DTU

UNIVERSITY OF COPENHAGEN

# Project Catalogue

2023

# Project Title:

# A Micropump for Biomedical Applications

Description:

Students will learn about micropump technology for wearable insulin delivery systems. They will design and test microfluidic valves, analyze fluid dynamics, and optimize pressure/flow rate control. Hands-on prototyping, testing, and calibration will be incorporated.

Required Qualifications: Interested in micropump mechanisms, microfluidics, fluid dynamics.

Responsible Institution/Department: DTU Healthtech, IDUN section, Building 345

Contact Information: Edwin En-Te Hwu (etehw@dtu.dk)

Allowed no of students per report: 2

DTU Supervisor: Jorge Pereda and Edwin En-Te Hwu

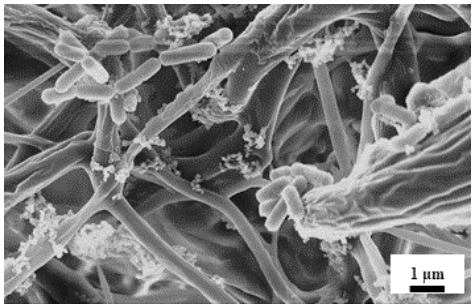
# MSc project for students in Biomedical Engineering and/or Health Technology relevant fields

**Project Title: Advanced Bacterial Identification and Discrimination through SERS Fingerprinting and Machine Learning**

**Project Description**: In this project, you'll have the opportunity to delve into the exciting world of bacterial identification and discrimination. We're combining Surface-Enhanced Raman Spectroscopy (SERS) with the power of machine learning to create a powerful and precise method for differentiating bacterial strains.

**Why This Project?**

- Innovative Technology: You'll work with SERS, a state-of-the-art technology that allows us to obtain unique "fingerprints" of bacteria. This technology opens up new horizons in microbiological research.
- Real-world Impact: Our research has practical applications in healthcare, environmental monitoring, and food safety. Identifying and discriminating bacteria with high accuracy can lead to significant advancements in these fields.
- Interdisciplinary Learning: You'll gain expertise in microbiology, spectroscopy, data analysis, and machine learning. This project offers a diverse set of skills that are highly valuable in today's scientific landscape.




**Required qualifications**: A background in biology, microbiology, chemistry, or related fields. A strong interest in data analysis, machine learning, or computational biology. A desire to work in a collaborative and innovative research environment.

**Responsible institution/department**: DTU. Health Tech

Contact information: Gohar Soufi gohsoo@dtu.dk

**Allowed no of students per report** (1-4): 2

**KU and/or DTU supervisor**: Gohar Soufi, Fatemeh Ajalloueian

# Advanced Conductive Composite for Pressure Sensing Applications

**Description:**

The primary aim of this research is to pioneer the development of a conductive elastomeric composite tailored for enhanced pressure sensing capabilities. The project seeks to address the existing limitations in current pressure sensor materials by integrating conductive fillers into a flexible elastomeric matrix, ensuring optimal performance without compromising mechanical flexibility. A secondary objective is to harness unique methodologies that optimize the alignment and distribution of these fillers within the matrix. This alignment, governed by external stimuli during the curing process, is hypothesized to significantly influence the composite's overall conductivity and sensitivity.

The research will commence with the synthesis of the composite, followed by the application of external stimuli to guide filler alignment during the curing phase. Subsequent characterization will assess the composite's mechanical robustness and electrical properties, ensuring it meets the desired benchmarks. The culmination of this project will be the design and testing of a prototype sensor based on the developed composite.

The expected outcome of this project is the development of a soft and flexible PDMS/MXene pressure sensor with high sensitivity, wide sensing range, and fast response time. The pressure sensor could have potential applications in wearable electronics, soft robotics, and human-machine interfaces.

**Required qualifications:**

- Educational Background: A Bachelor's degree in Chemistry, Materials Science, Chemical Engineering, or a related field.
- Research Experience: Prior experience in synthesizing and characterizing polymer composites.
- Familiarity with conductive materials and their integration into polymer matrices.
- Familiarity with material characterization techniques such as SEM, XRD, and four-point probe measurements.
- Technical Skills: Proficiency in using laboratory equipment related to polymer synthesis and processing.
- Knowledge of techniques for applying external stimuli to materials (e.g., electric or magnetic fields).
- Experience with sensor fabrication and testing would be advantageous.

Responsible institution/department: DTU – HealthTech department

Contact information: Morteza Alehosseini mortea@dtu.dk

Allowed no of students per report: 2

KU and/or DTU supervisor:

Alireza Dolatshahi-Pirouz aldo@dtu.dk Firoz Babu fbka@dtu.dk Morteza Alehosseini mortea@dtu.dk

# Project Title: Amplification for normal hearing tinnitus patients

Description:

Tinnitus derived from the Latin word tinnire meaning “to ring” is the sensation of sound without any external acoustic sound source and can be considered as a phantom perception of sound (Baguley et al., 2013). Tinnitus is defined as “the conscious awareness of a tonal or composite noise for which there is no identifiable corresponding external sound source” and is experienced by approx.. 15% of the European population (De Ridder et al., 2021, Biswas et al. 2022). A subgroup of tinnitus patients corresponding to 1.2% of the European population is suffering from tinnitus disorder where the perception of tinnitus is associated with “emotional and/or cognitive dysfunction, and/or autonomic arousal, leading to behavioral changes and functional disability” (De Ridder et al., 2021, Biswas et al. 2022). Hearing loss is the most common comorbidity for tinnitus patients and 80-90% of people with tinnitus have a measurable hearing loss (Baguley et al., 2013). There is scientific support of the use of hearing aids and combination devices for tinnitus patients with hearing loss (Jacquemin et al., 2022, Joergensen et al., 2022). Although the mechanism of the tinnitus relief by the devices is not understood yet, several mechanisms including reduction in central gain, habituation, improved communication, neuroplasticity and masking have been suggested (Jacquemin et al., 2022). However, patients with tinnitus and normal pure-tone sensitivity (i.e. a normal clinical audiogram) represents a minor yet not uncommon adult clinical population (Schaette et al., 2011). Anecdotally, some audiologists have tried to provide hearing aids with mild-gain amplification as a treatment for tinnitus and experienced good results. However, the effect of mild-gain amplification has not yet been studied. It is therefore essential to provide evidence to justify the practices to provide hearing aids to patients who otherwise do not qualify to receive the devices.

In this project we aim to investigate the effect of mild-gain amplification for normal hearing tinnitus patients. The main part of the study will be a two arm clinical study to investigate the effect of mild-gain amplification as tinnitus treatment. Participants with normal hearing (<20 dB) and problematic tinnitus will be recruited through the communication centre (Kommunikationscenteret, Hellerup). All participants will be enrolled in the standard treatment offered by the centre. The experimental group will furthermore be given hearing aids with mild-gain amplification in addition to receiving the standard treatment. The control group will only receive the standard treatment. The experimental group will visit Hearing Systems twice. During the first visit the loudness and likeness of the tinnitus percept will be measured. Furthermore, speech in noise levels will be measured. Finally, hearing aids with mild-gain will be fitted. The second visit will take place after the intervention and follow-up measurements of THI, tinnitus likeness, tinnitus loudness and speech in noise levels will be measured. The control group will visit Hearing Systems once to measure the loudness and likeness of the tinnitus percept and the speech in noise levels. In addition to the clinical study, the project also includes a pilot study to evaluate the mild-gain amplification.

The proposed project will cover:

- Literature review: tinnitus
- Basic knowledge of hearing aid fitting
- Pilot study on mild-gain amplification

- Clinical study with a baseline and a follow-up measurement

Required qualifications:

- Speaking and understanding Danish sufficiently to communicate with test subjects

Responsible institution/department:

DTU Health Tech

Contact information:

Mie Jørgensen

mielj@dtu.dk

Allowed no of students per report: 1 student

KU and/or DTU supervisor:

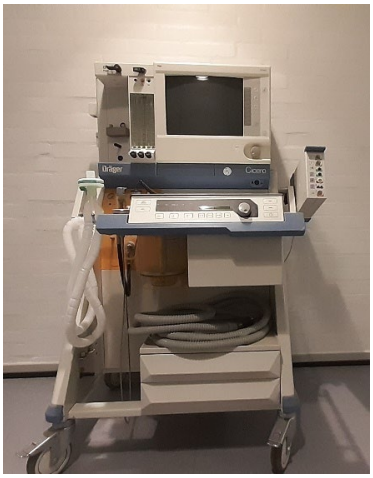
Mie Jørgensen, Hearing Systems, Building 352, Room 121 [mielj@dtu.dk]

