DTU

UNIVERSITY OF COPENHAGEN

Project Catalogue

2024

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

Project Title: 3D scaffolds for substrate-free production of cell-spheroids

Description: 3D cell culture is superior to 2D cell culture (conventional cell culture plate), because it provides more physiologically relevant information and is more similar to *in vivo* conditions where cells can grow in all directions. This explains why conventional 2D cell culture tests provide misleading and nonpredictive data for *in vivo* responses. There have been some methods for establishing 3D cell cultures such as use of hydrogel matrices (e.g. Matrigel), or scaffold-free systems (microfuidic platforms or hanging drop culture systems[4,5]). Due to difficulty in scale-up and the labor intensive nature of these methods, alternative ways to prepare 3D spheroids have been investigated. In this project, we aim to be innovative, and use large pore areas of a 3D scaffold as a platform for detachable 3D substrate-free culture of cell-spheroides. During this project, you learn:

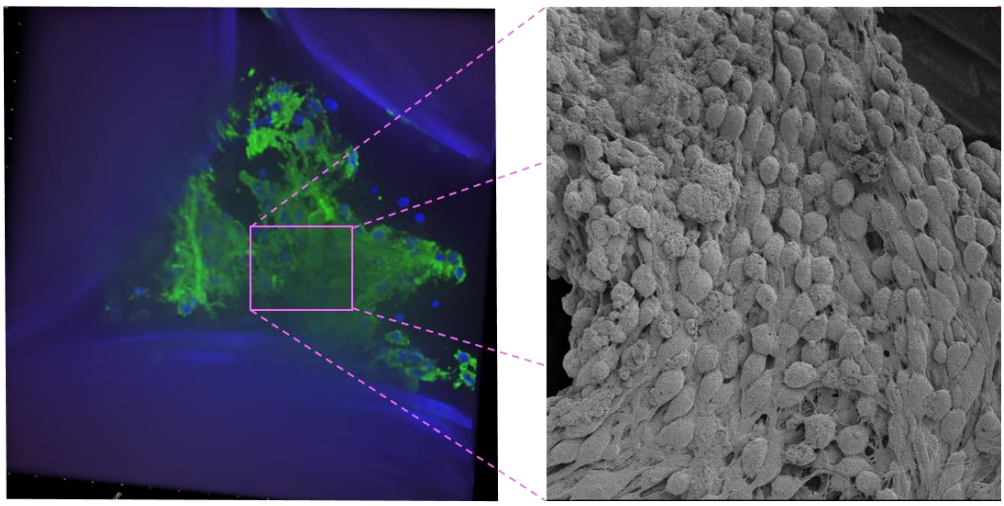
1. To culture cells under 2D and 3D conditions
2. To use a 3D scaffold for 3D in-depth cell culture
3. To characterize cell spheroids using live/dead assays and fluorescent microscopy techniques

Required qualifications: Basic knowledge in cell culture and material engineering (students can learn it during the thesis as well)

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



Project Title: Acute psychedelic effects on normalized global spatial complexity

Description:

Psychedelics acutely induce a profoundly altered stated of consciousness. They have gained recent attention as a promising therapeutic for hard-to-treat brain disorders. A prominent theory of psychedelics is that the acute experience is at least in part due to disrupted neural systems communication, manifested as increased entropy in brain function measured brain imaging (EEG or fMRI). The current project aims to replicate a recently reported acute effect of psychedelics on the entropy-related normalized global spatial complexity (NGSC) of fMRI signals measured during the psychedelic experience. The student will quantify NGSC based on fMRI scans acquired following drug administration or in the absence of drug (placebo or pre-drug). The project will include fMRI sessions from ~200 healthy participants scanned at different research centers and including the administration of different psychedelic drugs.

Required qualifications:

No required qualifications. Previous experience in R and/or Matlab is helpful.

Responsible institution/department:

Neurobiology Research Unit, Department of Neurology
Inge Lehmanns Vej 6-8, Rigshospitalet 8057
DK-2100

Contact information:

Senior Researcher, Patrick M. Fisher, PhD
Email: patrick@nru.dk

Allowed no of students per report: 1

KU and/or DTU supervisor:

Patrick M. Fisher (KU, Department of Drug Design and Pharmacology, SUND)

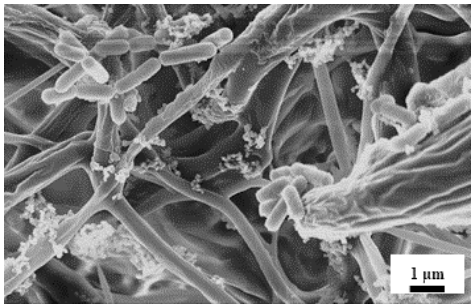
MSc project for students in Biomedical Engineering and/or Health Technology relevant fields

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

Project Title: Advanced dosimetry in preclinical models

Description: RadioLigand Therapy (RLT) is the concept of delivering radiation directly to the disease using by attaching radionuclides to targeted molecules. Although the concept is not new, recent technological breakthroughs and approval of novel therapeutics has sparkedrenewed interest in the field . Large pharmaceutical companies are now making large investments in the field in a race to develop the best radiopharmaceuticals[1].

A key factor in this development is establishing the optimal dose to be delivered, in order to both achieve adequate treatment and limit side-effects. Estimating the dose from a given injection is called dosimetry and is traditionally done using modelling of animal imaging studies, and later on using human imaging studies. These systems have not kept up with development, and the most used systems are not significantly different from their initial versions released in the early 1990s[2].

At Cluster for Molecular Imaging, we are developing several promising RLT candidates and have a lot of data for optimizing dosimetry calculations and verifying it with *ex-vivo* data. Other research groups have developed newer systems that take advantage of the computational powers and advanced imaging systems available today, which we would like to implement[3]. The students can also be involved in obtaining their own datasets or implement other modelling systems from scratch.

