BIOMEDICAL NETWORK - Members meeting, Bikuben, HUH, Bergen, 22.09 2016, 15:00-18:30

https://bergento.no/event/biomedical-network-members-meeting

Computational medicine

(Beregningsorientert medisin)

17:35-17:50

Prof. Arvid Lundervold BSc, MD, PhD

Department of Biomedicine, University of Bergen &
Department of Radiology, Haukeland University Hospital, Bergen, Norway

https://github.com/arvidl/computational-medicine

Biomedical Network – members meeting

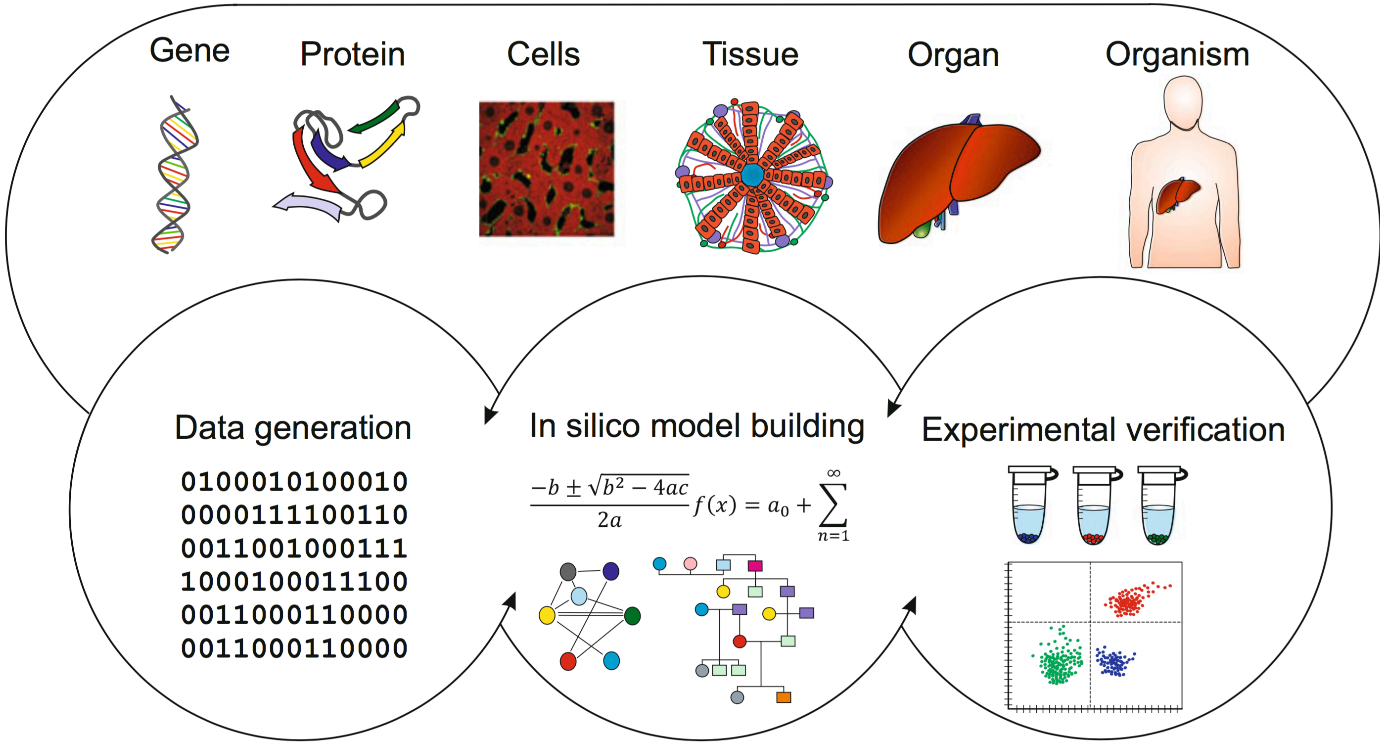
- *Biomedical Network is a network collaboration between Haukeland University Hospital, University of Bergen, Legemiddelindustrien and Bergen Teknologioverføring (BTO).*
- *The aim is to **establish a common platform for innovation and project development across academic and between public and private actors**.*
- *This meeting is the first in a series that will contribute to collaborative research between researchers, research institutions and companies.*

How does "Computational medicine" fit in ?