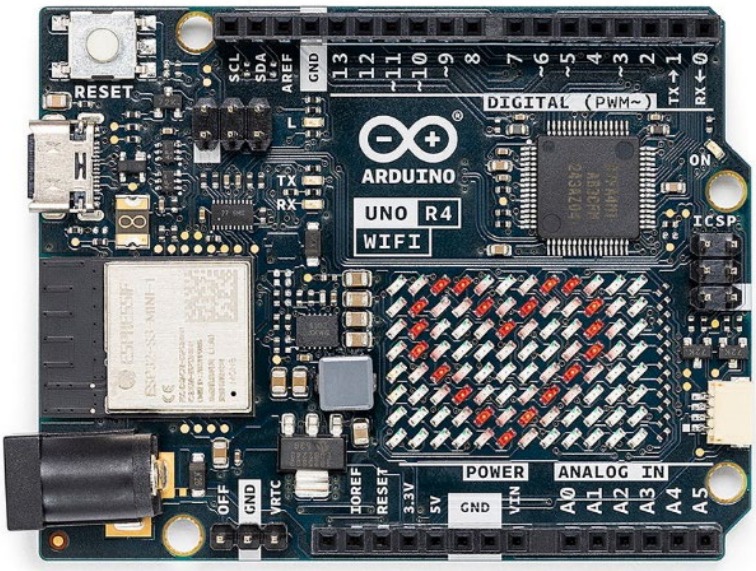
Susanne Nemholt, Kommunikationscenteret, Hellerup / Ekstern lektor KU

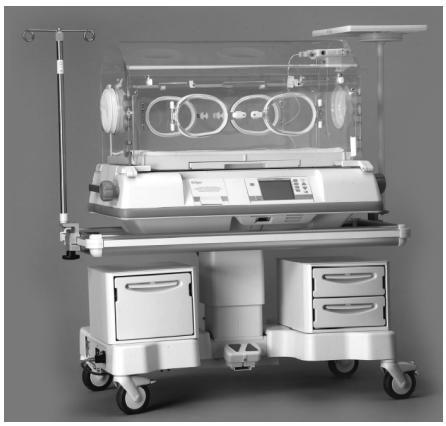
# Project Title: Applications of Arduino Uno R4 wifi in testing biomedical instrumentation

**Description:**

Arduino has released a new revision 4 of the Arduino Uno board. It is a massively upgraded board with a 32-bit Arm® Cortex®-M4 core, extended memory, 14-bit A/D converter, 12-bit D/A converter and built-in wifi and Bluetooth. In this Bachelor project, the project group will develop biomedical test equipment based on the Arduino Uno R4 wifi.





Each project group will be required to:

- Decide what type of biomedical equipment the test system is aimed at.
- Identify the system variables that need to be tested.
- Identify suitable sensors for the different tests.
- Combine all sensors and the Arduino Board into an integrated system.
- Write software in C to support user interaction, sensor measurements, local data display, wireless data transmission and storage.
- Integrate relevant components into a custom designed 3D printed enclosure.

Example applications include:

- Pressure, flow, tidal volume, inspiratory/expiratory ratio in anesthesia unit.
- Pressure, flow, and oxygen concentration in oxygen concentrator unit.
- Temperature, moisture, and O2/CO2 concentrations in infant incubator.

**Required qualifications:**

Courses 22433, 22437, 22050

Some a priori experience with the Arduino Uno R4 wifi will be an advantage.

**Responsible institution/department:**

Department of Health Technology

**Contact information:**

Kaj-Åge Henneberg, khen@dtu.dk

**Allowed no of students per report (1-4):**

3 – 4 students per team. Max two teams.

**KU and/or DTU supervisor:**

Kaj-Åge Henneberg, Associate professor, DTU.

# Project Title:

Developing a new automated method for measuring splenic function.

**Description:**

The spleen plays an important role in the body's defense against bacterial infections. **Measuring splenic function is of interest in multiple conditions, but there is currently no direct and simple way of measuring splenic function**.

Because of the nature of red blood cell (RBC) filtration in the spleen, certain RBC changes have been found to act as surrogate biomarkers of splenic filtration. These include pitted RBCs observed with differential interference contrast (DIC) microscopy, a special microscopy contrast technique. Pitted RBCs observed using DIC microscopy were first found to predict splenic function more than 50 years ago. Pits are large vacuoles beneath or attached to the RBC membrane, containing cell waste material. When filtering through a normally functioning spleen, RBCs are groomed by the spleen, removing waste such as pits, before being released back into the circulation. In cases where the spleen does not function, pits remain in the circulating RBCs. Thereby, the percentage of RBCs containing pits increases in individuals who have undergone splenectomy, or in conditions where there is a loss of splenic function. Unfortunately, the method of counting pitted RBCs with DIC microscopy is both user-dependent, time-consuming and requires high end microscope equipment.

In a previous study we successfully generated pitted RBC counts based on DIC images using neural network analysis (Nardo-Marino, A. et al. Front Physiol. 2022; 13: 859906.). Although simpler than manual counting, the technique continues to be demanding due to microscope equipment requirements. We are therefore trying to further simplify the method using fluorescent or chromogenic dyes and already have leads for the staining procedure. **The masters project would involve rigorous testing, refining and validation. The project would involve time in the laboratory (cell staining), microscopy and potentially image analyses.**

The project is a collaboration between the Danish Red blood Cell Center at Copenhagen University Hospital – Rigshospitalet and the Core Facility for Integrated Microscopy at the University of Copenhagen. **The daily workplace will be at the Core Facility for Integrated Microscopy, University of Copenhagen (Blegdamsvej 3, 2200 Copenhagen N), under supervision of PhD Thomas Hartig Braunstein.** The main supervisor for the project will Andreas Glenthøj, MD and head of the Danish Red Blood Cell Centre. **As part of the project, we can offer extensive microscope training, both practical and theoretical. It is also possible for the student to attend an extensive two-week light microscopy course for PhD students.** The project could possibly result in a patent and the Master student may have to sign a non-disclosure agreement.

**Required qualifications:**
Laboratory experience is required.
Experience with light microscopy is desired but not required.
Experience with image analysis/neural network analysis is desired but not required.

**Responsible institution/department:**
Danish Red Blood Cell Center,
Department of Haematology,
Copenhagen University Hospital – Rigshospitalet

*in collaboration with*

Core Facility for Integrated Microscopy,
Department of biomedical sciences,
University of Copenhagen

**Contact information:**
Andreas Glenthøj (main-supervisor) – andreas.glenthoej@regionh.dk
Thomas Braunstein (co-supervisor) – thobra@sund.ku.dk
Amina Nardo-Marino (co-supervisor) – amina.nielsen.nardo-marino@regionh.dk
Jesper Petersen – jesper.petersen@regionh.dk

**Allowed no. of students per report:** 1

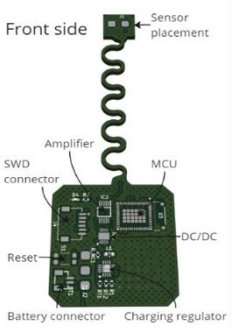
**KU and/or DTU supervisor:**

Primary supervisor:
- Andreas Glenthøj, KU

Co-supervisors:
- Thomas Braunstein, Core Facility for Integrated Microscopy, KU
- Amina Nardo-Marino, Danish Red Blood Cell Center, Copenhagen University Hospital – Rigshospitalet
- Jesper Petersen, Danish Red Blood Cell Center, Copenhagen University Hospital – Rigshospitalet

# Design and Development of Miniaturized, Wireless, Flexible PCB with Integrated Resistive Sensors for Health Applications

Description:




Dive into the cutting-edge world of health technology by designing, simulating, and analyzing a sleek, wireless printed circuit board (PCB) equipped with integrated resistive sensors and AC stimulators. This project offers students the opportunity to specialize in various facets, from in-depth theoretical studies to hands-on modeling of the PCB, sensors, and stimulators. By the end, participants will not only master the art of PCB simulation and creation but also be poised to spearhead the next wave of innovations in in-body sensing and stimulation.

Required qualifications:


Electronics and Circuitry: A grounding in electronic components, circuit design, and PCB layouts.

Simulation Software and PCB design tools.

Analytical Prowess: A knack for modelling, dissecting, and drawing insights from simulation results.

Communication Excellence: The ability to eloquently document findings, benchmark against existing tech, and share your discoveries.

Responsible institution/department: DTU – HealthTech department

Contact information: Morteza Alehosseini mortea@dtu.dk

Allowed no of students per report: 3

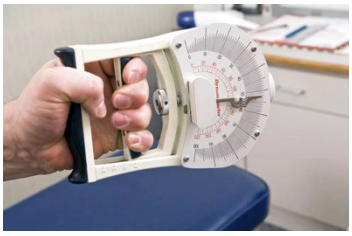
KU and/or DTU supervisor:

Alireza Dolatshahi-Pirouz aldo@dtu.dk  Firoz Babu fbka@dtu.dk  Morteza Alehosseini mortea@dtu.dk

# Development and Prototyping of a ForcePad for Advanced Physiotherapy

**Description:**

This force pad combines the capabilities of a dynamometer and an inclinometer into one compact, user-friendly tool. The ForcePad aims to provide precise measurements of muscular force, its angle, and the patient's range of motion. The primary goal is to develop a prototype that outperforms existing solutions in precision, range, and cost-effectiveness.



