Medical Biophysics
UNIVERSITY OF TORONTO

MEDICAL BIOPHYSICS

COURSE MODULES

2020 – 2021

***Note**: This document was last updated on April 30, 2021. Some information may have been altered since that time. To download the most up-to-date version, please visit: https://medbio.utoronto.ca/modulebooklet*

Special Message from Dr. Allan Kaplan, Vice Dean, Graduate Education

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.

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.

Medical Biophysics
UNIVERSITY OF TORONTO

COURSE MODULES
2020 - 2021

Mandatory Modules	
MBP 1201H - Introductory Biostatistics (0.25 credits)	Sept. 15 – Nov. 3
MBP 1200H - Scientific Exposition and Ethics (0.25 credits)	Sept. 16 – Nov. 11

BIOLOGY	DATES
MBP 1303H - Cell Signaling & Metabolism (0.25 credits)	Sept. 17 – Oct. 29
MBP 1305H - Experimental Models for Cancer Research (0.25 credits)	Nov. 5 – Dec. 17
MBP 1304H - Predictive Oncology & Therapeutics (0.25 credits)	Mar. 8 – Apr. 19
MBP 1300H - Quantitative Cancer Genomics (0.25 credits)	Jan. 7 – Feb. 18
MBP 1301H - Radiation Oncology: Clinical & Experimental Radiobiology (0.5 Credits)	Apr. 26–30 & May 21
MBP 1302H - Structural Biology & Proteomics (0.25 credits)	Mar. 4 – Apr. 15

PHYSICS	DATES
MBP 1400H - Advanced Magnetic Resonance Imaging (0.25 credits)	Mar. 3 – Apr. 14
MBP 1401H - Advanced Ultrasound (0.25 credits)	Will be offered next year.
MBP 1404H - Basics of Cell and Molecular Biology (0.25 credits)	Mar. 4 – Apr. 15
MBP 1402H - Biological Imaging (0.25 credits)	Mar. 1 – Apr. 19
MBP 1403H - Biophysics of Focused Ultrasound (0.25 credits)	Oct. 27 – Dec. 8
MBP 1405H - Introduction to Bio-Microscopies (0.25 credits)	Jan. 12 – Feb. 23
MBP 1406H - Introduction to Biophotonics (0.25 credits)	Mar. 5 – Apr. 23
MBP 1407H - Magnetic Resonance Imaging – Overview (0.25 credits)	Nov. 2 – Dec. 21
MBP 1409H - Medical Device Innovation and Entrepreneurship (0.25 credits)	Sept. 10 – Dec. 10
MBP 1410H - Nanotechnology for Medicine (0.25 credits)	Jan. 13 – Feb. 24
MBP 1411H - Overview of Medical Imaging (0.25 credits)	Sept. 16 – Oct. 28
MBP 1412H - Ultrasound Overview (0.25 credits)	Jan. 11, 15, 18, 22 & Mar. 12

PROJECTED COURSE MODULES*
2021 - 2022

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

BIOLOGY	DATES
MBP 1306H - Cancer Epigenetics	
MBP 1310H - Cancer Immunotherapy	
MBP 1307H - Development, Stem Cells and Cancer	
MBP 1308H - Radiation Biology and DNA Repair	
MBP 1301H - Radiation Oncology: Clinical & Experimental Radiobiology	
MBP 1311H - Tumor Microenvironment	

PHYSICS	DATES
MBP 1401H - Advanced Ultrasound	
MBP 1402H - Biological Imaging	
MBP 1404H – Basics of Cell and Molecular Biology	
MBP 1403H - Biophysics of Focused Ultrasound, Thermal Biophysics	
MBP 1406H - Introduction to Biophotonics	
MBP 1407H - Magnetic Resonance Imaging – Overview	
MBP 1408H - Medical Device Commercialization Essentials	
MBP 1409H - Medical Device Innovation and Entrepreneurship	
MBP 1411H - Overview of Medical Imaging	
MBP 1412H - Ultrasound Overview	

