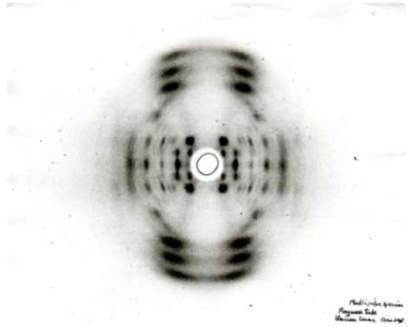
Biophysics and Medical Technology, Dept of Physics, NTNU

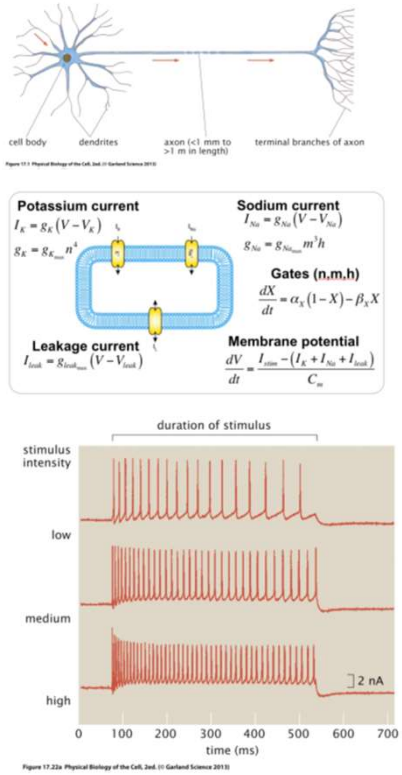
Bjørn Torger Stokke
Magnus Lilledahl

NTNU | Norwegian University of Science and Technology

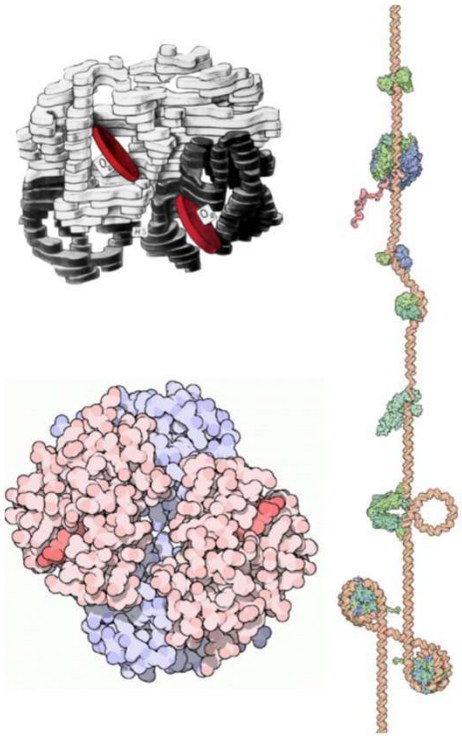
Biophysics - examples



Structure and function of DNA

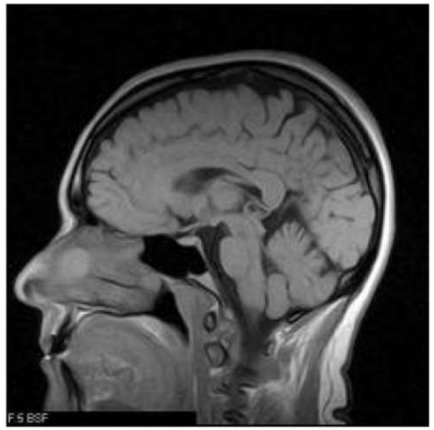


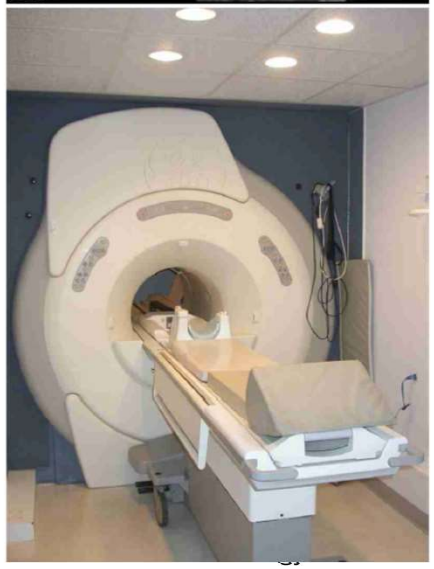
Hodgkin-Huxley model

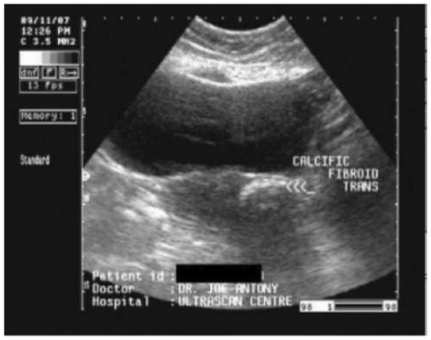


