of wide field and fluorescence microscopies
- Microscope elements: objectives, eyepiece, filters, sources, detectors
- Biomicroscopy application, - examples

Biomicroscopy I

Syllabus (Tentative)

Lecture 1	10 September
Lecture 2	17 September
Lecture 3	24 September
Lecture 4	01 October
Lecture 5	08 October
Lecture 6	15 October
Lecture X	22 October
Lecture 7	29 October
Lecture 8	05 November
Lecture 9	12 November
Lecture 10	19 November
Lecture 11	26 November
Lecture 12	03 December
Lecture 13	10 December
Lecture 14	17 December

Introduction & Ray Optics-1
Ray Optics-2 & Matrix Optics-1
Matrix Optics-2
Matrix Optics-3 & Microscopy Design-1
Microscopy Design-2
Microscopy Design-3
Holiday
Resolution-1
Resolution-2
Resolution-3
Contrast & Fluorescence-1
Fluorescence-2
Fluorescence-3, Sources
Filters & Detectors
Bio-application Examples

Biomicroscopy I

MICRO-561

■ LECTURE MATERIALS

- Course slides, exercises and solutions will be posted in Moodle.
- Any supporting reading materials and information will be posted in Moodle.

■ SUGGESTED BOOKS:

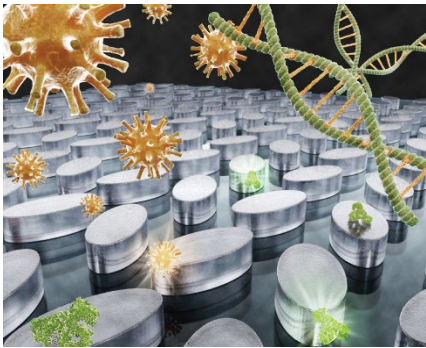
- Fundamentals of Light Microscopy and Electronic Imaging by Murphy and Davidson. 2nd Edition.
- Fundamentals of Photonics by Saleh & Teich. 2nd E
- Optics by Hecht 7th Ed.

BioNanoPhotonic Systems Labotatory

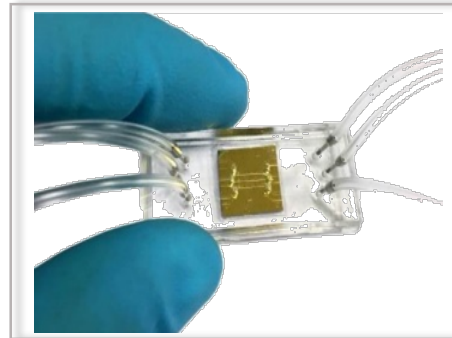
Mission

Develop *science & technology* for powerful *optical biosensors, bioimaging and spectroscopy systems* that can *impact* areas ranging from basic research in life sciences to applications such as diagnostics

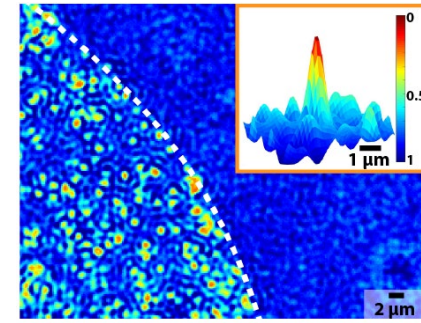
Nanophotonics



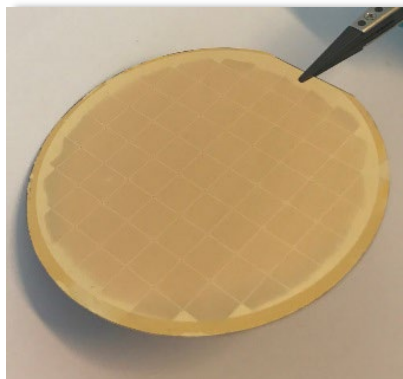
Microfluidics



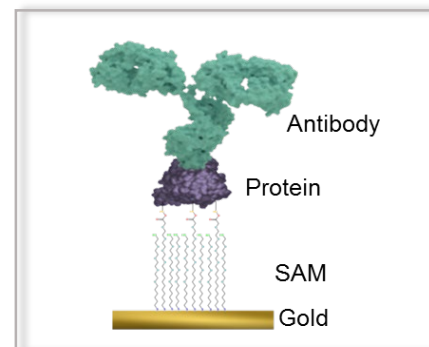
Imaging
Hyperspectral & Lens-free



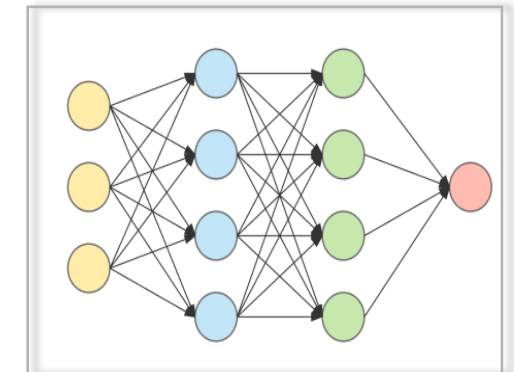
Nanofabrication



Surface Chemistry & Microarrays



Data Science



Ongoing Research Directions



Live Cell & Single-Cell Technologies

- Cell screening & profiling, e.g. for immunoengineering applications
- Real-time & label-free secretion analysis from single cells
- Cell-cell interactions & incorporation of biomimetic surfaces



Since Lab-on-a-Chip 2017 ...

