MEDICAL BIOPHYSICS
COURSE MODULES
2021 – 2022

__Note__: This document was last updated on September 13, 2021. Some information may have been altered since that time. To download the most up-to-date version, please visit:
https://medbio.utoronto.ca/handbook-and-forms

Special Message from the Department
Ontario's response to the COVID-19 pandemic continues to evolve. Changes will likely occur as the province and its municipalities adjust to new data about the virus. In these circumstances, please be advised that the manner of delivery of courses, co-curricular opportunities, programs, and services is subject to change, in accordance with university policies. The University thanks its students, faculty, and staff for their flexibility during these challenging times as we work together to maintain the standards of excellence that are the hallmark of the University.

Course module enrolment

To enroll, course modules must be requested by students on ACORN/ROSI. Instructions are available at https://medbio.utoronto.ca/course-registration. Students can only add a course module if no more than 15% of the course has been completed. Students who do not register (pay or defer fees) by the deadline will be removed from their course registration. Courses such as RST9999Y and the seminar course, MBP1015Y are preloaded and requests are not necessary. Students should check ACORN/ROSI to make sure they are enrolled in these two courses.

- If students encounter difficulty when enrolling in their courses, they should contact either Donna (uptown students) or Annette (downtown students).

Course module availability

All biology stream modules will be offered in alternate years. A core set of physics stream modules is offered every year while more specialized topics will be offered in alternate years or based on student and faculty response to the new curriculum. Course modules schedules can be reviewed on the MBP calendar at https://medbio.utoronto.ca/mbp-calendar.

Withdrawing from a course module

Students can withdraw from a course module up until the end of the 3rd class or as long as no more than 50% of the module has been completed. While many instructors and programs consider it best practice to provide students with an interim evaluation of their performance in the course prior to the drop date, this is not a requirement for graduate courses (as per the University Assessment and Grading Practices Policy 2012). To request withdrawal from a module, please email the Coordinator of the module and cc Chau Dang and withdraw in ACORN. If students are unable to withdraw in ACORN, they must complete the Drop Course form and email it to Chau Dang.

Policy for students receiving a failing grade in a course module

In the case where a student receives a failing grade in a module (less than 70%), the failing grade will appear on the student's transcript. If the module is one of the required modules MBP1200H or MBP1201H, the student will need to retake the module the following year. A passing grade is required for a module to count toward the graduation requirements.

Courses offered in other Departments

Graduate students at the University of Toronto can take graduate courses offered in any department, subject to availability and approval of their home department; the latter is given by the MBP graduate coordinators (Dr. Greg Stanisz or Dr. Lothar Lilge) on a case-by-case basis with approval of the student's supervisor and the course coordinator. Please provide Annette (Downtown Students) or Donna (Uptown Students) with a copy of the required approvals. If the student misses the deadline for course registration online, they will need to fill out an Add/Drop Course form: https://www.sgs.utoronto.ca/wp-content/uploads/sites/253/2019/06/AddDropCourses.pdf

Some examples of courses that may be of interest to MBP graduate students are listed below.

1. *IMM1431H – Immunotherapy*
2. *JNR1444Y – Fundamentals of Neuroscience: Cellular and Molecular*
3. *JEB1365H – Ultrasound: Theory and Applications in Biology and Medicine*
4. *BME1460H – Quantitative Fluorescence Microscopy: Theory and Application to Live Cell Imaging*
5. *JYG1555H – Advanced Topics: Cellular and Molecular Neurobiology*
6. *PSL1026H – Advanced Topics: Experimental Cell Physiology*
7. *CSC2515H – Introduction to Machine Learning*
8. *PSY5110H – Advanced Topics in Behavioural Neuroscience: Imaging Techniques in Preclinical Research*
9. *MSC1006H - Neuroanatomy – Introduction to Anatomical Organization of the Brain*
10. *PSY4706HS - Human Brain Anatomy*
11. *MSC1087H - Neuroimaging Methods using Magnetic Resonance Imaging*
12. *STA2005H - Applied multivariate analysis*
13. *STA4273H – Large Scale Machine Learning*
14. *MBP1023H - Clinical Radiation Physics and Dosimetry (to be confirmed for Winter 2022)*

COURSE MODULES
2021 – 2022
Course modules schedules can also be reviewed on the MBP calendar at https://medbio.utoronto.ca/mbp-calendar

Mandatory Modules

MBP 1201H - Introductory Biostatistics (0.25 credits)	Sept. 14 – Nov. 2, with Python Bootcamp on Sept. 10
MBP 1200H - Scientific Exposition and Ethics (0.25 credits)	Sept. 13 – Nov. 10

BIOLOGY	DATES	PHYSICS	DATES
MBP 1306H - Cancer Epigenetics (0.25 credits)	Nov. 4 – Dec. 16	MBP 1401H - Advanced Ultrasound (0.25 credits)	Mar. 2 – Mar. 23
MBP 1307H - Development, Stem Cells & Cancer (0.25 credits)	Jan. 17 – Mar. 7	MBP 1404H - Basics of Cell and Molecular Biology (0.25 credits)	Mar. 3 – Apr. 14
MBP 1300H - Quantitative Cancer Genomics (0.25 credits)	Sep. 16 – Oct. 28	MBP 1413H - Biomedical Applications of Artificial Intelligence	TBD – Winter 2022
MBP 1308H - Radiation Biology & DNA Repair (0.25 credits)	Nov. 1 – Dec. 13	MBP 1403H - Biophysics of Focused Ultrasound, Thermal Biophysics (0.25 credits)	Oct. 26 – Dec. 7
MBP 1301H - Radiation Oncology: Clinical & Experimental Radiobiology (0.5 Credits)	Apr. 25 – Apr. 29 (tentative dates, to be confirmed)	MBP 1405H - Introduction to Bio-Microscopies (0.25 credits)	Jan. 11 – Feb. 22
MBP 1311H - Tumor Microenvironment (0.25 credits)	Sept. 23 – Oct. 28	MBP 1406H - Introduction to Biophotonics (0.25 credits)	Mar. 4 – Apr. 1
		MBP 1407H - Magnetic Resonance Imaging – Overview (0.25 credits)	Nov. 1 – Dec. 20
		MBP 1408H - Medical Device Commercialization Essentials (0.25 credits)	Jan. 4 – Apr. 5
		MBP 1409H - Medical Device Innovation and Entrepreneurship (0.25 credits)	Jan 4 – Apr. 5
		MBP 1411H - Overview of Medical Imaging (0.25 credits)	Sep. 15 – Oct. 27
		MBP 1412H - Ultrasound Overview (0.25 credits)	Jan. 10 – Jan. 21