Structural biology

Medical Technology – application of biophysics in technology







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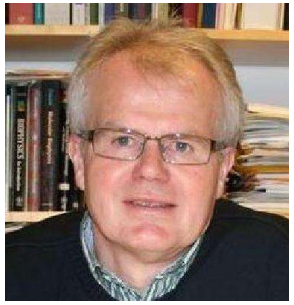




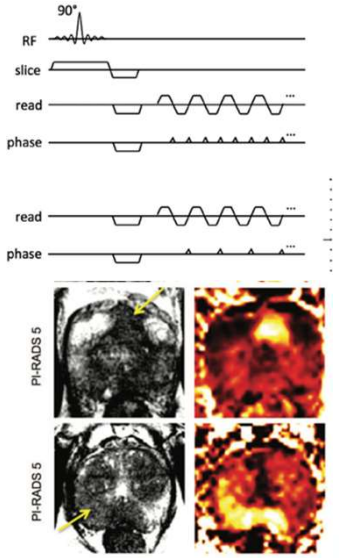

Magnetic Resonance Imaging

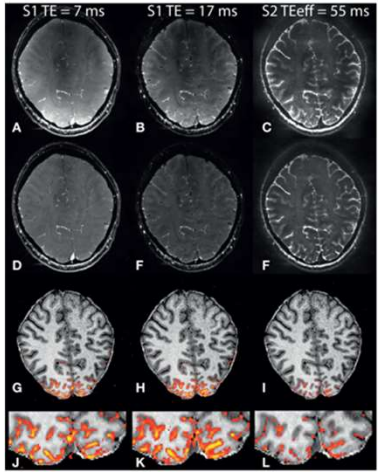
Contact: Pål Erik Goa, pal.e.goa@ntnu.no

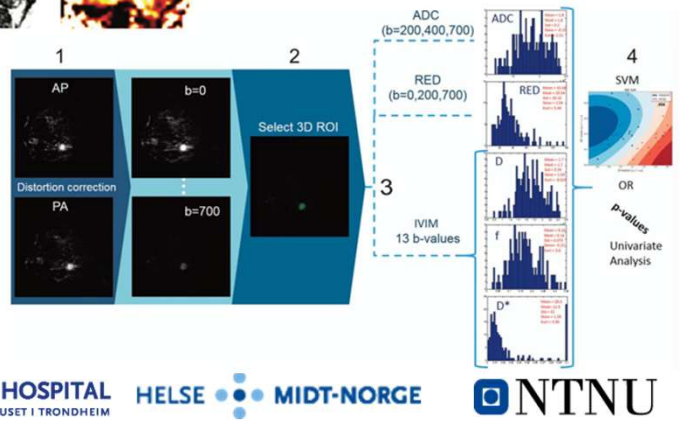
Development of methods in
- Signal Acquisition/Contrast
- Image Reconstruction
- Information Extraction

