National Institute of Biomedical Imaging and Bioengineering

Intramural Research Program

APRIL 2022

Introduction

The mission of the National Institute of Biomedical Imaging and Bioengineering (NIBIB) is to improve health by leading the development of biomedical technologies and accelerating their application. The NIBIB encourages the integration of the physical sciences and the life sciences to advance human health by improving quality of life and reducing the burden of disease.

The NIBIB's Intramural Research Program (IRP), based in Bethesda, Maryland, has expertise that spans technologies ranging in scale from near-atomic resolution to intact organisms.

Current Research

Molecular Imaging Probe Development

Developing molecular imaging probes for in vivo imaging of biochemical processes, including positron emission tomography, optical imaging (fluorescence and Raman), magnetic resonance imaging, as well as contrast enhanced ultrasound, photoacoustic, and multimodal imaging. Molecular imaging in combination with anatomic and functional imaging can improve understanding of disease, enable early detection, and enhance monitoring of therapeutic responses and drug discovery and development. Methods include chemical synthesis, protein engineering, bioconjugation, radio labeling, chemical analysis, pre-clinical studies, and clinical translation using various in vitro and in vivo techniques.

Nano Theranostics

Rational design of water-soluble, biocompatible nanoparticles for combined imaging and therapy. Nanoparticles (<100nm) synthesized from materials such as polymers, metals, ceramics, and lipids permit simultaneous diagnostic imaging, drug delivery, and monitoring of therapeutic responses. Methods include synthesis, physiochemical characterization, surface modification and bioconjugation, and pharmacokinetic and pharmacodynamic evaluation in rodents for translation to clinical application.

Cardiovascular Imaging

Developing patient- based methods for detection and quantitative characterization of subclinical cardiovascular disease of the myocardium and blood vessels in both early phase clinical trials as well as in multi-center studies. Areas of study include genetically determined disease and acquired cardiovascular disease as a result of common risk factors. Methods include advanced magnetic resonance techniques, cardiovascular computed tomography, photon counting computed tomography, and molecular probes. Assessing peripheral blood flow by video capillaroscopy.

High-Resolution Optical Imaging

Developing super-resolution optical imaging techniques, such as structured illumination microscopy, and applying them to the study of cells and tissues by combining optical sectioning techniques (such as pinholing) with existing approaches that utilize deconvolution. Developing fast optical sectioning techniques, such as multiview selective plane illumination microscopy and multiphoton temporal focusing, that enable high-speed volumetric imaging of cells and embryos.

Biophotonics

Developing probes and techniques for use in diffraction limited and subdiffraction limited fluorescence imaging of cells and tissues. Major emphasis is placed on developing new and improving existing genetically encoded fluorescent proteins for use as markers and sensors. Methods and technologies include confocal, total internal reflection fluorescence and widefield microscopies, single molecule imaging, fluorescence spectroscopy, and protein engineering.

Cellular and Supramolecular Structure and Function

Determining the organization and composition of supramolecular assemblies and small organelles in a cellular context and relating structure to function at the subcellular and molecular level, with the aim of expanding knowledge about complex biological and disease processes, as well as studying changes in morphology that characterize the action of diagnostic markers and therapeutic agents. Methods include quantitative, high-resolution electron microscopy, scanning transmission electron microscopy, electron tomography, serial block-face scanning electron microscopy, electron spectroscopy, nanoscale spectroscopic imaging, and novel labeling techniques.

Dynamics of Macromolecular Assembly

Developing biophysical methods to characterize macromolecules and their reversible interactions, including elucidating the relationship between protein structure and function and the assembly of multi-protein complexes and molecular machines. Methods include analytical ultracentrifugation, surface plasmon resonance biosensing, photon correlation spectroscopy, isothermal titration microcalorimetry, fluorescence, and circular dichroism.

Complex Biological Systems

Developing novel instrumentation and mathematical models

for improved understanding of complex biological systems at the nanoscale. Methods include high-resolution atomic force microscopy under physiological conditions with sensitive force measurements and mathematical modeling, optical and laser technologies, fluorescence and optical spectroscopy, and applications of novel reporter molecules.

Immunochemical Nanoscale Analysis and Diagnostic

Developing new technologies, including real-time, minimally invasive, microdialysis techniques and "lab on a chip" microfluidic immunoassays for the identification of biomolecules. Methods include microfabrication, laser-induced fluorescence detection, measurement of analytes at subfemtogram levels, mass spectrometry, time-resolved fluorescence, chromatographic analysis of protein expression, and secretion from single cells.

Non-invasive Optical Imaging and Remote Monitoring

Developing real-time, non-invasive methods to evaluate and monitor tissues and organs intraoperatively and at the patient's bedside. Clinical applications include monitoring the viability of organs and tissues destined for transplantation, and studies of obesity and sickle cell disease. Methods include optical subsurface imaging of fluorophores, functional laser speckle imaging, laser Doppler flowmetry, assessment of oxygen consumption and sensitive passive infrared imaging of thermal gradients in tissues. Developing wireless detectors for continues monitoring of such variables as microvascular status, motor activity, and circadian rhythm of patients at point of care.

Modeling the Cellular Environment

Developing in vitro platforms that model tissue environments for realistic studies of cellular interactions. Methods include microfabrication, electrospinning, hydrogel fabrication and characterization, and finite element analysis.

Quantitative Medical Imaging

Develops methods to derive biomarkers from data acquired by non-invasive imaging techniques (such as MRI) that are informative about anatomy and physiology and that provide new, accurate and reliable tools for assessment of various medical conditions.

Training Opportunities

The NIBIB's IRP offers training opportunities at several educational levels including:

Imaging Sciences Training Program

A joint NIBIB/NIH Clinical Center program for MDs and PhDs seeking research careers in clinical, translational, and basic imaging research.
www.cc.nih.gov/drd/training/index.html

Postdoctoral Fellowship Programs

Intramural Research Training Award Fellowships and Visiting Fellowships.
https://www.training.nih.gov/programs/postdoc_irp

Postbaccalaureate Programs

Training of recent college graduates.
https://www.training.nih.gov/programs/postbac_irta

Biomedical Engineering Summer Internship Program

For college students completing their junior year in a bioengineering program.
https://www.training.nih.gov/other_summer_programs_at_the_nih

NIH Summer Internship Program

https://www.training.nih.gov/programs/sip

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