Required qualifications:
KU180 – Medical Use of Radiation (preferred)
KU181 – Radioactive Isotopes and Ionizing 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:
Lars Hvass, lars.hvass@sund.ku.dk

Allowed no of students per report: 1-2

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

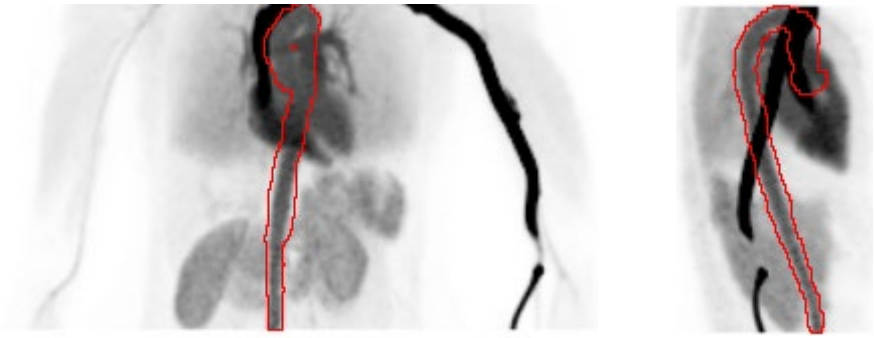
References:

1. Sgouros, G., Bodei, L., McDevitt, M. R., & Nedrow, J. R. (2020). Radiopharmaceutical therapy in cancer: clinical advances and challenges. Nat Rev Drug Discov, 19(9), 589-608. https://doi.org/10.1038/s41573-020-0073-9
2. Stabin, M. G., Sparks, R. B., & Crowe, E. (2005). OLINDA/EXM: the second-generation personal computer software for internal dose assessment in nuclear medicine. Journal of Nuclear Medicine, 46(6), 1023-1027. https://www.ncbi.nlm.nih.gov/pubmed/15937315
3. Carter, L. M., Crawford, T. M., Sato, T., Furuta, T., Choi, C., Kim, C. H., Brown, J. L., Bolch, W. E., Zanzonico, P. B., & Lewis, J. S. (2019). PARaDIM: A PHITS-Based Monte Carlo Tool for Internal Dosimetry with Tetrahedral Mesh Computational Phantoms. Journal of Nuclear Medicine, 60(12), 1802-1811. https://doi.org/10.2967/jnumed.119.229013

Project Title: Aorta Segmentation on dynamic PET data

Description:
Positron Emission Tomography (PET) is a highly sensitive technique for visualizing metabolism or receptor studies using tracers in-vivo. The time course of tracer uptake after injection is essential to understand the tissue response which can be modelled using pharmacokinetic modelling extracting physiological parameters of interest. An essential part of modelling the dynamic data is the knowledge of the tracer concentration in the blood as a function of time, i.e. the input function. Typically, a large vessel, such as the descending part of the aorta, is segmented from a CT scan performed prior to the PET examination. However, due to motion from the lungs and heart the mask is not always appropriate or well-matched to the PET data creating erroneous segmentation and quantification bias.

In this project a model for extracting the aorta from a dynamic PET series will have to be implemented, tested, and validated.



Required qualifications:
22485 Medical Imaging Systems (preferred)
KU005 Modelling of physiological systems (preferred)
General programming skills in either MatLab or Python

Responsible institution/department:
Department of Clinical Physiology and Nuclear Medicine, Copenhagen University Hospital – Rigshospitalet, Copenhagen, Denmark

Contact information:
Thomas Lund Andersen, thomas.lund.andersen@regionh.dk

Allowed no of students per report (1-4): 1-2
KU and/or DTU supervisor: Thomas Lund Andersen

Project Title: Comparison of dosimeters in medical device e-beam sterilization

Description:

The success of sterilization using ionizing radiation relies on accurate product dose mapping, demonstrating that the administered dose can be delivered to the product. A specified minimum dose is required to achieve sterility, ensuring that pathogens are not introduced to the user, while exceeding the maximum dose could compromise the functionality of the product due to material damage. Ultimately, the patient's safety is at risk if sterilization fails. In this project, we aim to compare two dosimeters commonly used in determining the dose during the sterilization of medical devices. This will be achieved through experiments conducted using a medical linear accelerator and/or an industrial irradiation facility, as well as developing Monte Carlo models for prediction and validation. Real industrial examples of medical devices will be used, such as injection devices from Novo Nordisk, and collaboration with manufacturers is expected.

What Can You Expect to Learn?

- Introduction to and expertise with Monte Carlo (MC) radiation transport principles and the software OpenTOPAS, which is based on GEANT4 (produced and used by CERN).
- Introduction to "dose mapping" (i.e., how the sterility of products is ensured) and the industry of radiation sterilization used in many medical device/pharma companies, including Novo Nordisk, Coloplast, and more.
- Self-selection, influence, and flexibility regarding medical devices of interest.
- A good working environment with an office spot and daily supervision.

Required qualifications: None.

Responsible institution/department: Dosimetry, Health Tech.

Contact information: Louis Lech Nissen (lonis@dtu.dk)

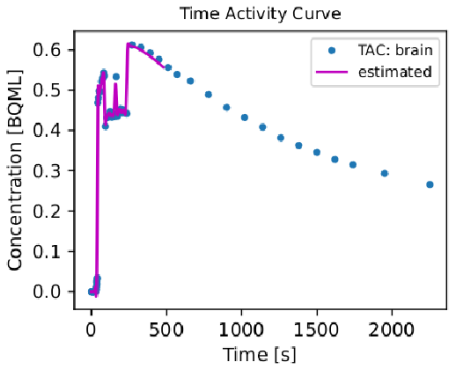
Allowed no of students per report: 1-2

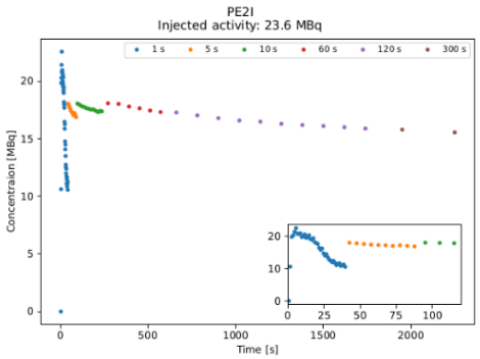
KU and/or DTU supervisor: Christina Ankjærgaard (cank@dtu.dk)

Project Title: Corrections to ultra-high time resolution PET data

Description:
Positron Emission Tomography (PET) is a highly sensitive technique for visualizing metabolism or receptor occupancy using tracers in-vivo. With the recent introduction of high sensitivity PET scanners, time resolution of down to 1 s. can be achieved enabling visualization of effects that has previously been unobtainable. However, for PET data to be quantitative several corrections need to be performed before final image analysis. For the ultra-high time resolution data in the current project these corrections do not seem to perform as well as previously and discontinuities in the temporal dimension of the data has been observed hampering the use of the data for new and exploratory analysis and further the understanding of basal physiology.

In this project ultra-high time resolution PET data will be investigated and characterized to enable further analysis of the images. Several datasets ranging across different tracers and injected activities are available for testing and characterization.