TRENDS

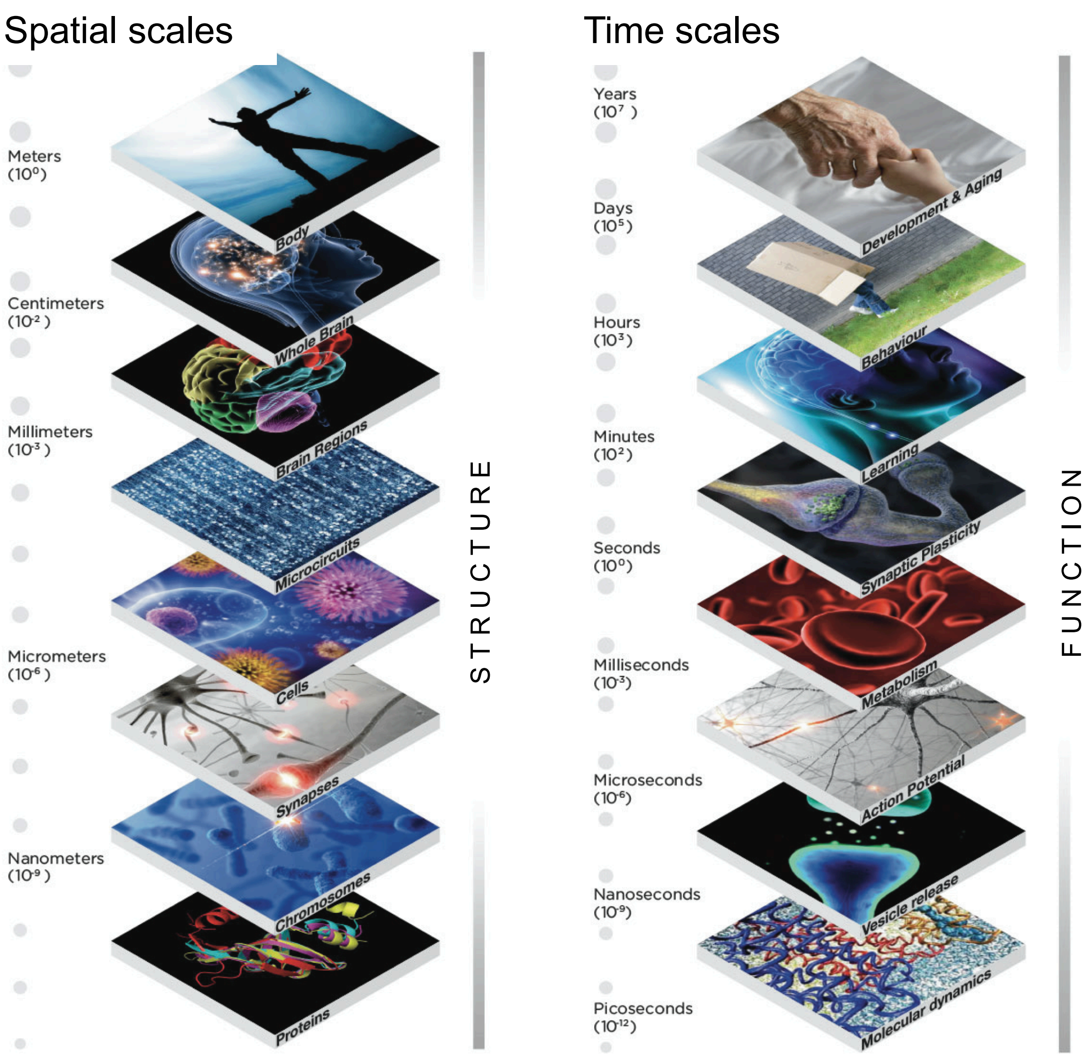
TRENDS

Systems medicine and computational imaging



Ulf Schmitz, Olaf Wolkenhauer (eds) Systems Medicine, Springer, 2016

MULTISCALE



https://www.humanbrainproject.eu

TRENDS

Computational Medicine

It will soon be common for clinical research studies to:

- Collect genetic, transcriptional, proteomic, imaging and clinical data from every patient in large, carefully selected cohorts sharing a specific disease diagnosis.

Johns Hopkins University

- The challenge of the coming decade will be
  - how best to use these *multi-scale* biomedical data
  - to gain a *quantitative understanding* of disease mechanisms
  - across *hierarchical levels* of biological organization
  - to identify *biological markers* which correlate with different disease states
  - and inter-individual differences in *disease risk*
- Discover more effective *therapeutics targeted to the individual*

http://www.icm.jhu.edu

TRENDS

Unit of Computational Medicine - **Karolinska Institutet**

Uniquely integrated multidisciplinary team of more than 30 scientists from

- **pure and applied mathematics**
- **immunology**
- **physics**
- **midwifery**
- **complexity theory**
- **cell and molecular biology**
- **computer science**
- **pharmacology**
- **engineering**
- **medicine**

- develop and apply integrative *computational-experimental approaches*
- provide fundamental insights of *life beyond physics*
- enable prediction, prevention and treatment of *diseases*

http://www.compmed.se

IBM

TRENDS

IBM Watson Health

http://www.ibm.com/smarterplanet/us/en/ibmwatson/health

"Welcome to the Era of Cognitive Health"

Cognitive computing

IBM Watson Health is pioneering a new partnership between humanity and technology with the goal of transforming global health. Cognitive systems that understand, reason and learn are helping people expand their knowledge base, improve their productivity and deepen their expertise.

With **cognitive computing**, we are now able to see health data that was previously hidden, and do more than we ever thought possible.

The Data Explosion

Medical data is expected to double every 73 days by 2020.

The Great Unknown

80% of health data is invisible to current systems because it's unstructured. Watson Health can see it.

A Quick Study

Watson can read 40 million documents in 15 seconds.

Broad Consensus

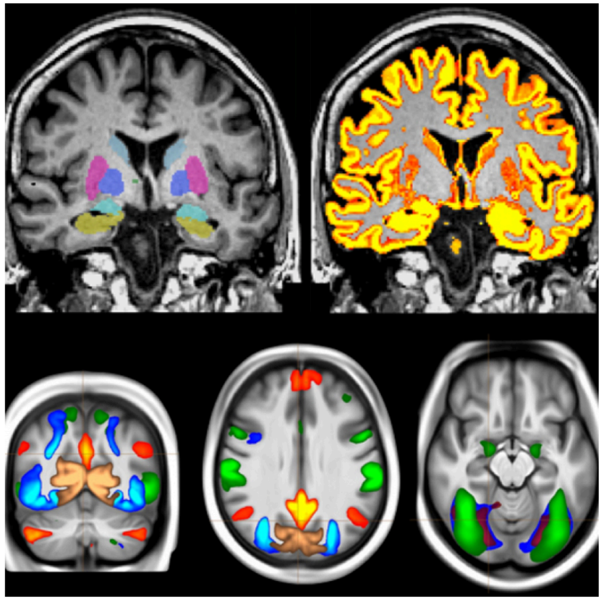
81% of healthcare executives familiar with Watson Health believe it will positively impact their business.

NEWS

TRENDS

First brain scans available from world's largest imaging study

N = 100 000



UK Biobank

http://www.ukbiobank.ac.uk

http://www.nature.com/neuro/journal/vaop/ncurrent/full/nn.4393.html

Five thousand brain scans from the UK Biobank imaging project are now available for use by the research community.

Medical imaging has enormous potential for early disease prediction, but is impeded by the difficulty and expense of acquiring data sets before symptom onset.

UK Biobank aims to address this problem directly by acquiring high-quality, consistently acquired imaging data from 100,000 predominantly healthy participants, with health outcomes being tracked over the coming decades.

The brain imaging includes structural, diffusion and functional modalities. Along with body and cardiac imaging, genetics, lifestyle measures, biological phenotyping and health records, this imaging is expected to enable discovery of imaging markers of a broad range of diseases at their earliest stages, as well as provide unique insight into disease mechanisms.

We describe UK Biobank brain imaging and present results derived from the first 5,000 participants' data release. Although this covers just 5% of the ultimate cohort, it has already yielded a rich range of associations between brain imaging and other measures collected by UK Biobank.