Required qualifications:

- **Electronics and Prototyping:** A strong foundation in electronic components, circuit design, and hands-on prototyping skills.
- **Biomechanics:** Knowledge of mechanical principles as they relate to human movement, force measurement, and the physiological aspects of physiotherapy.
- **Software Development:** Ability to develop software for data capture, analysis, and display on LCD screens.
- **Analytical Skills:** Proficiency in interpreting data, drawing insights, and refining device functionality based on feedback.
- **Collaborative Teamwork:** Willingness to work closely with physiotherapy consultants to ensure the device meets real-world needs.


Responsible institution/department: DTU – HealthTech department

Contact information: Morteza Alehosseini mortea@dtu.dk

Allowed no of students per report: 2

KU and/or DTU supervisor:

Alireza Dolatshahi-Pirouz aldo@dtu.dk Firoz Babu fbka@dtu.dk Morteza Alehosseini mortea@dtu.dk

# Development of a Compact, High-Resolution 3D Printer for Cell Culture Applications

Description:

This project focuses on the design and development of a compact 3D printer equipped with a user-friendly interface, tailored for high-resolution printing. The initiative seeks to overcome the challenges posed by contemporary commercial 3D printers, particularly in terms of size, cost, and operational complexity. The ultimate objective is to engineer a printer that is affordable and user-friendly and excels in precision and accuracy while maintaining ideal conditions for cell culture.

Required qualifications:

1. **Electronics** Proficiency: A solid grasp of basic electronic components and circuits, coupled with the capability to design and prototype custom circuits.
2. **Software and Firmware Development**: Competence in developing and refining software or firmware to manage and synchronize diverse electronic components, ensuring a smooth operation.
3. **Team Collaboration** and problem-solving skills.
4. Specialized Interests. Candidates should possess interest or familiarity in at least **one of the following areas:**
    a. Laser-based calibration techniques to guarantee printer precision and accuracy.
    b. Operation and integration of servomotors, particularly for tasks demanding high-resolution movement.
    c. Control mechanisms for temperature and humidity within a chamber.
    d. UV LED technology.
    e. Microscopy, lens systems, and camera operations.
    f. Mechanical design principles, with a focus on integrating electronic components and motion systems.



Responsible institution/department: DTU – HealthTech department

Contact information: Morteza Alehosseini mortea@dtu.dk

Allowed no of students per report: 4

KU and/or DTU supervisor:

Alireza Dolatshahi-Pirouz aldo@dtu.dk Firoz Babu fbka@dtu.dk Morteza Alehosseini mortea@dtu.dk

# Project Title: Development of an animal model of heart failure with preserved ejection fraction in mice

Description: (n.a. if confidential)

*Heart Failure with preserved Ejection Fraction (HFpEF) is a type of heart failure where the heart muscle contracts normally but is too stiff to relax properly during diastole – leading to impaired filling of the heart and thereby reduced cardiac output. This results in the heart not being able to pump enough blood to meet the body's needs and causes symptoms such as fatigue, shortness of breath, and edema. HFpEF typically affects elderly people and postmenopausal women, and given the rise in predisposing factors (hypertension, diabetes, and obesity) the global prevalence is increasing. Despite the substantial impact of life quality for patients and great socioeconomic costs, the pathophysiology of HFpEF is poorly understood and there is no curative treatment. Treatment options are limited to management of symptoms and underlying conditions, hence there is an imperative need for ongoing research.*

*With this project, we seek to develop a mouse model of HFpEF at Minerva Imaging. The aim is to explore and compare two different methods of model induction and investigate disease development through various imaging modalities such as cardiac MRI, PET and SPECT to monitor the progression of the disease. Based on the results we will refine the model to optimize translation to the human variant of the disease.*

*As a master student you will be part of our internal Minerva Imaging Scholar Program. The program is designed to support Minerva Imaging's continued development as a scientifically driven CRO and focuses on developing novel tools and procedures that expand the capabilities in our focus areas.*

*The programs we offer are often in areas where we see value in expanding our services for the benefit of our partners and healthcare overall. So, the work you do will often have an application in important drug development and you will be working with scientists and other co-workers who can guide and inspire you in your work efforts.*

***Applied methods***

- *Setup of in vivo mouse model*
- *Echocardiography*
- *MRI, PET and SPECT imaging*
- *Image analysis*
- *Histology and tissue sampling*

The project period is 6-12 months. Throughout the project you will be assigned to an internal senior researcher that will supervise you.

Required qualifications:

*The ideal candidate should have an interest in animal models as well as cardiovascular research and should be motivated to work with advanced imaging techniques. It is essential that you have a positive attitude, are proactive, take ownership of the project and drive it forward. It is also important that you set high quality standards for data deliveries.*

*You should be on a relevant master's program (DVM, nature and life sciences, MD, engineer or similar). It is an advantage if you have already passed a course in laboratory animal science (FELASA category AD or similar), but it is not a requirement.*

***As a person you are***

- *A proactive communicator and team-player*
- *Eager to learn, enthusiastic and passionate*
- *A problem-solver with strong analytical skills*
- *Flexible with an ability to thrive in a fast-paced and service-oriented organization*

Responsible institution/department:

*Minerva Imaging*

Contact information:

*Department Manager, In Vivo Pharmacology, Philip G. J. Pedersen*

*php@minervaimaging.com*

Allowed no of students per report (1-4):

*1*

KU and/or DTU supervisor:

*Lektor Morten Bækgaard Thomsen, Biomedicinsk Institut, KU SUND*

# BSc/MSc project for students in Biomedical Engineering and/or Quantitative Biology and Disease Modelling, DTU/KU

Project Title: **Method development for Magnetic Resonance Imaging (MRI)**

Description: Magnetic Resonance Imaging and Spectroscopy techniques (MRI/MRS) are challenging, but also safe and extremely flexible providing non-invasive and detailed tissue characterization. Magnetic fields of typically 1.5 to 3 tesla are used for humans. A new state-of-the-art 3 tesla human scanner is now ready for experimentation at DTU, for example, and a 7 tesla human scanner is available at Hvidovre Hospital as a result of a national collaboration involving DRCMR, DTU and other partners.

New innovations give more possibilities, but also challenges that need to be overcome. There are hundreds of magnetic resonance imaging and spectroscopy techniques and more are constantly being developed, refined, validated and employed for clinical or research uses at Danish MRI sites operating at different field strengths. There is a need for additional people to get involved, and interested students are invited to express interest, so project options can be discussed. There are possibilities for projects that are oriented toward physics, electronics, method development, statistics, medical applications, brain function and more.

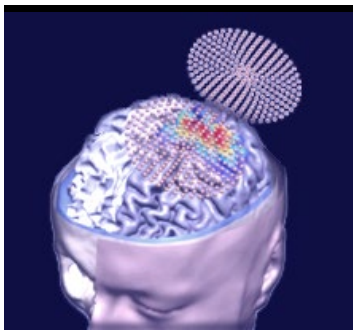
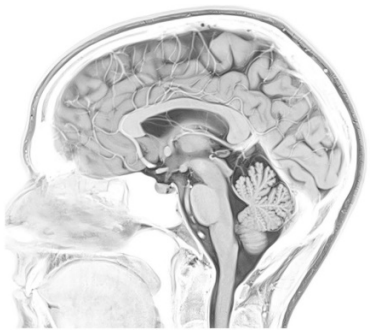
Required qualifications: Different competences are of interest, and projects matching your background can likely be proposed. It is an advantage to have one or preferably more of the courses 22481, 22485, 22506, 22507 or 22508 (see https://www.cmr.healthtech.dtu.dk/education/mr-courses-and-their-connection). MRI can be quite challenging, and some projects are therefore only suited for MSc students.

Responsible institution/department: DTU Health Tech / DTU Compute and/or Danish Research Centre for MR, DRCMR, http://www.cmr.healthtech.dtu.dk , http://www.compute.dtu.dk, http://drcmr.dk/

Contact information: Lars G. Hanson, lghan@dtu.dk or people mentioned below.

Allowed no of students per report: 1-4

KU and/or DTU supervisor: For example Axel Thielscher (neurophysics), Mathilde Hauge Lerche (brain metabolism), Henrik Lundell (microstructure & ultra-highfield MRI), Kristoffer Hougaard Madsen (machine learning), Tim Dyrby (microstructure), Vitaliy Zhurbenko (coil technology) or Lars G. Hanson (measurement design). See web for their mail addresses and interests (only examples are given).

