SEMMELWEIS UNIVERSITY

Georg von Békésy
Biophysics Research Center

"The pursuit of truth and beauty is a sphere of activity in which we are permitted to remain children all our lives."

Albert Einstein

Mission

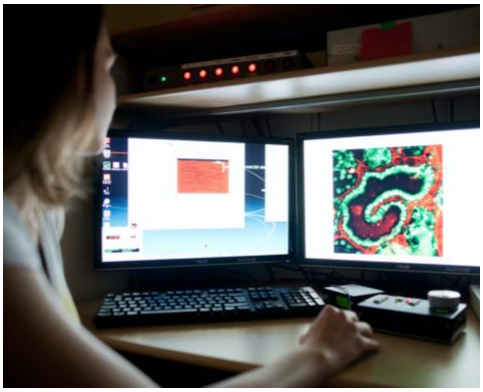
The mission of the ***Georg von Békésy Biophysics Research Center*** is to provide an imaginative playground for innovative research, where fundamental questions may be addressed, by using novel instrumentation, at all levels of biological organization ranging from individual molecules to the whole organism.

History

The Georg von Békésy Biophysics Research Center is maintained by the ***Department of Biophysics and Radiation Biology***. The department, established in 1948, has traditionally been devoted to high quality of research and education. Its earlier directors were Gyula Koczkás (1948-1950), Imre Tarján (1950-1982), Györgyi Rontó (1982-1999) and Judit Fidy (1999-2008). The first biomedical radioisotope laboratory of Hungary was established here. A crystal physics research group of international renown had been in operation for decades. The current director is Miklós Kellermayer. Research activities cover the fields of molecular and cellular biophysics, nanobiotechnology and radiation biophysics, single-molecule mechanics and in vivo imaging. Outstanding problems of biology are explored with novel and continuously developed methodologies and instrumentation. The predecessor of the von Békésy Center is the ***Nanobiotechnology and In Vivo Imaging Center*** which was established in 2009 as an important member of the Semmelweis Nanosciences Network. The von Békésy Center is a member of the Semmelweis BioImaging Consortium and the EuroBioImaging network.

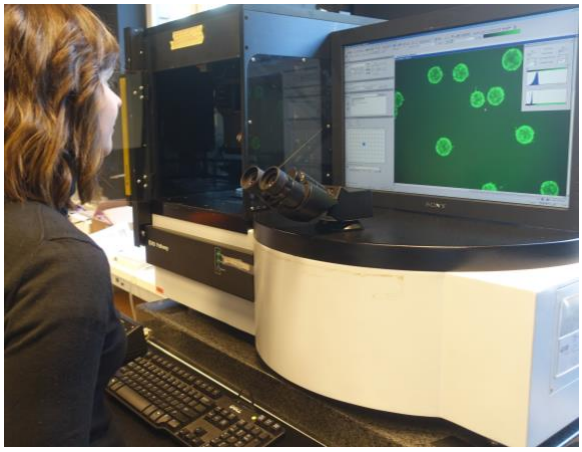
Facilities, Research, Innovation
Optical microscopy

***In vitro* motility assay**
In the *in vitro* motility assay, individual actin filaments can be visualized in real time as they glide over a surface coated with the motor protein myosin. Fluorescently labeled actin filaments are visualized with an epifluorescence microscope equipped with a microchannel-plate-intensified CCD camera.



Laser scanning multiphoton confocal fluorescence microscopy
In multiphoton fluorescence the fluorophore is excited by the simultaneous absorbance of two or more long-wavelength photons. Hence, non-harmful infrared excitation may be used in live specimen. Our Femtonics system is uniquely built around an inverted microscope, enabling unusual excitation possibilities.

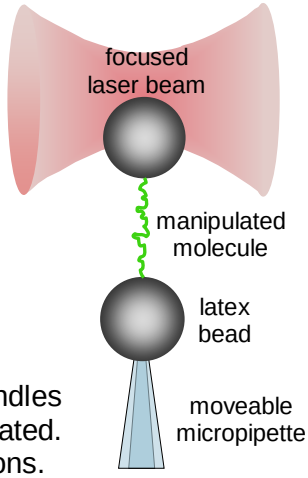
High content microscopy
High-content analysis is a phenotypic screening conducted in individual living cells within a culture by simultaneously reading out several microscopic parameters. In our BD Pathways system cells, in a 96-well plate, expressing or labeled with fluorophores are analyzed with a spinning-disc confocal microscope, while reactions may be initiated with a robotic pipettor.



Epifluorescence microscopy with single muscle fiber mechanics
Muscle contraction and force generation may be investigated by manipulating individual muscle fibers. The sarcomere length is followed in real time according to Fast Fourier Transformation of the phase-contrast image, whereas muscle force is simultaneously measured in the mN range.