Miller et al. Multimodal population brain imaging in the UK Biobank prospective epidemiological study. Nature Neuroscience (2016)

TRENDS

computationalmedicine.no

computationalmedicine.no

CM | HomePage   Helse og teknologi - Høgskolen i Bergen

Computational medicine
supported by UH-Nett Vest

LOG IN

Projects

- Kidney
- Brain connectivity
- ML and cancer
- BHCS
- Cell segmentation
- Larynx simulation
- Extra: Kiwi segmentation

Workshop

- Workshop at HiB, January 2016

UiB, IRIS, HiB

Menu

- Home
- Members
- Discussion forum

Projects

- Kidney
- Brain connectivity
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- BHCS
- Cell segmentation
- Larynx simulation
- Extra: Kiwi segmentation

Workshop

- Workshop at HiB, January 2016

Poliklinikk

- Program
- About

Computational medicine: Numerical models for medical images and signals

The research program aims to create and promote collaborations between researchers at Bergen University College, Haukeland University Hospital, the University of Bergen and the University of Stavanger, within the field of **computational medicine** and **biomedical engineering**, focusing on image data and clinical applications.

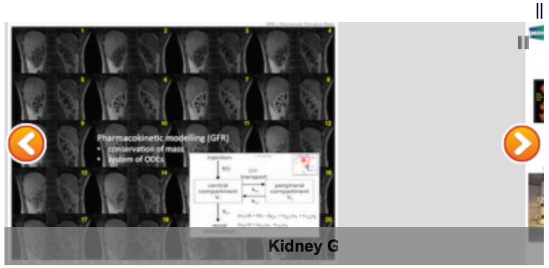
We are currently pursuing four main topics of research: (i) MRI-based biomarkers for the prediction of kidney functions, (ii) Brain networks in health and disease, (iii) Multiparametric MRI and machine learning in cancer diagnosis and monitoring, and (iv) The Bergen hip-cohort study—Big data and analysis of longitudinal phenotypes. Details can be found in the individual project pages.

The activities are anchored in several established research programs, in particular MedViz and ICT Engineering.

MedViz is a research & development cluster based in Bergen, performing interdisciplinary research in advanced image analysis and visualisation. ICT Engineering is a strategic research program at Bergen University College, consisting of six research groups: Model-driven software engineering, engineering computing, computational intelligence, grid computing and physics data analysis, secure and reliable communication, and communication systems and sensor networks.

Supported by UH-Nett Vest. The project application (in Norwegian) can be found here:

UH-Nett-søknad



Reproducible research – Open Science – Open source

TRENDS

Computational medicine

& Software development

GitHub

From Wikipedia, the free encyclopedia

GitHub is a web-based Git repository hosting service. It offers all of the distributed revision control and source code management (SCM) functionality of Git as well as adding its own features. Unlike Git, which is strictly a command-line tool, GitHub provides a Web-based graphical interface and desktop as well as mobile integration. It also provides access control and several collaboration features such as bug tracking, feature requests, task management, and wikis for every project.[3]

GitHub offers both plans for private repositories and free accounts,[4] which are usually used to host open-source software projects.[5] As of April 2016, GitHub reports having more than 14 million users and more than 35 million repositories,[6] making it the largest host of source code in the world.[7]

"Build software better, together"

README.md

Example

MITK

The Medical Imaging Interaction Toolkit (MITK) is a free open-source software system for development of interactive medical image processing software. MITK combines the Insight Toolkit (ITK) and the Visualization Toolkit (VTK) with an application framework.

The links below provide high-level and reference documentation targeting different usage scenarios:

- Get a high-level overview about MITK with pointers to further documentation
- End-users looking for help with MITK applications should read the MITK User Manual
- Developers contributing to or using MITK, please see the MITK Developer Manual as well as the MITK API Reference

See the MITK homepage for details.

Supported Platforms

MITK is a cross-platform C++ toolkit and officially supports:

- Windows
- MacOS X
- Linux

For details, please read the Supported Platforms page.

License

Copyright (c) German Cancer Research Center.

MITK is available as free open-source software under a BSD-style license.

Download

Data analytics - Machine learning

Deep learning is a growing trend in general data analysis and has been termed one of the 10 breakthrough technologies of 2013 [1]. Deep learning is an improvement of artificial neural networks, consisting of more layers that permit higher levels of abstraction and improved predictions from data [2]. To date, it is emerging as the leading machine-learning tool in the general imaging and computer vision domains.

IEEE TRANSACTIONS ON

MEDICAL IMAGING

A PUBLICATION OF
THE IEEE ENGINEERING IN MEDICINE AND BIOLOGY SOCIETY
THE IEEE NUCLEAR AND PLASMA SCIENCES SOCIETY
THE IEEE SIGNAL PROCESSING SOCIETY
THE IEEE ULTRASONICS, FERROELECTRICS, AND FREQUENCY CONTROL SOCIETY

MAY 2016 VOLUME 35 NUMBER 5

HAYIT GREENSPAN, *Guest Editor*
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National Institutes of Health Clinical Center
Bethesda, MD 20892 USA