PROJECTED COURSE MODULES*
2022 - 2023

Mandatory Modules

MBP 1201H - Introductory Biostatistics	
MBP 1200H - Scientific Exposition and Ethics	

BIOLOGY	DATES	PHYSICS	DATES
MBP 1303H - Cell Signaling & Metabolism (0.25 credits)		MBP 1400H - Advanced Magnetic Resonance Imaging (0.25 credits)	
MBP 1305H - Experimental Models for Cancer Research (0.25 credits)		MBP 1401H - Advanced Ultrasound (0.25 credits)	
MBP 1304H - Predictive Oncology & Therapeutics (0.25 credits)		MBP 1404H - Basics of Cell and Molecular Biology (0.25 credits)	
MBP 1300H - Quantitative Cancer Genomics (0.25 credits)		MBP 1402H - Biological Imaging (0.25 credits)	
MBP 1301H - Radiation Oncology: Clinical & Experimental Radiobiology (0.5 Credits)		MBP 1403H - Biophysics of Focused Ultrasound (0.25 credits)	
MBP 1302H - Structural Biology & Proteomics (0.25 credits)		MBP 1405H - Introduction to Bio-Microscopies (0.25 credits)	
		MBP 1406H - Introduction to Biophotonics (0.25 credits)	
		MBP 1407H - Magnetic Resonance Imaging – Overview (0.25 credits)	
		MBP 1409H - Medical Device Innovation and Entrepreneurship (0.25 credits)	
		MBP 1410H - Nanotechnology for Medicine (0.25 credits)	
		MBP 1411H - Overview of Medical Imaging (0.25 credits)	
		MBP 1412H - Ultrasound Overview (0.25 credits)	

*Projected course offerings subject to change.

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List of Course Modules 2021 - 2022

Fall 2021

Biophysics of Focused Ultrasound, Thermal Biophysics

Cancer Epigenetics

Introductory Biostatistics - MANDATORY

Magnetic Resonance Imaging – Overview

Overview of Medical Imaging

Radiation Biology and DNA Repair

Scientific Exposition and Ethics - MANDATORY

Quantitative Cancer Genomics

Tumor Microenvironment

Winter 2022

Advanced Ultrasound

Basics of Cell and Molecular Biology

Biomedical Applications of Artificial Intelligence

Development, Stem Cells & Cancer

Introduction to Bio-Microscopies

Introduction to Biophotonics

Medical Device Commercialization Essentials

Medical Device Innovation and Entrepreneurship

Radiation Oncology: Clinical & Experimental Radiobiology

Ultrasound Overview

<u>NOTE:</u> Should there be insufficient enrolment in a module listed above, it will be offered the following year.

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Fall 2021	
Topic	**MBP 1403H - Biophysics of Focused Ultrasound, Thermal Biophysics**
Coordinator	Dr. Meaghan O'Reilly
Day & Time	Tuesdays, 12:30 – 2:30 pm
Location	Delivered online via Zoom Meeting
Recommended Prerequisites	NONE
Module Goals	Focused ultrasound can induce both thermal and non-thermal effects in biological tissues. These biophysical interactions form the basis of a range of therapeutic applications in current medical practice and in leading-edge research. The first half of this course will focus on thermal biophysics, drawing examples from focused ultrasound therapy as well as from other thermal modalities, such as radiofrequency and microwave. The physical and biophysical interaction mechanisms between the energy sources and tissue will be emphasized. Fundamentals of thermal dosimetry will be covered, with reference to the relevant tissue properties, the models of energy propagation within tissues, experimental techniques for dosimetry measurements, and the resulting biological effects. In the second half of this course nonthermal bioeffects of focused ultrasound will be examined. The physical mechanisms behind these mechanical effects will be covered, with an emphasis on cavitation and cavitation-mediated effects. Treatment monitoring considerations for non-thermal therapies will be discussed. The current status of thermal medicine and of focused ultrasound therapies will be reviewed using select clinical and pre-clinical examples.
Evaluation Method	Exam (100%)
Schedule	

Date	Instructor	Lecture
October 26	Meaghan O'Reilly	Biology/Rationale/Nomenclature
November 2	Meaghan O'Reilly	Blood Flow/Modelling/Energy Delivery
November 9	Meaghan O'Reilly	Energy Delivery (Cont'd)/Thermometry/Treatment Monitoring
November 16	Meaghan O'Reilly	Non-Thermal Mechanisms of Ultrasound/Bioeffects
November 23	Meaghan O'Reilly	Cavitation/Cavitation Nucleating Agents
November 30	Meaghan O'Reilly	Treatment Monitoring for Non-Thermal Therapies
December 7	**Exam**	

Medical Biophysics
UNIVERSITY OF TORONTO

Fall 2021	
Topic	**MBP 1306H - Cancer Epigenetics**
Coordinators	Drs. Daniel De Carvalho & Hansen He
Day & Time	Thursdays, 9:00 – 11:00 am
Location	Delivered online via Zoom Meeting
Recommended Prerequisites	NONE
Module Goals	Epigenetic regulation is critical in cancer development and progression. Moreover, epigenetic modifications can be used as therapeutic targets as well as biomarkers in cancer. This course will introduce basic concept in epigenetics and the frontiers in cancer epigenetics. Each class will consist of a one-hour student lecture reviewing the day's topic, followed by a one-hour student-led interactive discussion around the specific papers.
Evaluation Method	Presentation and participation in discussion. Each student will be responsible for a lecture topic review to be held in the first hour (35% of their grade) and for a scientific manuscript presentation in the second hour (35% of their grade) of each lecture. All other students are expected to contribute to the scientific manuscript discussion in each lecture (30% of their grade). Lecturers will provide the lecture topic and suggest manuscripts to be discussed at least two weeks prior to the lecture date. The selected scientific manuscripts will need to be shared with all students at least one week before the lecture. Lecturers will be available in person or by email to provide an optional review of the students' proposed presentation and discussion plan. The lecturers are responsible for assigning the student's grade using an evaluation form common across all of the lectures.

