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X-radiation in health and disease: Novel approaches to the study of disease processes and therapy

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Our current medical knowledge and understanding of human biology and physiology have been predicated by our capacity to image organs, body structures, different types of tissues and particular cell types. These imaging modalities range from advanced microscopy for imaging of cells and tissues through to 2D and 3D macroscopic techniques for imaging of tissues and organs. Soft tissues in particular are difficult to image, especially when surrounded by dense structures such as bone. Also, some regions, such as the brain, require special investigative techniques as they are closed tissue/organ structures with low contrast features.

Medical diagnoses, monitoring of disease progression, efficacy of therapies and the recent advent of ‘targeted imaging’ rely upon techniques such as X-ray analysis, MRI, Positron Emission Tomography (PET) and more. In this seminar several recent adaptations of X-ray and synchrotron-based X-ray science will be related. In particular, Phase-contrast X-ray imaging (PCXI), also termed microfocus imaging, X-ray Fluorescence Microscopy (XFM) and Microbeam X-ray Therapy (MRT) will be discussed.

Since the discovery of X-rays and development of medical X-ray sources, X-ray imaging has accounted for approximately 60% of medical diagnostic procedures; X-ray imaging is still the predominant technology used in medicine. Over the past 30 years radioisotope-based imaging has expanded substantially with 3D positron emission tomography (PET) and combined PET/MRI being developed for simultaneous structural and functional imaging. More recently, advanced 3D imaging techniques have been aligned with targeted therapies and high resolution multi-modal imaging to improve our capabilities in definition of organ boundaries and particular tumours and organ abnormalities. Microbeam radiation therapy (MRT) is another capability and this is currently being developed at the Australian Synchrotron.

Synchrotrons produce a broad range of electromagnetic radiation applicable for diverse analyses such as protein crystallography, X-radiation for fluorescence spectroscopy, for mapping and quantification of trace metals, and for fast X-ray tomography for structural imaging. Access to synchrotron light sources has led to a renaissance in utilisation of X-rays for diverse imaging applications and novel radiation therapies.

During this seminar the importance of advanced imaging techniques and synchrotron radiation to enable investigation of a range of diseases will be related. This presentation will include specific studies in which application of synchrotron radiation has aided investigations into bone disease and bone cancers, the study of brain abnormalities including epilepsy and traumatic brain injury and targeted therapy using MRT.

Advanced medical imaging techniques have been central to our understanding of disease processes and have the potential to aid clinicians when considering therapeutic interventions. The strong synergy that occurs in interdisciplinary research has been crucial to these developments. Project design and efficient implementation of advanced imaging techniques to achieve meaningful outcomes in science and medicine will also be discussed.

Acknowledgement: The contribution of the many scientists and organisations involved with this work will be related during delivery of this invited seminar.

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