SPECIAL ISSUE ON DEEP LEARNING IN MEDICAL IMAGING

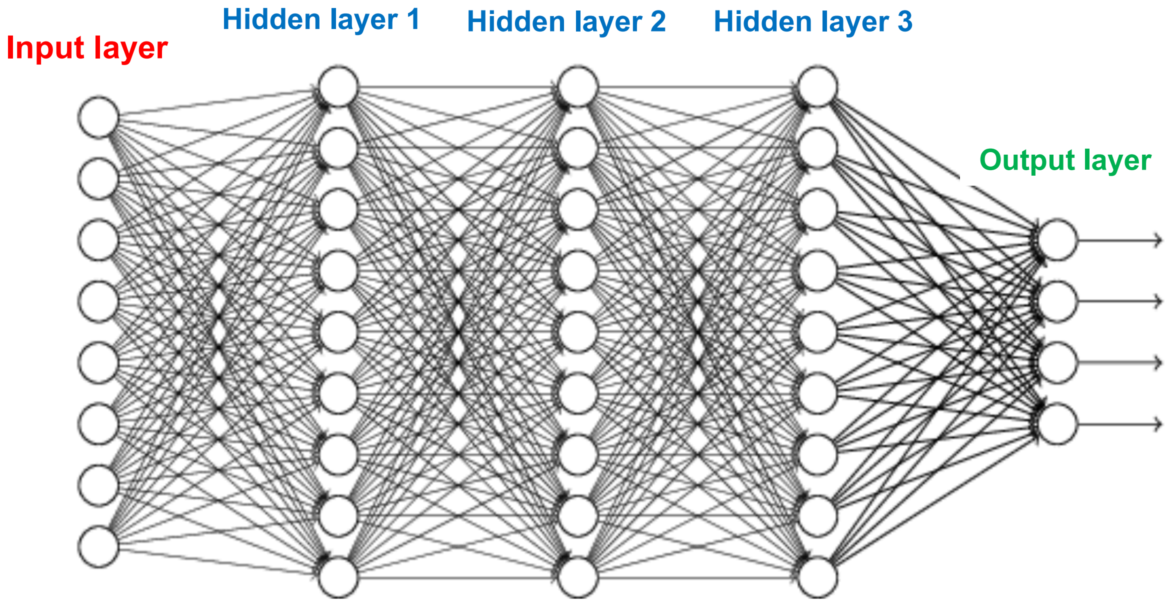
GUEST EDITORIAL

SPECIAL ISSUE PAPERS

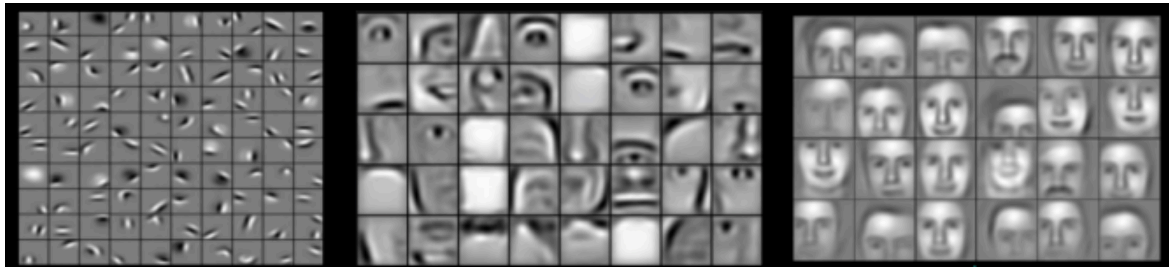
(Contents Continued on Back Cover)

Neural networks - deep learning

TRENDS



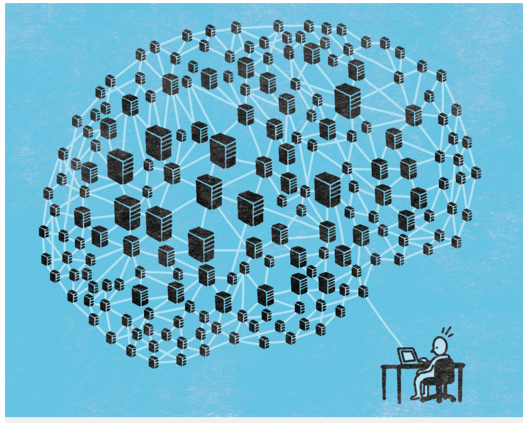
layers of features

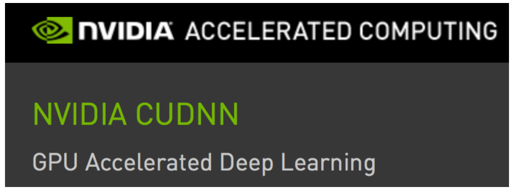


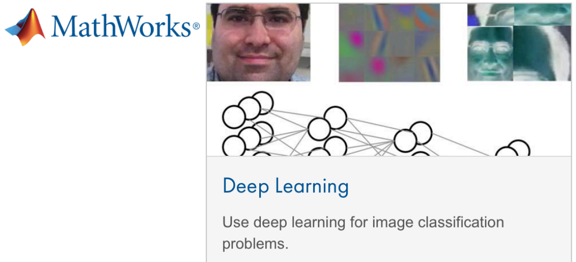
Deep learning is a branch of machine **learning** based on a set of algorithms that attempt to model high-level abstractions in data by using multiple processing layers, with complex structures or otherwise, composed of multiple non-linear transformations

Wikipedia

Microsoft releases CNTK, its open source deep learning toolkit, on GitHub







SFF PROPOSAL ~~2013-2022~~

Imaging-based Computational Medicine
- from Vision to Decision

Scientific leadership team

Mathematical imaging: Prof. Antonella Zanna Munthe-Kaas
Dept. of Mathematics, Univ. of Bergen

Physics and radiology: Assoc. Prof. Renate Grüner
Dept. of Radiology & Dept. of Physics and Technology, Univ. of Bergen

Biomedical visualization: Prof. Helwig Hauser
Dept. of Informatics, Univ. of Bergen

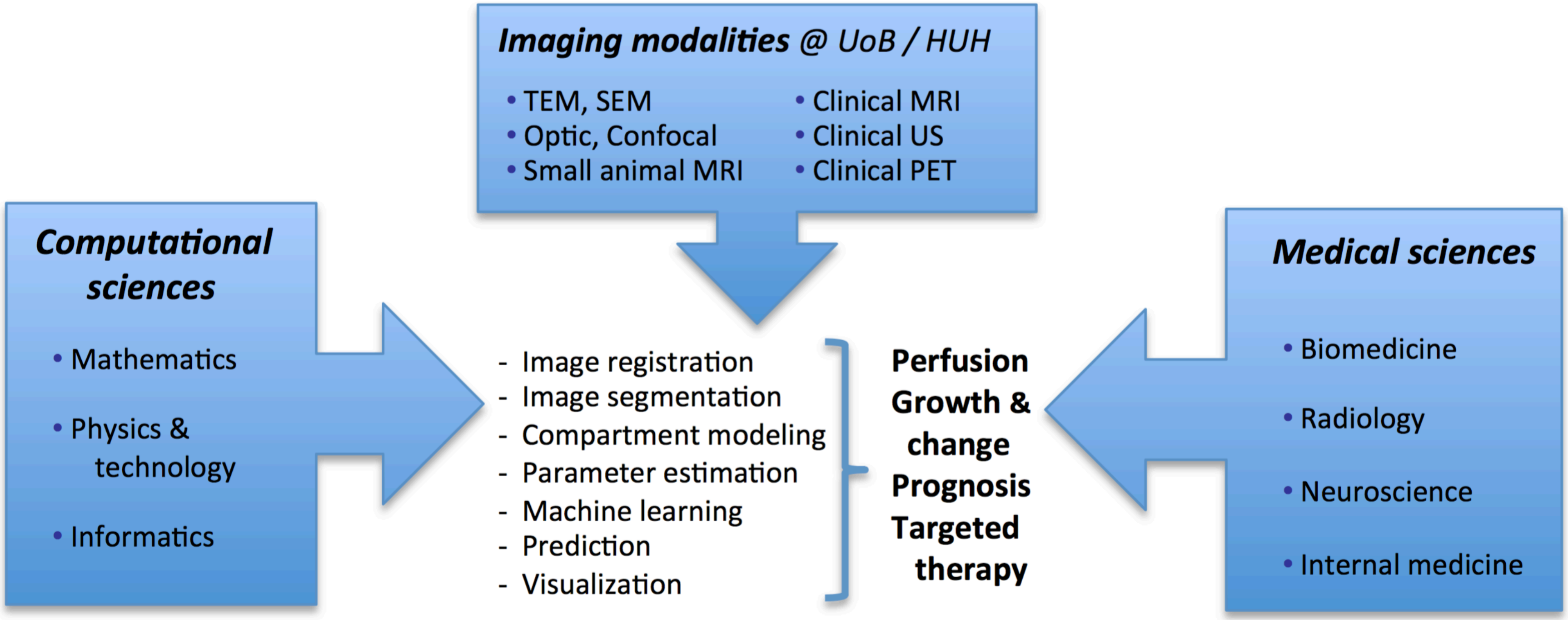
Translational imaging (neuro-oncology): Prof. Frits Thorsen
Dept. of Biomedicine / Molecular Imaging Center, Univ. of Bergen