Schedule

Date	Instructor	Lecture
November 4	Daniel De Carvalho & Housheng Hansen He	Course overview and setting expectations
November 11	Cheryl Arrowsmith	Pharmacologically manipulating the epigenome
November 18	Michael Hoffman	Machine learning for epigenomics
November 25	Daniel De Carvalho	Epigenetics and liquid biopsy
December 2	Faiyaz Notta	Epigenetic mutations in cancer
December 9	Housheng Hansen He	Frontier in RNA epigenetics
December 16	Mathieu Lupien	Chromatic Hacking

Medical Biophysics
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Fall 2021	
Topic	**MBP 1201H - Introductory Biostatistics - MANDATORY**
Coordinator	Drs. Nilesh Ghugre & Maged Goubran
Teaching Assistant	Nicholas Luciw
Day & Time	Tuesdays, 10 am – 12 noon, followed by one-hour TA session 12 noon – 1 pm Special TA session (Python bootcamp), Fri. Sept. 10, 9 am – 12 noon TA office hours for Python Q/A, one hour per week (time TBD)
Location	Delivered online via Zoom Meeting
Recommended Prerequisites	Required module – there are no prerequisites. However, students are recommended to obtain working knowledge of the Python programming language. (Online Python resources will be distributed to students in advance of the term so that they can be prepared for the Bootcamp session.)
Module Goals	This course will serve as a rapid introduction to probability and statistical thinking with methods drawn from frequentist as well as Bayesian statistics. Students will gain a thorough understanding of how statistical inference is conducted and will, by the end of the course, be able to critically assess our use of statistics in the search for scientific truths.
Evaluation Method	5 assignments (10% each) and final exam (50%)

Schedule		
Date	**Instructor**	**Lecture**
September 10	TA	Statistical Analysis in Python Bootcamp
September 14	Bojana Stefanovic	Probability and Exploratory Data Analysis
September 21	Nilesh Ghugre	Hypothesis Testing
September 28	**No class – Virtual Departmental Retreat**	
October 5	Kamil Uludag	Linear Models
October 12	Maged Goubran	Inference and Prediction
October 19	Jüri Reimand	Introduction to Non-Parametric Statistics
October 26	Bo Wang	Introduction to Artificial Intelligence in Healthcare
November 2	**Exam**	

Fall 2021	
Topic	**MBP 1407H - Magnetic Resonance Imaging Overview**
Coordinator	Dr. Jean Chen
Teaching Assistant	Jaykumar Patel
Day & Time	Mondays, 12:30 – 2:30 pm
Location	Delivered online via Zoom Meeting
Recommended Prerequisites	A foundation in signals and systems theory and Fourier transforms is required. Students are strongly advised to take the **Overview of Medical Imaging module** prior to this module.
Module Goals	Since development of the first hospital-grade systems in the 1980s, magnetic resonance imaging (MRI) continues to make a profound impact on how physicians evaluate soft tissues within the human body. This course provides students with an overview of MRI technology covering the underlying physical principles of signal generation, signal contrast mechanisms, process of image formation, and basic instrumentation. The course is a prerequisite for students who subsequently wish to take Advanced Topics in MRI.
Evaluation Method	Lab (40%) and Final Assignment (60%)

Schedule		
Date	**Instructor**	**Lecture**
November 1	Kamil Uludag	Basic MR Physics 1
November 8	Kamil Uludag	Basic MR Physics 1
November 15	Brian Nieman	Imaging Physics 1
November 22	Brian Nieman	Imaging Physics 2
November 29	Jean Chen	Laboratory
December 6	Jean Chen	Instrumentation
December 13	**Tutorial**	
December 20	**Final Assignment**	

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Fall 2021	
Topic	**MBP 1411H - Overview of Medical Imaging**
Coordinators	Dr. John G. Sled
Day & Time	Wednesdays, 9:30 – 11:30 am
Location	Delivered online via Zoom Meeting
Recommended Prerequisites	Students are expected to have a foundation in undergraduate level mathematics including differential and integral calculus, complex numbers, linear algebra, and probability theory. Students entering from an engineering or physics undergraduate program will likely need no additional preparation. Students from another discipline may need additional preparation and should contact the module coordinator well in advance as to whether self-directed reading prior to the module start is recommended.
Module Goals	This module provides the mathematical preliminaries of medical imaging and introduces concepts of image formation, inverse problems, stochastic processes and instrument performance that are common to many medical imaging modalities. An introduction and historical perspective on the major medical imaging technologies is also presented. This course is a recommended prerequisite for many the imaging modules offered by MBP including those on MRI and ultrasound.
Evaluation Method	Exam (70%) and Lab Report (30%)
Schedule	

Date	Instructor	Lecture
September 15	TBD	Introduction to Medical Imaging: a brief history
September 22	John G. Sled	Linear Systems and Fourier Transform Theory I
September 29	John G. Sled	Linear Systems and Fourier Transform Theory II
October 6	John G. Sled	X-rays and Projections
October 13	John G. Sled	Tomography and Inverse problems
Week of October 18-22	John G. Sled	X-ray CT lab (may need to be scheduled on multiple days to accommodate the number of lab groups)
October 27	**Exam**	

