Icahn School of Medicine at Mount Sinai

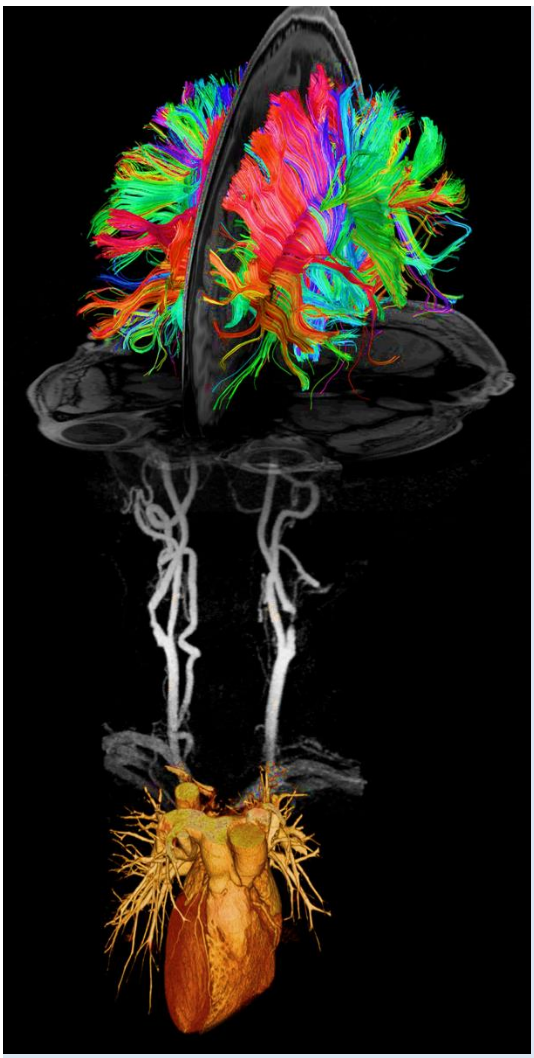
Translational & Molecular Imaging Institute

tmii.mssm.edu

Summer 2015

NEUROIMAGING

The **Neuroimaging Research Program** is focused on the development of novel imaging techniques to elucidate changes in brain structure, metabolism, and function in the presence of disease. The brain is considered one of the last research frontiers because it is far more complicated than any other organ – it has 100 billion nerve cells that form hundreds of trillions of nerve connections. Unlike other organ, the living brain cannot be examined by touch without risking significant damage, so it is no wonder that *90 percent of brain research has come to rely on advanced imaging for new discoveries.*



Mount Sinai imaging specialists have developed several techniques to harness the power of high-field MR magnets in order to visualize the human brain in unprecedented structural and metabolic detail. These techniques have the potential for drastic improvement of the diagnosis, treatment, and monitoring of neurological diseases and disorders as well as for advancing our understanding of the brain in its normal state. Alzheimer’s disease and dementia are associated with neuronal loss or dysfunction resulting in atrophic changes in the brain.

High-resolution MR imaging and spectroscopy can noninvasively reveal these often subtle brain abnormalities. Metabolic information provided through imaging can also aid the differentiation between Alzheimer’s disease and other types of dementia, as well as assist in monitoring disease progression and response to therapy. In the case of Alzheimer’s disease, volumetric MRI allows for the detection of presymptomatic changes in the hippocampus area of the brain, enabling an earlier diagnosis.

Going forward, scientists working within the Neuroimaging Research Program will continue to create imaging tools to improve diagnosis, ensure appropriate treatment, and aid in surgical planning for diseases and disorders of the brain. In addition, they will put a new focus on imaging techniques for the earliest stages of brain disease. Imaging at the onset of disease provides an important assessment of injured tissues, which is critical because this is the time when therapies are most effective and precise. There is tremendous potential for early diagnosis and treatment with the aid of neuroimaging.