Applications in
- Cancer
- Neuroscience

Main local partners
- Medical - faculty
- St.Olavs Hospital







NORWEGIAN/7T MR/CENTER

ST. OLAVS HOSPITAL
UNIVERSITETSSYKEHUSET I TRONDHEIM

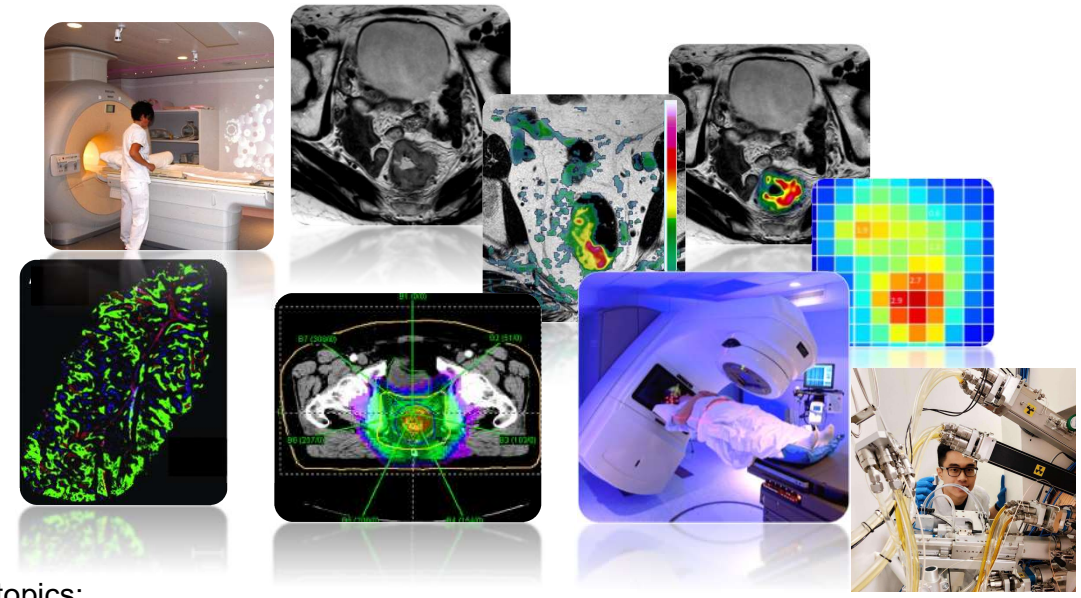
HELSE MIDT-NORGE

NTNU

Medical radiation physics

Contact: Kathrine Røe Redalen, kathrine.redalen@ntnu.no

More info: https://www.ntnu.edu/physics/radiotheraphyphysics#/view/tags



You can learn:

- MRI and PET
- Image analysis
- Radiotherapy physics
- Radiobiology
- Cancer biology
- Mathematical/ biophysical modeling

Research topics:

- Quantitative analysis of MRI and PET images for more precise cancer diagnostics
- Biologically adaptive image-guided radiotherapy with photons and protons
- New radiopharmaceuticals for PET imaging and therapy
- Experimental models to understand mechanisms

National collaborations with St. Olavs hospital, Akershus University Hospital, University Hospital North Norway, University of Oslo, University of Bergen

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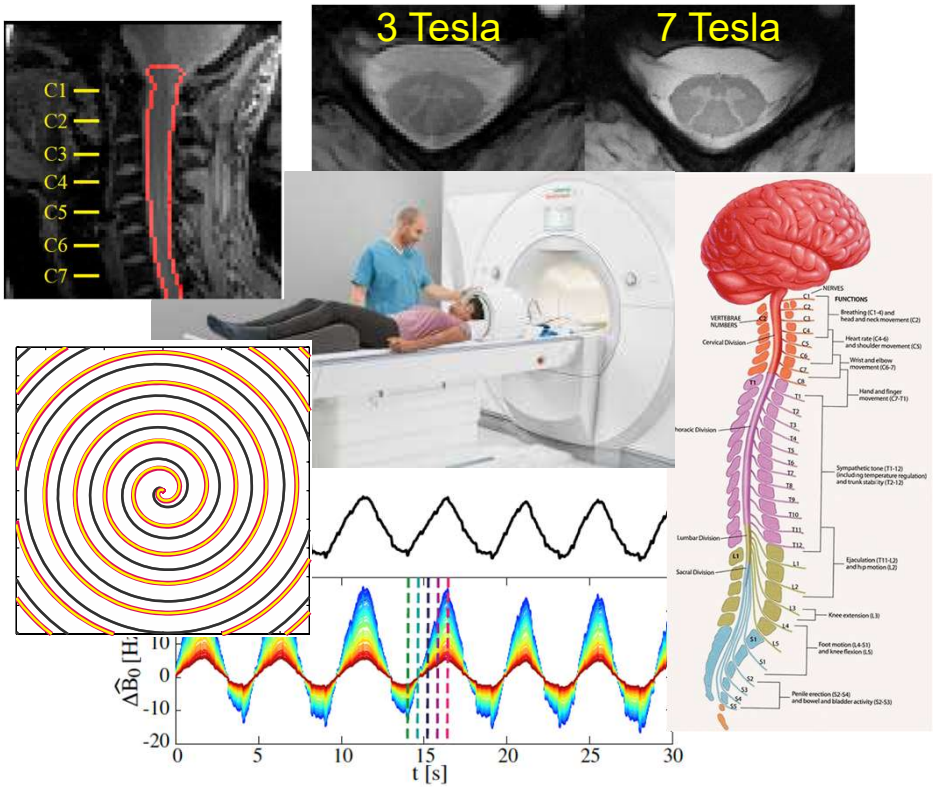
Ultra-high field MRI

Contact: Johanna Vannesjö, johanna.vannesjo@ntnu.no

Research aim: Improve resolution and image quality in spinal cord MRI at 7 Tesla



Focus areas

- Spatial encoding
- Image reconstruction
- Magnetic field homogeneity
- Physiological perturbations
- System characterization