# Project Description

"Dose Accumulation for Adaptive Radiotherapy and Re-irradiation workflows in an MR-linac"

October 10, 2023

*"... Get a good idea and stay with it. Dog it, and work at it until it's done right ..."*

*Walt Disney*

## 1 Description

### 1.1 Motivation and Background

Radiotherapy has been one of the most powerful tools for treating cancer in the past few decades [1]. The aim of radiotherapy is to destroy the cancer cells with focused radiation while sparing the organs at risk that lie in the surroundings. Technological advances have allowed radiotherapy to develop rapidly, and treatments have consequently become more and more accurate. A clear example of this is the combination of magnetic resonance (MR) imaging, and a linear accelerator (linac). This combination enables the possibility to deliver radiotherapy based on MR images that have superior soft tissue contrast compared to the standard imaging with computed tomography (CT).

The usage of MR-linacs has exploded in the past years in part due to the possibility of performing online adaptive radiotherapy (OART) [2]. OART is a technique that allows adjusting (adapting) a radiotherapy plan to the daily anatomy of the patient while the patient lies on the treatment couch. This is, in contrast to non-adaptive (standard) radiotherapy, where a radiotherapy plan is created based on the patient's anatomy from pre-treatment simulation scans, and it is assumed that the patient's anatomy is exactly the same for every fraction (treatment day).

In order to perform OART treatments, a "base" treatment plan is prepared before the treatment as a starting point. This base plan is created using images of the patient taken in the simulation phase, which is approximately a week before the treatment, and the doctor uses those images to contour (draw) structures (both organs at risk and tumor). On each day of the treatment, a new scan is acquired, and the structures are propagated via deformable or rigid propagation and subsequently re-contoured or verified by the doctors. Once the new contours are completed, the base plan is reoptimized (adapted) for the conditions of each treatment day.

Several advantages come from the possibility of using OART. One important advantage is that a more accurate treatment plan will be delivered, as the organs and the tumor will be contoured right before generating the plan. Furthermore, a reduction of extra margins can be obtained as the plan is created using the anatomical conditions of the day. In addition, sometimes it is possible to give an even higher radiation dose to the tumor if the anatomy of the day is more favorable than the day from which the base plan was made. One type of cancer, where the use of OART on the MR-linac has the potential to improve survival for patients, is pancreatic cancer [3].

Even though the OART technique has many advantages, there are some challenges that have yet to be overcome. One issue that has yet to be addressed is how to add the dose from different treatment days (dose accumulation) when treating with adaptive radiotherapy. The challenge arises from the fact that the organs change both their geometrical position and

also their density from one day to another (e.g. filling of the stomach with more air). 1.1 shows how different the structures can be on the first adaptive fraction day and the simulation day. Therefore, assessing which part of the organ received what dose becomes a complex problem as it involves image deformation fields, contour deformations and dose deformations among others.

In spite of the MR-linac system having the capability of performing OART, it lacks the possibility of performing deformable dose accumulation. Because we lack tools to perform deformable accumulation of the dose, the way it is currently approximated in clinical practice assumes that the patient will always receive the same dose as the base plan, multiplied by the number of fractions. Therefore, a few questions remain, for example: Can we do better than we are already doing if we take the daily differences into account? or How much better can we do?

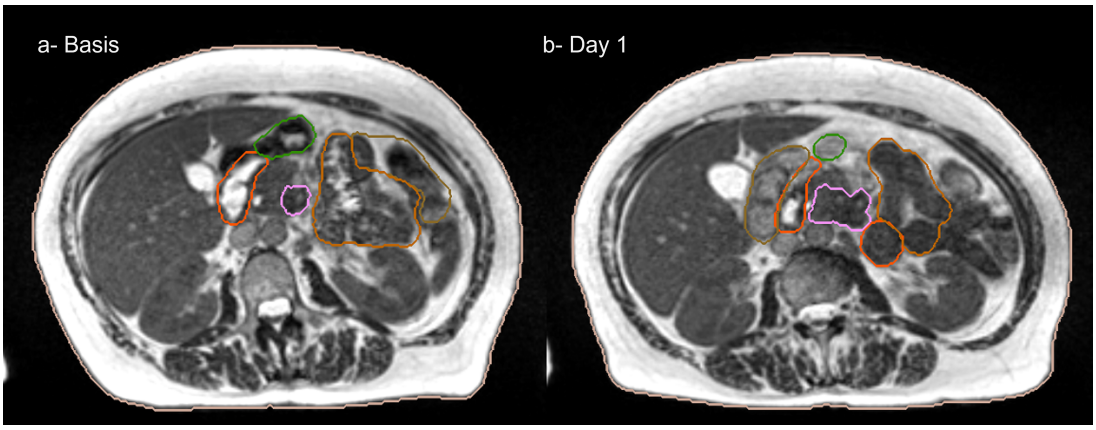



Figure 1.1: Contours in the axial plane for the base plan (a) and the adaptive plan of the first fraction (b)

Another situation where dose accumulation can be critical is when a patient has previously had radiotherapy in an area that overlaps with an area where they need another round of radiotherapy (re-irradiation). In this case, the patient's anatomy is often significantly different between the time points and it is not straightforward how decide what dose can be safely delivered for the new treatment.

The **purpose** of this project is to **quantify** how much the patients treated for pancreatic cancer are over or under-dosed when using dose accumulation procedures as compared to clinical practice without dose accumulation, and to develop this dose accumulation workflow for re-irradiation patients. The realization of this project will help with the clinical implementation of dose accumulation and re-irradiation workflows at Herlev Hospital.

## 1.2 Hypothesis and Objectives

The hypothesis of this project is that dose accumulation can be performed in a clinical environment safely leading to a more accurate representation of the dose delivered to a patient in an online adaptive radiotherapy treatment.

This project comprises the following objectives:

1. **Identify/create** a workflow for performing dose accumulation
2. **Perform** the dose accumulation workflow for a small group of representative patients (pancreatic and re-irradiation) using the available software: 3DSlicer, Velocity or MIM
3. **Quantify** which of the software perform best based on commonly used metrics: Dice score, Hausdorff distance, etc.

4. **Perform** the dose accumulation for all the fractions of all adaptive patients and for a few re-irradiation cases
5. **Compare** the accumulated dose versus the base plan dose in terms of representative dose volume histogram (DVH) values
6. **Identify** possible correlations between the accumulated dose and structure margins or metrics used for the evaluation of the dose
7. **Providing** data for writing a feasibility report for clinical implementation

### 1.3 Clinical Impact

The quantification of a dose accumulation procedure versus the base plan will have an enormous clinical impact as it will allow a more accurate assessment of the dose that has been given to the patients. Moreover, it will allow us to adjust the plan by giving the patient either more dose to the tumor or improved sparing of organs and reduced toxicity. Furthermore, a well-designed workflow for dose accumulation will also be used for patients who have previously had radiotherapy and need another round of radiotherapy treatments

## 2 Require Qualifications

Bachelor in natural sciences. *Knowing programming is a plus

## 3 Responsible institution/department:

This project will be conducted at the Herlev's Hospital Oncology department, specifically at the radiotherapy section.

## 4 Contact information

Grichar Valdes Santurio (grichar.valdes.santurio@regionh.dk)
Laura Ann Rechner (laura.ann.rechner@regionh.dk)
Susan Blak Nyrup Biancardo (susan.blak.nyrup.biancardo.01@regionh.dk)

## 5 Allowed no of students per report (1-4):

1-2

## 6 KU and/or DTU supervisor:

Not defined

## References

[1] Abshire, D. and M. K. Lang (2018). The evolution of radiation therapy in treating cancer. *Seminars in Oncology Nursing 34*(2), 151-157. Technology in Cancer Care.

[2] Brock, K. K. (2019). Adaptive radiotherapy: moving into the future. In *Seminars in radiation oncology*, Volume 29, pp. 181. NIH Public Access.

[3] Chuong, M. D., R. Herrera, A. Kaiser, M. Rubens, T. Romaguera, D. Alvarez, R. Kotecha, M. D. Hall, J. McCulloch, A. Ucar, et al. (2022). Induction chemotherapy and ablative stereotactic magnetic resonance image-guided adaptive radiation therapy for inoperable pancreas cancer. *Frontiers in Oncology 12*, 888462.

# MSc project for students in Biomedical Engineering and/or Health Technology relevant fields

**Project Title:** Electrospun Nanofibers as Ingestible Micro-supercapacitor in the Gut

**Description**: Electrospun nanofibers exhibit superior electrochemical performance in smart applications such as sensing, capacitance and batteries. Against several progresses in optimization of electrospun nanofibers for smart energy-relevant applications, there are still hurdles with use of toxic materials and fluorinated polymers. In this project, we aim at design and development of more green procedures where natural biopolymers loaded by smart biocompatible conductive particles are applied for electrospinning. We will test electronic conductivity, electrochemical response and durability of different electrospun nanofibers along with cytotoxicity and rechargeability of supercapacitors under the wet conditions of body (simulated intestine).

