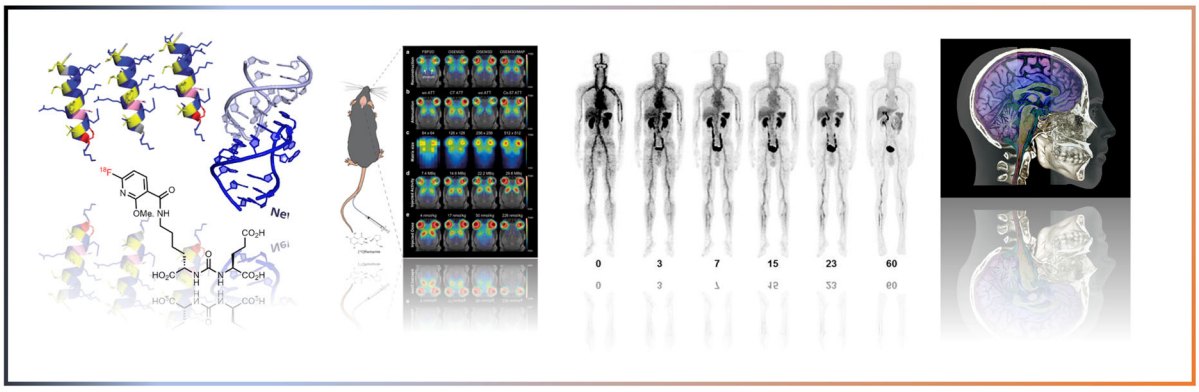
From Molecules to Mice to Men

Research Focus Module by the MUPIC Consortium

Module coordinators: apl.-Prof. Dr. Heike Endepols, Prof. Dr. Holger Grüll



Structural imaging systems such as *Computer Tomography (CT)*, *Magnetic Resonance Imaging (MRI),* as well as the nuclear imaging modalities *Single Photon Emission Computer Tomography (SPECT)* and *Positron Emission Tomography (PET)* offer the unique opportunity to non-invasively study biological processes such as disease development or response to therapy in vivo. While MRI and CT offer superb contrast for soft tissue and bone, respectively, PET and SPECT provide molecular information at tissue or cellular level using target specific probes - termed molecular imaging. Nuclear imaging in combination with MRI or CT is widely used to visualize e.g. targets related to tumor development, the tumor microenvironment, immune response or also related to neurological diseases. Moreover, molecular imaging allows assessing pharmacokinetics and biodistribution of radiolabeled molecules or drugs in vivo, making it a perfect tool for (bio-)chemical and pharmacological research. To optimize synergies among all groups working on imaging methods and applications for oncology and neurology, we established the interfaculty network “Molecular Imaging Platform of the University of Cologne (MUPIC)”. One goal of the MUPIC consortium is to introduce these methods to chemistry and neuroscience students in form of a research focus module.

The lectures will cover (radio, bio-) chemistry including probe design and synthesis, radiolabeling, biodistribution of drugs, biological targets & multimodal imaging in neurological disorders and oncology, imaging methods, computer science incl. image data analysis, 2D and 3D visualization. The module will also comprise a visit to the CAVE (https://rrzk.uni-koeln.de/hpc-projekte/visualisierung/cave), with a demo of 3D visualization of selected medical images covering neurology and oncology. Furthermore, a hands-on 1-day course on MRI, CT, SPECT or PET will be offered. As part of the seminar, each student will present a research paper, which will be graded.

The module will be open to students from programs including M.Sc Chemistry, M.Sc. Neuroscience and M.Sc. Experimental and Clinical Neurosciences.

From Molecules to Mice to Man (MoMiMa)

Type of module	Module code
• Research Focus Module	MM

ID	Workload	Credit points	Term	Offered every	Start	Duration
MN-C-MM	180 h	6	1. or 2. semester	every WiSe	WiSe24/25	1 semester

1	Course types	Contact time	Private study
	a) Lecture b) Seminar c) Practical Exercises	3 SWS / 45 h 1 SWS / 15 h 10 h	60h: Preparation and follow-up of lectures and seminars, report of practical exercises

2 Module objectives and skills to be acquired

- Concepts of (molecular) Imaging and Image-guided Drug Delivery
- Understanding of medical imaging technology (CT, MRI, PET, SPECT)
- Basic concepts of pharmacokinetics/pharmacodynamics (PKPD)
- Fundamentals of radiochemistry and radiolabeling
- Contrast agents and tracers by modality and applications
- Preclinical molecular imaging: a research tool
- Clinical (molecular) imaging: addressing appplications, clinical diagnostics/therapy
- Data analysis and visualization, radiomics, AI in image analysis

3 Module content

- Imaging systems:

→ Overview on *computed tomography* (CT), *magentic resonance imaging* (MRI), *positron emmission tomography* (PET), *single photom emission computed tomography* (SPECT), difference between preclinical and clinical systems.

- Exemplary studies of contrast agents/tracers with respect to their PKPD. Where do they go upon injection?
- Radiochemistry:

→ decay schemes of radionuclides used in medicine, radiolabeling, specific acivity

→ radiolabeling of molecules, covalent chemistry, chelates

- Synthesis of contrast agents and tracers

→ peptide probes,

→ small organic molecules, MRI contrast agents (dendrimers, nanoparticles) etc.

- Preclinical research using molecular Imaging

	→ neurology, oncology, reporter gene imaging, → MRI & high intensity focused ultrasound (HIFU) & smart materials for drug delivery • Clinical examples of molecular imaging and theranostics → PSMA PET & therapy, octreotide, FAPI… • Data Analysis using Ai and radiomics approaches, data visualization
4	**Teaching methods** • Lecture (45 h) • Seminar with presentation of a scientific paper (15) • Lab course in imaging facility, hands on MRI, SPECT (7 hours) • Visit to the CAVE (RRZK), 3D data visualization (3 hours)
5	**Prerequisites (for the module)** **Formal requirements:** none **Additional academic requirements:** none
6	**Type of the examination:** seminar talk + discussion **Requirements for examination:** none **Examination restrictions:** none
7	**Credits awarded** Graded talk (+ discussion) at least “sufficient”
8	**Compatibility with other curricula** M.Sc. Neuroscience
9	**Proportion of the final grade** 6/120
10	**Module coordinator** Prof. Holger Grüll (Chemistry), apl.-Prof. Heike Endepols (Biology) **Speakers** Prof. Stephanie Kath-Schorr, Prof. Ines Neundorf, et al.
11	**Further Information**