Master of Molecular Imaging Course Outline

Graduate Outcomes

On completion of the course, graduates will have achieved the following skills, knowledge and attributes:

		chemistry/pharmacy	physics/engineering	medical science
Assumed knowledge	*all students:*	• first year undergraduate maths • first year biology/physiology preferred		
	discipline specific:	• principles of medicinal/organic synthetic chemistry	• intermediate (2nd and 3rd year) undergraduate maths • high level programming	• pathology, cell biology • mammalian physiology
Graduate knowledge	*all students:*	• able to understand and integrate concepts of tracer principle, image signal amplification & affinity/specificity of tracers • able to explain physical principles of PET, SPECT and MRI • able to explain and justify choice of tracer kinetic model and interpret model parameters		
	discipline specific:	• know how to identify target and drug candidates as potential imaging agents • able to understand and explain labelling strategy and approach • know how to validate a radiopharmaceutical for use in molecular imaging experiments	• able to discuss pros/cons of current and future detector technologies • able to explain rationale for different reconstruction methods • able to discuss challenges/solutions in multi-modality imaging	• able to discuss common pathways and receptor systems in molecular imaging • able to make informed choices on target and tracer selection • able to correlate molecular images with pathology and histopathology in several disease states
Graduate skills	*all students:*	• able to acquire and analyse a molecular imaging study (reconstruct data, draw ROIs, plot kinetics, fit model)		

	discipline specific:	• able to use molecular modelling software to predict tracer properties • able to develop and perform HPLC for purification & QC of a radiopharmaceutical • able to design a molecular imaging study to evaluate a tracer	• able to implement and evaluate iterative reconstruction using appropriate image quality metrics • able to model an imaging system using Monte Carlo simulation • able to model tracer kinetics and evaluate candidate models & model parameters	• able to perform in vitro binding assay • able to use a cryotome and prepare a tissue slice for autoradiography • able to perform autoradiography
Graduate attributes	*all students:*	• able to critically question current knowledge in the field • able to explore new and challenging concepts in molecular imaging • demonstrate attributes of a beginning researcher – enquiring mind, critical and independent thinker		

Unit of Study Descriptions

Core Units

MRTY5109 Molecular Targets and Imaging Probes

This unit of study explores the characteristics of molecular targets and imaging probes that are required for successful molecular imaging experiments. A molecular target should: (i) detect a fundamental feature of a pathophysiological process, (ii) be validated by pathology, (iii) allow detection of disease early in its time course and (vi) lend itself to measurement with a biomarker that is reliable and minimally invasive. Once a molecular target for a particular disease is identified the methodology and requirements of a molecular probe suitable for imaging that target will be described. For example, in brain studies these include: (i) the imaging probe enters the brain in sufficient quantities, (ii) is stable in vivo, (iii) has moderate lipophilicity, (vi) exhibits low uptake of metabolites in brain, (v) is retained in the brain, (vi) displays high specificity and (vii) displays low non-specific binding.

On completion of this unit of study, students should be able to identify molecular targets that may be useful in studying disease processes and have a clear understanding of the properties an imaging probe should possess to enable in vivo imaging of the molecular target of interest. In addition, this unit will provide the rationale for determining whether a drug is suitable for development into an imaging probe and the isotopes and radiolabelling methodologies associated with that process.

MRTY5109 Radiotracer Based Molecular Imaging

This unit of study explores the principles and methods that underpin two key molecular imaging techniques based on the radioactive tracer principle: single photon emission computed tomography (SPECT) and positron emission tomography (PET). Topics covered include the radioactive tracer principle, radioisotope production and decay, radiation transport in tissue, radiation detection, PET and SPECT instrumentation, tomographic reconstruction and an introduction to tracer kinetic modelling. On completion of this unit, students will have a thorough understanding of the imaging chain as it relates to PET and SPECT, starting with the emission of radiation in the body, leading to its external detection and, finally, a reconstructed image of the radioactive tracer distribution in the body. The factors affecting the accuracy and noise properties of molecular images will be explored. Students will also have an appreciation of how to use these imaging technologies to exploit the properties of the radioactive tracer principle and make estimates of important physiological parameters.