**Required qualifications**: Background in material engineering, biomedical engineering or electrochemistry

**Responsible institution/department**: DTU. Health Tech

Contact information: Fatemeh Ajalloueian faaj@dtu.dk

**Allowed no of students per report** (1-4): 2

**KU and/or DTU supervisor**: Santanu Patra, Fatemeh Ajalloueian

# MSc project for students in Biomedical Engineering and/or relevant fields

**Project Title:** Energy harvesting potential of ingestible biomaterials fabricated via different techniques

**Description:** The use of piezoelectric generators for possible energy scavenging applications from mechanical strain has attracted many attentions. Mechanical energy scavenging using materials with different architectures such as 2D films, 3D-printed constructs and electrospun nanofibers, with or without added nanostructures, can lead to different sources for energy generation. In this project, our aim is to design, fabricate and test the piezo-electric properties of micro-nanostructured selected materials fabricated using different techniques such as spin coating, electrospinning and 3D printing. The final aim is to apply the optimum construct for energy harvesting from gut.

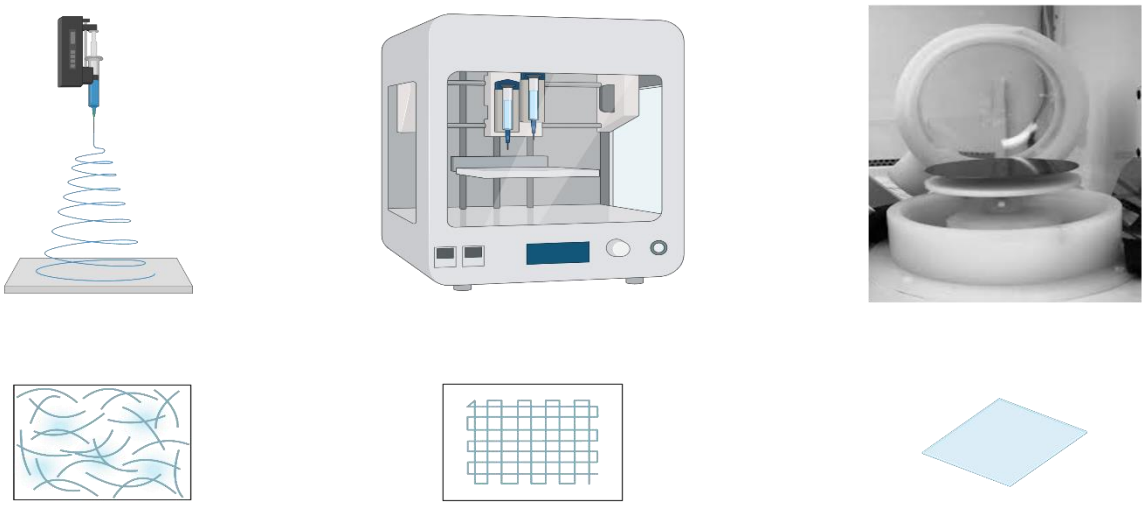


Fig 1. An illustration of different fabrication techniques to prepare potential piezo-electric substrates

During this project, you learn:

1- Fabrication techniques to make dense thin films, and high porosity micro/nanofiber sheets
2- Structural, chemical, and mechanical characterizations
3- Piezoelectric measurements under mechanical loading-unloading cycles

Students with a materials, physics, mechanical or electrical engineering background are encouraged to apply.

**Responsible institution/department:** Department of Heath Technology (DTU)

**Contact information:** Fatemeh Ajalloueian (faaj@dtu.dk)

Supervisor(s): Fatemeh Ajalloueian, Nasim Golafshan

**Allowed no of students per report (1-4):** 2 students

# BSc/MSc project for students in Biomedical Engineering and/or Health Technology relevant fields, DTU/KU

**Project Title:** Microporous Nanostructures and nanofibrous microparticles for smart drug delivery and tissue engineering applications

**Description:** Nanofibrous structures (e.g. electrospun sheets) mimicking the ECM fibrous structure of native tissue play an important role in drug delivery and tissue engineering applications. On the other side, micro particles have demonstrated a profound role as carriers of drugs/bioactive agents in oral drug delivery systems (DDS). Both these systems, in their conventional form, suffer from deficiencies preventing them from efficient clinical applications. Whilst Nanofibers suffer from limited cell infiltration due to their small pore sizes (against their high total porosity), micro particles have appeared inferior to nanoparticles (in several studies) due to their incapability in passing through mucus barrier in order to deliver their drug. In this project, we use our fabrication knowledge to design and develop nanofibers with regular micro-pores for improved cell adhesion and infiltration, as well as fabricating nanostructured micro particles with possibility of delivering nanocarriers to pass through mucus barrier. In this project, you will work on either of these structures, and will learn how to fabricate them, and use them for cell culture studies or for drug loading and oral delivery. You will also learn several characterization techniques including imaging, drug release and cell-scaffold interactions.

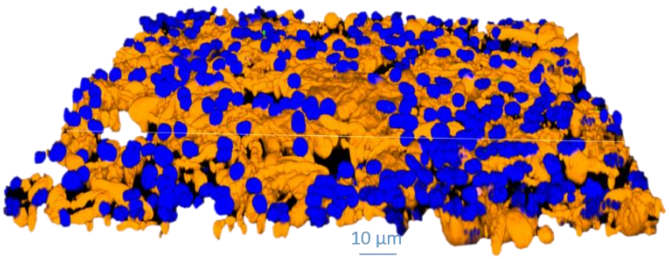
**Required qualifications:** None

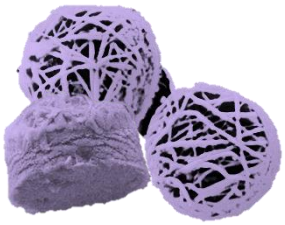
**Responsible institution/department:** Department of Health Technology, DTU

**Contact information:** Fatemeh Ajalloueian (faaj@dtu.dk)

**Allowed no of students per report (1-4):** 4

**Supervisors:** Anja Boisen, Fatemeh Ajalloueian



# Project Title: Model of kidney destruction induced by clinical radionuclide cancer therapy

Description: (n.a. if confidential)

*Radiopharmaceutical drugs used for cancer therapy are highly selective, designed to kill malignant cells and spare healthy tissues. However, compounds in some drug-classes are bound or reabsorbed in the kidney instead of being excreted in the urine, leading to kidney damage due to the increased radiation. We hypothesize that we can establish a model that can accurately evaluate the radionuclide induced kidney toxicity and thereby speed up the development of safer drugs.*

*In this project, mice will be treated with radionuclide compounds that are known to induce kidney damage. After treatment, in vivo imaging and blood sampling will be used to evaluate biodistribution and hematology parameters. In addition, both acute and long-term kidney damage will be investigated using renal function measurements and histology. Kidneys will be stained with relevant special stains and immunohistochemical markers and images will be scored manually according to the severity of the damage. Based on the scoring it will be investigated if an AI software can be trained to automatically perform the scoring.*

*As a master student you will be part of our internal Minerva Imaging Scholar Program. The program is designed to support Minerva Imaging's continued development as a scientifically driven CRO and focuses on developing novel tools and procedures that expand the capabilities in our focus areas.*

*The programs we offer are often in areas where we see value in expanding our services for the benefit of our partners and healthcare overall. So, the work you do will often have an application in important drug development and you will be working with scientists and other co-workers who can guide and inspire you in your work efforts.*

***Applied methods***

- *In vivo molecular imaging*
- *Blood sampling*
- *Renal function*

- *Organ harvest from mice*
- *Fixing of tissue for histology*
- *Processing of tissue for histology*
- *Cutting of tissue for histology*
- *Special stain*
- *Immunohistochemistry (IHC)*
- *Manual scoring kidney damage*
- *Training and evaluation of kidney damage by AI-software*

*The project period is 6-12 months. Throughout the project you will be assigned to an internal senior researcher that will supervise you.*

Required qualifications:

*The ideal candidate must have an interest in animal experiments and enjoy working with histology as well as images. It is essential that you have a positive attitude, are proactive, take ownership of the project and drive it forward. It is also important that you set high quality standards for data deliveries.*

*You should be on a relevant master's program (DVM, nature and life sciences, MD, engineer or similar). It is an advantage if you have experience with histology from courses or other projects. It is an advantage if you have already passed a course in laboratory animal science (FELASA category AD or similar), but it is not a requirement.*

***As a person you are***

- *A proactive communicator and team-player*
- *Eager to learn, enthusiastic and passionate*
- *A problem-solver with strong analytical skills*
- *Flexible with an ability to thrive in a fast-paced and service-oriented organization*

Responsible institution/department:

*Minerva Imaging*

Contact information:

*Jennifer Solgaard Sommer, Senior Scientist*

*jsj@minervaimaging.com*

Allowed no of students per report (1-4):

*1*

KU and/or DTU supervisor:

*Professor Andreas Kjær, Cluster for Molecular Imaging, KU SUND*

# MSc project for students in Biomedical Engineering and/or Health Technology relevant fields

**Project Title:** Nanofibrous microparticles and Microporous Nanostructures for smart drug delivery and tissue engineering applications

**Description:** Nanofibrous structures (e.g. electrospun sheets) mimicking the ECM fibrous structure of native tissue play an important role in drug delivery and tissue engineering applications. On the other side, micro particles have demonstrated a profound role as carriers of drugs/bioactive agents in oral drug delivery systems (DDS). Both these systems, in their conventional form, suffer from deficiencies preventing them from efficient clinical applications. Whilst Nanofibers suffer from limited cell infiltration due to their small pore sizes (against their high total porosity), micro particles have appeared inferior to nanoparticles (in several studies) due to their incapability in passing through mucus barrier in order to deliver their cargo. In this project, we use our fabrication knowledge to design and develop nanofibers with regular micro-pores for improved cell adhesion and infiltration, as well as fabricating nanostructured micro particles with possibility of delivering nanocarriers to pass through mucus barrier. You will work on either of these structures, and will learn how to fabricate them and use them for cell culture studies or for drug loading and delivery. You will also learn several characterization techniques including SEM imaging, FT-IR, drug release and cell-scaffold interactions.