Stimulated Emission Depletion (STED) microscopy with multiphoton excitation
STED microscopy is an important member of the family of superresolution microscopes. In our system a unique multiphoton excitation, enabling the initiation of photochemical reactions, is built on top of a system capable of high, below 100 nm optical resolution.

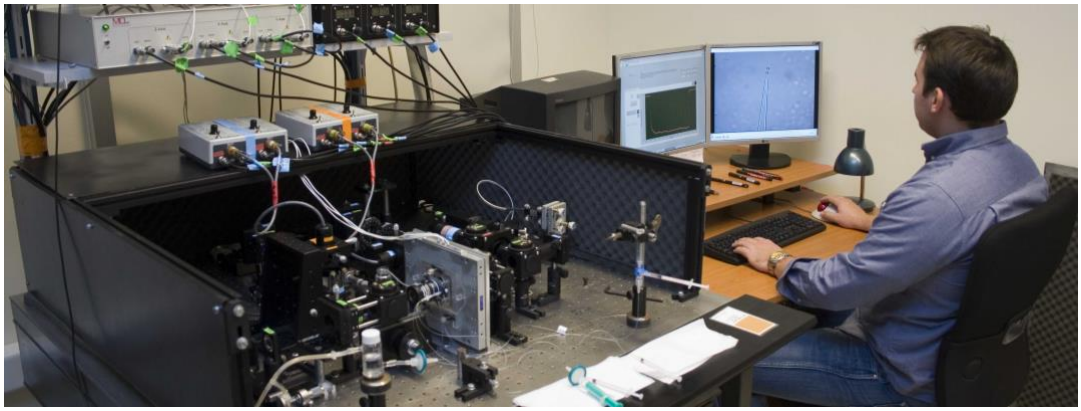
Optical tweezers



In optical tweezers tiny refractile microparticles are manipulated with a focused, powerful laser beam. Because optical tweezers function as picotensiometers, that is, they can be used to measure miniscule forces, it is possible to investigate the nanomechanics of individual molecules and intermolecular interactions.

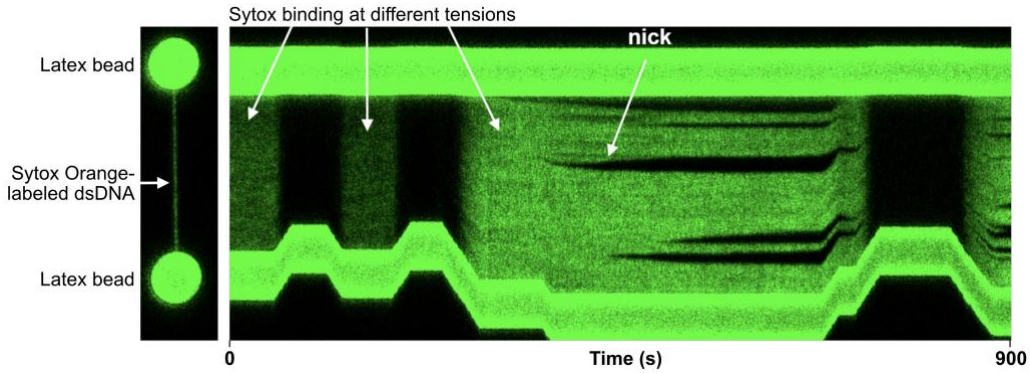
Dual-beam counter-propagating optical tweezers

A custom-built unique, double-beam apparatus that directly measures molecular forces based on photon momentum exchange. The microparticles or microbeads function as handles by which individual molecules may be grabbed and manipulated. The available force range is between 0.1 and 150 piconewtons.



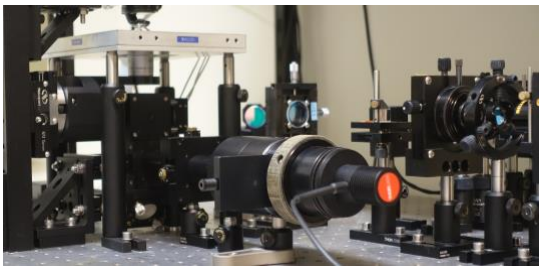
Double optical trap combined with confocal microscopy

Integrated correlative optical trap - fluorescence system (LUMICKS C-Trap) that combines multi-trap tweezers with multi-color confocal microscopy and multi-channel laminar-flow microfluidics. Dedicated to manipulating single, fluorescently labeled molecules (e.g., dsDNA below) so that they can be visualized while under tension.