Radiological applications (kidney): Prof. Jarle Rørvik
Dept. Surgical Sciences, Univ. of Bergen & Dept. of Radiology, Haukeland Univ. Hospital

Cognitive neuroscience: Prof. Kenneth Hugdahl
Dept. of Biological & Medical Psychology, Univ. of Bergen

Clinical applications (brain): Prof. Lars Thomassen
Dept. of Neurology & Dept. of Clinical Medicine, Univ. of Bergen

Clinical and translational applications (abdominal): Prof. Bjørn Tore Gjertsen
Institute of Medicine, Univ. of Bergen & Dept. of Medicine, Haukeland Univ. Hospital



Bergen-based collaboration

- HiB (matematikk/data/helse)
- Uni Research Computing (Center for Big Data Analysis)
- CMR
- IRIS
- NordicNeuroLab

Interdiciplinary collaboration

FROM VISION TO DECISION

Imaging-based Computational ↓ Medicine → in the MedViz CoE	ClinWP1 *Brain*: normal appearing tissue	ClinWP2 *Brain*: lesions and image-guided therapy	ClinWP3 *Abdomen*: organ function assessment	ClinWP4 *Abdomen*: lesions and image-guided therapy
MethWP1 *Image registration and classification*	**Meth**: Registration in time, segmentation **Clin**: Finding key biomarkers	**Meth**: Multimodal registration of lesions, Tissue characterization **Clin**: Longitudinal biomarkers	**Meth**: Registration of physiology in time; time-course segmentation **Clin**: Classification of healthy and at risk tissue	**Meth**: Registration in real-time **Clin**: Classification of inflammation vs. neoplasms
MethWP2 *Compartment modeling*	**Meth**: Time series, tracer kinetics **Clin**: Brain function microvasculature	**Meth**: Modeling in presence of pathology **Clin**: Angiogenesis permeability	**Meth**: Single and multi-Channel AIFs **Clin**: Voxel-wise GFR, RPF	**Meth**: Contrast and micro-bubbles **Clin**: Blood flow, inflammation, drug delivery
MethWP3 *Machine learning and prediction*	**Meth**: Feature extraction: micro & macro, Graph metrics **Clin**: Grouping subjects and tissues	**Meth**: Feature extraction: texture and macro features **Clin**: Grouping subjects and tissues	**Meth**: Pattern recognition micro, physiol. params. **Clin**: Grouping subjects and tissues; Prognostics	**Meth**: Pattern recognition macro **Clin**: Grouping subjects and tissue states
MethWP4 *Multidimensional visualization*	**Meth**: Multimodal visualization and brain connectivity **Clin**: Highlighting abnormal findings in time and space	**Meth**: Visualization (patho)physiology/ morphology **Clin**: Decision making in time	**Meth**: Quantitative data visualization (confidence) **Clin**: Set value limits for normal / abnormal tissue conditions	**Meth**: Feature-based medical visualization **Clin**: Localizing lesions and therapeutic agent

Multimodal registration in time and space

Multimodal perfusion in time and space

Multimodal data mining in time and space

Multimodal visualization in time and space

Novel diagnostic categories and biomarkers

Differential diagnostics in time

Early detection of dysfunction

Differential diag-nostics & therapy

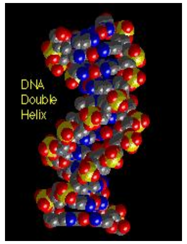
Matrix coupling between the MethWPs and the ClinWPs

Imaging infrastructure at HUH and MIC

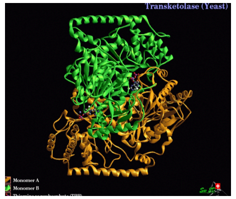
INFRASTRUCTURE

- Superresolution microscopy (STED)
- MRI expert (acquisition + analysis)

DNA

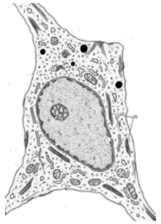


Protein



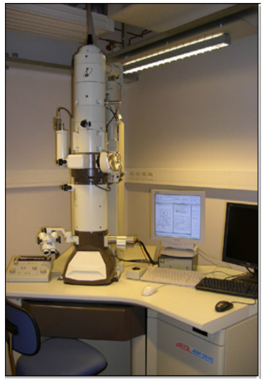
Organelle

Cell



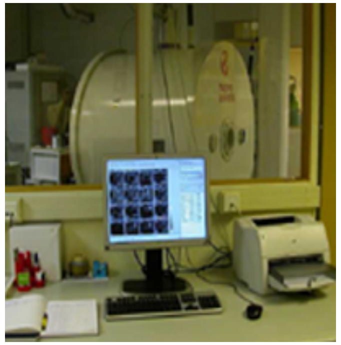
Microscopy

EM



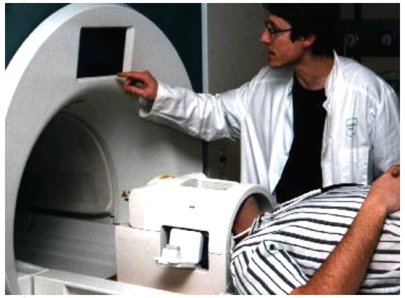
Confocal

Animal MRI



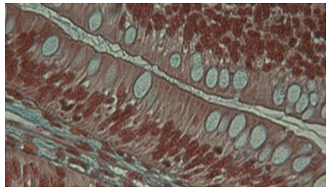
7 Tesla Bruker Pharmascan

Clinical MRI



1 GE + 2 x Siemens 3 Tesla

Tissue



$$\frac{\partial M_x(t)}{\partial t} = \gamma(\mathbf{M}(t) \times \mathbf{B}(t))_x - \frac{M_x(t)}{T_2}$$

$$\frac{\partial M_y(t)}{\partial t} = \gamma(\mathbf{M}(t) \times \mathbf{B}(t))_y - \frac{M_y(t)}{T_2}$$