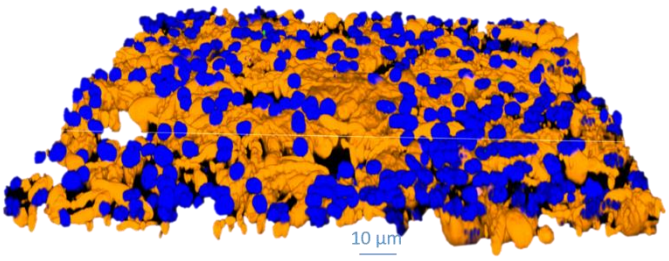
**Required qualifications:** None

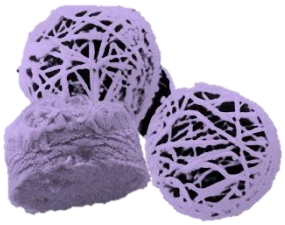
**Responsible institution/department:** Department of Health Technology, DTU

**Contact information:** Fatemeh Ajalloueian (faaj@dtu.dk)

**Allowed no of students per report (1-4):** 4

**Supervisors:** Fatemeh Ajalloueian



# Project Title:

# Nanotexture Based Skin Barrier Function Assessment

Description:

Students will learn to operate an atomic force microscope (AFM) to image and analyze the nanotexture of human skin corneocytes. This will allow quantification of skin barrier function through circular nanotexture that relates to skin diseases like atopic dermatitis.

Required Qualifications: Interested in nanotechnology, bioengineering.

Responsible Institution/Department: DTU Healthtech, IDUN section, Building 345

Contact Information: Jorge Pereda (joper@dtu.dk) and Edwin En-Te Hwu (etehw@dtu.dk)

Allowed no of students per report: 4

DTU Supervisor: Jorge Pereda and Edwin En-Te Hwu

# Optical coherence tomography-derived biomarkers for diagnosis and monitoring of diseases

**Description:**

This project comprises a range of possible projects working with optical coherence tomography. The project can be more engineering focused, image processing, or application focused depending on the student. Some opportunities could include:

-Quantitative analysis of microvasculature using OCT

-Analyzing optical attenuation from OCT images in bone

-OCT imaging and analysis of tumor spheroids and co-cultures

-Imaging and analysis of mouse cochlea model of hearing loss

-Design and fabrication of fiber optic catheters for OCT

-Building and characterizing OCT systems

-Acquiring and analyzing OCT data from in vitro samples, animal models, and human patients

**Required qualifications:**

Project description can be adjusted to reflect the background and interest of individual students

**Responsible institution/department:** DTU Health Tech

**Contact information:**

Gavrielle Untracht: greun@dtu.dk

**Allowed no of students per report:** We prefer students to work independently

**KU and/or DTU supervisor:** Gavrielle Untracht and Peter Andersen

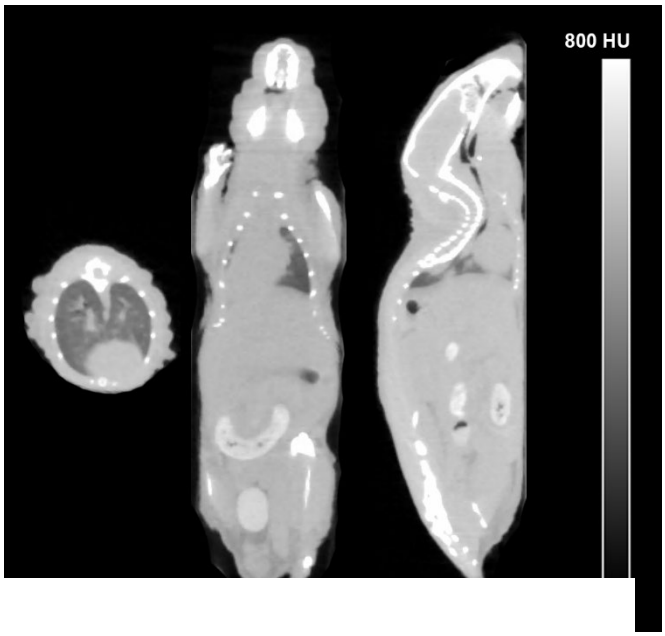
# Optimizing soft tissue contrast in preclinical CT imaging using contrast agents

*Description:*
Computed Tomography (CT) is used for diagnostics and as anatomical reference to functional imaging in both clinical and preclinical settings. Clinical CT scanners offer a reasonable soft tissue contrast in diagnostic quality imaging due to their speed and power, but preclinical CT scanners struggle to obtain soft tissue contrast in a reasonable time.

One option for creating better contrast is to use contrast agents, often based on iodine. However, this comes with an extra cost and complication. We wish to examine to what degree these contrast agents can improve imaging and how different agents compare to each other. The project consists of testing 3-5 different contrast agents in phantoms and animals, analysis of the data, and a recommendation for further use.

*Required qualifications:*
22485 Medical Imaging Systems (preferred)
KU180 – Medical Use of Radiation (preferred)
General programming skills in either MatLab or Python

*Responsible institution/department:*
Cluster for Molecular Imaging, Department of Biomedical Sciences & Department of Clinical Physiology and Nuclear Medicine, University of Copenhagen and Rigshospitalet




*Contact information:*
Emil Christensen, emil.christensen@sund.ku.dk

*Allowed no of students per report: 1-2*

*KU and/or DTU supervisor:*
Professor Andreas Kjær, MD, DSc, PhD

References:


- Boll, H. et al. (2011) Micro-CT based experimental liver imaging using a nanoparticulate contrast agent longitudinal study in mice. PLoS ONE 6: e25692.
- Hua, X.W. et al. (2015) Contrast-enhanced micro-computed tomography using ExiTron nano 6000 for assessment of liver injury. World J Gastroenterol 21(26): 8043-8051.

# Project Title: Optimization of a pre-clinical model of chronic obstructive pulmonary disease

Description: (n.a. if confidential)

*Chronic obstructive pulmonary disease (COPD) refers to a group of progressive lung diseases including chronic bronchitis and emphysema. The underlying molecular mechanisms are poorly understood, and the presentation and progression of disease are varied, though damaged lung tissue, inflammation, and impaired respiration are common denominators. Treatment options today are few, and often only involve relieving symptoms, highlighting the need for further research within the area.*

*Current pre-clinical COPD models suffer from large variations in lung damage and fibrosis and also suspected "off-target" tissue damage. At Minerva Imaging we would like to conduct a study investigating options of refining the bleomycin induced COPD model and the model induction traditionally performed by dosing bleomycin in the trachea directly or by inhalation of droplets placed at the tracheal opening. The model refinement evaluation will be based on welfare parameters, reproducibility and distribution of lung fibrosis using CT imaging and histology. Furthermore, the model will be used to test a positive control treatment to evaluate longitudinal treatment effect of a compound using CT imaging. Ultimately, tissue for hydroxyproline analysis and histology will be sampled and bronchoalveolar lavage will be performed to look at inflammatory cells using flow cytometry.*

*As a master student you will be part of our internal Minerva Imaging Scholar Program. The program is designed to support Minerva Imaging's continued development as a scientifically driven CRO and focuses on developing novel tools and procedures that expand the capabilities in our focus areas.*

*The programs we offer are often in areas where we see value in expanding our services for the benefit of our partners and healthcare overall. So, the work you do will often have an application in important drug development and you will be working with scientists and other co-workers who can guide and inspire you in your work efforts.*

***Applied methods***

- *Setup of in vivo model in rodents*
- *CT imaging*
- *Flow cytometry*
- *Image analysis*
- *Histology and tissue assays*

The project period is 6-12 months (for shorter projects some methods might not be included). Throughout the project you will be assigned to an internal senior researcher that will supervise you.