Required qualifications:
22485 Medical Imaging Systems (preferred)
KU005 Modelling of physiological systems (preferred)
General programming skills in either MatLab or Python

Responsible institution/department:
Department of Clinical Physiology and Nuclear Medicine, Copenhagen University Hospital – Rigshospitalet, Copenhagen, Denmark

Contact information:
Thomas Lund Andersen, thomas.lund.andersen@regionh.dk

Allowed no of students per report (1-4): 1-2
KU and/or DTU supervisor: Thomas Lund Andersen

Project Title: Deep molecular phenotyping of patients with heart disease by mass spectrometry based proteomics

Description:

Cardiovascular disease is the leading cause of death in the Western world, and we need to improve our molecular understanding of what drives disease progression to ultimately design strategies to prevent the disease progression. Mass spectrometry based proteomics allows for an unbiased and deep evaluation of the molecular landscape of cardiac tissue samples. As such, proteomics based studies of cardiac samples collected from patients with cardiovascular disease presents systems level investigations of protein remodeling characterizing a disease state, thereby offering data-driven insights on disease mechanisms. Cardiac biopsies collected from patients for diagnostic purposes have routinely been archived in pathology sections by formalin fixation and paraffin-embedding (FFPE). Cardiac FFPE specimens thereby represent an archived resource of samples for studying protein remodeling characterizing cardiac disease states. It is very attractive to pursue evaluation of the molecular phenotypes characterizing hearts from patients with a given cardiac condition by mass-spectrometry based investigations from such archived cardiac FFPE samples. The ambition is to outline cardiac protein remodeling characterizing the molecular phenotype of patients with a given cardiac disorder. In this thesis project, you will be involved in optimizing the methodology for proteomic quantification of cardiac proteomes from human heart FFPE samples.

Required qualifications:

Knowledge within fields related to mass spectrometry based proteomics, protein biochemistry or bioinformatics would be an advantage.

Responsible institution/department:

Department of Biomedical Sciences, Faculty of Health and Medical Sciences, University of Copenhagen.

The Lundby Group is an interdisciplinary research group investigating cardiac (patho)physiology by proteomics. We are particularly interested in pinpointing changes in protein expression that lead to cardiac disease. We work in close collaboration with clinicians at Rigshospitalet allowing us to study material directly from patients. Our group consists of an international mix of backgrounds in biotechnology, biochemistry and bioinformatics – resulting in a dynamic and inspiring work environment!

Contact information:

Professor Alicia Lundby. Email: alicia.lundby@sund.ku.dk; web: lundbylab.com

Allowed no of students per report: 1

KU and/or DTU supervisor: Professor Alicia Lundby, KU.

Project Title: Development of an ultrasound-transmitting membrane allowing echocardiography in explanted, large animal hearts

Description:

Echocardiography is a frequently used clinical tool to assess cardiac function in patients with heart diseases. Translational research using large animal models is considered necessary to improve the understanding of heart diseases and develop new treatment options for these patients. For our research in heart failure and cardiac arrhythmias, we make use of a working-heart technology, permitting explanted large animal hearts to function ex vivo. This project intends to develop and test a membrane structure encircling these explanted hearts that will allow transmission of ultrasound, and thereby clinically relevant echocardiographic measures using a clinical scanner.

Required qualifications:

We seek a student with an independent, goal-oriented, and collaborative mindset as well as having interests in cardiac mechanics, ultrasound, and plastic materials.

Responsible institution/department:

Department of Biomedical Sciences, University of Copenhagen.

Contact information:

Lisa Gottlieb, MD PhD, postdoc gottlieb@sund.ku.dk.

Allowed no of students per report: 1-2

KU and/or DTU supervisor:

Main supervisor: Professor Thomas Jespersen, Cardiac Physiology Laboratory, KU

Primary co-supervisor: Lisa Gottlieb, Postdoc, KU.

Project Title: Effect of magnetic fields during cell growth on abundance of free radicals

Description: BSc or MSc thesis project

MOTIVATION:

There are indications in literature that cells grown under very low magnetic fields (i.e. smaller than the Earth magnetic field) have a higher abundance of reactive oxygen species than cells grown under "normal" conditions. This project aims to explore that statement and test the hypothesis by means of intracellular nanodiamond sensing.

CONTENT:

The method we use to measure abundance of reactive oxygen species requires nanodiamonds to be taken up by the cell. Therefore, the very first step in the project is for you to optimize the protocol for nanodiamond uptake in HEK cells. For this, confocal microscopy will be used to assess the uptake. Next, you will learn how to use our custom-built optical setup for nanodiamond quantum sensing by means of T1-relaxometry. Once you master that technique, you are to let cells grow under “normal” conditions as well as under close to zero magnetic field conditions. These two different groups of cells are then used for T1-relaxometry measurements with intracellular nanodiamonds, for comparison. Control experiments with more conventional assessment of reactive oxygen species will be carried out to the extent that time allows.

Depending on your prior experience with mammalian cell cultures, with optics experiments, with light microscopy, and with image- and data analysis, the project will be tailored for you to learn missing competencies.

Required qualifications: Basic cell biology and introductory physics passed well as well as some programming and image analysis skills (and have passed compulsory courses in your program).

Responsible institution/department: Department of Health Technology, DTU

Contact information: kibs@dtu.dk; tel 22275868

Allowed no of students per report: 1-2

KU and/or DTU supervisor: Kirstine Berg-Sørensen and Aldona Mzyk

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.

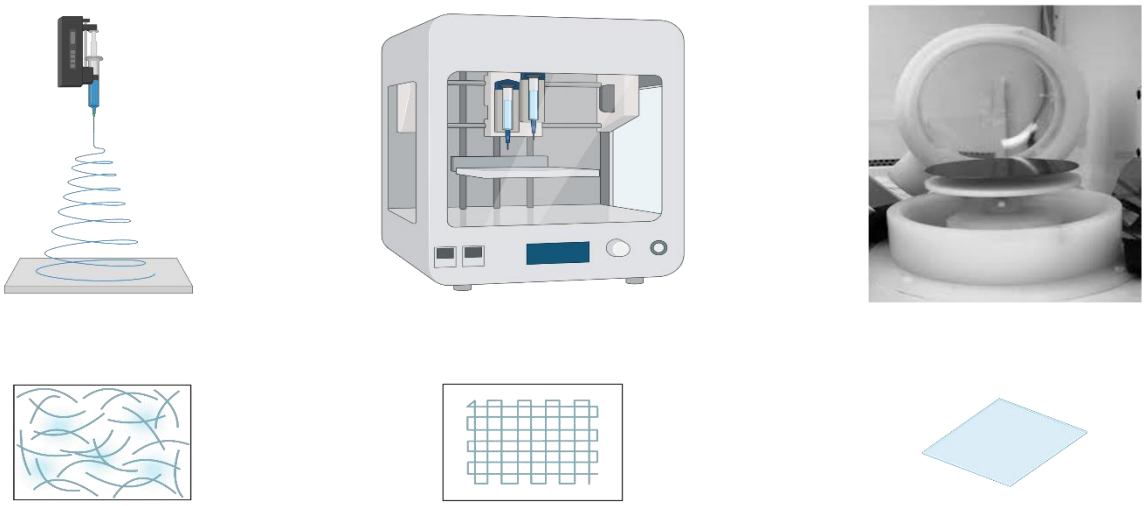


Fig 1. An illustration of different fabrication techniques to prepare potential piezo-electric substrates