You can learn

- MR physics
- System modeling
- Signal processing
- Image analysis

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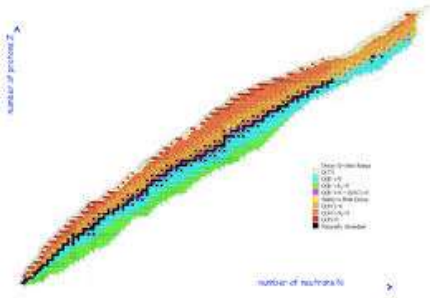
Nuclear Magnetic Moments and Hyperfine Anomalies

Determination of nuclear magnetic moments are important from both a fundamental and applied physics view. Precision values are needed in NMR-studies using different isotopes and elements.

The project aims at finding the limitations of the present values and through calculations of atomic and nuclear properties improve the accuracy of the values.



Contact: jonas.persson@ntnu.no

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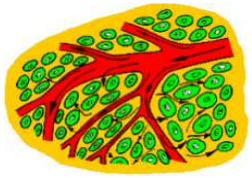
Multifunctional nanoparticles and ultrasound to improve cancer therapy

Contact: Catharina Davies, Catharina.davies@ntnu.no
https://www.ntnu.edu/physics/biophysmedtech/drugdel

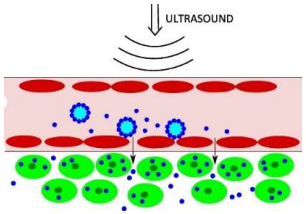
A problem using nanoparticles to treat cancer is that the uptake is low and heterogeneously distributed in the tumor.

Ultrasound alone or i combination with microbubbles can improve the distribution of nanoparticles.

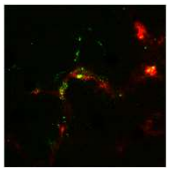
Projects and master thesis:
- Contribute to understand the mechanisms for ultrasound-improved delivery of drugs and nanoparticles
- Especially through the extracellular matrix
- Is immune response induced?
- Both experimental and theoretical/simulation projects

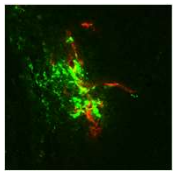


4 steps in delivery of nanoparticles:
- Vasculature
- Transport across capillary wall
- Penetration through extracellular matrix
- Cellular uptake



Ultrasound increases the permeability of the blood vessel wall and push the nanoparticles through the extracellular matrix





Uptake of nanoparticles in green in tumors growing in mice. Red is blood vessels
Left: No ultrasound. Rigth: Tumor exposed to focused ultrasound shows much more green nanoparticles in the tumor. The mouse was cured from cancer.

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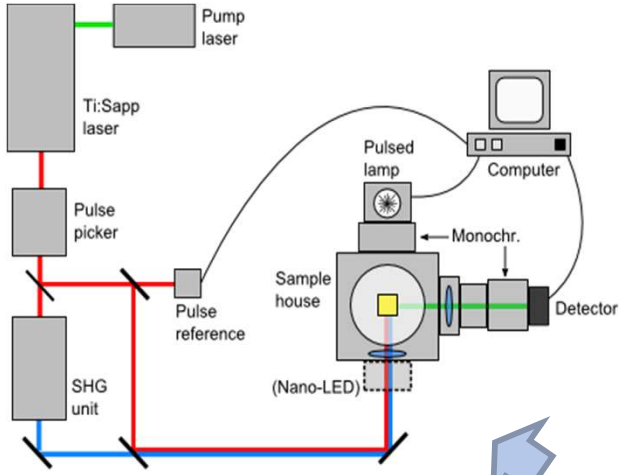
Advanced optical spectroscopy and microscopy of molecules relevant for biomedical applications

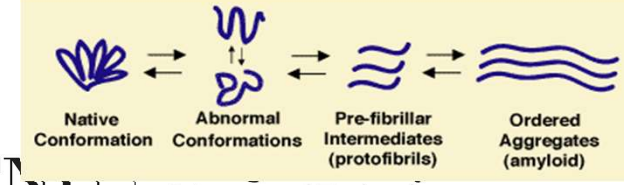
Mikael Lindgren Email: mikael.lindgren@ntnu.no

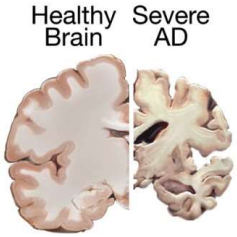
- We are studying photophysics of molecules applied in cancer treatment with light and for learning more about amyloid protein diseases diseases - **we are starting up a new project about Parkinson's disease H2022**.
- We are developing and using advanced spectroscopy and microscopic imaging/imaging spectroscopy to learn how such diseases spread and progress: in patient sections, animal models, in vitro protein systems, and cells.
- **From V2023 there might be master projects to carry out in collaboration with Japan (maybe even go there).**
- Projects are designed according to the interest of the student. Thus, you can have a interest in biological or chemical topics e.g., protein structure, or more technical aspects such as development of new sensor modalities and signal processing.