*Projected course offerings subject to change

Medical Biophysics
UNIVERSITY OF TORONTO

List of Course Modules 2020 - 2021

Fall 2020

Biophysics of Focused Ultrasound, Thermal Biophysics

Cell Signalling & Metabolism

Experimental Models for Cancer Research

Introductory Biostatistics - MANDATORY

Magnetic Resonance Imaging - Overview

Medical Device Innovation and Entrepreneurship

Overview of Medical Imaging

Scientific Exposition and Ethics - MANDATORY

Winter 2021

Advanced Magnetic Resonance Imaging

Advanced Ultrasound

Basics of Cell and Molecular Biology

Biological Imaging

Introduction to Bio-Microscopies

Introduction to Biophotonics

Nanotechnology for Medicine

Predictive Oncology & Therapeutics

Quantitative Cancer Genomics

Radiation Oncology: Clinical & Experimental Radiobiology

Structural Biology & Proteomics

Ultrasound Overview

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

Fall 2020		
Topic	**MBP 1403H - Biophysics of Focused Ultrasound, Thermal Biophysics**	
Coordinator	Dr. Meaghan O'Reilly	
Day & Time	Tuesdays, 12:30 - 2:30 pm	
Location	Zoom link will be provided to registered students	
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 non-thermal 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 27	Meaghan O'Reilly	Biology/Rationale/Nomenclature
November 3	Meaghan O'Reilly	Blood Flow/Modelling/Energy Delivery
November 10	Meaghan O'Reilly	Energy Delivery (Cont'd)/Thermometry/Treatment Monitoring
November 17	Meaghan O'Reilly	Non-Thermal Mechanisms of Ultrasound/Bioeffects
November 24	Meaghan O'Reilly	Cavitation/Cavitation Nucleating Agents
December 1	Meaghan O'Reilly	Treatment Monitoring for Non-Thermal Therapies
December 8	**Exam**	

Return to Fall 2020 Course List

Medical Biophysics
UNIVERSITY OF TORONTO

Fall 2020		
Topic	**MBP 1303H – Cell Signalling and Metabolism**	
Coordinators	Dr. Jane McGlade & Dr. Vuk Stambolic	
Day & Time	Thursdays, 9:00 - 11:00 am	
Location	Zoom link will be provided to registered students	
Recommended Prerequisites	None	
Module Goals	This module will cover a spectrum of topics in cell biology and biochemistry, including cell-to-cell communication, sensing of extracellular signals, surface receptors as signaling modalities, second messengers, modular architecture of proteins, post-translational modifications as instructive signals, intracellular signal transduction and signaling pathways, effectors of signaling pathways, protein stability and turnover. The module will also encompass a series of themes in cellular metabolism, including cellular energetics, nutrient transport and utilization, plasticity in metabolic networks, cellular metabolism in disease and the interface between cell signaling and cell metabolism. The use of model systems in the study of signaling and metabolism, as well as methodologies for cell signaling research will be discussed. The students should expect to get an advanced understanding of signaling networks and metabolic pathways and knowledge of means for their interrogation.	
Evaluation Method	Students will be evaluated based on a written summary, analysis and critique of a research article related to one of the topics covered in the module. The course coordinators will provide a list of articles to choose from at least two weeks before the due date.	
Schedule		
Date	**Instructor**	**Lecture**
September 17	Shane Harding	Genome Stability and the DNA Damage Response
September 24	David Andrews	Regulation of Programmed Cell Death
October 1	Courtney Jones	Metabelomics and Targeting Tumour Metabolism
October 8	Mohammad Mazhab-Jafari	Fatty Acid Metabolism in Health and Disease
October 15	Jorge Filmus	Wnt and Hedgehog Signalling.
October 22	Linda Penn	The MYC Signalling Network.
October 29	Rob Rottapel	Receptor Tyrosine Kinase Signaling

Return to Fall 2020 Course List

Fall 2020		
Topic	**MBP 1305H - Experimental Models for Cancer Research**	
Coordinators	Dr. Laurie Ailles & Dr. Shane Harding	
Day & Time	Thursdays, 9:00 - 11:00 am	
Location	Zoom link will be provided to registered students	
Recommended Prerequisites	None	
Module Goals	We will discuss the various model systems used in cancer research, including in vitro models, mouse models, and others as well as models with a specific focus (e.g. metastasis models). There will be an emphasis on the pros and cons of each and the importance of using the correct model for the specific research question. There will be an introductory lecture, then the students will be assigned papers that exemplify the best (or worst) use of different types of models to present/critique. The course evaluation will be based on presentations and a written assignment.	
Evaluation Method	The course evaluation will be based on presentations and a written assignment.	
Schedule		
Date	**Instructor**	**Lecture**
November 5	Laurie Ailles & Shane Harding	Experimental Models for Cancer Research
November 12	Laurie Ailles & Shane Harding	Student presentations of selected papers
November 19	Laurie Ailles & Shane Harding	Student presentations of selected papers
November 26	Laurie Ailles & Shane Harding	Student presentations of selected papers
December 3	Laurie Ailles & Shane Harding	Student presentations of selected papers
December 10	Laurie Ailles & Shane Harding	Student presentations of selected papers
December 17	Laurie Ailles & Shane Harding	Student presentations of selected papers

