Biomedical Imaging
The pioneering work of determining the biological mechanisms of disease and the lifesaving work of diagnosing and treating medical problems rely on sophisticated imaging techniques developed by engineers. At Cornell, collaborations among engineers, physical scientists, life scientists, and clinicians provide superb opportunities to create and improve these tools.

BME faculty members focus on time-resolved and spectrally-resolved measurement and visualization of biological structures across scales, with spatial scales ranging from macromolecular complexes to cells to whole organisms, temporal scales ranging from milliseconds to years, and spectral scales ranging from megahertz radiofrequency waves to exahertz x-rays. A wide range of imaging modalities and methods for achieving contrast are developed and used, including optical imaging, MRI, and CT. Cornell is known for pioneering development and application of nonlinear optical imaging techniques for in vivo imaging. Cornell researchers are also inventing new image analysis methods and novel contrast agents for clinical and research use. BME faculty apply these imaging tools to a diverse set of human health problems including neurodegenerative disease, cancer, and congenital heart disease. Biomedical imaging is also tightly interconnected with other areas of BME, providing in vitro and in vivo tools to evaluate biomaterials, validate systems biology models, monitor drug delivery, and map biomechanical properties.

Some specific faculty projects
Prof. Steven Adie’s lab develops optical coherence tomography (OCT)-based methods for the diagnosis and longitudinal tracking of diseases, such as cancer. This includes physics-based computed imaging techniques to optimize resolution in volumetric OCT, and methods for high-resolution 3D imaging of soft tissue biomechanics. These techniques will be utilized to study the important role of mechanical properties in carcinogenesis, in vitro and in vivo.

In Prof. Jonathan Butcher’s lab, multiple different imaging modalities are applied to the study of cardiac development, the dynamics of heart valve operation, as well as models of congenital and acquired cardiac disease. His lab uses multiphoton microscopy, high frequency ultrasound and micro-CT to investigate the structure and dynamics of living hearts in normal and disease states.
Prof. Peter Doerschuk’s group develops quantitative image analysis algorithms that are used for a diverse set of imaging problems, including determining virus structure from electron microscopy and inferring the state of the brain’s neurovascular system from optical images.

In Prof. Chris Schaffer’s lab, light is used not only to visualize biological systems, but also for targeted ablation and manipulation. For example, using extremely short laser pulses, Schaffer’s lab causes localized injuries to individual blood vessels in the brains of rodents, triggering a small stroke. These targeted microstrokes allow the lab to study the role of microvascular lesions in neurodegenerative diseases, such as Alzheimer’s disease.

Prof. Nozomi Nishimura’s lab is interested in understanding how inflammation, blood flow and cell death are linked in several different diseases. The cellular responses to stress and injury in various organ systems can be compared in various situations to study how stimuli trigger different responses. The lab uses in vivo optical imaging in mouse models, because the diversity of cellular phenotypes and structures is best appreciated in a whole, living organism. Targeted diseases include heart disease, neurodegeneration and cancer.

Prof. Yi Wang holds a joint appointment with Radiology at Weill Cornell Medical College and is the technical director of the new MRI imaging center in Ithaca which is equipped with a new state-of-the-art GE 3 Tesla imager. His research interest is to develop and improve MRI methods using mathematics, physics, electronic engineering, biological, and computer science tools to help physicians better diagnose diseases. His research activities include fast organ functional imaging, suppressing motion artifacts in MRI of the heart, and developing tools to quantitatively map magnetically susceptible biomarkers.

Prof. Warren Zipfel’s lab focuses on the development of two-photon excited fluorescence microscopy, the imaging technique invented in Prof. Watt Webb’s lab at Cornell and now the tool of choice for cell-resolved, in vivo optical imaging. They apply this imaging technique to a variety of research problems, focusing on direct visualization of the initiation and growth of tumors in animal models of cancer.

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**Representative publications**


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Endoscopic two-photon imaging of tissue morphology using intrinsic fluorophores and collagen second harmonic. Three color multiphoton imaging delineates different tissue structures in the colon of a live rat. (Zipfel)

Imaging Alzheimer’s disease: Blood vessels (yellow) and amyloid plaques (green), the hallmark of Alzheimer’s disease, imaged in the brain of a mouse. (Schaffer)

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