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)

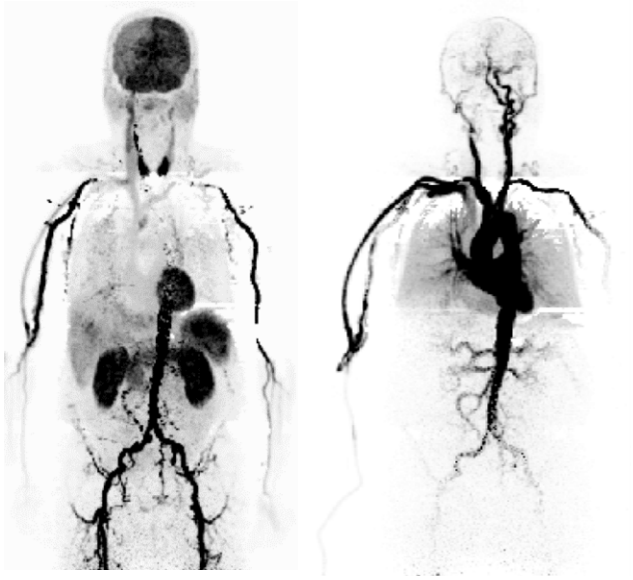
Supervisor(s): Fatemeh Ajalloueian, Nasim Golafshan

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

Project Title: Fractional tissue perfusion

Description:
Positron Emission Tomography (PET) is a highly sensitive technique for visualizing metabolism or receptor occupancy using tracers in-vivo. Perfusion, that is the passage of fluid from the circulatory system to an organ or tissue, can be quantitatively measured with PET using a radioactive isotope of oxygen bound to water, i.e. [^{15}O]-H_2O. The measurement across typically 3 minutes due to the short physical half-life ^{15}O of approx. 2 min. With new high-sensitive scanners the measurement time can now be expanded to and beyond 12 minutes. Such measurements offer a unique insight into the physiology of more slowly perfused tissues. Longer measurement times also open for more advanced models to estimate the perfusion components of the underlying tissue.

In this project novel models for perfusion imaging calculation should be investigated, implemented, and characterized tested on long time scale [^{15}O]-H_2O scans.



Required qualifications:
22485 Medical Imaging Systems (preferred)
KU005 Modelling of physiological systems (preferred)
General programming skills in either MatLab or Python

Responsible institution/department:
Department of Clinical Physiology and Nuclear Medicine, Copenhagen University Hospital – Rigshospitalet, Copenhagen, Denmark

Contact information:
Thomas Lund Andersen, thomas.lund.andersen@regionh.dk

Allowed no of students per report (1-4): *1-2*
KU and/or DTU supervisor: Thomas Lund Andersen

Project Title: Investigating how obstructive sleep apnea influences the heart in a Danish patient cohort

Description:

Recent studies show that almost half of patients with the cardiac arrhythmia atrial fibrillation also suffer from obstructive sleep apnea. Obstructive sleep apnea alters physiology by causing changes in the autonomic nervous activity, blood gases, and blood pressure. These alterations influence the heart tissue, making it more prone to arrhythmias. However, it is largely unknown which of these pathophysiological changes trigger arrhythmias immediately after the apnea as well as on the long term. This project makes use of a cohort of Danish patients having undergone a sleep study (continuous measurements of blood pressure, blood oxygen saturation, electrocardiography (ECG) throughout a night) at Rigshospitalet. The objective is to determine which pathophysiological patterns associate with arrhythmias in patients.

Required qualifications:

We seek a student with an independent, goal-oriented, and collaborative mindset, and having competencies in data handling as well as an interest in cardiovascular physiology. This project is based on a close collaboration between the Department of Biomedical Sciences, KU and Rigshospitalet and will give the student the possibility to integrate into both basic and clinical science.

Responsible institution/department:

Department of Biomedical Sciences, University of Copenhagen.

Contact information:

Lisa Gottlieb, MD PhD, postdoc gottlieb@sund.ku.dk.

Allowed no of students per report: 1-2.

KU and/or DTU supervisor:

Main supervisor: Professor Thomas Jespersen, Cardiac Physiology Laboratory, KU

Primary co-supervisor: Lisa Gottlieb, Postdoc, KU. In close collaboration with Professor Poul Jennum, Sleep Clinic, Rigshospitalet.

Project Title: Investigating the effects of stored charge on dose distribution in medical device sterilization

Description:

When electrically non-conductive materials, such as plastics, are irradiated with electron beams, the incident electrons can become thermalized in the material, generating an electrostatic field. This field affects the trajectories of the incoming electrons and ultimately influences the dose distribution. This phenomenon can impact radiotherapy in cancer treatment if the patient has plastic implants, as well as the sterilization of a wide variety of medical devices used for treating patients. In this project, we aim to investigate how this electrostatic field alters the distribution of ionizing radiation. This will be achieved through experiments conducted using a medical linear accelerator and/or an industrial irradiation facility, as well as developing Monte Carlo models for prediction and validation. Understanding the effects of stored charge will undoubtedly benefit the radiation processing community.

What Can You Expect to Learn?

- Introduction to and expertise with Monte Carlo (MC) radiation transport principles and the software OpenTOPAS, which is based on GEANT4 (produced and used by CERN).
- Introduction to "dose mapping" (i.e., how the sterility of products is ensured) and the industry of radiation sterilization used in many medical device/pharma companies, including Novo Nordisk, Coloplast, and more.
- A good working environment with an office spot and daily supervision. High chance of authoring or co-authoring a publication.

Required qualifications: None.

Responsible institution/department: Dosimetry, Health Tech.