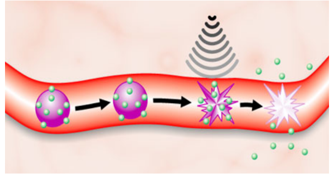
$$\frac{\partial M_z(t)}{\partial t} = \gamma(\mathbf{M}(t) \times \mathbf{B}(t))_z - \frac{M_z(t) - M_0}{T_1}$$

- New visualization center from 2017

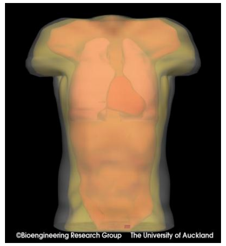
Clinical US

Clinical PET/CT

Organ



Organism



Selected research project proposals

MEDVIZ FROM VISION TO DECISION

“ NeuroAGE ”

- Centre for research into age-related neurodegenerative diseases

SFF-application
Prof. Laurence Bindoff /
Prof. Aurora Martinez

“ Gut Feelings “

- The brain-gut-microbiota interaction: role in functional gastrointestinal disorders

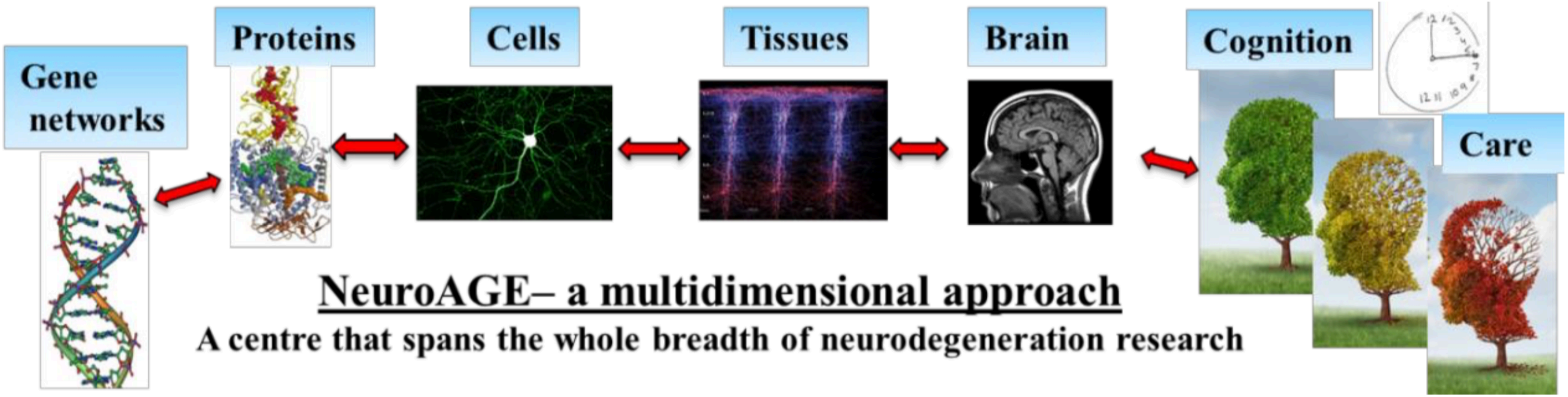
NFR FRIMEDBIO
Prof. Trygve Hausken

“ From geophysics to cancer “

- Imaging-based modeling and in-vivo estimation of interstitial fluid flow in cancer