STATE-OF-THE-ART EQUIPMENT

3T Skyra

PET/MR

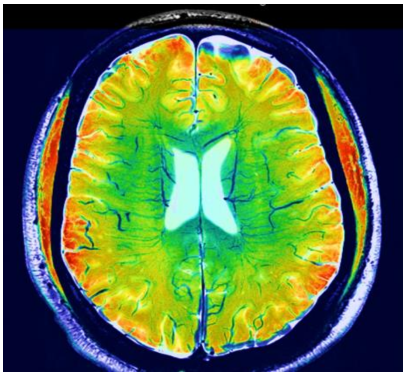
7T

Force CT

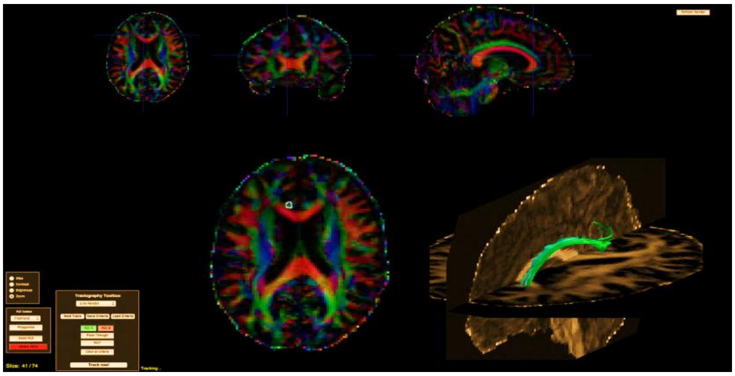
MR Simulator

The Translational and Molecular Imaging Institute (TMII) is responsible for providing support for all in vivo imaging research at The Mount Sinai Medical Center. TMII Imaging Core is the backbone of the Translational and Molecular Imaging Institute and is responsible for coordinating, supporting and executing imaging research at Mount Sinai including, neuroimaging, cardiovascular imaging, cancer imaging, nanomedicine (molecular imaging and drug delivery), and image processing in the preclinical and clinical settings.

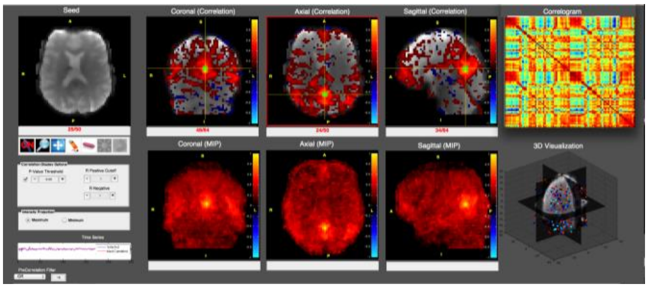
CLINICAL IMAGING CORE



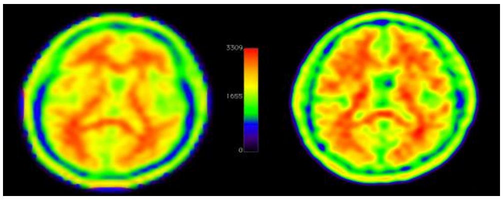
MRI susceptibility weighted imaging at 7 Tesla



TMII Tracer (DTI-Tractography)