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Fall 2021	
Topic	**MBP 1308H - Radiation Biology & DNA Repair**
Coordinator	Drs. Marianne Koritzinsky & Razq Hakem
Day & Time	Mondays at 10:00 am – 12:00 pm
Location	Delivered online via Zoom Meeting
Recommended Prerequisites	None
Module Goals	DNA repair is critical for maintaining genomic integrity and its defects increase cancer risk. In addition, mutations in genes involved in DNA damage signaling or repair have also been associated with other human diseases and syndromes. DNA damage can also be induced to treat cancer patients as is the case for radiotherapy and a number of genotoxic anti-cancer drugs widely used in the clinics. This module will focus on DNA damage repair mechanisms and the physiological response to DNA insults, including radio- and chemo- therapies.
Evaluation Method	- Presentation/discussion of scientific papers assigned a week ahead of time by the lecturers. - Class participation in all lectures. - Students will be required to submit research proposals to address questions that have arisen out of the topics covered in the module. On Dec. 6, each student will be assigned by the coordinators a specific topic/lecture to cover with the research proposal. Oral Presentation: 45% Class Participation: 15% Research Proposal: 40%

Schedule

Date	Instructor	Lecture
November 1	Marianne Koritzinsky	Introduction to Radiation Biology
November 8	Razq Hakem	Preclinical models to study mechanisms of DNA double strand breaks repair and their role in cancer
November 15	Benjamin Lok	Clinical Radiotherapy Overview and Predictive Biomarkers in the Clinic
November 22	Karim Mekhail	R-loops, DNA repair and genomic instability
November 29	Shane Harding	Cell cycle control and cellular responses to radiation/DNA damage
December 6	David Malkin	The role of p53 in cancer development
December 13	Research proposals to be submitted before 4PM on Dec. 13th.	

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Fall 2021	
Topic	**MBP 1200H - Scientific Exposition and Ethics - MANDATORY**
Coordinator	Drs. David Malkin & Jim Woodgett
Teaching Assistant	Andrea Tench
Day & Time	Wednesdays, 1:30 – 3:30 pm - with the exception of the first class scheduled for Monday, September 13 at 1:30 pm.
Location	Delivered online via Zoom Meeting
Recommended Prerequisites	NONE
Module Goals	Scientific exposition, discourse and ethics are fundamental principles to the conduct of responsible basic, translational and clinical research. This course will use a combination of didactic lectures and interactive group discussion to explore key elements of these principles under the broad headings of: 1) Principles of Ethical Conduct and Protection of Research Subjects; 2) Scientific Fraud, Plagiarism and Data Misrepresentation – Flagrant and Unintended; 3) Privacy and Confidentiality in the Genome Era (Data Sharing/Validation/Clinical Translation); 4) Authorship Responsibility in the Spirit of Collaboration and Intellectual Property Protection; and 5) Equity, Diversity and Inclusion in Science. The format of each lecture will be both didactic, with the lecturer discussing fundamental issues and principles relevant to the topic, and interactive with opportunity for open discussion of a foundational aspect of the subject being addressed in the lecture.
Evaluation Method	End of course exam with a combination of short- and long- answer questions based on information discussed in the lectures, and supplemented with materials provided by the lecturers, and an end-of-course assignment which will involve discussion of a problem-based 'scenario'. The topics for the 'scenarios' will provided by the course co-directors. The 'exam' will count for 50% of the final mark and the in-class problem/discussion session will count for 50%.
Schedule	

Date	Instructor	Lecture
September 13	Jim Woodgett	Research Ethics: Responsibilities and Best Practices
September 22	David Malkin	Authorship Responsibility in the Spirit of Collaboration and Intellectual Property Protection
September 29	Stephen Scherer	Privacy and Confidentiality in the Genome Era (Data Sharing/Validation/Clinical Translation)

October 6	Ivan Topisirovic	Biomedical Research: Ethos, Logos... and Pathos (on research misconduct)
October 13	Beth Stephenson	Principles of Ethical Conduct and Protection of Research Subjects
October 20	Bojana Stefanovic	Equity, Diversity and Inclusion in Science
October 27	Jim Whitlock	How do children in Canada (and the rest of the world) access promising new cancer therapies?
November 3	Group presentations	
November 10	**Exam**	

Medical Biophysics
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Fall 2021	
Topic	**MBP 1300H - Quantitative Cancer Genomics**
Coordinators	Drs. Trevor Pugh & Mathieu Lupien
Day & Time	Thursdays, 1:00 – 3:00 pm* (*except the intro session on Sept 16, 2:00 – 4:00 pm and October 14 lecture, 12:30 - 2:30 pm.)
Location	Delivered online via Zoom Meeting
Recommended Prerequisites	Undergraduate molecular biology and genetics
Module Goals	Each class will consist of a 1-hour student lecture reviewing the day's topic in detail, followed by interactive discussion around a specific paper, case report, or mini-workshop illustrating the application of research findings in a novel way (e.g. clinical application, meta-analysis, new use for old data). The organizing Instructor will provide a list of topics that must be covered by the student in the review portion of the class and moderate discussion during the more open portion.
Evaluation Method	Each student will be responsible for a Lecture Topic Review to be held in the first hour (35% of their grade) and for a Scientific Manuscript Presentation in the second hour (35% of their grade) of each lecture. All other students are expected to contribute to the Scientific Manuscript Discussion in each lecture (30% of their grade). The class accepts a minimum of 6 and maximum of 14 students. Instructors are to provide the lecture topic and can suggest manuscripts to be discussed in the second hour at least one week prior to the start date. The selected Scientific Manuscript is to be shared with all students at least 3 days before the lecture (usually Monday the week of the class). Lecturers will be available in person or by email to provide an optional review of the student's proposed presentation and discussion plan up to 3 days prior to student's presentation. The Instructors are responsible for assigning the student's grade using an evaluation form common across all of the lectures.
Schedule	