MRTY5110 Magnetic Resonance Imaging Fundamentals

Students will enrol in this unit of study at the University of Queensland as a cross-institutional student. The unit will be credited to the Master of Molecular Imaging on successful completion of this unit of study at UQ.

This unit of study explores the principles and methods that underpin Magnetic Resonance Imaging (MRI), a key molecular imaging technique. Topics covered include Physical principles of nuclear magnetic resonance (MR), underlying mechanisms of relaxation in MR & descriptions of the way in which pulse sequences are able to exploit relaxation to produce contrast. On completion of this unit, students will have a thorough understanding of the MRI methodology, and the molecular basis for endogenous contrast. The use of contrast agents to modify image contrast and target particular

molecular features will be introduced. The factors affecting the accuracy and potential sources of artefact in MRI images will be explored.

MRTY5111 Pathological Correlates of Molecular Imaging

Although molecular imaging techniques are non invasive and are performed in vivo (on the intact living body), it is common to take a tissue biopsy or post mortem sample for further analysis and comparison with the in vivo imaging findings. This unit of study will explore the techniques used to analyse such samples microscopically and how the pathology observed at the cellular level may be correlated with disease related changes observed in vivo through molecular imaging techniques. Topics covered include tissue preparation, staining techniques, light microscopy, autoradiography and pathological interpretation of tissue samples and in vivo images. On completion of this unit, students will have a good understanding of the key cellular processes and features measured by immunohistochemical staining techniques, autoradiography, and their in vivo counterparts in molecular imaging.

Research Stream

MRTY5112 Advanced Molecular Imaging

This unit of study will build on the knowledge gained in the core units of study in semester 1. It will explore molecular imaging technology in more depth and discuss realistic scenarios as they are encountered in research. Topics for discussion include the choices researchers make about suitable biological targets, radiopharmaceuticals, subjects (animal models and patient populations), molecular imaging instruments, experimental protocols and computational algorithms. Students will learn how to extract more useful information from the molecular imaging study through the use of pharmacological models and advanced methods of analysis. On completion of this unit, students will have the requisite knowledge and skills to join a multidisciplinary research team and make contributions to the experimental design and execution of a molecular imaging study.

MRTY5113 Research Project

Molecular Imaging is a technology driven field which is continually evolving as new technologies emerge giving rise to new applications. In this unit, you will undertake a research project that requires you to use the knowledge and skills gained throughout the course to solve a real problem aligned with your disciplinary area and interests. You will choose from a list of topics and undertake the design and preparatory phase of the project by distance learning with support from your supervisor. The data collection phase will take place in the research facilities of the partner Universities during an on campus block of up to 10 weeks.

On completion of this unit, students will have gained research skills and acquired some practical experience of formulating a problem, designing a study using the most appropriate methodology, acquiring and analysing data and drawing conclusions. Thus, the research project together with the coursework you have completed throughout this program will provide an ideal preparation for those who choose to go on to PhD research.

Industry Stream

Elective A and Elective B

Students who choose the Industry stream undertake two elective units of study. They are strongly encouraged to take MRTY5112 Advanced Molecular Imaging as one of the electives. For the other elective, students may choose any one of the following units according to their specific interests, or any other suitable unit offered by the University at postgraduate level subject to eligibility:

- PHYS5020 Computation and Image Processing
- MCAN5101 Confocal & Fluorescence Microscopy
- MCAN5111 Microscopy of Biomolecular Processes
- MRES7009 MR Spectroscopy & Applications (offered externally by UQ)
- PHAR5515 Pharmaceutical Science
- PHAR5513 Pharmaceutical Chemistry 1A
- COMP5424 Information Technology in Biomedicine

HSGS5001 Dissertation

The dissertation provides candidates with an opportunity to undertake an advanced investigation in a topic or issue through the development of either a proposal for independent research on that topic or a substantial paper that demonstrates the application of scholarly literature to a practical problem or issue. This unit integrates the knowledge gained throughout the course.