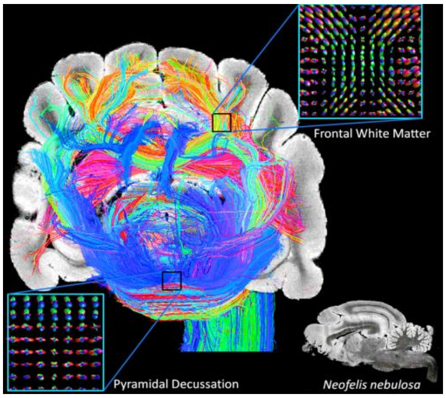


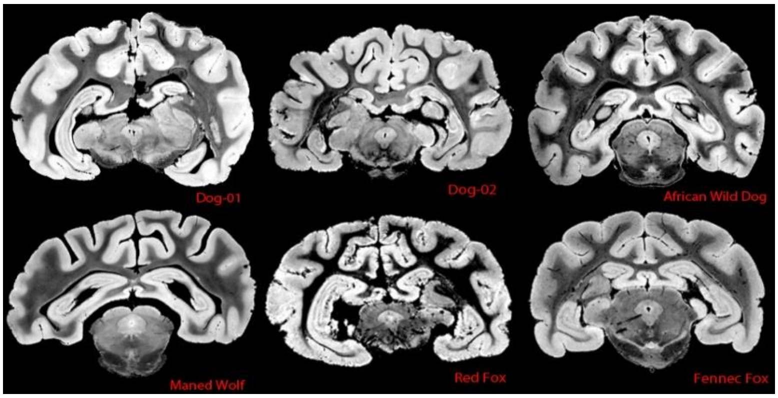
TMII Connectivity Explorer



Amyloid Imaging (AV45): PET-MR vs PET-CT

PRE-CLINICAL IMAGING CORE





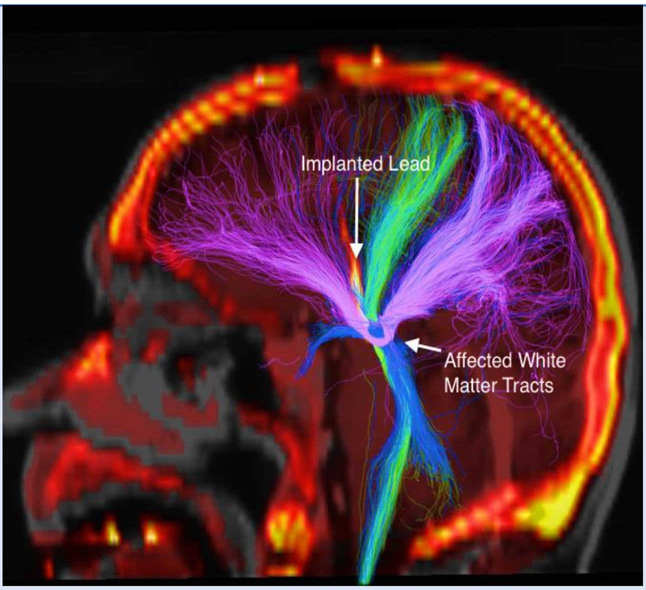
7T: Canine brains (hi-res T1, DSI) ***Drs. Spocter, Tang, Hof***

EQUIPMENT HIGHLIGHT: SIEMENS 7 TESLA (7T) MRI

High-Field MRI and Deep Brain Stimulation

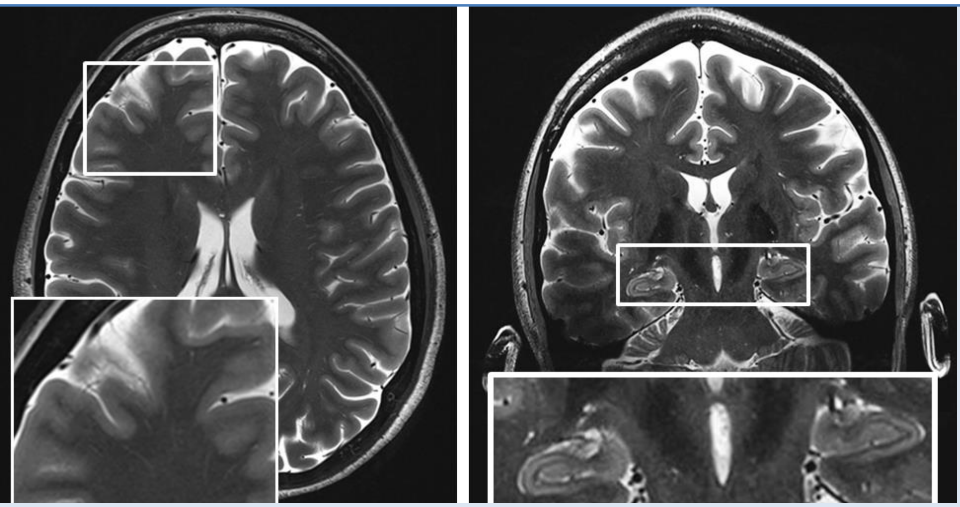
Many disorders, ranging from depression, to Parkinson's disease, can be managed with pharmaceuticals, however, for those patients with severe forms of disease or who simply do not respond to medication, deep brain stimulation (DBS) can be a useful alternative. DBS can be used to treat depression, Parkinson's disease, obsessive compulsive disorder, dystonia, and many other otherwise intractable conditions by surgically implanting an electrical lead into a precise location in the brain - exactly where it is placed depends on the condition being treated. Success depends on precision placement of the electrical lead.