Date	Instructor	Lecture
September 16 (2:00 - 4:00 pm)	Trevor Pugh & Mathieu Lupien	Course overview and setting expectations.
September 23	Mathieu Lupien	Genome hacking: how to alter chromatin states in cancer
September 30	Trevor Pugh	Clinical cancer genomics: Approaches to analysis of cancer genomes to guide patient care.
October 7	Benjamin Haibe-Kains	Pharmacogenomics: Identifying opportunities for drug repositioning in cancer through aggregation of public data sets
October 14 (12:30 – 2: 30 pm)	Daniel De Carvalho	Epigenomic weaknesses and immunotherapy: Improving

		immunotherapy through the power of epigenetic modulation
October 21	Hansen He	Transcriptional Regulation: A quantitative approach to identify new therapeutic targets within the cancer transcriptional landscape
October 28	Michael Hoffman	Cancer Epigenomics

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Fall 2021	
Topic	**MBP 1311H - Tumor Microenvironment**
Coordinators	Drs. Rama Khokha & Bradly Wouters
Teaching Assistant	Lauren Katz
Day & Time	Thursdays, 9:15 – 11:15 am, with the exception of one lecture on Friday, October 15 at 9:15 am
Location	Delivered online via Zoom Meeting
Recommended Prerequisites	None
Module Goals	The tumor microenvironment (TME) is a complex entity in human cancers. It is constituted by multiple structural and cellular aberrations that arise during tumorigenesis. How cellular and molecular features of TME underlie tumor development and progression, as well as how these characteristics form the basis for new biomarkers and cancer therapies will be covered in this topic. The class will be split into groups of ~5 students. The instructor will deliver a lecture, followed by a presentation (30-40 minutes) delivered by a selected student group. The presentation will be based on 3-4 papers that have been provided at least two weeks ahead of the class. A set of instructions will also be provided to groups ahead of time. The non-presenting groups will actively participate in the review/criticism of these presented papers, as well as be prepared to cover the next set of questions in this field. Depending on the number of students enrolled, there will be either 1 or 2 rounds of presentations. Some lecturers will use a variation of the above format for class participation.
Evaluation Method	Attendance/Participation/ Presentation (50%) Exam (50%)

Schedule		
Date	**Instructor**	**Lecture**
September 23	Anastasia Tikhanova	The Bone Marrow Niche
September 30	Brad Wouters	Hypoxia
October 7	Tracy McGaha	Immune cells
October 15	Steven Chan	Mitochondria
October 21	Aaron Schimmer	Mitochondrial Proteases
October 28	Rama Khokha & Barbara Grunwald	Stromal Heterogeneity
October 28	**Take Home Exam**	

Medical Biophysics
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Winter 2022	
Topic	**MBP 1401H - Advanced Ultrasound**
Coordinator	Dr. David Goertz
Day & Time	Wednesdays, 9:30 am – 3:00 pm
Location	SRI, 2075 Bayview Ave. Room TBD
Recommended Prerequisites	Ultrasound Overview module or its equivalent (Please contact Dr. Goertz if uncertain)
Module Goals	This module builds upon the introductory material covered in the Ultrasound Overview course and is intended to provide a more substantial foundation for students pursuing thesis research involving biomedical ultrasound. Linear and nonlinear wave interactions with tissue will be covered, along with their implications for imaging and therapeutic applications. Selected topics will then be presented, including transducer principles of design and fabrication, advanced beamforming methods, cavitation and contrast agents.
Evaluation Method	Exam and assignment
Schedule	

Date	Instructor	Lecture
March 2	David Goertz	Wave interactions with tissue; cavitation
March 9	Christine Demore	Transducers; beamforming
March 16	Olivier Villemain	Doppler Ultrasound; contrast agents; selected topics
March 23	TBA	Tutorial

Winter 2022	
Topic	**MBP 1404H - Basics of Cell and Molecular Biology** (in ACORN referred to as "Cell and Molecular Biology for Physicists")
Coordinators	Drs. Margarete Akens & Arash Zarrine-Afsar
Day & Time	Thursdays, 9:00 – 11:00 am
Location	TBD
Recommended Prerequisites	NONE
Module Goals	This course provides introduction to basic concepts of anatomy, cellular & molecular biology and cell signaling related to cancer formation and progression. Methods for the analysis of genome & proteome will be discussed along with computational image analysis principles. The course will stress breadth of knowledge rather than depth. Participation mark combines attendance and active engagement in the discussions.
Evaluation Method	75% exam, 25% participation
Schedule	

Date	Instructor	Lecture
March 3	TBD	TBD
March 10	TBD	TBD
March 17	TBD	TBD
March 24	TBD	TBD
March 31	TBD	TBD
April 7	TBD	TBD
April 14	**Exam**	

Medical Biophysics
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Winter 2022	
Topic	**MBP 1413H - Biomedical Applications of Artificial Intelligence**
Coordinators	Drs. Jüri Reimand & John G. Sled
Day & Time	TBD
Location	TBD
Recommended Prerequisites	MBP1201H – Introductory Biostatistics or equivalent. Students should have a good working knowledge of probability, differential and integral calculus. The assignments will require programming in Python. A good understanding of the core syntax and principles of structured programming in Python or another programming language is required.
Module Goals	This module is a graduate level course in machine learning and artificial intelligence applied to biomedical research. It covers core concepts, machine learning algorithms, and deep learning approaches. Applications in medical imaging, genomics and clinical information are discussed. Students will have an in-depth course project applying these techniques to real-world datasets from their own research.
Evaluation Method	Assignments (40%) and final project (60%)
Schedule	

Date	Instructor	Lecture
Week 1 - TBD	Anne Martel	Core concepts and algorithms
Week 2 - TBD	TBD	Applications in medical imaging, radiomics I
Week 3 - TBD	TBD	Applications in genomics, epigenomics and sequence models
Week 4 - TBD	TBD	Application in medical imaging, radiomics II
Week 5 - TBD	TBD	Applications to biomarkers, multi-omics, time to event models
Week 6 - TBD	TBD	Applications in single cell genomics
Week 7 - TBD	TBD	Project presentations