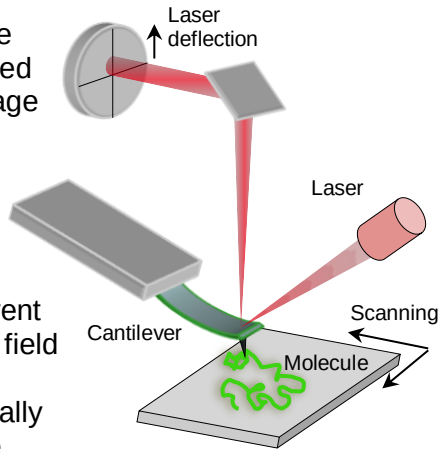
Double optical trap combined with magnetic tweezers

Custom-built instrument in which molecules can be pulled and twisted via a magnetic bead. Integrated with PDMS-based microfluidics.



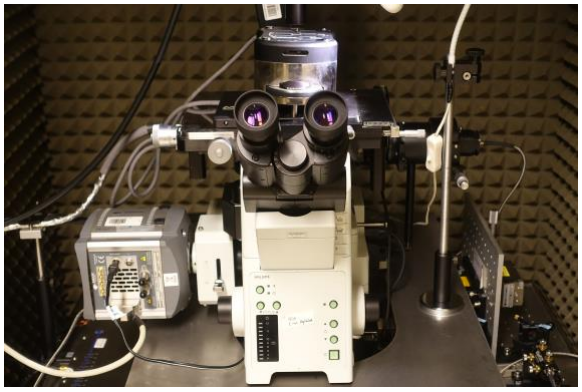
Atomic Force Microscopy (AFM)

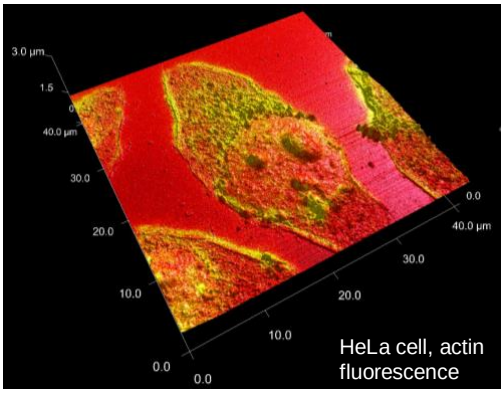
The AFM is a scanning probe device in which the sample surface is scanned with a sharp tip at the end of a flexible cantilever. Cantilever bending is monitored by measuring the position of a reflected laser beam while the sample is scanned with piezoelectric actuators. As a result, a topographical image with atomic/molecular resolution is obtained.



AFM synchronized with Total Internal Reflection Fluorescence (TIRF) Microscopy

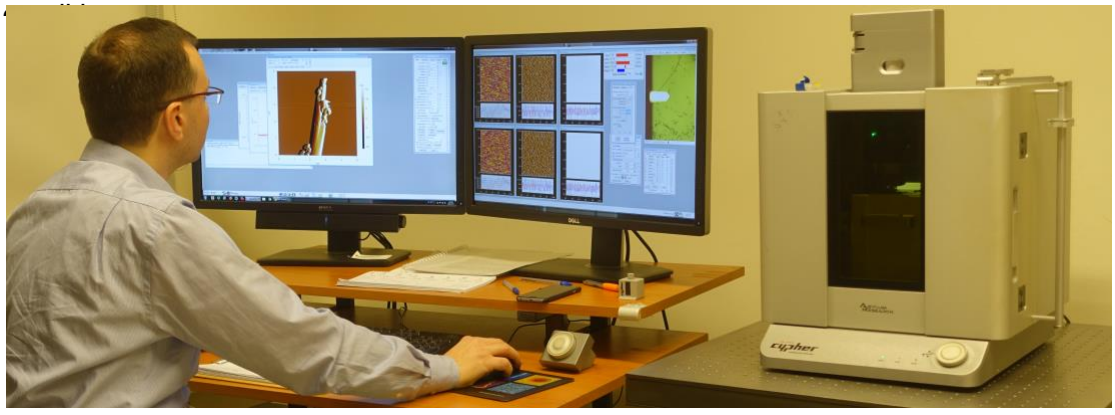
TIRF microscopy utilizes the phenomenon of total internal reflection that arises as light travels across media with different refractive indeces. A narrow electric field called evanescent field arises which excites suitable flurescent molecules. Our instrumental arrangement is unique in that it allows for spatially and temporally synchronized acquisition of the fluorescence emission and topographical or mechanical data.