Return to Fall 2020 Course List

Medical Biophysics
UNIVERSITY OF TORONTO

Fall 2020		
Topic	**MBP 1201H - Introductory Biostatistics - MANDATORY**	
Coordinator	Dr. Bojana Stefanovic	
Day & Time	Tuesdays, 10:00 am - 12:00 pm	
Location	Zoom link will be provided to registered students	
Recommended Prerequisites	Required module – no prerequisites	
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	TBD	
Schedule		
Date	**Instructor**	**Lecture**
September 11	TA	Statistical Analysis in R Bootcamp
September 15	Bojana Stefanovic	Probability and Exploratory Data Analysis
September 22	Bojana Stefanovic	Hypothesis Testing
September 29	**No class**	
October 6	Kamil Uludag	Linear models
October 13	Bojana Stefanovic	Estimation and Prediction
October 20	Juri Reimand	Aparametric Statistics
October 27	Bo Wang	Improving Your Statistical Questions
November 3	**Exam**	

Return to Fall 2020 Course List

Fall 2020		
Topic	**MBP 1407H - Magnetic Resonance Imaging - Overview**	
Coordinator	Dr. Jean Chen	
Day & Time	Mondays, 12:30 - 2:30 pm	
Location	Zoom link will be provided to registered students	
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 Exam (60 %)	
Schedule		
Date	**Instructor**	**Lecture**
November 2	Kamil Uludag	Basic MR Physics 1
November 9	Kamil Uludag	Basic MR Physics 1
November 16	Brian Nieman	Imaging Physics 1
November 23	Brian Nieman	Imaging Physics 2
November 30	Jean Chen	Virtual Laboratory
December 7	Jean Chen	Instrumentation
December 14	**Tutorial**	
December 21	**Exam**	

Return to Fall 2020 Course List

Fall 2020	
Topic	**MBP 1409H - Medical Device Innovation and Entrepreneurship**
Coordinators	Dr. Graham Wright, Dr. Brian Courtney & Dr. Ahmed Nasef
Day & Time	Thursdays, 5:00 - 6:00 pm
Location	Zoom link will be provided to registered students
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. This year's projects will include, but not limited to, any of the following pandemic-related focus areas: (i) optimization of isolation/quarantine, (ii) prevention of transmission and personal protective equipment, and (iii) surge capacity for ventilation and critical care.

	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	Tutorial
September 10 (4:00-5:00 pm)	Graham Wright	Orientation	
September 10 (5:00-6:00 pm)	Harindra Wijeysundera	Understanding the Canadian Healthcare System	
September 17	Brian Courtney	Strategic Trends in the Canadian Medical Devices Industry	Time: 6:15-7:15PM Goups & team projects
September 24	Kieran Murphy	Needs Finding & Medical Technology Entrepreneurship	
October 1	Peter Fenwick	Market Research and Validation	Time: 6:15-7:15PM Validation exercise
October 8	Hassan Jaferi	Business Model Canvas	Time: 6:15-7:15PM Canvas exercise
October 15	Stephen Dibert	Medical Devices Reimbursement Strategy	

October 22	Steve Leonard	Technology Transfer & Intellectual Property Basics	Time: 6:15-7:15PM Entrepreneurial Tools, Tips & Tricks
October 29	Frank Shannon & Michaela Shaw	Medical Devices Regulation Primer	Time: 6:15-7:15PM Regulation: Digital Vs. Devices
November 5		No Lecture (Medventions Innovation Day). This event is highly recommended for students, but attendance is optional. Talks will be recorded and archived on the Sunnybrook website.	
November 12	Joseph Ferenbok	Ideation & Translational Thinking Methods	Time: 6:15-7:15PM Design Thinking Exercise
November 19	Neil Godara	Research & Development & Clinical Strategy Fundamentals	Time: 6:15-7:15PM Prior art search exercise
November 26	Stefano Picone	Analyzing publicly-traded medical device companies	Time: 6:15-7:15PM Medical Device Early Stage Funding: The Roadmap (Case Study: XPan)
December 3	Martin Gurbin	Crafting the Elevator Pitch	Time: 6:15-7:15PM Presentations Dry Runs
December 10	**Group Presentations**		