Medical Biophysics
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Winter 2022	
Topic	**MBP 1307H- Development, Stem Cells and Cancer**
Coordinators	Dr. Norman Iscove
Day & Time	**Mondays 2:30 pm – 4:30 pm**
Location	**TBD**
Recommended Prerequisites	The course is tailored for students <u>from physics/engineering backgrounds</u> with <u>minimal prior exposure to biology</u>. Applicants with more than 1 - 2 biology courses completed should not be applying to this course; it is tailored to math/engineering students newly engaged in biologly-related graduate research.
Module Goals	This module will cover the nature, biology, medical applicability and cancer relevance of developmental concepts and stem cells. The topics will be developed in a 6-session lecture series. Each topic, listed below, will be covered in 2 hr.
Evaluation Method	Conceptual understanding rather than memorization of detail within each topic will be tested in a written exam (100% of the grade).at the end of the series.
Schedule	

Date	Instructor	Lecture
January 17	N. Iscove	Stem cells, self-renewal and the origin of leukemia
January 24	J. Dick	Concepts of "stemness" in human normal and leukemic hemopoiesis
January 31	C. O'Brien	Architecture, regulation and microenvironment in normal and malignant gastrointestinal stem cell systems
February 7	R. Khokha	Architecture, regulation and microenvironment in the mammary epithelial stem cell system
February 14	L. Ailles	Detection and quantitation of cancer stem cells and microenvironmental impact in epithelial and mesenchymal cancers
February 21	no class	
February 28	G. Keller	Principles of embryonic development applied to derivation of adult cells and tissues from embryonic stem cells
March 7	**Written examination**	

Winter 2022	
Topic	**MBP 1405H - Introduction to Bio-Microscopies**
Coordinators	Dr. Brian Wilson
Day & Time	Tuesdays, 9:00 – 11:00 am
Location	TBD
Recommended Prerequisites	None
Module Goals	Various forms of microscopy are widely used in biomedical research as well as in clinical medicine. Major classes of microscopy include: a) optical techniques (wide-field, fluorescence, laser-scanning confocal, Raman, bioluminescence, near-field, super-resolution, non-linear, light-sheet, intravital), together with a variety of fluorescent and other probes (dyes, fluorescent proteins, small-molecules), b) electron microscopy in transmission and surface-scanning modes, and cryoEM, and c) scanning-probe techniques. The goal of this Module is to introduce the basic physical principles of the different forms of microscopy and survey the different techniques, instruments and probes used in studying bio-specimens (cells, tissues, biomaterials), illustrating these with examples of biomedical applications. The role of digital techniques and image processing/analysis will be considered. As well as the lectures, there will be a hands-on session held at the Advanced Optical Microscopy Facility
Evaluation Method	Multiple Choice Examination

Schedule		
Date	**Instructor**	**Lecture**
January 11	TBD	TBD
January 18	TBD	TBD
January 25	TBD	TBD
February 1	TBD	TBD
February 8	TBD	TBD
February 15	TBD	TBD
February 22	**Exam**	

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Winter 2022	
Topic	**MBP 1406H - Introduction to Biophotonics**
Coordinators	Drs. Alex Vitkin & Lothar Lilge
Day & Time	Fridays, 10:00 am – 12:00 pm
Location	TBD
Recommended Prerequisites	None
Module Goals	The use of light in medical diagnostics, therapeutics and biomedical research is increasing, driven by the advent of new light sources, inexpensive imaging detectors, advanced fiber-optic delivery systems, better understanding of light-tissue interactions, and proven research and clinical applications. The course will focus mostly on *in vivo* photonics and initially cover (1) the relevant issues of light propagation in / interaction with turbid media such as tissue. The bulk of the course will focus on (2) particular technical implementations and research / pre-clinical / clinical results in photo-diagnostics (effects of *tissue on light*) and photo-therapeutics (effects of *light on tissue*). Advanced topics such as (3) molecular imaging, nanophotonics, optical clearing and theranostics will also be briefly covered. As such, the course goals include basic competencies in these three [(1)-(3)] areas. For students with limited background in optics and photonics, we will also run a series of tutorials to provide some "light" basics we deem useful for the course. These will be offered prior to the module itself, and will be optional for interested students.
Evaluation Method	Class participation (25%), and the oral exit exam (75%)
Schedule	

Date	Instructor	Lecture
February 4	Lothar Lilge	Pre-Module Tutorial "Optics Background 1" Wave opitics versus Ray optics
February 11	Lothar Lilge	Pre-Module Tutorial "Optics Background 2" Spectroscopy and light sources
February 18	Lothar Lilge	Basic biophotonics – light propagation in tissue (Maxwell's equations, transport / diffusion theory and statistical Monte Carlo methods), light-tissue interactions, tissue optical properties, fundamentals of photodiagnostics and phototherapeutics.
February 25	Alex Vitkin	Diagnostic <u>imaging</u>, discussions of resolution, contrast, turbidity, imaging depth issues. High resolution diagnostics including optical coherence imaging, photoacoustics, optical projection tomography, confocal and multi-photon

		techniques; low(er) resolution approaches including diffuse optical imaging
March 4	Lothar Lilge	Diagnostic spectroscopy techniques including hyperspectral imaging, fluorescence and Raman spectroscopy
March 11	Alex Vitkin	Photo-therapeutics based on non-thermal interactions (photo bio-modulation therapy)
March 18	Lothar Lilge	Photo-therapeutics based on temporally-controlled (rapidly pulsed) laser delivery, including photo-ablation and selective photothermolysis
March 25	Alex Vitkin	Selected advanced topics such as nanophotonics, molecular imaging, optical clearing and theragnostics
April 1	**Exam**	