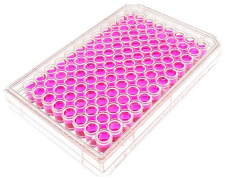


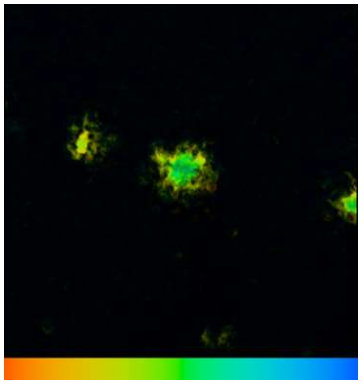
Time-resolved multiphoton spectroscopy

Insulin derived amyloidosis →

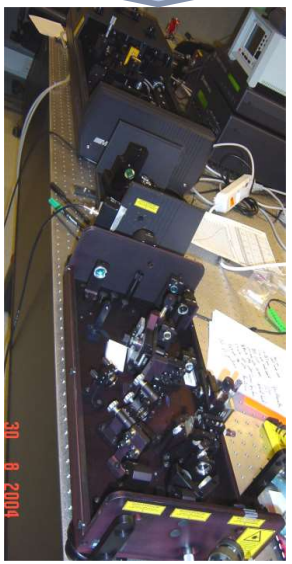








FLIM mapping of mouse-brain with Alzheimer disease



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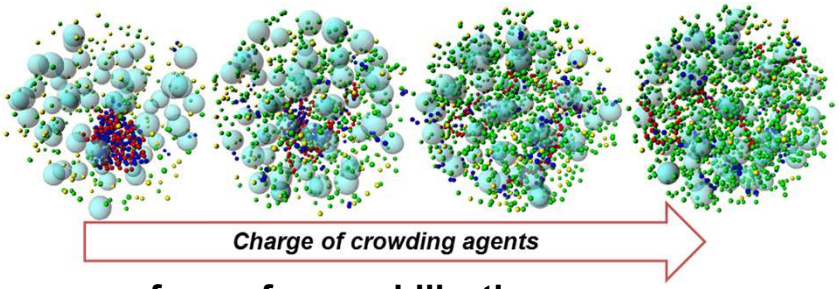
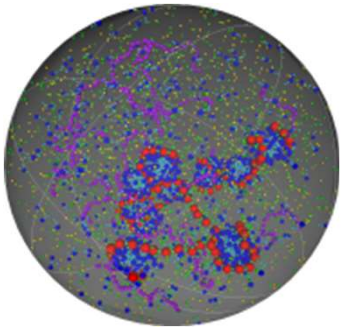
Macromolecules under confinement: an experimental and modeling approach

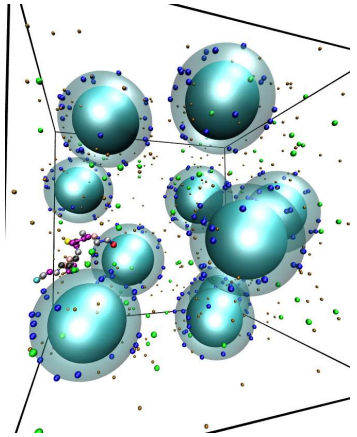
Contact: Rita Dias, rita.dias@ntnu.no

Focus on fundamental studies involving macromolecules and systems of biological relevance. The obtained knowledge is further applied in technological problems: e.g., enzyme immobilization and formulation stability. Whenever possible we use a **joint** experimental and modeling approach. Students may choose to work with one or both approaches.
Examples of projects:

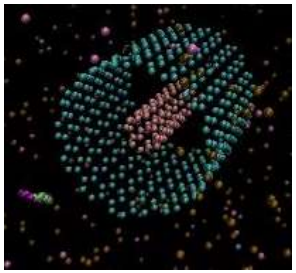
Effect on intracellular crowding in DNA condensation and protein diffusion:



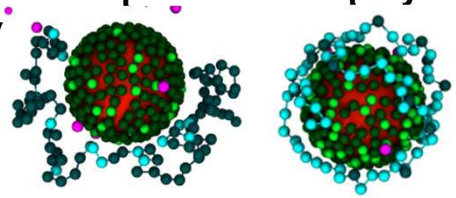




Designing enzymes for surface mobilization



Titratable nanoparticles and polyelectrolytes for formulation stability



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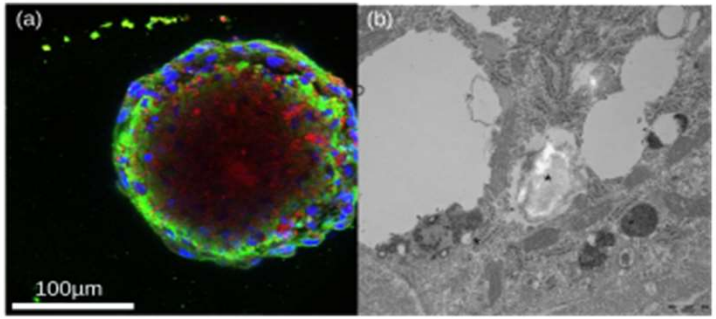
Biomaterials and bone mineralisation

Contact: Pawel Sikorski, pawel.sikorski@ntnu.no
https://www.ntnu.edu/physics/research/bionano

Aim of the research: Use cell culture techniques to make miniature bone-like constructs in the lab. Study how bone matrix is formed in these constructs and how it is mineralized with calcium phosphate.

You can learn: Cell culture rechniques, optical microscopy, electron microscopy, microfabrication, data analysis and modeling

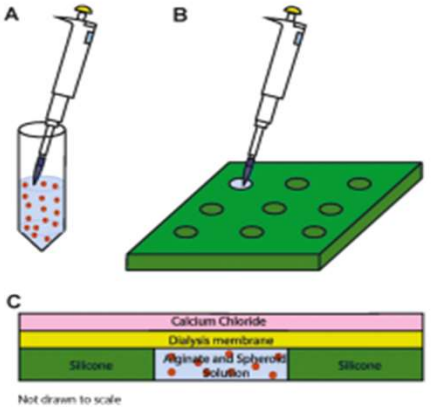
Relevance: biomaterials, bioengineering, cellular biophysics, multidisciplinary research.



Projects and master thesis:

- Establish methods to make multicellular spheroids from cells relevant to bone and bone formation

- Test experimental methods to study mineralization of extracellular matrix



UC DAVIS UNIVERSITY OF CALIFORNIA

NTNU Norwegian University of Science and Technology

Vorwald, C. E. et al. High-throughput formation of mesenchymal stem cell spheroids and entrapment in alginate hydrogels. 2018.

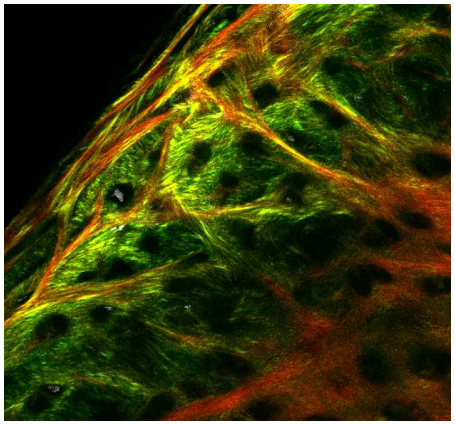
Connective tissue and nonlinear optical microscopy

Magnus Borstad Lilledahl
magnus.lilledahl@ntnu.no

Questions we try to answer

- How does connective tissue self-organize in functional structures?
- Can structural changes in connective tissue be used for diagnosis and understanding pathology?
- Which treament results in optimal repair tissue?

We develop instrumentation to answer these questions



Who is it for? If you like
- hands-on technical work and getting things do work,
- Programming and imaga analysis,
- Intersection between experimental physics and biological applications,

then this is for you!

What you can learn:
- Hands-on instrument construction (optics, electronics, programming)
- Data/image analysis
- Properties of connective tissues.