Mount Sinai is a leading center for DBS with over 60 patients every year. Brian Kopell, MD, Associate Professor of Neurosurgery, leads a team of researchers dedicated to improving patient outcomes for DBS in a range of disorders. Rafael O'Halloran, PhD, Assistant Professor of Radiology, specializes in imaging of the white matter pathways, the ``wiring'' of the brain. Working together they hope to use cutting edge imaging to understand the effect of the DBS electrodes and ultimately improve patient outcomes by smarter, more-personalized lead placement.



A post-surgical CT image (orange) showing the placement of the implanted lead overlaid on pre-surgical MRI (grey) and fiber tractography showing three distinct fiber pathways potentially affected by the lead (purple, green, and blue lines).

Advances in high-field MRI have allowed doctors to view the structure of the brain with unprecedented detail. At Mount Sinai, our state-of-the-art Siemens 7T MRI system is the highest field strength commercially available. We plan to use 7T MRI in planning the placement of the DBS leads, particularly in visualizing the white matter connections of the motor area of the brain in fine detail. This will allow more informed lead placement, interpretation of patient response, and hopefully better results.



High resolution T2 -weighted images of the brain. The cerebral cortex and hippocampus, where epileptogenic abnormalities are often located, are visualized in fine detail.

Ultra-High Field Imaging in Epilepsy

Epilepsy adversely affects **almost 3 million people** in the United States.

15%-30% of these individuals do not respond to medication and may be candidates for surgical intervention.

Due to excellent soft tissue contrast and high-resolution visualization of brain anatomy, magnetic resonance imaging (MRI) plays a vital role in the preoperative localization and characterization of brain abnormalities for patient undergoing epilepsy surgery.

Ultra-high field MRI has great potential to unearth subtle abnormalities in vivo that are undetectable at lower fields. At Mount Sinai, we use the 7T MRI to design and validate new imaging techniques and apply them to study disease. It is a powerful non-invasive tool to:

1. Increase conspicuity of epileptogenic abnormalities resulting in improved detection efficiency and reduced use of invasive electrophysiological evaluation, and
2. Provide more accurate delineation of lesion boundaries aiding in neurosurgical planning and leading to better patient outcomes.

Balchandani Lab

Priti Balchandani, PhD
Assistant Professor of Radiology
Director, High Field MRI Program

Dr. Balchandani's research is focused on the design of innovative radio frequency (RF) pulses and pulse sequences that harness the power of high-field magnets and exploit new contrast mechanisms in order to enable novel applications of magnetic resonance imaging (MRI). Her lab explores engineering solutions for MR imaging and spectroscopy at high magnetic fields such as 7 Tesla (7T).

Beyond higher resolution images that elucidate finer anatomical features, high-field MR offers greater spectral resolution for spectroscopic imaging, new and enhanced contrast mechanisms and improved detection of nuclei other than protons that are essential to cell processes. A main goal of Dr. Balchandani's lab is to develop techniques that exploit the benefits offered by 7T magnets for neuroimaging applications by overcoming the limitations associated with their operation. Dr. Balchandani's additional research interests include creative pulse and pulse sequence designs for nontraditional MR applications such as multinuclear imaging and stem cell tracking.

Hadrien Dyvorne, PhD
Balchandani Lab

Dr. Dyvorne's research is centered on the development of novel pulse sequence, acquisition and reconstruction techniques in order to provide faster and more robust methods for high field MR imaging. The goal is to improve widespread clinical applications in neuroimaging and body imaging, such as:

- Anatomical imaging (T1, T2) at ultrahigh field. Novel techniques are developed to reduce radiofrequency power deposition and combat static and radiofrequency field inhomogeneity occurring at 7T.
- Diffusion weighted imaging at 3T and 7T, using adiabatic radiofrequency pulses to achieve homogeneous excitation.
- Blood flow imaging, using highly accelerated phase contrast techniques to perform comprehensive hemodynamic exams in a short scan time.