Required qualifications:

*The ideal candidate must enjoy working with data analysis and assays as well as animal models and have an interest in advanced imaging techniques. It is essential that you have a positive attitude, are proactive, take ownership of the project and drive it forward. It is also important that you set high quality standards for data deliveries.*

*You should be on a relevant master's program (DVM, nature and life sciences, MD, engineer or similar). It is a requirement that you have some relevant knowledge or experience with one of the applied methods from courses or other projects. It is also a requirement that you have already passed a course in laboratory animal science (FELASA category AD or similar).*

***As a person you are***

- *A proactive communicator and team-player*
- *Eager to learn, enthusiastic and passionate*
- *A problem-solver with strong analytical skills*
- *Flexible with an ability to thrive in a fast-paced and service-oriented organization*

Responsible institution/department:

*Minerva Imaging*

Contact information:

*Department Manager, In Vivo Pharmacology, Philip G. J. Pedersen*

*php@minervaimaging.com*

Allowed no of students per report (1-4):

*1*

KU and/or DTU supervisor:

*Professor Andreas Kjær, Cluster for Molecular Imaging, KU SUND*

# BSc/MSc project for students in Biomedical Engineering and/or Quantitative Biology and Disease Modelling, DTU/KU

Project Title:

**Real-time monitoring of free radicals generation in function of single organelle stiffness of cardiac cells**

Description:

**Motivation**

Heart failure is a condition when one's heart is unable to pump blood around the body properly, which is afflicting more than 23 million individuals worldwide. The myocardial scar formation known as cardiac fibrosis is a key contributor to heart failure. Anti-fibrotic therapies are still under development due to limited understanding of molecular processes behind scar formation. The cardiac fibrosis starts with changes in the mechanical properties of a heart extracellular matrix, which leads to transdifferentiation of cardiac fibroblasts into myofibroblasts. We have very little knowledge about how mechanical stimuli govern fibroblasts plasticity. Free radicals (FRs), a class of reactive molecules with a free electron, have emerged to be crucial for intracellular signalling, therefore we belive also in mechanostimulated cardiac fibrosis.

**Goal of the project**

In this project we aim to reveal the role of FRs in plasticity of cardiac fibroblasts in response to mechanical stimuli using a new technique called nanodiamond magnetometry.

**Research plan and learning outcomes**

You will learn how to apply nanodiamond magnetometry (it is type of nanoscale MRI under the microscope), which is a quantum-based sensing method to measure FRs generation in real time inside living cardiac fibroblasts. In this method we will use fluorescent nanodiamonds (FNDs) with nitrogen vacancy centers as probes. You will focus on stiffness measurements of mitochondria (Student 1) and endoplasmic reticulum (Student 2) as they are potentially the main source of FRs crucial for fibroblasts plasticity. You will target FNDs delivery to mitochondria (Student 1) and endoplasmic reticulum (Student 2) and evaluate efficiency of that process via fluorescent imaging and colocalization analysis. You will learn how to optically trap FND and use quantitative recordings of the FND displacement over time to determine the organelle stiffness (Student 1 and Student 2). You will use the exact FND to monitor changes in FRs generation by the organelle of interest (Student 1 and Student 2). All measurements will be performed for cardiac fibroblasts and myofibroblasts.

Required qualifications: Cell biology, insight in microscopy, experience with image analysis

Responsible institution/department:

DTU, Department of Health Technology

Contact information:

Prof. Kirstine Berg-Sørensen: kibs@dtu.dk

Dr. Aldona Mzyk – ailmz@dtu.dk

Allowed no of students per report: 2

KU and/or DTU supervisor:

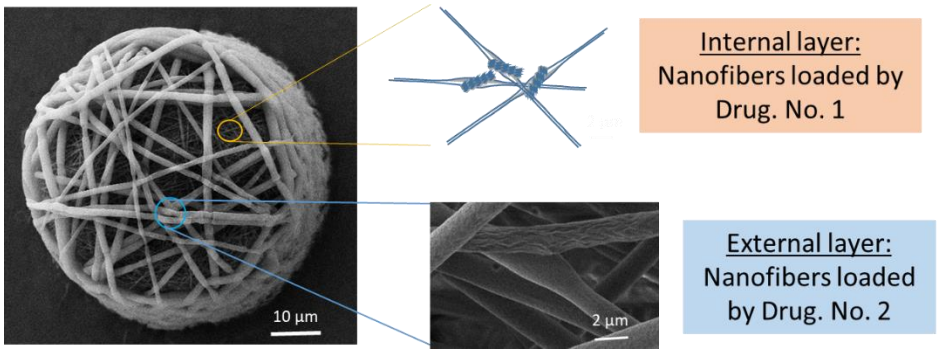
Prof. Kirstine Berg-Sørensen: kibs@dtu.dk

Dr. Aldona Mzyk – ailmz@dtu.dk

# MSc project for students in Biomedical Engineering and/or Health Technology relevant fields

**Project Title:** Orally administered Multilyer Nanostructured microparticles containing natural compounds for combinatorial treatment of breast cancer

**Description:** Traditional chemotherapeutics are effective, but suffer from low therapeutic efficiency and harmful side effects. Recently, it has been reported that some natural compounds possess a wide range of biological activities including anti-inflammatory, anti-atherosclerotic, and anti-cancer properties. The drawback with such natural compounds is usually their low bioavailabilty. Nanoformulations could enhance their solubility and bioavailability, and therefore we aim for loading two to three natural compounds in a monodisperse nanostructured micropartcile system and study how this combination can assist with enhanced cancer therapy relating to suppression of tumor initiation, progression and metastasis.




**Required qualifications:** None

**Responsible institution/department:** Department of Health Technology, DTU

**Contact information:** Fatemeh Ajalloueian (faaj@dtu.dk)

**Allowed no of students per report (1-4):** 4

**Supervisors:** Fatemeh Ajalloueian

# Project Title: Signal processing techniques to improve the analysis of auditory responses measured with functional near-infrared spectroscopy (fNIRS)

**Description:**

With functional near-infrared spectroscopy (fNIRS), changes in blood oxygen are measured using near-infrared light generated by LEDs or lasers. In the last couple of years, fNIRS has gained attention for investigating human hearing, as it runs silently and does not interfere with the patients' hearing devices. This has potential for future clinical practice for hearing-impaired patients.

However, the technique is still relatively new in the field of hearing and using auditory stimulation, and the analysis procedures are not yet standardized. The aim of this project is to investigate the impact of parameter selections and improve different analysis methods from literature, applied to fNIRS data collected to auditory stimulation. These analysis methods include block averaging and generalized linear models. Filtering techniques as well as signal enhancement techniques can be investigated, such as short channel regression and negative correlation enhancement. The project can be further defined depending on the student's interests.

**Required qualifications:**

We are looking for one or more students interested in fNIRS signal processing and in programming using the fNIRS analysis toolbox from Python. New data collection is not necessary but is possible. The lab facilities are located at Rigshospitalet.

**Responsible institution/department:**

The study is a collaboration between DTU hearing systems and the Ear, Nose, Throat & Audiology department at Rigshospitalet. The analyses can be performed at any computer, meetings can take place either at DTU Hearing Systems in Lyngby or at Rigshospitalet in the city center.

**Contact information:**

Maaike Van Eeckhoutte: mcvee@dtu.dk, assistant professor

**Allowed no of students per report:** 4

**KU and/or DTU supervisor:**

Maaike Van Eeckhoutte (DTU Hearing Systems and Copenhagen Hearing and Balance Centre Rigshospitalet)

# Super resolution microscopy of biological nanoparticles

**Description:**

You will learn how to perform super resolution fluorescence microscopy on model samples then apply this knowledge to perform super resolution microscopy of biological nanoparticles. The extend of the project depends on the level (BSC or MSc) and the number of ECTS dedicated to this project.

**Required qualifications:**

An interest in lab work.

**Responsible institution/department:**

DTU Health Tech

**Contact information:**

rcwm@dtu.dk

**Allowed no of students per report:** 2

**DTU supervisor:**

Rodolphe Marie.

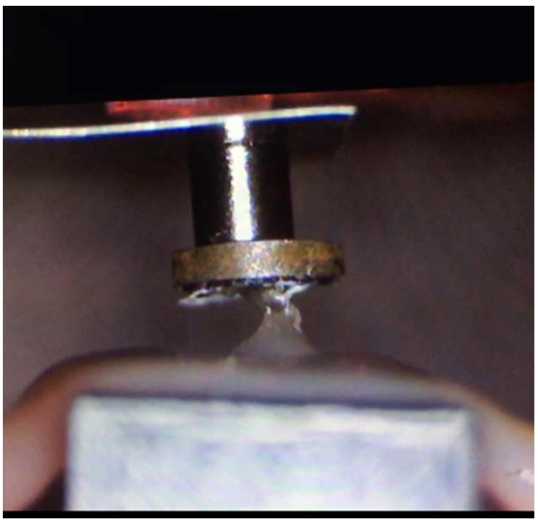
## MSc project for students in Biomedical Engineering and/or relevant fields

**Project Title:** Surface-modified nanostructured µparticles for increased intestinal retention

**Description:** Rapid clearance of the drug and the drug delivery system from the gastrointestinal (GI) tract is a major barrier to oral delivery and intestinal absorption. While mucus can act as a barrier to effective drug delivery, it can also assist with improved intestinal residence with anchoring mechanism. Special muco-adhesive micro/nano drug delivery systems can enable longer residence time, improving the efficacy of oral drug delivery.