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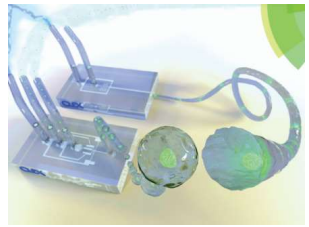
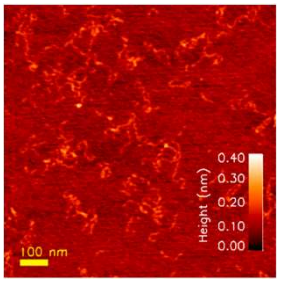
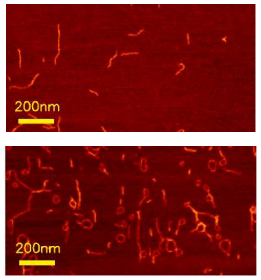
Bjørn Torger Stokke, NTNU Eksempler fra forskningen

Molekylær biofysikk: Struktur-funksjons sammenhenger, interaksjoner, hydrogeler, biosensorer, mikrofluidikk



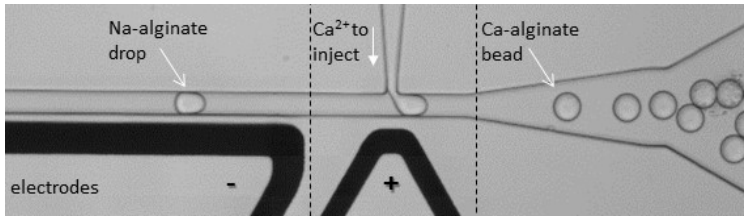
AFM: Struktur

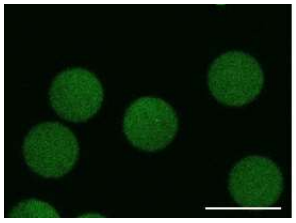




Mikrofluidikk: laging av små gelkuler

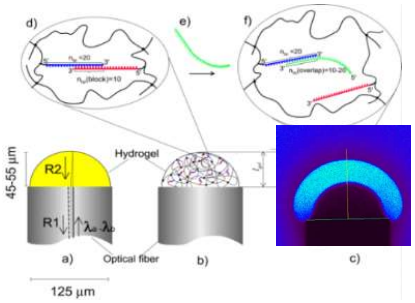
Picoinjeksjon (sol-gel overgang) 7-50 μm Ø

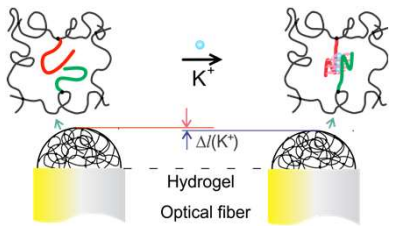




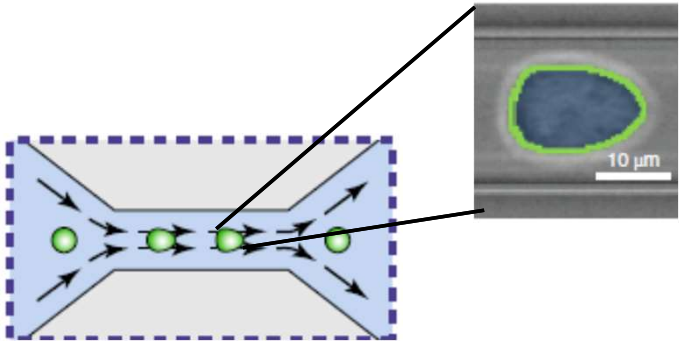
Responsive hydrogeler - biosensorer

DNA inkl reaksjon – diffusjon; K+ sensor





Mikrofluidikk: «High throughput screening»



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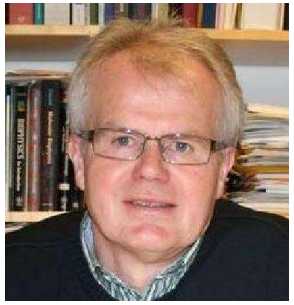




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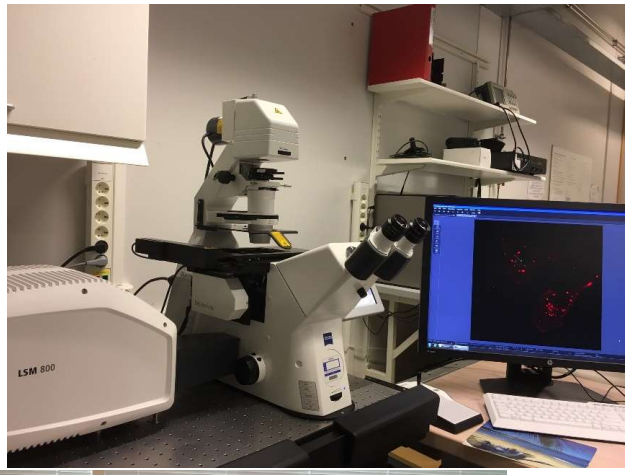
Research infrastructure

- Atomic Force Microscopes
- Confocal Microscopes
- Flow Cytometry
- Plate Reader
- Microfluidics setup
- Interferometry
- Rheology
- Cell laboratory
- Preparatory laboratory