Winter 2022	
Topic	**MBP 1408H - Medical Device Commercialization Essentials**
Coordinators	Drs. Graham Wright, Brian Courtney & Ahmed Nasef
Day & Time	Tuesdays, 5:45 – 7:30 pm (lecture dates subject to change) Orientation: January 4, 4:30-5:30PM.
Location	SRI, 2075 Bayview Ave. Room TBD
Recommended Prerequisites	Medical Device Innovation & Entrepreneurship is a co-requisite (must be taken at the same time)
Module Goals	Not all medical device innovations will make it into patient care. Without a compelling, accessible market, a sustainable business model and operating plan, a well-thought-out plan for acquiring and managing intellectual property, and strong regulatory and reimbursement strategies, even the seemingly most important medical innovations are unlikely to be commercialized. The Medical Device Commercialization Essentials course complements the Medical Device Innovation and Entrepreneurship module and provides students with an experiential connection to the process of commercializing novel medical discoveries. The course focuses on systematic examination of issues and factors that directly affect the financial viability and sustainability of a medical device innovation and impact the innovator's ability to successfully commercialize a solution. The delicate and frequently conflicting interplay between intellectual property, regulatory environment, reimbursement mechanisms, business strategy and financial modelling are explored with hands-on exercises and interactive workshops. The module is recommended for students who would like to: (1) catalyze innovation in major medtech companies; (2) build their own medtech start-ups; (3) draw on world-class innovative research conducted in Canadian universities, research institutes and hospitals; and (4) lead translational research projects.
Evaluation Method	In the Medical Device Innovation & Entrepreneurship module, students present a systematic review of significant clinical challenges and propose the development of novel medical device solutions that address the gaps in these challenges. In this commercialization module, students are required to incorporate the analysis and critical review of the prospective novel medical device concept from assignment 1 into a high-level report or a business case proposal. Students are to assume that this high-level proposal will be reviewed by an industrial technology advisor (ITA) through Sunnybrook's technology transfer office. The ITA will assess the potential of financially supporting the commercialization of this technology and determine whether or not an adequate market opportunity exists to support the development of an innovation. The students should draft the business case proposal within this commercialization context. The business case proposal should include the following sections to demonstrate commercialization potential: technology overview, market opportunity, industry analysis, business model/value proposition, and associated preliminary IP and reimbursement strategies. Grading Scheme: Class participation (10%), Group Report (90%).

Schedule		
Date	**Instructor**	**Lecture**
January 4	TBD	Orientation
January 18	TBD	The Art of the Start!
January 25	TBD	Innovation and Design Thinking in Healthcare
February 1	TBD	Market Research Exercise
February 8	TBD	Business Model Canvas Exercise
February 22	TBD	Prior Art Search Exercise
March 1	TBD	Medical device regulation Exercise
March 8	TBD	Brainstorming & Ideation Exercise
March 15	TBD	Panel discussion on raising capital & talking to investors
March 22	TBD	The Art of the Start!
April 5	**Final Report due**	

Winter 2022	
Topic	**MBP 1409H - Medical Device Innovation and Entrepreneurship**
Coordinator	Drs. Graham Wright, Brian Courtney & Ahmed Nasef
Day & Time	Tuesdays, 4:30 – 5:30 pm
Location	SRI, 2075 Bayview Ave. Room TBD
Recommended Prerequisites	NONE
Module Goals	Innovations in Medical technology have led to revolutionary advancements in health care. As new devices and technologies are developed, patients are benefiting from more targeted, less invasive treatments. However, new standard of care technologies won't reach the bedside unless inventors have the skills to bring them to market. The Medical Device Innovation and Entrepreneurship course is an opportunity to explore and navigate the principles underlying the challenges of medical device development. The course is designed to engrain the key mindsets and skill sets that help make successful medtech entrepreneurs. The course addresses the fundamental aspects from developing an idea to commercial success, enabling students to gain knowledge of the role of intellectual property management, regulatory pathways, reimbursement mechanisms, funding models, and business strategy in the successful commercialization of new medical device technologies. The course is delivered using a mix of lectures, guest speakers, team projects, recommended readings and online learning materials. In addition, students get the opportunity to network with local experts and thought leaders in the medtech field. The module is recommended for students who would like to: (1) catalyze innovation in major medtech companies; (2) build their own medtech start-ups; (3) draw on world-class innovative research conducted in Canadian universities, research institutes and hospitals; and (4) lead translational research projects.
Evaluation Method	Teams of students will have the opportunity to examine and analyze medical technologies that address unmet healthcare needs. Students will be required to explore the clinical problem context, assess the clinical need, motivations and influences of all stakeholders, identify and analyze existing solutions and treatment options, and assess market and commercialization potential with the goal of providing a critical review and strategic assessment of the identified technologies. Students will be evaluated based on: (i) in-class participation; and (ii) a presentation, which will include the following sections: • An assessment of the clinical need & underlying problem leading to the new device. Students are expected to perform medical literature reviews through online sources e.g., PubMed, Harrison's online, etc.

	• Market analysis including market size, segments, attractiveness, and competitive dynamics • Analysis of the different parties and stakeholders involved in delivering and financing care related to the clinical challenge (e.g. patients, physicians, hospitals, government officials/legislators, MOHLTC, nurse practitioners, etc.) • Analysis of treatment options and innovations available prior to the identified novel device that tried to address the identified clinical challenge. Students are expected to perform a comprehensive review of previous innovations outlining their strengths and weaknesses. • An overview of the medical device concept that has been developed to address the need including associated regulatory & reimbursement considerations. • A critical review of possible areas of improvement for the identified device Students will be evaluated on how well they have taken the lessons taught during the course and applied them. For all evaluations, students are required to demonstrate both that they have the evidence to support their claims as well as that they have added value by extending the analysis and using creativity. Grading Scheme: Class participation (10%), Group Presentation (90%).

