Biomedical Imaging and Therapy Beamline at the Canadian Light Source

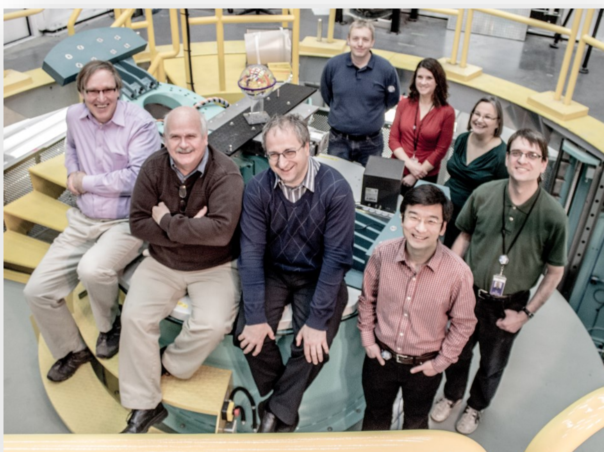
What is Synchrotron BioMedical Imaging?

Recent discoveries in synchrotron X-ray research have spawned the development of new soft-tissue imaging techniques that provide unprecedented resolution of nature's smallest details, and an astounding ability to deliver large doses of radiation to highly targeted sites such as tumours.

Unlike X-rays from conventional radiographic equipment, synchrotron light is monochromatic, polarized, extremely intense, and fine-tunable regarding its energy. These characteristics provide the opportunity to image both bone and soft tissues with micrometre-scale resolution, and to measure tissue properties never before accessible (using refraction, phase, and scatter). Furthermore, the monochromatic radiation used for synchrotron-based imaging results in lower tissue radiation doses than the wider-spectrum X-rays of conventional radiography. Synchrotron-based imaging also provides the ability to conduct longitudinal studies (serial imaging) and to obtain quantitative data. These two key features allow researchers to address questions related to the dynamics of structure and function.

The BMIT project

BMIT is one of only three dedicated synchrotron-based medical beamlines in the world, and the only one in North America.



The BMIT beamlines (bend magnet and insertion device) and associated facilities provide exceptional imaging capabilities, including K-Edge Subtraction Imaging (KES), Diffraction Enhanced Imaging (DEI), and Phase Contrast Imaging (PCI). In addition, work is ongoing to develop new methods of imaging through the creative use of perfect silicon crystals to bend the x-ray beam (beam-expansion, spectral-KES, multi-energy techniques).

BMIT also includes the necessary ancillary laboratories and preparation areas for tissues, small and large animals, and humans and is the only facility of its type in the western hemisphere.

BMIT is designed to accommodate many species of animals, from mice to horses. It will surpass the capabilities of competing facilities by enabling imaging and radiation therapy research on humans, and a wide range of living animals and plants. This flexibility will position Canada as a world leader in biomedical imaging, and will greatly facilitate development of animal models of human disease.

Life Sciences Lab

The life sciences lab, available for use by CLS staff and users, includes a microtome, centrifuges, autoclave, deionized water system, COY anaerobic glove box, PCR and qPCR machines, Qubit fluorometer, hach spectrophotometer, microplate spectrophotometer, oven, epifluorescence and dissecting microscopes, pH and weighing station, fridge, and -80 C and -20 C freezers.

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Live Animal Imaging

Lighting Up the Lungs

Researchers are developing synchrotron imaging protocols suitable for live animal imaging and for determining viable lung volume using DEI-Multiple Image Radiography (MIR).

Respiratory gated breath hold imaging on live mice has been performed using the CLS-developed constant pressure ventilator technique. The ventilator system is software controlled so that images can be taken at peak expiratory and inspiratory lung pressures.

The fine contrast mechanism of DEI-MIR was also utilized at these pressures, capitalizing on the differences in refractive indices of air and lung parenchymal tissue. Synchrotron imaging allows for the effective evaluation of gross changes in lungs exposed to inflammogens or carcinogens, offering the potential for animal longevity studies with more accurate evaluation of pathology, inflammation, and cancer biology as well as the response to and the effectiveness of therapies, while reducing the number of animals killed/expended in research.