Contact information: Louis Lech Nissen (lonis@dtu.dk)

Allowed no of students per report: 1-2

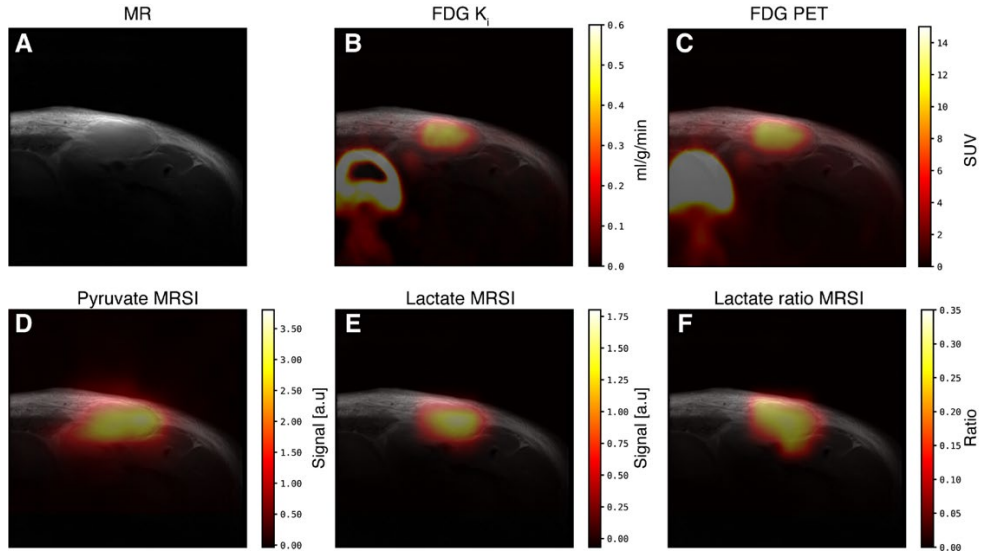
KU and/or DTU supervisor: Christina Ankjærgaard (cank@dtu.dk)

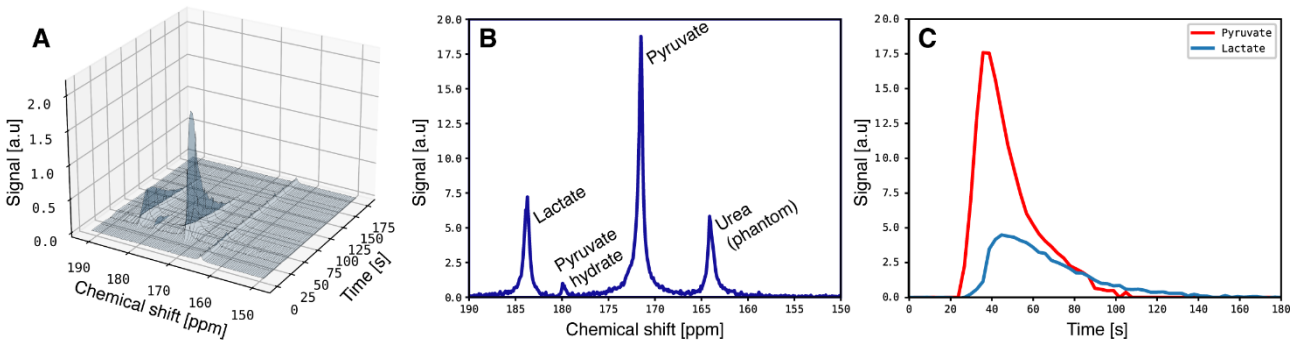
Project Title: Kinetic analysis of hyperpolarized ^{13}C data and dynamic PET imaging

Description:

Hyperpolarized Magnetic Resonance Spectroscopy (MRS) is a functional imaging technique that can examine downstream metabolites of e.g. cancer metabolism where an elevated glycolysis and lactate production is present, the so-called *Warburg effect.* PET imaging is a highly sensitive imaging technique capable of visualizing the metabolism of FDG, a glucose analog. At Rigshospitalet, time-resolved hyperpolarized MRS are acquired simultaneously with dynamic PET data on a clinical PET/MR scanner, named hyperPET, to get the best of both worlds.

The data has been acquired but should be analyzed further to add knowledge of the kinetics of the [^{18}F]FDG PET data and the hyperpolarized data in-vivo and the differences between them. In this project, we will implement kinetic modeling of both MRS and PET data and compare the results. Both temporally and spatially resolved data is available, providing a unique dataset.





Required qualifications:

22485 Medical Imaging Systems (preferred)
KU005 Modelling of physiological systems (preferred)
General programming skills in either MatLab or Python

Responsible institution/department:

Department of Clinical Physiology and Nuclear Medicine, Copenhagen University Hospital – Rigshospitalet, Copenhagen, Denmark

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

Project Title: Layer-by-Layer electrospinning of piezoelectric energy harvesting devices for ingestible electronics

Description: The aim of this project is to develop biocompatible energy harvesting devices via electrospinning. The project fits within the broader scheme of the Novo Nordisk Foundation Challenge – Energy Materials for the Gut (EMGUT) project at IDUN.

In this project, the student would work with various biodegradable and biocompatible polymeric materials to develop a monomaterial piezoelectric energy harvesting device with varying layer microstructures. The project would involve chemical processing of polymers, developing fiber composites using nanomaterials like graphene and CNTs, and/or conductive polymers like PEDOT: PSS or Polypyrrole (PPy). The different combinations of polymers, polymer composites and inorganic materials would be used for layer-by-layer electrospinning to fabricate the energy storage device. Fabrication of these devices will be followed by characterization and testing of the devices, including dielectric constant measurement and electromechanical tests. Depending on the extent of completion, the project may involve performing biocompatibility tests for the fabricated devices since these devices would interface with the internal organs of the body.

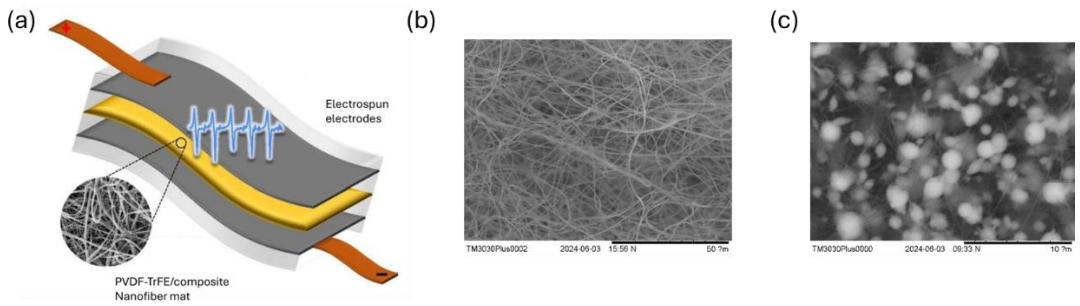


Fig 1. (a) PVDF-TrFE piezoelectric device. (b), (c) SEM images of PVDF nanofiber mat and nanoparticles respectively.