Kundu Lab

Prantik Kundu, PhD
Assistant Professor of Radiology and Psychiatry
Chief, Section on Functional Neuroimaging Methods
Chief, ANALYZE Image Analysis Section

Dr. Kundu's research is focused on the development and application of advanced neuroimaging and functional MRI (fMRI) techniques towards the study of healthy and pathological brain function. As the Chief of the Image Analysis Core, Dr. Kundu implements neuroimaging analysis workflows and collaborative analysis platforms to make cutting-edge functional and structural imaging techniques more accessible to researchers

As Chief of the Advanced Functional Neuroimaging Section, Dr. Kundu develops fMRI acquisition and analysis approaches that are robust to the numerous sources of artifact in fMRI data (motion, cardiopulmonary physiology, equipment) while remaining highly sensitive to brain activity from neuropsychological tasks, the "resting state", and pharmacological challenges, in humans and animals. Altogether, Dr. Kundu's efforts target the in vivo characterization of neurobiological processes and the development of clinical neuroimaging biomarkers of neuropsychiatric disease using a collaborative approach.

O'Halloran Lab

Rafael O’Halloran, PhD
Assistant Professor, Radiology and Psychiatry
Chief, Imaging Acquisition Core

As Chief of the Image Acquisition Core, Dr. O'Halloran's work is focused on bringing innovative new imaging techniques to bear on problems in basic and clinical research. His primary area of focus is on diffusion weighted imaging (DWI), in particular on high-resolution DWI. At high spatial resolution, DWI allows visualization of the white matter pathways that connect functional areas of the brain. One application of this technique that Dr. O'Halloran is focused on is in the planning of deep brain stimulation surgery to treat conditions such as Parkinson's disease, dystonia, and depression.

Dr. O'Halloran's other interests include image reconstruction and motion correction. Patient motion continues to be a major problem in MRI, causing failed or prolonged exams which ultimately results in increased heath care costs. Solutions to patient motion can be implemented on both the acquisition and image reconstruction side, and can potentially benefit a wide range of MR imaging techniques.

Tang Lab

Cheuk Y. Tang, PhD
Director, Neurovascular Imaging Research
Associate Director, Imaging Science Laboratories
Director, In-Vivo Molecular Imaging SRF

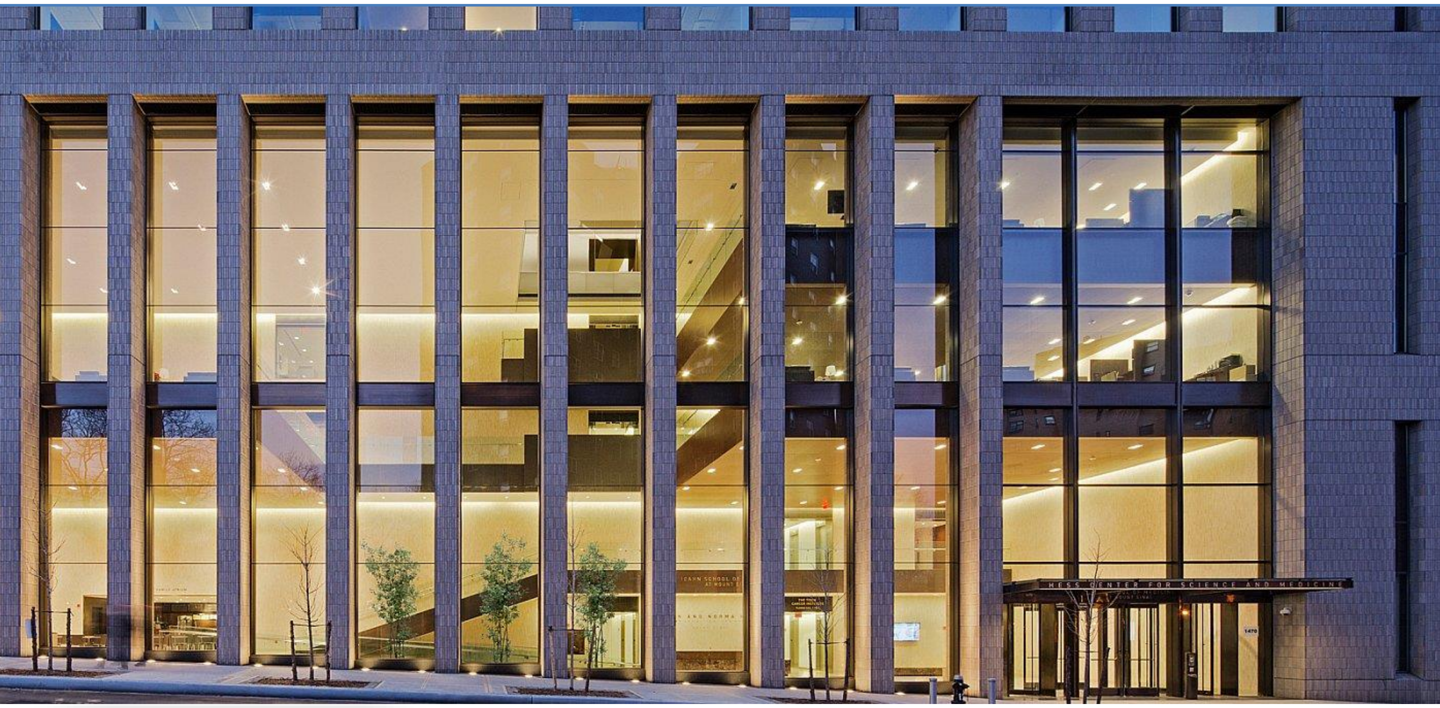
Dr. Tang’s lab is involved with the research and development of novel imaging strategies for the study of neuro-psychiatric diseases. The work consists of both hardware and software development. The lab develops novel image analysis software approaches to integrate functional and structural connectivity using DTI, DSI and fMRI. The lab has also developed novel technologies (e.g. olfactory meter, real time fMRI) in use for the study of memory, OCD and mood-disorders.