Return to Fall 2020 Course List

Medical Biophysics
UNIVERSITY OF TORONTO

Fall 2020		
Topic	**MBP 1411H - Overview of Medical Imaging**	
Coordinator	Dr. John G. Sled	
Teaching Assistant	Ryan Oglesby	
Day & Time	Wednesdays, 9:30 - 11:30 am (unless otherwise noted)	
Location	Zoom link will be provided to registered students	
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 16	Martin Yaffe	Introduction to Medical Imaging: a brief history
September 23	John G. Sled	Linear Systems and Fourier Transform Theory I
September 30	John G. Sled	Linear Systems and Fourier Transform Theory II
October 7	John G. Sled	X-rays and Projections
October 13, 1:30 to 3:30 pm	John G. Sled	Tomography and Inverse problems
Week of October 19-24	John G. Sled	Virtual X-ray CT lab
October 28	**Exam**	

Return to Fall 2020 Course List

Fall 2020		
Topic	**MBP 1200H - Scientific Exposition and Ethics – MANDATORY**	
Coordinators	Dr. David Malkin & Dr. Jim Woodgett	
Day & Time	Wednesdays, 1:30 - 3:30 pm	
Location	Zoom link will be provided to registered students	
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); and 4) Authorship Responsibility in the Spirit of Collaboration and Intellectual Property Protection. 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 be an essay discussing one aspect of the course – topics 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 16	Jim Woodgett	TBD
September 23	Beth Stephenson	TBD
September 30	Ivan Topsirovic	TBD
October 7	David Malkin	TBD
October 14	Steve Scherer	TBD
October 21	Jim Whitlock	TBD
October 28	Bojana Stefanovic	TBD

November 4	Jim Woodgett/David Malkin	Problem-Based Discussion
November 11	**Exam**	

Return to Fall 2020 Course List

Medical Biophysics
UNIVERSITY OF TORONTO

Winter 2021		
Topic	**MBP 1400H - Advanced Magnetic Resonance Imaging**	
Coordinator	Dr. Charles Cunningham	
Day & Time	Wednesdays, 12:30 - 2:30 pm	
Location	Zoom link will be provided to registered students	
Recommended Prerequisites	Overview of Medical Imaging, Magnetic Resonance Imaging – Overview	
Module Goals	To gain an advanced understanding of how MRI works	
Evaluation Method	Assignments only	
Schedule		
Date	**Instructor**	**Lecture**
March 3	Charles Cunningham	Phase encoding, frequency encoding, hybrids, RF pulses
March 10	Christopher Macgowan	Effects of motion, ghosting, motion compensation methods
March 17	Christopher Macgowan	Phase contrast and flow (2D & 4D), non-contrast angio, myocardial tagging, clinical implementation
March 24	Giles Santyr	MRI Contrast Mechanisms, endogenous and exogenous
March 31	Giles Santyr	Paramagnetic, susceptibility-based, CEST contrast, magnetization transfer, hyperpolarized agents
April 7	Philip Beatty	Image reconstruction - non-cartesian sampling and gridding
April 14	Philip Beatty	Multi-channel signal acquisition and image reconstruction

Return to Winter 2021 Course List

Medical Biophysics
UNIVERSITY OF TORONTO

Winter 2021		
Topic	**MBP 1401H - Advanced Ultrasound***	
Coordinator	Dr. David Goertz	
Day & Time	Wednesdays, 9:30 am - 3:00 pm	
Location	Zoom link will be provided to registered students	
Recommended Prerequisites	Ultrasound Overview module or its equivalent	
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. The module will be offered in alternate years.	
Evaluation Method	Exam	
***Schedule** *This module is offered in alternating years. It will next be held in Winter 2021/22.		
Date	**Instructor**	**Lecture**

Return to Winter 2021 Course List

Medical Biophysics
UNIVERSITY OF TORONTO

Winter 2021		
Topic	**MBP 1404H – Basics of Cell and Molecular Biology**	
Coordinators	Dr. Margarete Akens & Dr. Arash Zarrine-Afsar	
Day & Time	Thursdays, 9:00 - 11:00 am	
Location	Zoom link will be provided to registered students	
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	25% Assignment, 75% final exam. * Regular attendance is required, and will be taken into consideration for borderline grades.	
Schedule		
Date	**Instructor**	**Lecture**
March 4	Margarete Akens / Arash Zarrine-Afsar	Cell structure & function
March 11	Michael Rauth	Signalling
March 18	Arash Zarrine-Afsar	Methods in molecular biology & proteomics
March 25	Margarete Akens	Developmental biology & anatomy
April 1	Chris McIntosh	Computational methods for image analysis
April 8	Trevor Pugh	Genomics
April 15	**Evaluation (Classroom exam)**	