Required qualifications: The student is expected to have laboratory work experience and a good problem-solving mindset. Experience of working with polymers, electrospinning or piezoelectric materials would be good to have, but is not required.

Responsible institution/department: DTU Health Tech

Contact information: karsha@dtu.dk or faaj@dtu.dk .

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

KU and/or DTU supervisor: Kartikeya Sharma, Fatemeh Ajalloueian

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.

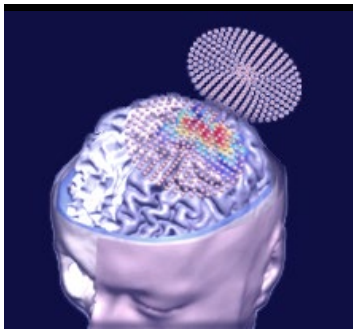
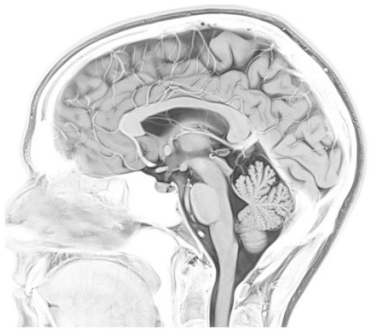
Required qualifications: Different competences are of interest, and projects matching your background can likely be proposed. It is an advantage to have one or preferably more of the courses 22481, 22485, 22506, 22507 or 22508 (see https://www.cmr.healthtech.dtu.dk/education/mr-courses-and-their-connection).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

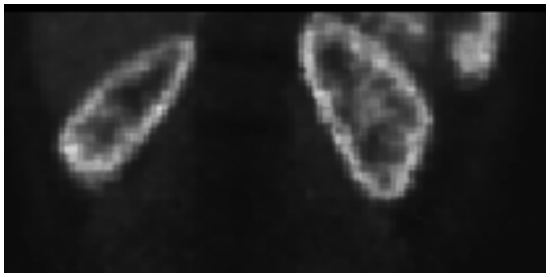
KU and/or DTU supervisor: For example Axel Thielscher (neurophysics), Mathilde Hauge Lerche (brain metabolism), Henrik Lundell (microstructure & ultra-highfield MRI), Kristoffer Hougaard Madsen (machine learning), Tim Dyrby (microstructure), Vitaliy Zhurbenko (coil technology) or Lars G. Hanson (measurement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

Project Title: Motion correction of the kidneys for perfusion modelling

Description:
Positron Emission Tomography (PET) is a highly sensitive technique for visualizing metabolism or receptor-based tracers in-vivo. Perfusion, that is the passage of fluid from the circulatory system to an organ or tissue, can be quantitatively measured with PET using a radioactive isotope of oxygen bound in water, i.e. [^{15}O]-H_2O. The measurement across typically 3 minutes where the tracer uptake and washout are visualized and subsequently modelled. Historically, the methodology has been applied primarily in the brain, but recent advances of PET instrumentation has enabled perfusion calculations in other organs as well. In this respect the kidneys have attracted interest due to their central function of controlling, among others, body fluids, acid-base balance and electrolyte concentrations. However, due to the acquisition of data across several minutes organs such as the kidneys suffer from motion primarily due to respiratory effects. Such motion complicates and biases the modelling for calculation of the perfusion.

In this project motion correction of the kidneys should be investigated and characterized. Furthermore, the effect of perfusion calculations should be evaluated.



Required qualifications:
22485 Medical Imaging Systems (preferred)
KU005 Modelling of physiological systems (preferred)
General programming skills in either MatLab or Python

Responsible institution/department:
Department of Clinical Physiology and Nuclear Medicine, Copenhagen University Hospital – Rigshospitalet, Copenhagen, Denmark

Contact information:
Thomas Lund Andersen, thomas.lund.andersen@regionh.dk

Allowed no of students per report (1-4): 1-2
KU and/or DTU supervisor: Thomas Lund Andersen / Ulrich Lindberg

Project Title:

Nanodiamond-based quantum sensing for correlation of free radical generation with viscoelastic properties of brain tumour spheroids

Motivation

Glioblastoma (GBM) is the brain tumor for which there is no cure yet. Bioengineered GBM models, such as hydrogel-encapsulated spheroids, that capture both cell-cell and cell-matrix interactions could facilitate testing of much needed therapies. Understanding of mechanoregulated free radical generation by spheroids would enhance the usefulness of GBM models as predictive drug screening platforms. Free radicals (FRs), a class of reactive molecules with a free electron, have emerged to be crucial for intracellular signalling, cancer cell migration and therapeutic resistance. It is also well known that tumour mechanical properties are changing depends on the disease stage. However, we do not understand what is the correlation betwen these two factors and how we could manipulate them to decrease therapuetic resistance.

Goal of the project

In this project we aim to reveal the correlation between changes in FR concentration and mechanical properties of cells in U87MG brain cancer spheroids using a nanodiamond magnetometry (quantum sensing technique) combined with optical tweezers.

Research plan and learning outcomes

You will learn how to apply nanodiamond magnetometry to simultaneously measure FRs generation and local viscoelastic properties in living cells of brain cancer spheroids. In this method you will use fluorescent nanodiamonds (FNDs) with nitrogen vacancy centers as probes. You will learn how to culture tumour spheroids in hydrogels of various stiffness to stimulate changes in their mechanical properties. Further you will explore how to obtain spheroids of desired size compatibile with nanodiamond-based quantum sensing protocols, how to use fluorescent microscopy to determine nanodiamonds penetration inside spheroids and determine how cell heterogeneity may influence the nanodiamonds uptake.

Student 1: You will develop hydrogel system of various stiffness to modulate brain cancer spheroids response. You will study nanodiamonds uptake by cells, penetration depth inside spheroid depends on the mechanical properties of applied hydrogel. You will simultaneously track nanodiamonds in spheroids and measure free radical concentration using nanodiamond magnetometry technique. You will calculate cell viscoelastic properties based on parameters obtained from tracking and correlate them with FRs concentration in response to the stiffness of developed hydrogel.

Stundent 2: You will functionalize surface of nanodiamonds to obtain their optimal targeting to mitochondria of cells of brain cancer spheroid. You will study nanodiamonds uptake by cells, penetration depth inside spheroid depends on the mechanical properties of applied hydrogel. You will use nanodiamond magnetometry combined with optical trapping to study correlation between FR concentration and local viscoelastic properties of mitochondria inside living brain cancer spheroids encapuslated in hydrogel of various stiffness.

