# FROM TECHNOLOGY TO DISCOVERY: DEEPER, FASTER, AND COLORFUL PHOTOACOUSTIC IMAGING IN LIFE SCIENCES

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Photoacoustic imaging (PAI) is an increasingly powerful technique for multi-scale anatomical, functional, and molecular imaging by acoustically detecting the optical absorption contrast in biological tissues. In PAI, a short-pulsed laser beam is used to illuminate the tissue, generating a tiny but rapid temperature rise and resulting in the emission of ultrasonic waves through thermoelastic expansion. The wideband ultrasonic waves are then detected to create high-resolution tomographic images that map the tissue's optical absorption.

In my talk, I will focus on several technological advancements in PAI that have collectively enabled fast, deep, and high-sensitivity biomedical applications and discoveries in life sciences, such as functional stroke imaging, drug testing, cancer detection, and interventional therapy. First, PAI has overcome the penetration limit by utilizing advanced internal light delivery techniques, allowing for super-deep (>10 cm) imaging. This breakthrough has extended the applicability of PAI to internal organ imaging in large animal models and humans. Second, innovative scanning technologies and deep-learning models have significantly accelerated PAI, enabling imaging speeds that are more than 1000 times faster while maintaining a large field of view and high spatial resolution. This enhancement facilitates the monitoring of highly dynamic biological processes at the microscopic scale, such as functional brain activities and glassfrog transparency. Third, through the use of novel fabrication technologies in optics and acoustics, miniaturized PAI systems have been developed. These handheld, wearable, and head-mounted imaging devices offer high spatial-temporal resolutions and high throughput, providing greater flexibility and accessibility in imaging applications. Lastly, PAI has greatly benefited from the genetically-encoded switchable or tunable near-infrared photoacoustic-specific probes. By incorporating these probes, the sensitivity and specificity of PAI have been improved by more than 1000 times, enabling highly sensitive detection of malignant cancer, tissue hypoxia, and neuronal activities.

By highlighting these technological advancements, my talk aims to update the recent progress made in PAI and its potential for a wide range of biomedical applications in life sciences.

## Biography

Our mission at PI-Lab is to develop state-of-the-art photoacoustic tomography (PAT) technologies and translate PAT advances into diagnostic and therapeutic applications, especially in functional brain imaging and early cancer theranostics. PAT is the most sensitive modality for imaging rich optical absorption contrast over a wide range of spatial scales at high speed, and is one of the fastest growing biomedical imaging technologies. Using numerous endogenous and exogenous contrasts, PAT can provide high-resolution images at scales covering organelles, cells, tissues, organs, small-animal organisms, up to humans, and can reveal tissue's anatomical, functional, metabolic, and even histologic properties, with molecular and neuronal specificity.

At PI-Lab, we develop PAT technologies with novel and advanced imaging performance, in terms of spatial resolutions, imaging speed, penetration depth, detection sensitivity, and functionality. We are interested with all aspects of PAT technology innovations, including efficient light illumination, high-sensitivity ultrasonic detection, super-resolution PAT, high-speed imaging acquisition, novel PA genetic contrast, and precise image reconstruction. On top of the technological advancements, we are devoted to serve the broad life science and medical communities with matching PAT systems for various research and clinical needs. With its unique contrast mechanism, high scalability, and inherent functional and molecular imaging capabilities, PAT is well suited for a variety of pre-clinical applications, especially for studying tumor angiogenesis, cancer hypoxia, and brain disorders; it is also a promising tool for clinical applications in procedures such as cancer screening, melanoma staging, and endoscopic examination.