Return to Winter 2021 Course List

Winter 2021		
Topic	**MBP 1402H - Biological Imaging**	
Coordinators	Dr. Brian Nieman & Dr. Chris Macgowan	
Day & Time	Mondays, 10:00 am - 12:00 pm	
Location	Zoom link will be provided to registered students	
Recommended Prerequisites	None	
Module Goals	Participants will gain proficiency in reading, evaluating and writing grant proposals. Each lecture will be paired with reading from a funded grant application. Grantsmanship insights, strategies and pitfalls will be discussed with the speakers. Through the module, students will generate and pitch their own project idea, participate in peer grant feedback, and craft their own short grant proposals. Module participants will also learn about how imaging tools can be used to probe important questions in biology. A series of lectures will address: (1) knowledge gaps where imaging can be beneficial; (2) methodological developments required to address those gaps; and (3) how imaging advanced our knowledge of the field.	
Evaluation Method	Students will prepare a short grant proposal of their own design related to imaging in biological research. Evaluation will be based on general participation (10%), idea pitches (20%), peer review and evaluation (20%), and a written proposal (50%).	
Schedule		
Date	**Instructor***	**Lecture**
March 1	Chris Macgowan & Brian Nieman	Module Introduction & Lecture 1
March 8	Ultrasound Theme	Lecture 2 & Grant Discussion, Module Instruction 1
March 15	Optics Theme	Lecture 3 & Grant Discussion, Module Instruction 2
March 22	Chris Macgowan & Brian Nieman	Grant Pitches
March 29	MRI Theme	Lecture 4 & Grant Discussion, Module Instruction 3
April 5	Chris Macgowan & Brian Nieman	Peer Review of Grant Proposals
April 12	Microscopy Theme	Lecture 5 & Grant Discussion
April 19	**Final Grant Proposals Due, Module Feedback**	

*The themes and ordering of lectures are subject to change based on speaker availability.

Return to Winter 2021 Course List

Medical Biophysics
UNIVERSITY OF TORONTO

Winter 2021		
Topic	**MBP 1405H - Introduction to Bio-Microscopies**	
Coordinator	Dr. Brian Wilson	
Day & Time	Tuesdays, 9:00 - 11:00 am	
Location	Zoom link will be provided to registered students	
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 microscopy (wide-field, fluorescence, laser-scanning confocal, Raman, bioluminescence, near-field/scanning-probe, super-resolution, non-linear, light-sheet, intravital), together with a variety of fluorescent and other probes (dyes, fluorescent proteins, small-molecules) and B) electron microscopy, in both transmission and surface-scanning modes. 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.	
Evaluation Method	Written Assignment	
Schedule		
Date	**Instructor**	**Lecture**
January 12	Brian Wilson	Introduction and Optical Microscopy-1
January 19	Brian Wilson	Optical Microscopy-2
January 26	Ralph DaCosta	Intravital Microscopy
February 2	Brian Wilson	Optical Microscopy 3
February 9	Mohammad Mazhab-Jafari	Electron Microscopy
February 16	All	Group Discussion/Tutorial
February 23	AOMF	Virtual Hands-On (optional)

Return to Winter 2021 Course List

Medical Biophysics
UNIVERSITY OF TORONTO

Winter 2021		
Topic	**MBP 1406H - Introduction to Biophotonics**	
Coordinators	Dr. Alex Vitkin & Dr. Lothar Lilge	
Day & Time	Fridays, 10:00 am - 12:00 pm	
Location	Zoom link will be provided to registered students	
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 theragnostics 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 5	Lothar Lilge	Pre-Module Tutorial "Optics Background 1" Wave optics versus ray optics
February 12	Lothar Lilge	Pre-Module Tutorial "Optics Background 2" Spectroscopy and light sources
March 5	Alex Vitkin	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.
March 12	Alex Vitkin	Diagnostic imaging, 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 19	Lothar Lilge	Diagnostic spectroscopy techniques including hyperspectral imaging, fluorescence and Raman spectroscopy
March 26	Lothar Lilge	Photo-therapeutics based on non-thermal interactions (photo bio-modulation therapy)
April 2	**Good Friday – no class**	
April 9	Lothar Lilge	Photo-therapeutics based on temporally-controlled (rapidly pulsed) laser delivery, including photo-ablation and selective photothermolysis
April 16	Alex Vitkin	Selected advanced topics such as nanophotonics, molecular imaging, optical clearing and theranostics
April 23	Lothar Lilge/Alex Vitkin	**Exam**
NOTE: *Changes in the sequence of the lectures may occur and an update will be posted in early February.*		

