

# MASTER OF SCIENCE CELLULAR AND MOLECULAR MEDICINE AND SPECIALIZATION BIOINFORMATICS

## Summary

- Degree offered: Master of Science (MSc)
- Registration status option: Full-time
- Language of instruction:
  - French
  - English

Note: Most of the courses in this program are offered in English.

- Primary program: MSc in Cellular and Molecular Medicine
- Collaborative specialization: Bioinformatics
- Program option (expected duration of the program):
  - with thesis (6 full-time terms; 24 consecutive months)
- Academic units: Faculty of Medicine (<http://med.uottawa.ca/en/>), Department of Cellular and Molecular Medicine (<http://med.uottawa.ca/cellular-molecular/>).

## Program Description

The programs prepare candidates for a variety of careers in teaching and research both within and outside of academia. During training, the student will develop a critical approach to published work and to his own work. Graduates acquire an excellent knowledge of their chosen field and a general understanding of the areas related to their own particular research project. They must demonstrate research skills and credibility as professionals in their area of research.

The Department is a participating unit in the collaborative programs in Bioinformatics (at the master's level), in Human and Molecular Genetics (at the master's and doctoral levels), and in Pathology and Experimental Medicine (at the master's and doctoral levels).

## Collaborative Program Description

Bioinformatics is an emerging and increasingly important scientific discipline dedicated to the pursuit of fundamental questions about the structure, function and evolution of biological entities through the design and application of computational approaches. Fundamental research in these areas is expected to increase our understanding of human health and disease which translates into innovation in industry. Bioinformaticians today must be able to appreciate significant research in other fields and therefore require an understanding of the basic principles of other disciplines.

The degree awarded specifies the primary program and indicates "specialization in Bioinformatics."

## Main Areas of Research

Most research groups in the Department are part of a research centre. These centres include the Centre for Neuromuscular Disease, the Kidney

Research Centre, and the Centre for Research in Biopharmaceuticals. Members of the Department are involved in three main research fields:

- Growth and development
- Pharmacology
- Physiology

## Other Programs Offered Within the Same Discipline or in a Related Area

- Master of Science Cellular and Molecular Medicine (MSc)
- Master of Science Cellular and Molecular Medicine Specialization in Human and Molecular Genetics (MSc)
- Master of Science Cellular and Molecular Medicine Specialization in Pathology and Experimental Medicine (MSc)
- Master of Science Neuroscience (MSc)
- Master of Science Neuroscience Specialization in Human and Molecular Genetics (MSc)
- Master of Science Neuroscience Specialization in Pathology and Experimental Medicine (MSc)
- Doctorate in Philosophy Cellular and Molecular Medicine (PhD)
- Doctorate in Philosophy Cellular and Molecular Medicine Specialization in Human and Molecular Genetics (PhD)
- Doctorate in Philosophy Cellular and Molecular Medicine Specialization in Pathology and Experimental Medicine (PhD)
- Doctorate in Philosophy Neuroscience (PhD)
- Doctorate in Philosophy Neuroscience Specialization in Human and Molecular Genetics (PhD)
- Doctorate in Philosophy Neuroscience Specialization in Pathology and Experimental Medicine (PhD)

## Fees and Funding

- Program fees:

The estimated amount for university fees (<https://www.uottawa.ca/university-fees/>) associated with this program are available under the section Finance your studies (<http://www.uottawa.ca/graduate-studies/programs-admission/finance-studies/>).

International students enrolled in a French-language program of study may be eligible for a differential tuition fee exemption (<https://www.uottawa.ca/university-fees/differential-tuition-fee-exemption/>).

- To learn about possibilities for financing your graduate studies, consult the Awards and financial support (<https://www.uottawa.ca/graduate-studies/students/awards/>) section.

## Notes

- Programs are governed by the general regulations (<http://www.uottawa.ca/graduate-studies/students/general-regulations/>) in effect for graduate studies.
- In accordance with the University of Ottawa regulation, students have the right to complete their assignments, examinations, research papers, and theses in French or in English. Research activities can be conducted either in English, French or both, depending on the language used by the professor and the members of his or her research group.