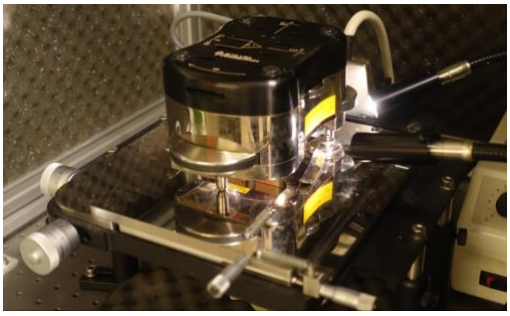
Atomic-resolution AFM with photothermal cantilever resonance control

This high-end AFM (AsylumResearch Cypher) allows for fast imaging with high resolution under environmentally controlled (temperature 0-150 ˚C, solution and gas exchange)



Molecular Force Spectrometer

With the Molecular Force Probe force spectra of mechanically manipulated single molecules may be rapidly collected.

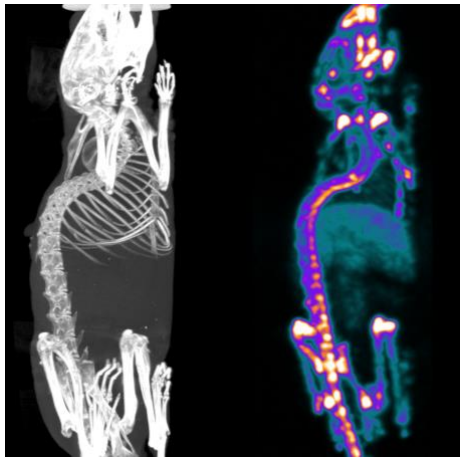


Quantitative *In Vivo* Molecular Imaging

The laboratory hosts a number state-of-the-art multi-modal iaging devices that allow the superposition of functional information (e.g., accumulation and clearance of isotope-labeled compounds or nanoparticles) on high-resolution anatomical images. Besides nanoSPECT/CT and nanoPET/MRI, a dedicated µCT (nanoXCT) and fluorescence imagers (FOBI), including a CellVizio Dual Band fluorescence endoscope, are available.

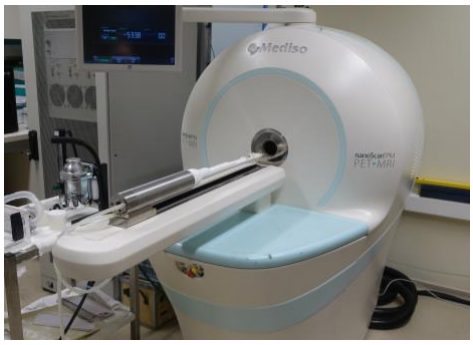
NanoSPECT/CT

Single Photon Emission Computed Tomography (SPECT) imaging system by Mediso Ltd combined with a low-dose high-resolution micro X-ray CT scanner. It offers the unique combination of 400 µm resolution in SPECT with high throughput and absolute quantitation of image data. It enables the detection of pM quantities with precise anatomical details (40 µm resolution).



NanoScan PET/MRI

The NanoScan PM PET/MRI by Mediso Ltd combines a 1 Tesla permanent-magnet MRI, that offers 100 µm spatial resolution, with a PET detector ring usine Tera-Tomo PET engine capable of 700 µm resolution. The images of the two modalities are collected in a tandem arrangement through a common user interface.



Optical Spectroscopy

The optical spectroscopy laboratory offers state-of-the-art steady-state and time-resolved luminescence (fluorescence, phosphorescence) and absorption (UV, VIS, IR) spectroscopies under a wide range of experimental (temperature, pressure) conditions. Temperatures as low as a few kelvins may be achieved with a cryostat, and spectra may be recorded at pressures as high as ten of kilobars.

Molecular Interactions

The Molecular Interactions laboratory contains technologies that allow the recording of structural, kinetic and thermodynamic parameters which are sensitive to the interaction between biological molecules. The instrumentation contains a dynamic light scattering device, a quartz-crystal microbalance and an isothermal titrating calorimeter.

Georg von Békésy Biophysics Research Center
Semmelweis University, Basic Medical Science Center
Department of Biophysics and Radiation Biology

- Websites:
  http://biofiz.semmelweis.hu
  http://semmelweis.hu/molecularimaging/

- Location:
  Budapest, Hungary
  Tűzoltó utca 37-47
  H-1094

- Facility locations:
  Atomic Force Microscopy - Room 0.202
  Quantitative In Vivo Molecular Imaging - Rooms 0.201, 0.204, 0.205, 0.207
  Molecular Interactions - Room 2.227
  Optical Microscopy - Room 2.219
  Optical Spectroscopy - Room 2.220
  Optical Tweezers - Room 0.203

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