Return to Winter 2021 Course List

Medical Biophysics
UNIVERSITY OF TORONTO

Winter 2021		
Topic	**MBP 1410H – Nanotechnology for Medicine**	
Coordinator	Dr. Gang Zheng	
Day & Time	Wednesdays, 12:30 - 2:30 pm	
Location	Zoom link will be provided to registered students	
Recommended Prerequisites	None	
Module Goals	This course is a critical and timely analysis of the current state of the nanomedicine field, how it has become incorporated in to multiple disciplines, and the factors that must be considered for its future progress and successful clinical implementation. The course will begin with an introduction to nanotechnology, the unique physical properties that define nanoscale materials, and the state of art techniques to study the nanobiointerface. The course will focus on the design considerations for nanoparticles will be considered through a discussion of how they interface with biology, which make them advantageous additions to the toolkit of agents for disease diagnosis and therapy. The course will then progress to sophisticated approaches for nanomedicine applications. Finally, the course will conclude by covering challenges and opportunities in translation of nanomedicines to the clinic.	
Evaluation Method	Each student will produce a written report of a topic covered in the course but unrelated to their thesis project plus an oral presentation on the March 1st class. Format: journal mini-review style, max. 5 pages (1.5 space, pt 12 font) with one figure plus references. Evaluation criteria will be heavily weighted on quality of analysis. The grade will be a combination of attendance and participation (10%),written report (70%) and oral presentation (20%).	
Schedule		
Date	**Instructor**	**Lecture**
January 13	Warren Chan	Nanomedicine Introduction
January 20	Gilbert Walker	Physical Properties Unique to Nanoscale Materials
January 27	Shana Kelley	Nanotechnology for Disease Diagnosis
February 3	Naomi Matsuura	Nanotechnology in Drug Delivery
February 10	Raymond Reilly	Nanotechnology in Radiation Medicine
February 17	Gang Zheng	Nanotheranostics and Clinical Translation
February 24	**Evaluation**	

Return to Winter 2021 Course List

Winter 2021		
Topic	**MBP 1304H - Predictive Oncology & Therapeutics**	
Coordinators	Dr. Benjamin Haibe-Kains & Dr. Ming Tsao	
Day & Time	Mondays, 1:00 - 3:00 pm	
Location	Zoom link will be provided to registered students	
Recommended Prerequisites	None	
Module Goals	One of the main challenges in precision medicine is the selection of the therapeutic strategy that will benefit the most to each individual patient. With the advent of high-throughput profiling technologies, more and more data can be generated to deeply characterize the molecular state of cancer cells and the phenotypes resulting from drug treatment both in vitro and in vivo. The "Predictive Oncology & Therapeutics" course will be composed of a series of lectures on the key topics related to drug development. The goal of this course is to provide students with a translational view of drug development, from basic research to clinical implementation. The students are expected to learn about the biological, computational and clinical aspects of the development of cancer therapeutics and their associated biomarkers (companion tests). For each session, 3 groups of 2 students will be formed. The lecturer gives a 45-minute lecture. Each group will then present one paper (10 minutes presentation + 5 minutes for questions). The paper will be selected by the students from a set of 3 papers provided by the lecturer, as well as one question to be discussed by the students for each paper, 2 weeks prior to the session.	
Evaluation Method	Evaluation of the presentation (30%) + exam with multiple-choice questions (70%)	
Schedule		
Date	**Instructor**	**Lecture**
March 8	Aaron Schimmer	Drug discovery and development
March 15	Benjamin Haibe-Kains & Scott Bratman	Biomarker discovery in preclinical setting
March 22	Geoffrey Liu	Pharmacogenetics and pharmacokinetics
March 29	Tracy Stockley & Ming Tsao	Implementation and application of biomarkers in clinical settings
April 12	Philippe Bedard	Design of clinical trials for cancer therapeutics
April 26	David Cescon	Preclinical testing of experimental therapeutics
May 3	Benjamin Haibe-Kains & Ming-Sound Tsao	Evaluation - short exam with multiple-choice questions

Return to Winter 2021 Course List

Winter 2021		
Topic	**MBP 1300H - Quantitative Cancer Genomics**	
Coordinators	Dr. Mathieu Lupien & Dr. Trevor Pugh	
Day & Time	Thursdays, 9:00 - 11:00 am	
Location	Zoom link will be provided to registered students	
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**
January 7	Trevor Pugh & Mathieu Lupien	Course overview and setting expectations.
January 14	Mathieu Lupien	**Noncoding cancer genome:** Understanding the contribution of genetic alterations from their chromatin context
January 21	Trevor Pugh	**Clinical cancer genomics**: Approaches to analysis of cancer genomes to guide patient care.
January 28	Benjamin Haibe-Kains	**Pharmacogenomics**: Identifying opportunities for drug repositioning in cancer through aggregation of public data sets
February 4	Daniel De Carvalho	Epigenomic weaknesses and **immunotherapy**: Improving immunotherapy through the power of epigenetic modulation