Xu Lab

Junqian Xu, PhD
Assistant Professor, Radiology
Neuroimaging

Dr. Xu’s lab develops quantitative and functional magnetic resonance (MR) techniques and applies them to study neurometabolism and neuropathophysiology. Our current projects are to develop:
(1) fast MR imaging and spectroscopy methods for quantitative neuroimaging, (2) reliable MR techniques for functional assessment of spinal cord, and (3) a “Connectomic” imaging approach for tissue recovery, repair and clinical outcomes in multiple sclerosis.

LEADERSHIP



Dr. Zahi Fayad is Director of the Imaging Research Center and the Translational and Molecular Imaging Institute, Director and Founder of the Eva Morris Feld Imaging Science Laboratories, and Director of Cardiovascular Molecular Imaging Research at the Icahn School of Medicine at Mount Sinai. He is a world leader in the development and use of multimodality cardiovascular imaging including: cardiovascular magnetic resonance (CMR), computed tomography (CT), positron emission tomography (PET). He holds twelve U.S. and worldwide patents and/or patent applications.

Dr. Fayad is the recipient of multiple prestigious awards and was recently honored with the John Paul II Medal from the City of Krakow, Poland, in recognition of the potential positive impact of his work on humankind and he holds the title of Honorary Professor in Nanomedicine at Aarhus University in Denmark.

In 2013, he was elected Fellow of the International Society of Magnetic Resonance In Medicine, Magnetic Resonance Imaging, received a Distinguished Reviewer from Magnetic Resonance in Medicine, and was selected as an Academy of Radiology Research, Distinguished Investigator. In 2014 his alma mater, Bradley University, awarded him its highest honor, the Centurion Society Award, for bringing national and international credit to his university.

Dr. Fayad has authored more than 300 peer-reviewed publications, 50 book chapters, and more than 400 meeting presentations. He is currently the principal investigator of four federal grants/contracts funded by the National Institutes of Health's National Heart, Lung and Blood Institute and the National Institute of Biomedical Imaging and Bioengineering, with a recent large award from NHLBI to support the Program of Excellence in Nanotechnology. In addition, he serves as principal investigator of the Imaging Core of the Mount Sinai National Institute of Health (NIH)/Clinical and Translational Science Awards (CTSA).

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If you wish to make a donation to support the Translational & Molecular Imaging Institute, please contact:
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646.605.8742 or victoria.medford@mountsinai.org