In this project, we aim to design, fabricate and validate a special drug delivery system based on muco-adhesive nanoparticles covering a µparticle structure. We will perform in vitro, ex vivo and (if possible) in vivo studies to evaluate our drug delivery system from muco-adhesive, mucus-penetrating, and mucolytic aspects.

Hydrophobic polymer sheet



Surface modified hydrophobic polymer sheet

**Responsible institution/department:** Department of Heath Technology (DTU)

**Contact information:** Fatemeh Ajalloueian (faaj@dtu.dk)

**Allowed no of students per report (1-4):** 2 students

**About IDUN**

*IDUN is a center of excellence funded by the Danish National Research Foundation and the Villum Foundation. The center is divided into two parts: IDUN Drug and IDUN Sensor, focusing on drug delivery and nanomechanical sensors, respectively.*

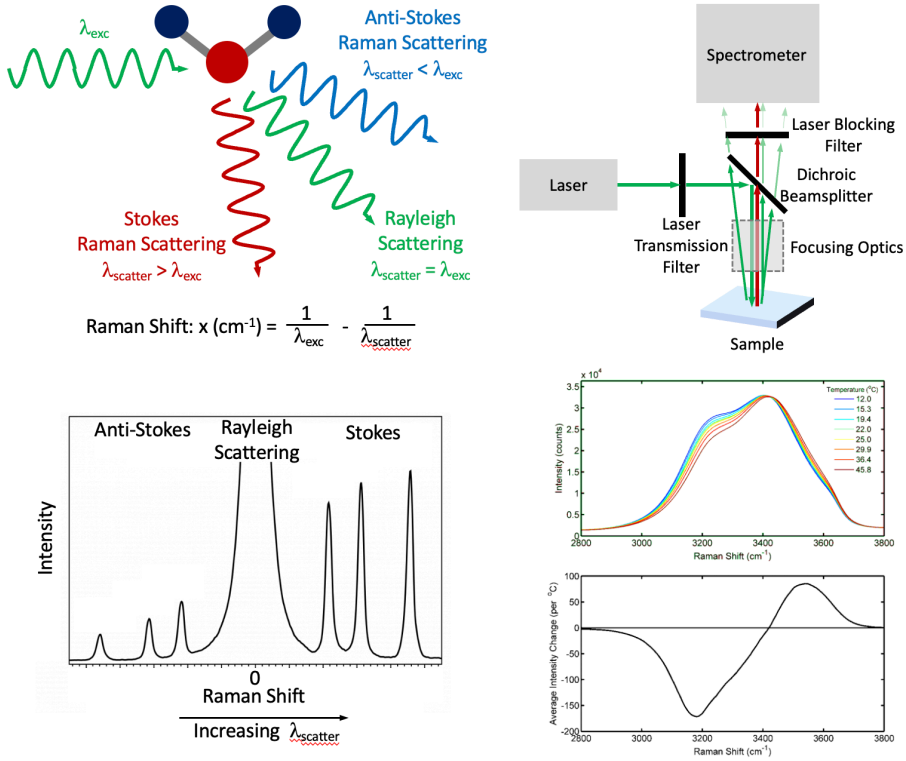
# Temperature imaging in microfluidics by Raman Spectroscopy

Description:

This project aims to explore Raman spectroscopy for 3D imaging of temperature profiles in microfluidics.

Temperature plays an important role in many chemical, biological and physical processes. Precise measurement of temperature profiles is often required to obtain reproducible results. This is also the case in our current research on light driven drug delivery: actuating/pushing molecules and nanoparticles in liquids (water) by a focused, near-infrared laser beam. Absorption of the infrared radiation creates a local temperature increase in the focal spot of the laser beam – a "hot-spot", and the generated local temperature gradient induces forces, e.g. thermophoresis, on molecules and nanoparticles.

It is challenging to integrate conventional technology such as thermometers, thermocouples, and NTC thermistors with our concept of light driven drug delivery, and remote optical sensing is preferred. Temperature imaging based on the temperature dependent fluorescence of the Ruthenium complex $[Ru(bpy)_3]^{2+}$ [1] is widely used in microfluidics, and high spatial resolution can be obtained with a fluorescence microscope. However, a non-labelling, optical temperature probe is preferable. Raman spectroscopy is a non-labelling and non-destructive identification method for chemical compounds, probing the molecular energy spectrum via in-elastic scattering of light, see figure. The Raman spectrum of water changes with temperature [2], and temperature profiles can be obtained by hyperspectral Raman imaging, where a Raman spectrum is recorded in each pixel.



Project work will include:

- Describe the physics behind Raman spectroscopy
- Describe the experimental setup for Raman spectroscopy
- Perform literature survey on measurement of temperature profiles in microfluidics
- Design and build flow cell with temperature control for Raman spectroscopy on water
- Establish a calibration curve for extracting temperature from Raman spectra on water
- Measure 3D temperature profile of laser induced hot spot in water

References:
[1] O. Filevich and R. Etchenique, Analytical chemistry, "1D and 2D Temperature Imaging with a Fluorescent Ruthenium Complex", 78, 7499–7503 (2006).

[2] C. P. Arlett and H. M. Pask, "Optical remote sensing of water temperature using Raman spectroscopy", Optics Express 31844 (2015

Required qualifications:

Basic knowledge on electromagnetism, optics and fluid dynamics.
Python programming

Responsible institution/department: DTU Health Tech

Contact information:

Anders Kristensen
DTU Health Tech
Ørsteds Plads 345C
DK-2800 Kongens Lyngby

tel.: +45 25171852
e-mail: akri@dtu.dk

Allowed no of students per report: 2

KU and/or DTU supervisor:

Anders Kristensen (akri@dtu.dk)

Co-supervisor team:
Jonas Nyvold Pedersen (jnpe@dtu.dk), Murat Serhatlioglu (murse@dtu.dk), Joachim Hermansen (joher@dtu.dk), Emil Alstrup Jensen (ealje@dtu.dk)

# Two-photon microscopy for diagnosis and monitoring of diseases

**Description:**

This project comprises a range of possible projects working two-photon microscopy. The project can be more engineering focused, image processing, or application focused depending on the student. Some opportunities could include:

-Investigation of metabolic biomarkers using 2D and 3D cultured cells and cancer models

-Beam shaping through multi-core and multi-mode optical fibers

-Dynamic beam shaping for light-sheet microscopy with exotic beams

-Imaging and analysis of cultured skin or colon samples with two-photon light sheet microscopy

-Imaging and analysis of autofluorescence and/or exogenous biomarkers with two-photon microscopy

-Analysis of laser damage to cells using two-photon microscopy

-Comparison of benchtop and fiber probe-based two-photon imaging systems

**Required qualifications:**

Project description can be adjusted to reflect the background and interest of individual students

**Responsible institution/department:** DTU Health Tech

**Contact information:**

Madhu Veettikazhy: madve@dtu.dk

Freja Høier: frejhoi@dtu.dk

**Allowed no of students per report:** We prefer students to work independently

**KU and/or DTU supervisor:**

Madhu Veettikazhy and Peter Andersen

# Validation of the forced oscillation system in differentiating different lung diseases

Description:

The forced oscillation technique (FOT) enables the evaluation of the mechanical properties of the respiratory system. The FOT system used in these projects is the AOS (termoflo c-100 Airway Oscillation System), integrated in clinical routines as a complementary rather than a stand-alone reliable diagnostic tool for lung diseases.

The aim of the project is to evaluate the reliability and validity of the diagnostic indices of the AOS system for obstructive and restrictive diseased patient using real patient data.

FOT measures the respiratory system impedance (Zrs), which consists of two components: the respiratory system resistance (Rrs) and the respiratory system reactance (Xrs). (Fisher, DuBois, and Hyde 1968)

The resistance describes the vanishing or dissipation of the pressure/energy in the airway and lung tissue i.e. the properties of the airway caliber.

The reactance on the other hand describes the viscoelastic properties of the lung system i.e the compliance or tendency/ability of the airway to extend/open.

The datasets used in the project are real patient data of categorized in normal, obstructive, restrictive and vascular diseased groups.

Required qualifications: No prerequisite

Responsible institution/department: Biomedical institute (BMI) Copenhagen University

Contact information:

*Associate Professor. Henrik H. El ALI, HLK, BMI, Copenhagen University*

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Allowed no of students per report: 1-4

KU and/or DTU supervisor:

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