Recent highlights:

ACS Sensors 2018

Small 2018

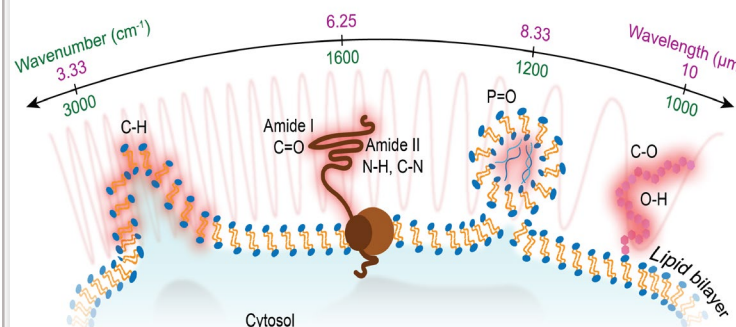
Science Advance 2021

Biosensors and Bioelectronics 2022

Nature Biomedical Engineering 2023 ...

Surface Enhanced IR Spectroscopy

- Chemical-specific & fingerprint detection
- Monitor conformational/structural changes
- Real-time measurements in aqueous solution



Since PNAS 2009 ...

Recent highlights:

Nature Communications 2013 → patent granted

Science 2015

Nature Communications 2018

Science 2018

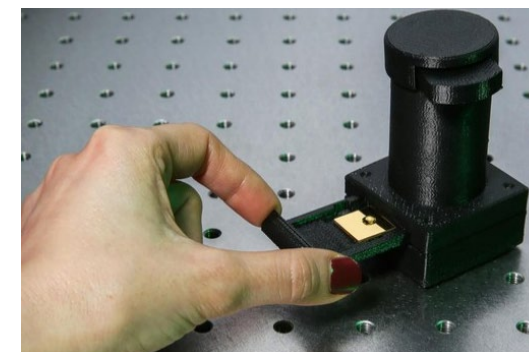
Science Advance 2019

Advanced Materials 2021 & 2022

PNAS 2023 ...

Point-of-Care Diagnostics

- Low-cost, portable, rapid & multiplexed microarray technologies.
- New device schemes including lens-free microscopy, hyperspectral imaging ...



Since PNAS 2011 ...

Recent highlights

Light Science and Technology 2018

ACS Photonics 2015 → patent granted

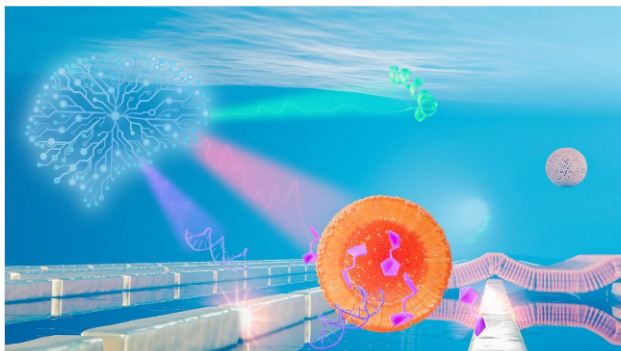
ACS Nano 2018 → patent filed

Nature Photonics 2019

Small 2020

Nature Communications 2021 ...

BIOS: Student Projects Available



Metasurface-enhanced infrared spectroscopy for biosensing applications

Description:

Infrared (IR) spectroscopy is a gold-standard bioanalytical technique for label-free, non-destructive and chemical-specific detection of biomolecules such as proteins, lipids, and nucleic acids by studying the vibrations of their molecular bonds. Recently, engineered nanophotonic metasurfaces have emerged as a powerful approach to significantly enhance the performance of IR spectroscopy for extreme sensitivity, faster response time,



Machine Learning for Chiral Metasurfaces

Description: Metasurfaces offer the possibility for manipulating light at the nanoscale. This disruptive technology can be used for a wide field of applications. However, challenges in designing the best possible metasurfaces persist and cannot keep up with the demand for advanced optical functionality. This project aims to tackle the optical design challenge of metasurfaces for chiral sensing. We want to use modern machine learning approaches with high quality optical simulations to find the metasurfaces suited best to characterize chiral molecules such as DNA, drugs or



Advanced Nanofabrication for Nanophotonics-Enhanced Biosensing

Project Description:

This project focuses on developing the advanced fabrication technique for nanophotonic structures using Deep-UV lithography. As a master Student, you'll work at the renowned CMi facility, developing and optimizing a process for fabricating nanoplasmonic structures in the cleanroom. Using cutting-edge techniques like DUVL lithography, ion beam etching, and advanced characterization tools, you'll process wafers