NTNU NanoLab



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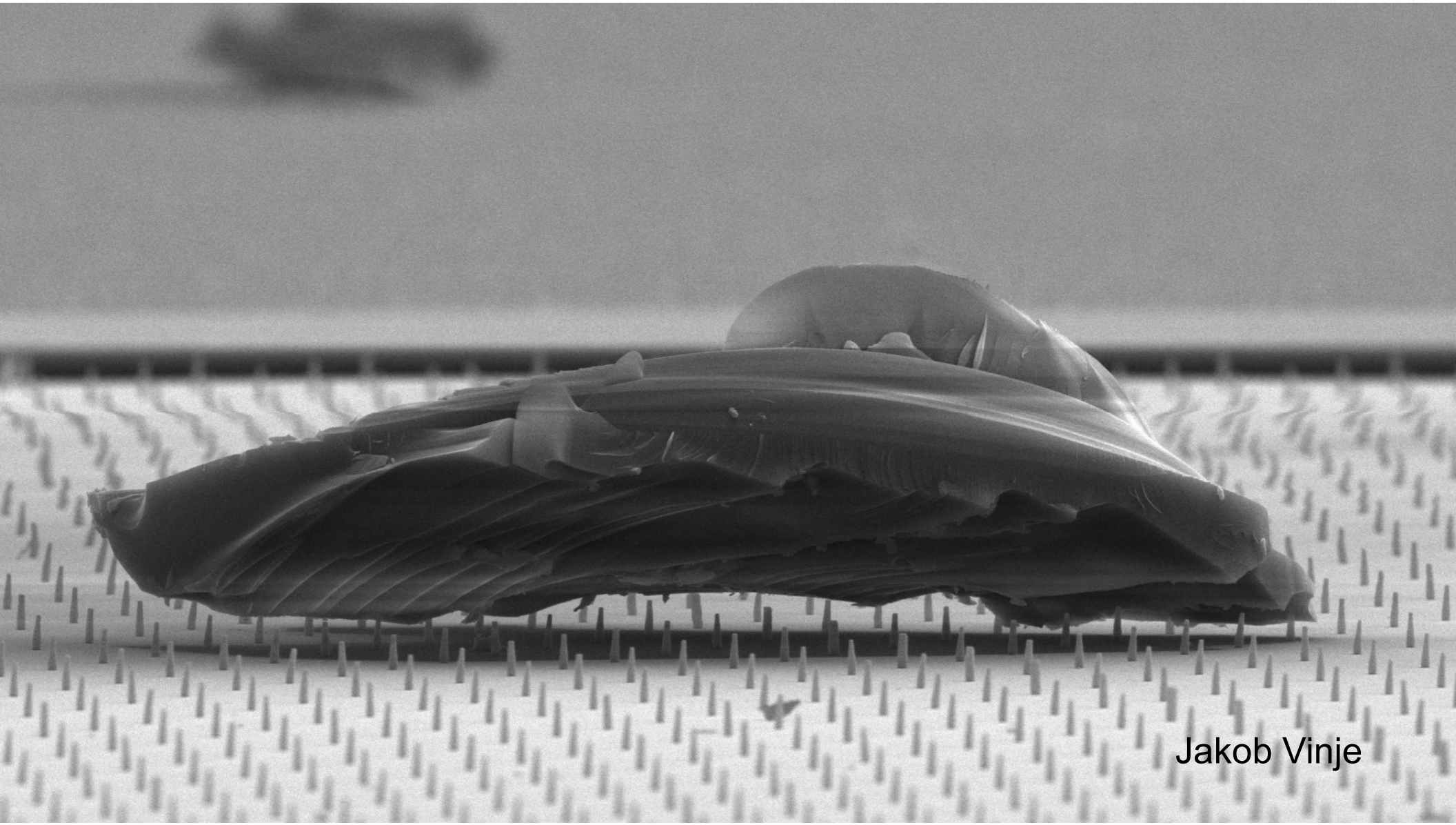
More info


Jakob Vinje

Biophysics

Physics looks for mathematical laws of nature and how to apply these to understand the universe, solar systems, climate, geological processes, falling apples, electromagnetic waves, electric currents, sound waves,..

Biology is a natural science concerned with the study of life and living organisms, including their structure, function, growth, evolution, distribution, and taxonomy a.

Biophysics aims at understanding of life through understanding of physical processes that are essential for life or that can be used, for example in medical diagnostics (interactions between electromagnetic radiation and living tissues used in medical imaging).

Biophysicists study life at every level, from atoms and molecules (nm-m) to cells (10m), organisms (mm-m), and environments (km).