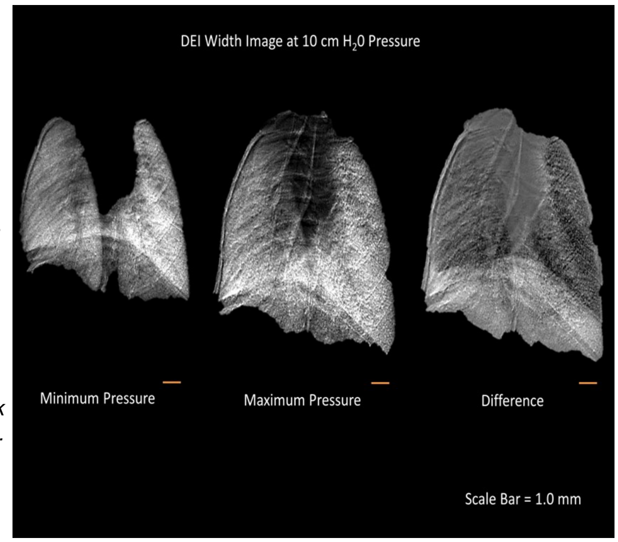


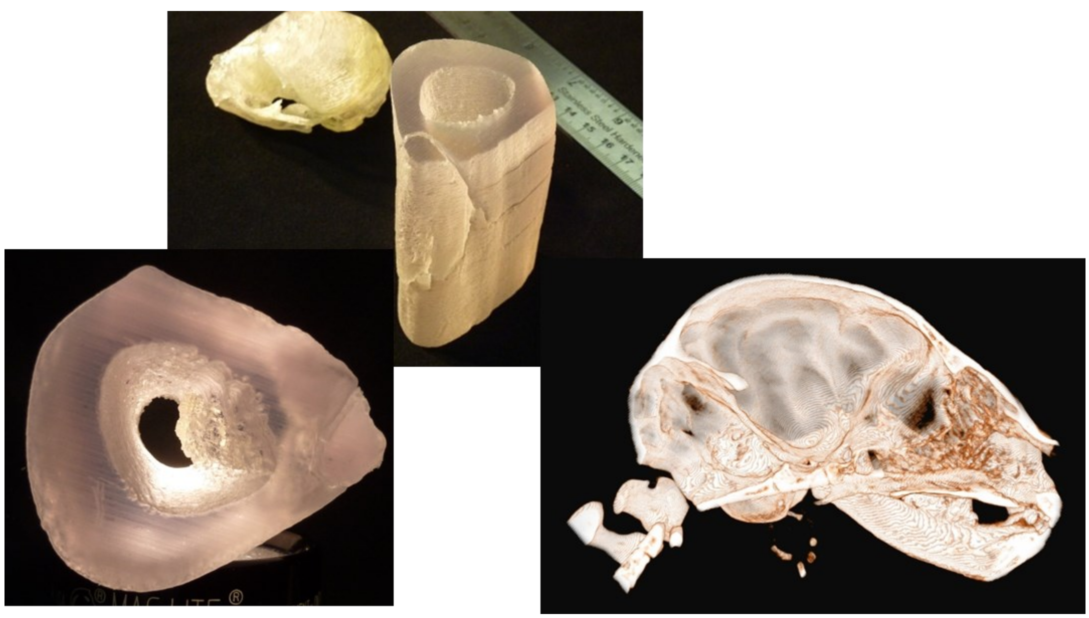
Image: Synchrotron-based DEI width images of a healthy mouse lung at peak expiratory, maximum inspiratory, and difference lung capacities.

Evaluation of microscopic tissue characteristics in vivo

In 2010, entire feline and canine bodies, were imaged, as well as an equine distal limb, using CT, DEI and K-edge subtraction methods on BMIT. Future goals include developing synchrotron based imaging protocols suitable for live animal imaging and to perform accuracy studies between synchrotron (CT, DEI, K-edge, Phase contrast), and conventional (CT, MRI, ultrasonography) imaging techniques.

Synchrotron imaging allows for evaluation of microscopic tissue characteristics in vivo which will permit longitudinal survival studies in large animal species, for evaluation of pathology, cancer biology and response to therapy, while reducing the number of animals used in research.

Synchrotron CT images have also been used in the production of 3D rapid prototyping models of equine limbs and feline skulls, with applications in surgical planning and for teaching anatomy.



Images: synchrotron-based CT images and pictures of 3D models printed from the CT scan data of an equine tibia showing a comminuted fracture with endosteal and periosteal callus formation and the feline skull (4-6 week old kitten).

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Light exploring life
BMIT

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