Schedule		
Date	**Instructor**	**Lecture**
January 4	TBD	Orientation
January 11	TBD	The Canadian Healthcare & Medtech Ecosystem
January 18	TBD	Entrepreneurship in Healthcare
January 25	TBD	Clinical Needs Finding
February 1	TBD	Market Research and Analysis
February 8	TBD	The Business Model Canvas
February 15	TBD	Medical Devices Reimbursement Strategy
February 22	TBD	Technology Transfer & Intellectual Property Basics
March 1	TBD	Medical Devices Regulation Primer
March 8	TBD	Health Design Thinking
March 15	TBD	R&D Strategy + **Group Presentations**

March 22	TBD	Elements of a Sound Business Case
March 29	TBD	Funding Models and Business Development
April 5	TBD	Quality and Process Management

Winter 2022	
Topic	**MBP 1301H - Radiation Oncology: Clinical & Experimental Radiobiology*** ***Please note enrollment for this course is limited to MBP Graduate Students only.**
Coordinator	Dr. Marianne Koritzinsky
Day & Time	Mon, April 25 to Fri, April 29, 10:00 am – 6:00 pm **Dates and times are tentative and to be confirmed.**
Location	TBD
Recommended Prerequisites	The suggested textbook for this course is Basic Clinical Radiobiology, Fifth Edition. It is strongly recommended that you read this book before attending the course.
Module Goals	This program provides a comprehensive overview of radiation biology with a particular emphasis on aspects of direct relevance to the practice of radiation oncology. It addresses the molecular and cellular responses to radiation-induced damage that influence cell death in both tumors and normal tissues. Quantitation of radiation effects and the underlying biological basis for fractionation of radiotherapy and dose-response relationships in the clinic are covered in depth. The biological basis for current approaches to improve radiotherapy will be described including novel fractionation schemes, retreatment issues, targeting hypoxia, biological modifiers and combined radiotherapy/chemotherapy. Suggested textbook for this topic is: https://www.amazon.ca/Basic-Clinical-Radiobiology-Michael-Joiner/dp/1444179632 This topic is also offered through the Department of Radiation Oncology to residents in radiation oncology and physics, as well as other radiobiology researchers.
Evaluation Method	Exam (100% of the grade). Friday, May 6th (tentative). Location TBD
Schedule	

MONDAY, April 25 2022 – Schedule TBD		
Time	**Lecture**	**Faculty speakers**
10:00-10:30		
10:30-11:15		
11:15-11:30	Break	
11:30-12:15		
12:15-1:00		
1:00-2:00	Lunch	
2:00-2:30		
2:30-3:15		
3:15-4:00		
4:00-4:15	Break	
4:15-5:00		
5:00-6:00		

TUESDAY, April 26, 2022 – Schedule TBD		
Time	**Lecture**	**Faculty speakers**
10:00-10:45		
10:45-11:30		
11:30-11:45	Break	
11:45-12:15		
12:15-1:00		
1:00-2:00	Lunch	
2:00-2:45		
2:45-3:15		
3:15-4:30	Break	

Time	Lecture	Faculty speakers
4:30-5:30		
5:30-5:45		
5:45-6:00		

WEDNESDAY, April 27, 2022 – Schedule TBD		
Time	**Lecture**	**Faculty speakers**
10:00-10:30		
10:30-11:15		
11:15-11:45		
11:45-12:00	Break	
12:00-12:45		
12:45-1:30		
1:30-2:30	Lunch	
2:30-3:15		
3:15-4:00		
4:00-4:15	Break	
4:15-5:00		
5:00-5:45		
5:45-6:00		

THURSDAY, April 28, 2022 – Schedule TBD		
Time	**Lecture**	**Faculty speakers**
10:00-11:00		
11:00-11:45		
11:45-12:15		
12:15-12:30	Break	
12:30-1:15		
1:15-1:30		
1:30-2:30	Lunch	
2:30-3:15		
3:15-3:30		
3:30-3:45	Break	
3:45-4:30		
4:30-4:45		
4:45-5:00	Break	
5:00-6:00		

FRIDAY, April 29, 2022 – Schedule TBD		
Time	**Lecture**	**Faculty speakers**
10:00-10:45		
10:45-11:30		
11:30-11:45	Break	
11:45-12:30		
12:30-1:30		
1:30-2:00		

Note: *Lectures/schedule is subject to change – Last updated on July 27, 2021.*

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Winter 2022	
Topic	**MBP 1412H - Ultrasound Overview**
Coordinator	Dr. Christine Démoré
Day & Time	Mondays & Fridays, 9:30 am – 3 pm
Location	TBD
Recommended Prerequisites	A foundation in signals and systems theory and Fourier transforms is required. Students are strongly advised to take the Overview of Medical Imaging module prior to this one.
Module Goals	This course covers the fundamental principles of ultrasound for both imaging and therapy applications. Ultrasound imaging is a high-resolution and rapid imaging modality with many clinical applications, from monitoring fetus in pregnancy, to diagnostic imaging of breast, abdomen and vasculature, and guiding interventional tools in minimally-invasive procedures. Ultrasound therapy is a targeted method of delivering energy into tissue for treatment of disease or for drug delivery, with a broad range of clinical applications. This course will introduce the principles of ultrasound imaging, starting with a general overview of this imaging modality and its applications. It will cover the basic physics of ultrasound, interaction of ultrasound waves with tissue, transducers and arrays, image formation, signal processing, flow detection, ultrasound contrast agents, and example implementations of ultrasound. The lectures will be given over four days with two practical laboratory sessions to reinforce the taught concepts.
Evaluation Method	Lab report (50%) and exam (50%)
Schedule	

Date	Instructor	Lecture
January 10	Olivier Villemain Christine Démoré	Introduction to Ultrasound History Basic physics and principles in ultrasonics
January 14	Christine Démoré	Image generation & quality Application & implementation examples Practical Lab – Session 1
January 17	Christine Démoré Olivier Villemain	Systems Signal analysis Application & implementation examples
January 21	David Goertz	Doppler & colour flow imaging; Application & implementation examples Contrast imaging Practical Lab – Session 2

March 11	Exam