February 11	Hansen He	**Transcriptional Regulation**: A quantitative approach to identify new therapeutic targets within the cancer transcriptional landscape
February 18	Michael Hoffman	**Cancer epigenomics**

Return to Winter 2021 Course List

Medical Biophysics
UNIVERSITY OF TORONTO

Winter 2021

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	April 26 - 30, 10:00 am - 6:00 pm
Location	Zoom link will be provided to registered students
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) on May 14th 9:00 am – 12:00 pm – location TBA

Schedule

MONDAY APRIL 26, 2021

Time		Lecture	Faculty speakers
10:00-10:30	0	Introduction to course	Marianne Koritzinsky
10:30-11:15	1	Importance of radiobiology in the clinic	Scott Bratman
11:15-11:30		Break	
11:30-12:15	2	Hallmarks of cancer	Marianne Koritzinsky
12:15-1:00	3	Radiation induced damage and the DNA damage response	Bradley Wouters
1:00-2:00		Lunch	
2:00-2:30	T1	Tutorial and Question period (L2, L3)	Marianne Koritzinsky, Bradley Wouters
2:30-3:15	4	Molecular basis of cell death	Bradley Wouters
3:15-4:00	5	Cell survival - in vitro and in vivo	Albert van der Kogel
4:00-4:15		Break	
4:15-5:00	6	Quantifying cell kill and cell survival	Michael Joiner
5:00-6:00	T2	Tutorial and Question Period (L4, L5, L6)	Bradley Wouters, Albert van der Kogel, Michael Joiner

TUESDAY APRIL 27, 2021

Time		Lecture	Faculty speakers
10:00-10:45	7	LET and RBE	Richard Hill
10:45-11:30	8	Particles in radiotherapy	Michael Joiner
11:30-11:45		Break	
11:45-12:15	T3	Tutorial and Question period (L7, L8)	Richard Hill, Michael Joiner
12:15-1:00	9	Dose response relationships in radiotherapy - TCP, NTCP, therapeutic ratio	Michael Joiner

1:00-2:00		Lunch	
2:00-2:45	10	The linear-quadratic approach to fractionation	Michael Joiner
2:45-3:15	T4	Tutorial and Question period (L9, L10)	Michael Joiner
3:15-4:30		Break	
4:30-5:30	11	Modified fractionation schedules (and limits)	Scott Bratman
5:30-5:45	T5	Tutorial and Question Period (L11)	Scott Bratman
5:45-6:00	W	The LQ-model workshop	Michael Joiner and Marianne Koritzinsky

WEDNESDAY APRIL 28, 2021

Time	Lecture		Faculty speakers
10:00-10:30	12	Dose rate effect - intro to RB concepts	Albert van der Kogel
10:30-11:15	13	Clinical radiobiology of brachytherapy	Gerard Morton
11:15-11:45	T6	Tutorial and Question period (L12, L13)	Albert van der Kogel, Gerard Morton
11:45-12:00		Break	
12:00-12:45	14	Pathogenesis of normal tissue side effects	Shun Wong
12:45-1:30	15	The volume effect in radiotherapy	Albert van der Kogel
1:30-2:30		Lunch	
2:30-3:15	16	Retreatment tolerance of normal tissues	Shun Wong
3:15-4:00	T7	Tutorial and Question Period (L14, L15, L16)	Shun Wong, Albert van der Kogel
4:00-4:15		Break	
4:15-5:00	17	Stromal effects	Stanley Liu
5:00-5:45	18	Tumour growth, stem cells, and response to irradiation	Stanley Liu
5:45-6:00	T8	Tutorial and Question Period (L17, L18)	Stanley Liu

THURSDAY APRIL 29, 2021

Time	Lecture		Faculty speakers
10:00-11:00	19	Oxygen effect and tumour microenvironment	Marianne Koritzinsky
11:00-11:45	20	Clinical approaches to target hypoxia	Kathy Han
11:45-12:15	T9	Tutorial and Question Period (L19, L20)	Marianne Koritzinsky, Kathy Han
12:15-12:30		Break	
12:30-1:15	21	Stereotactic and high dose radiotherapy	To be announced
1:15-1:30	T10	Tutorial and Question Period (L21)	To be announced
1:30-2:30		Lunch	
2:30-3:15	22	Radiation-induced malignancies	David Hodgson
3:15-3:30	T11	Tutorial (L22)	David Hodgson
3:30-3:45		Break	
3:45-4:30	23	Predictive biomarkers and patient individualization	Scott Bratman
4:30-4:45	T12	Tutorial and Question Period (L23)	Scott Bratman
4:45-5:00		Break	
5:00-6:00		Final Tutorial and Question Period	Marianne Koritzinsky