Required qualifications:

Insight in cell biology, preparation of spheroids and/or in microscopy, image analysis with python or MatLab, ability to program (in python or MatLab).

Responsible institution/department:

DTU, Department of Health Technology

Contact information:

Prof. Kirstine Berg-Sørensen: kibs@dtu.dk
Dr. Aldona Mzyk: ailmz@dtu.dk
Maria Niora, MSc: marnio@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
Maria Niora, MSc: marnio@dtu.dk

Project Title:

Nanodiamond-based quantum sensing for detection of free radical generation by single cells in cardiac fibrosis

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 nanodiamond magnetometry (quantum sensing technique).

Research plan and learning outcomes

You will learn how to apply nanodiamond quantum sensing to simultaneously measure FRs generation and local viscoelastic properties in living cardiac fibroblasts. In this method we will use fluorescent nanodiamonds (FNDs) with nitrogen vacancy centers as probes. Cardiac fibroblasts will be cultured on dishes coated with thin polymer films of various stiffness for mechanical stimulation. We will obtain cell transdifferentiation to myofibroblasts on a surface of higher stiffness.

Student 1: You will use nanodiamond magnetometry to track and measure FRs generation in transporting vesicles inside cardiac fibroblasts growing on the substrates of various stiffness. You will calculate cell viscoelastic properties based on parameters obtained from tracking and correlate them with FRs concentration at different maturation stage of transporting vesicles (early/late endosome and lysosome) identified based on images from the fluorescent confocal microscope.

Stundent 2: You will use nanodiamond magnetometry combined with optical trapping to study correlation between FR concentration and local viscoelastic properties of organelles (mitochondria, endoplasmic reticulum) inside living cardiac fibroblasts growing on substrates of various stiffness.

Student 3: You will develop polymer based substrate of dynamicaly tunable viscoelastic properties. You will use developed material to control free radical generation in cardiac fibroblasts. You will verify with nanodiamond magnetometry if your material stimulates cells.

Required qualifications:

Insight in cell biology, preparation of polymer coatings and/or in microscopy, image analysis with python or MatLab, ability to program (in python or MatLab).

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: 3

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: 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.

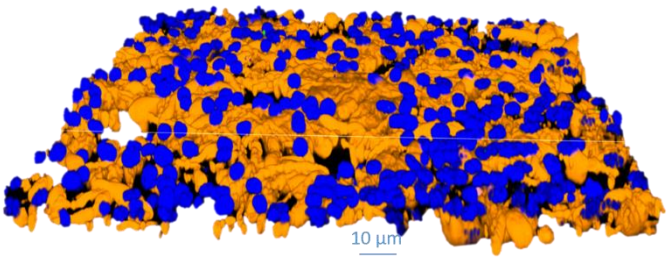
Required qualifications: None

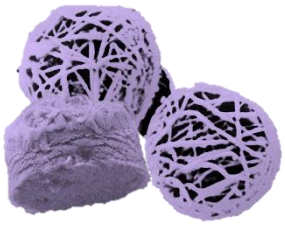
Responsible institution/department: Department of Health Technology, DTU

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

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

Supervisors: Fatemeh Ajalloueian

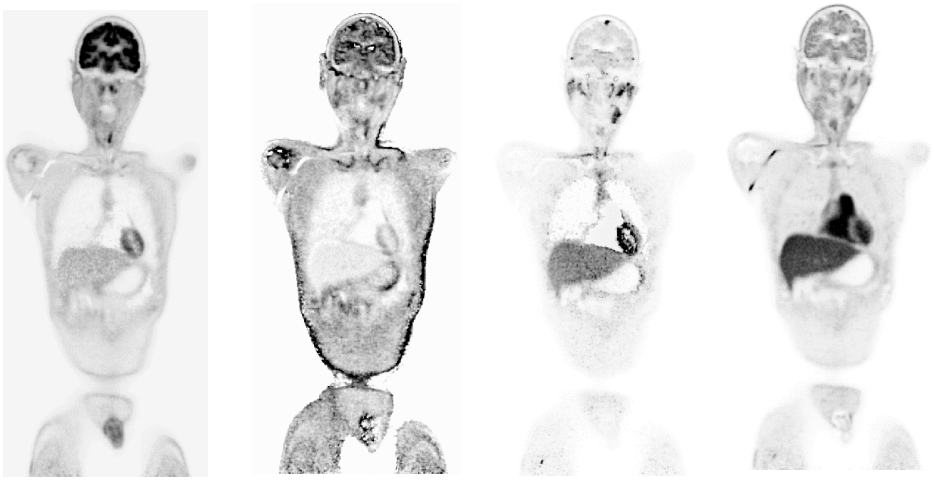




Project Title: Normative values for glucose metabolism in-vivo

Description:
Positron Emission Tomography (PET) is a highly sensitive technique for visualizing metabolism or receptor occupancy using tracers in-vivo. The most common tracer, [^{18}F]-FDG, a glucose analogue, can be used to measure glucose metabolism in-vivo. With new and longer high-sensitive PET scanners recently introduced in the clinic, measurement of the whole body can now be performed in the multiple organs simultaneously as opposed to previous regional scans. This enables measurements of glucose metabolism in multiple organs at once learning not only about the rate of glucose metabolism of the individual organs but also the interaction between them. To establish both the normal values of glucose metabolism we have scanned a cohort of 100 healthy individuals across a wide age range.

In this project the glucose metabolism for a range of organs should be calculated. This will, for the first time, establish a normal material of glucose metabolism atlas from which future studies can be compared.



Required qualifications:
22485 Medical Imaging Systems (preferred)
KU005 Modelling of physiological systems (preferred)
General programming skills in either MatLab or Python

Responsible institution/department:
Department of Clinical Physiology and Nuclear Medicine, Copenhagen University Hospital – Rigshospitalet, Copenhagen, Denmark

Contact information:
Thomas Lund Andersen, thomas.lund.andersen@regionh.dk

Allowed no of students per report (1-4): *1-2*
KU and/or DTU supervisor: Thomas Lund Andersen

Project Title: Optimal performance of preclinical PET scanners

Description:
Positron Emission Tomography (PET) is used for functional imaging, where a positron-emitting isotope is injected into a patient or animal, which a PET scanner can then detect. This consists of a ring of crystals that detects characteristic annihilation photons with an energy of 511 keV, whose distribution can ultimately be reconstructed into a tomographic image.