Norwegian Cancer Society
Prof. Antonella Z Munthe-Kaas / IRIS

NeuroAGE - Centre for research into age-related neurodegenerative diseases



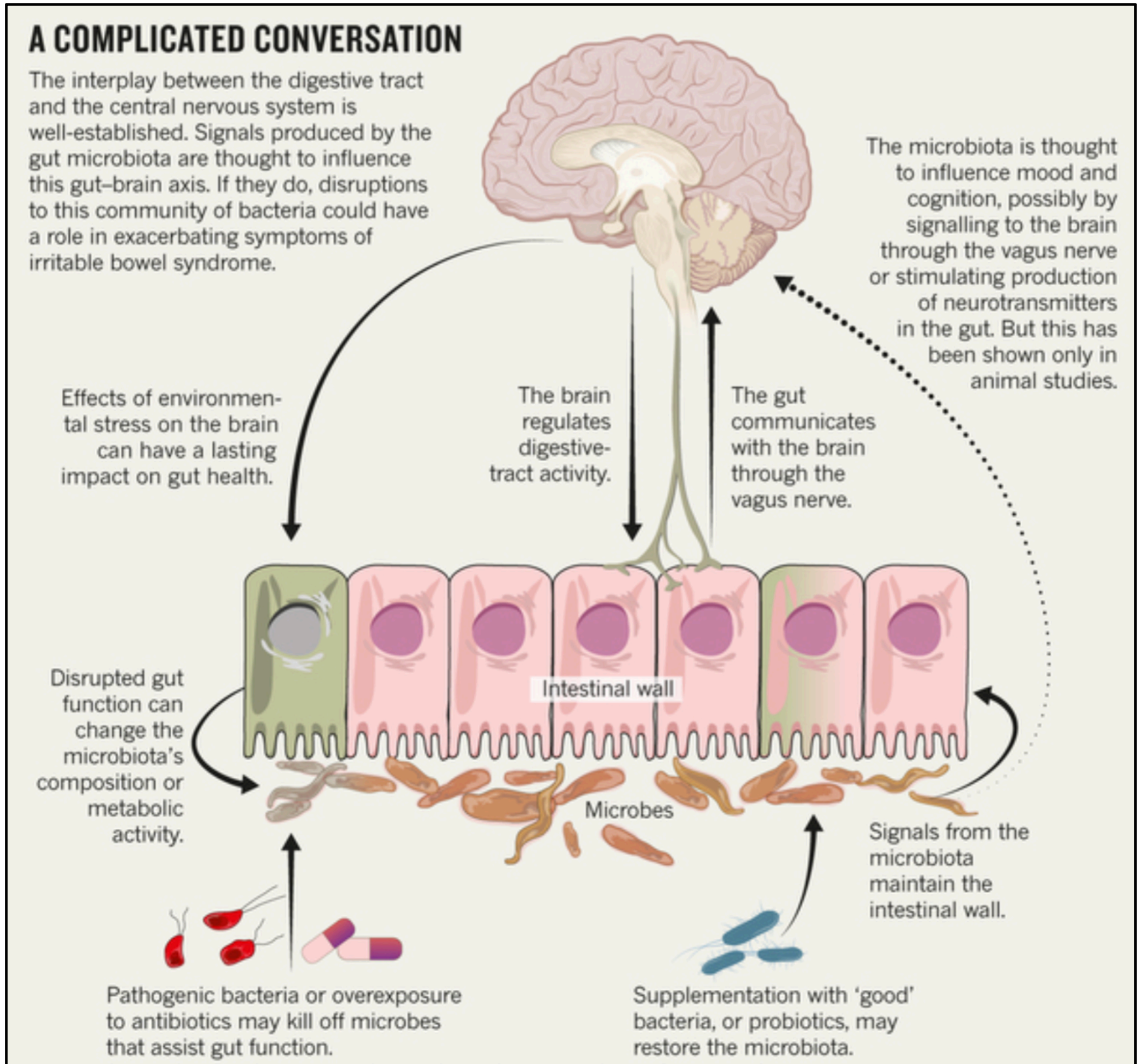
Vision

NeuroAGE will develop a radical new, cross-disciplinary approach to integrates **i) reductionist** analysis of disease mechanisms using novel and more relevant models with **ii) integrative systems biology** studies using state of the art computational neuroimaging and high throughput sequencing to identify new and more specific biomarkers and **iii) healthcare studies** informed by patients, families and healthcare workers focussed across the whole spectrum from earlier diagnosis to end-of-life care.

Gut Feelings: Brain-gut-microbiota interaction in functional gastrointestinal disorders

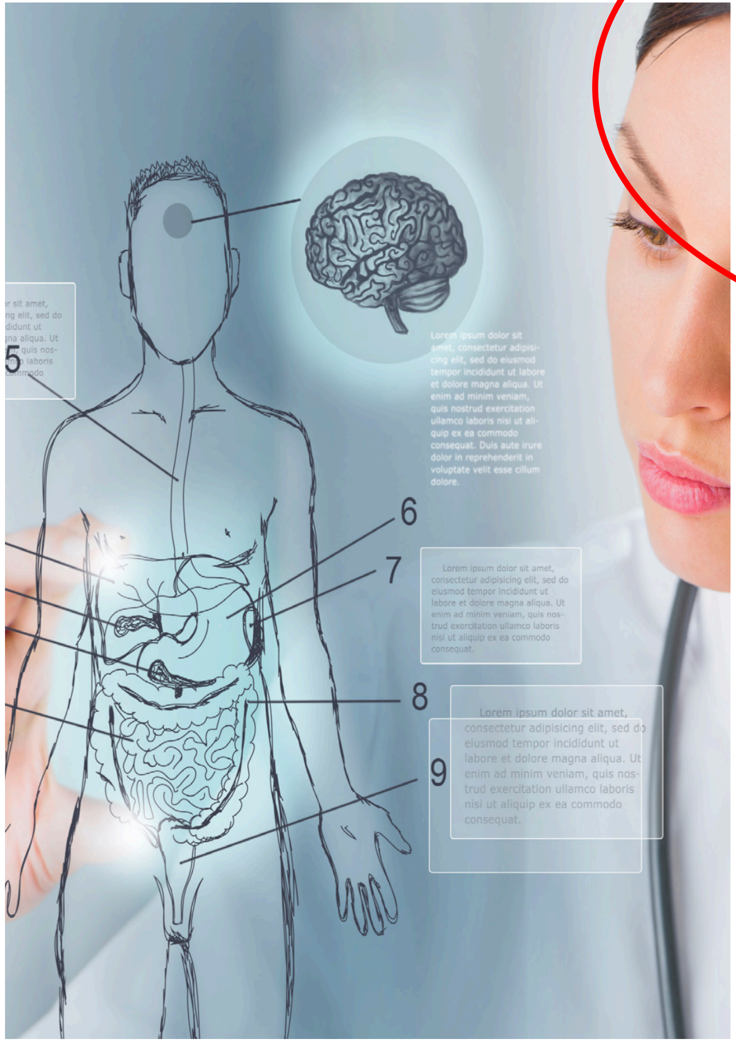
Project manager: Trygve Hausken

Collaborators: Arvid Lundervold, Jan G. Hatlebakk, Odd Helge Gilja, Robin Spiller, Michael Horowitz, Karen L Jones, Beate Niesler, Magdy El Salhy, Astri J.Lundervold, Synne Ystad, Jørgen Valeur, Harald Wiker, Dag Arne Hoff, Gülen Arslan Lied, Tarek Mazzavi, Eivind Valestrand, Kiniena F Tekie, Lionel Giriteka.