FRIDAY APRIL 30, 2021

Time	Lecture		Faculty speakers
10:00-10:45	24	Combined radiotherapy and chemotherapy	Andrew Hope
10:45-11:30	25	Biological response modifiers in tumours – concepts	Marianne Koritzinsky
11:30-11:45		Break	
11:45-12:30	26	Biological response modifiers in tumours – clinical implementation	Alejandro Berlin
12:30-1:30	T14	Tutorial and Question Period (L24, L25, 26)	Andrew Hope, Marianne

			Koritzinsky, Alejandro Berlin
1:30-2:00		Concluding Remarks	Marianne Koritzinsky

Note: *Lectures/schedule is subject to change – Last updated on Feb 8, 2021*

Return to Winter 2021 Course List

Medical Biophysics
UNIVERSITY OF TORONTO

Winter 2021		
Topic	**MBP 1302H - Structural Biology & Proteomics**	
Coordinators	Dr. Mohammad Mazhab-Jafari & Dr. Gil Privé	
Day & Time	Thursdays, 2:00 - 4:00 pm	
Location	Zoom link will be provided to registered students	
Recommended Prerequisites	None	
Module Goals	This course offers six lectures in structural biology and proteomics. While the methodological basis for the techniques will be covered, the emphasis will be on what structural biology and proteomics teach us about biology. The course will address protein structure and dynamics, structures of membrane proteins, and structures of supramolecular assemblies. You will learn how various research tools such as X-ray crystallography, NMR spectroscopy, and electron microscopy are used to determine atomic-resolution structures of biological macromolecules (proteins, nucleic acids, carbohydrates, and lipids), with a special emphasis on macromolecular complexes and assemblies. The course will also focus on various applications of mass spectrometry-based proteomics, including the mapping of large-scale protein-protein interactomes and the global characterization of post-translational modifications in proteomes – advances that are revolutionizing our understanding of the molecular workings of biological systems.	
Evaluation Method	Report or essay (to be confirmed)	
Schedule		
Date	**Instructor**	**Lecture**
March 4	Gil Privé	Introduction to protein structure
March 11	Gil Privé	Proteins at high resolution: X-ray diffraction
March 18	Mohammad Mazhab-Jafari	Protein assemblies: electron cryo-microscopy
March 25	Geneviève Seabrook	Proteins in solution: nuclear magnetic resonance
April 1	Brian Raught	Protein interaction networks: mass spectrometry
April 8	Chris Marshall	Screening for ligands: biophysical methods
April 15	**Evaluation**	

Return to Winter 2021 Course List

Medical Biophysics
UNIVERSITY OF TORONTO

Winter 2021		
Topic	**MBP 1412H - Ultrasound Overview**	
Coordinator	Dr. Christine Demore	
Day & Time	Various (see below), 9:30 am - 2:00 pm	
Location	Zoom link will be provided to registered students	
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	Ultrasound is a high-resolution and rapid imaging modality that applies high-frequency acoustic waves to create images based on echoes that are generated by acoustic impedance heterogeneity between different materials in a sample. Ultrasound imaging has many clinical applications from monitoring fetus in pregnancy, to diagnostic imaging of breast, abdomen and vasculature, and guiding interventional tools in minimally-invasive procedures. This course will introduce the principles of ultrasound imaging, starting with a general overview of this imaging modality and its applications. It will cover ultrasound beam profiles and the basic physics of ultrasound, interaction of ultrasound waves with tissue transducers, signal processing and image formation and beam forming, transducer design, flow detection, contrast imaging, and assorted topics. The lectures will be given over two intensive days on consecutive weeks, followed by the practical laboratory to reinforce the taught concepts.	
Evaluation Method	Lab report (50%) and exam (50%)	
Schedule		
Date	**Instructor**	**Lecture**
January 11	Villemain, Demore	▪ Introduction to Ultrasound; ▪ History; ▪ Basic physics and principles in ultrasonics
January 15	Demore	▪ Image generation & quality; ▪ System & signal analysis; ▪ Application & implementation examples
January 18	Goertz, Villemain, Demore	▪ Doppler & colour flow imaging; ▪ Contrast imaging; ▪ Application & implementation examples
January 22	**Virtual Lab with TAs (3 hours; times finalised during lectures)**	
March 12 (TBC)	**Exam**	

Return to Winter 2021 Course List