Several parameters can be adjusted during both acquisition and reconstruction and while the manufacturer gives a set of recommendations, these can be optimized to individual isotopes. This project will consist of both phantom scans of the standard NEMA NU 4 preclinical PET phantom along with *in-vivo* imaging, both parts can be done with different tracers. We would then want to investigate the reconstruction algorithm's influence on quantitative and qualitative image quality.

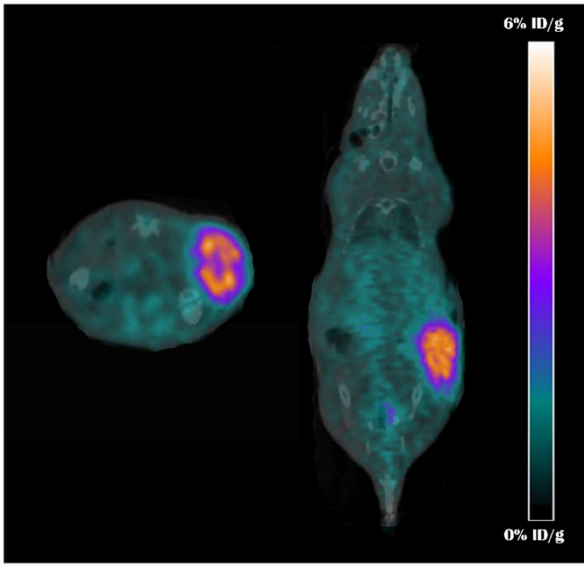
At Cluster for Molecular Imaging, we now have three PET systems, each with individual characteristics. The analysis above will allow us to compare the performance of each system. Furthermore, the stability and linearity of the systems are of great interest to current studies.

Generally, this project offers both theoretical and practical challenges and a chance to get realistic experience with the analysis of data generated by yourself. We expect students to be ambitious and to take initiative, and in return, you get to be part of a social and diverse research group with great opportunities for staying on.

Required qualifications:
22485 – Medical Imaging Systems (preferred)
KU180 – Medical Use of Radiation (preferred)
KU181 – Radioactive Isotopes and Ionizing 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



[^{68}Ga]-RGD-PET SCAN OF A MOUSE WITH SUBCUTANEOUS TUMOR

Allowed no of students per report: 1-2

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

References:

- Emvalomenos, G., Trajanovska, S., Pham, B.T.T. et al. Performance evaluation of a PET insert for preclinical MRI in stand-alone PET and simultaneous PET–MRI modes. EJNMMI Phys 8, 68 (2021). https://doi.org/10.1186/s40658-021-00415-1Bao,
- Qinan, et al. "Performance evaluation of the inveon dedicated PET preclinical tomograph based on the NEMA NU-4 standards." Journal of Nuclear Medicine 50.3 (2009): 401-408.

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

Project Title:

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. Optical coherence tomography is a non-invasive optical imaging modality that provides volumetric images of tissue microstructure without the need for contrast agents. OCT is most commonly used in ophthalmology, however, our research group aims to expand the use of OCT to other diagnostics, including in dermatology and oncology. 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

-Identifying biomarkers of small fiber neuropathy using OCT

-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: No preference – the project can be adjusted to reflect the number of students

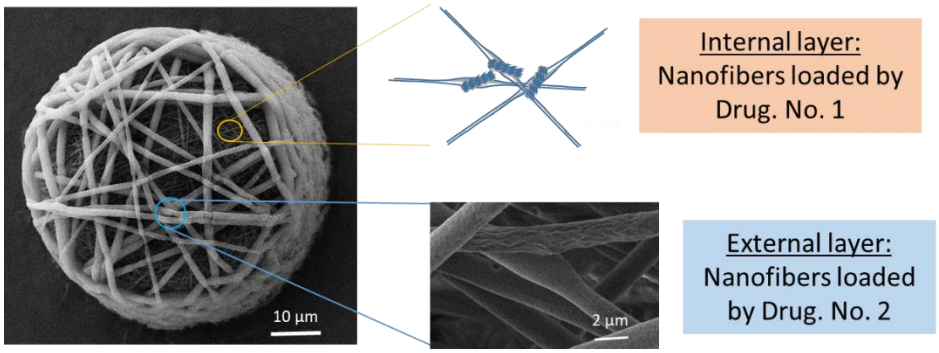
KU and/or DTU supervisor:

Gavrielle Untracht and Peter Andersen

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

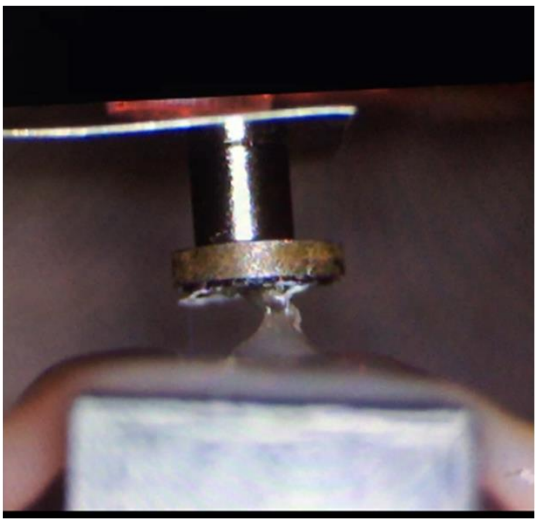
MSc project for students in Biomedical Engineering and/or relevant fields

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.

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

Project Title:

Two-photon microscopy for diagnosis and monitoring of diseases

Description:

This project comprises a range of possible projects working on two-photon fluorescence 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

-Applications of two-photon fluorescence imaging in neuroscience

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

Peter Andersen: peta@dtu.dk

Allowed no of students per report: No preference – the project can be adjusted to reflect the number of students

KU and/or DTU supervisor:

Madhu Veettikazhy and Peter Andersen

Project student for R&D

Who is O2matic?

O2matic is a certified medtech/digital health company that develops innovative class IIB products for patients in need of oxygen therapy. Our products are used both in Europe and abroad. Our mission is to improve the quality of life for patients with respiratory diseases.

We are pioneers in this area and would like to maintain our position by continuing to focus on product development.

Project Proposal 1

Cyber security is very essential in systems that are used to treat patients. The purpose of this project is to plan and carry out a penetration test and based on the results of the test make some recommendations for improving cyber security.

Project Proposal 2

Our proprietary technology to treat respiratory patients has documented the best clinical outcome, but we want to move our algorithm to the next level and explore the opportunities for using AI to better support the clinician. We can define the final outcomes of the project based on the student's background and interest.

Contact information

Further information about the projects can be obtained by contacting Farzad Saber on tel. 2886 9200 or email to fas@o2matic.com.

Our office is located at Nørrelundvej 10, 2720 Herlev.