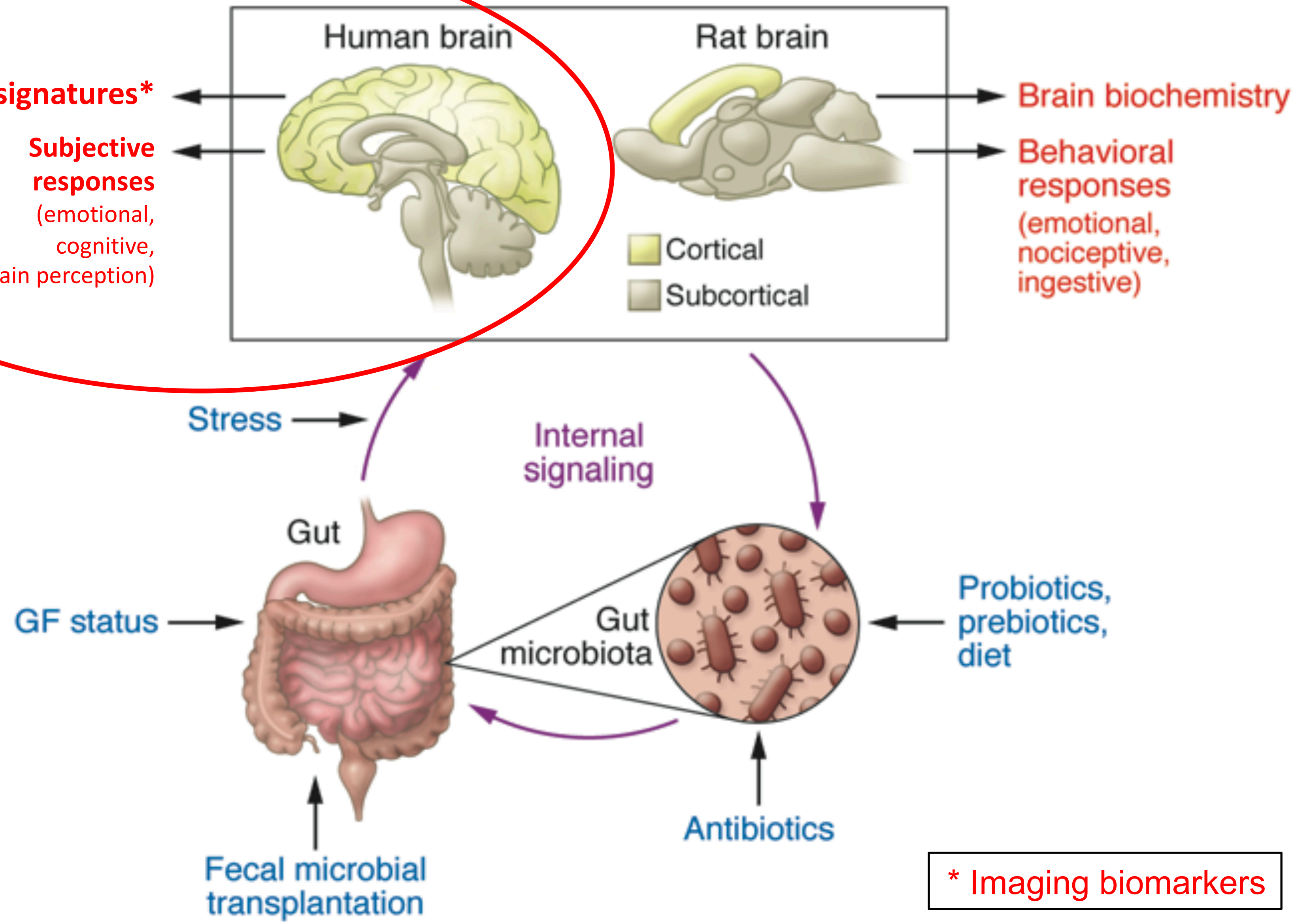
Figur 1: Brain-gut-microbiota interaction, from [72]

The Brain-Gut axis and the irritable bowel syndrome (IBS)



Brain signatures*

Subjective responses (emotional, cognitive, pain perception)



* Imaging biomarkers

Adopted from: Mayer EA, Tillisch K, Gupta A. Gut/brain axis and the microbiota. The Journal of Clinical Investigation 2015;125(3)

#182534 Imaging-based modeling and in-vivo estimation of interstitial fluid flow in cancer

APPLICATION INFORMATION

Application ID	182534
Call	Open Call 2016
Applicant	Antonella Zanna Munthe-Kaas
Project Manager	Antonella Zanna Munthe-Kaas

KREFTFORENINGEN

Dato: 01.06.2016

Imaging-based modeling and in-vivo estimation of interstitial fluid flow in cancer

Overall aims

The main goal is to develop key technologies to enable measurements of interstitial fluid flow in cancerous tissue using dynamic magnetic resonance image acquisitions (DCE-MRI) combined with mathematical modeling and data assimilation, a workflow that has been successful in the geosciences. Expected outcome is a quantitative tool for in-vivo monitoring of disease progression and assessment of therapeutic drug delivery in cancer. The current project has a special focus on method development having access to data from a large collection of patients with prostate cancer including joint DCE-MRI recordings and histological verification. The modeling and software implementation will have a core component that is generic, and will also be tested and adopted to cancer in other organs (kidney, brain).

The future of medicine …

- **SYSTEMS BIOLOGY , SYSTEMS MEDICINE** and **COGNITIVE HEALTHCARE**
- **INTERDISCIPLINARITY** and **COMPUTATIONAL APPROACHES** addressing the multi-scale nature of organs and tissues in health and disease

➡ **- mindset**

- skillset

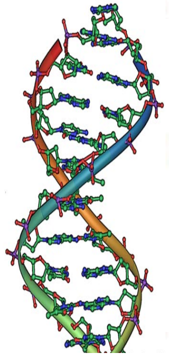
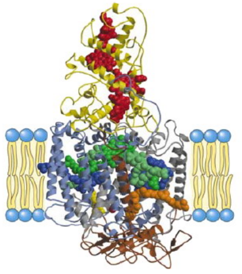
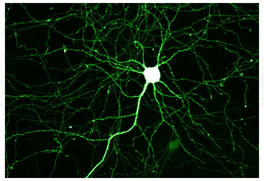
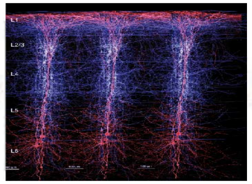
- toolset

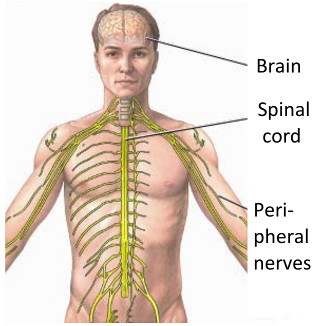
- open science

- reproducible research

SPACE:

Atom	Protein	Cell	Tissue	Organ	Organ system & organism
10^{-12} m	10^{-9} m	10^{-6} m	10^{-3} m	10^{0} m Anatomy	Physiology



Gene networks	Pathway models	Stochastic models	Ordinary Differential Equations	Continuum models (Partial Differential Equations)	Systems models

TIME:

10^{-6} s	10^{-3} s	10^{0} s	10^{3} s	10^{6} s	10^{9} s
molecular events (ion channel gating)	diffusion cell signalling	motility	mitosis	protein turnover	human lifetime

From: C. Dollery and R. Kitney, Systems biology: A vision for engineering and medicine, Tech. report, The Academy of Medical Sciences and The Royal Academy of Engineering, London, UK, Feb. 2007.

Biomedical Network

- *The aim is to* ***establish a common platform for innovation and project development across academic and between public and private actors.***

➡ Collaborative projects in "Computational medicine", e.g.

? APPLICATIONS

- Imaging-based biomarkers
- Aging and neurodegeneration
- Brain-Gut-Microbiota interaction
- Kidney function

? METHODS

- Computational imaging
- Machine learning
- Predictive modelling
- Visual analytics