**Program Contact Information**  
Graduate Studies Office, Faculty of  
Medicine (<https://med.uottawa.ca/graduate-postdoctoral/>)  
**451 Smyth Road, Room RGN 2016**  
**Ottawa, Ontario, Canada**  
**K1N 6N5**

**Tel.: 613-562-5215**

**Email: [grad.med@uottawa.ca](mailto:grad.med@uottawa.ca)**

**Twitter | Faculty of Medicine (<https://twitter.com/uOttawaMed/>)**

**Youtube | Faculty of Medicine (<https://www.youtube.com/channel/UCP2nDlrjFEetyfMiOmlE2HA/>)**

**Flickr | Faculty of Medicine (<https://www.flickr.com/photos/uottawamed/>)**

## Admission Requirements

For the most accurate and up to date information on application deadlines, language tests and other admission requirements, please visit the specific requirements (<https://www.uottawa.ca/graduate-studies/programs-admission/apply/specific-requirements/>) webpage.

### To be eligible, candidates must:

- Have a bachelor of sciences (BSc) degree with a specialization or major (or equivalent) in one of the following areas: biology, biochemistry, pharmacology, physiology, human kinetics (kinesiology), biopharmaceutical or biomedical sciences with a minimum average of 75% (B+).

Note: International candidates must check the admission equivalencies (<https://www.uottawa.ca/graduate-studies/international/study-uottawa/admission-equivalencies/>) for the diploma they received in their country of origin.

- Demonstrate a good academic performance in previous studies as shown by official transcripts, research reports, abstracts or any other documents demonstrating research skills.
- Identify at least one professor who is willing to supervise your research and thesis.

- We recommend that you contact potential thesis supervisors as soon as possible.
- To register, you need to have been accepted by a thesis supervisor.
- The thesis director must be a member of the collaborative program.
- Be sponsored into the collaborative specialization by a faculty member of the collaborative program, normally the thesis supervisor, who must be appointed, cross-appointed or stand as an adjunct at the primary program.

## Language Requirements

Applicants must be able to understand, write and fluently speak the language of instruction (French or English) in the program to which they are applying. Proof of linguistic proficiency may be required. Most of the courses in this program are offered in English.

Applicants whose first language is neither French nor English must provide proof of proficiency in the language of instruction.

Note: Candidates are responsible for any fees associated with the language tests.

## Notes

- The admission requirements listed above are minimum requirements and do not guarantee admission to the program.
- Admissions are governed by the general regulations (<http://www.uottawa.ca/graduate-studies/students/general-regulations/>) in effect for graduate studies and by the general regulations of the Ottawa-Carleton Institute.
- Candidates must apply to the primary program and indicate in their application for admission to the master's program in Cellular and Molecular Medicine that they wish to be accepted into the collaborative-specialization in Bioinformatics. Students are normally informed about their acceptance into the collaborative program at the same time as being informed about their admission into the primary program. To be admitted to the collaborative program, candidates must also be accepted in the primary program.

## Program Requirements Master's with Collaborative Specialization

The Department may require students to take additional courses, depending on their backgrounds.

Students must meet the following requirements for the master's with collaborative specialization:

### Compulsory Courses (CMM):

MED 8166	Professionalism and Professional Skills	
3 optional course units in cellular and molecular medicine (CMM) at the graduate level <sup>1</sup>		3 Units

### Compulsory Course (BNF):

BNF 5106	Bioinformatics	3 Units
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### Seminars:

CMM 8324S	Seminars I	3 Units
BNF 6100	MSc Seminar <sup>2</sup>	3 Units

## Thesis:

THM 7999 Master's Thesis<sup>3, 4</sup>

### Note(s)

1

The list of courses being offered in each field in any given year will be indicated on the program website.

2

The seminar course involves the presentation of a seminar and attendance at the seminars approved by the Department.

3

Presentation and defence of a research thesis on a topic in bioinformatics based on original research carried out under the supervision of a faculty member participating in the bioinformatics collaborative program.

4

Students are responsible for ensuring they have met all of the thesis requirements (<http://www.uottawa.ca/graduate-studies/students/theses/>).

## Fast-Track from Master's to PhD

Students enrolled in the master's program in Cellular and Molecular Medicine at the University of Ottawa may be eligible to fast-track directly into the doctoral program without writing a master's thesis. For additional information, please consult the "Admission Requirements" section of the PhD program.

## Minimum Requirements

The passing grade in all primary program courses is C+. The passing grade in all BNF courses is B.

Students who fail two courses (equivalent to 6 units) must withdraw from the program.

## Research

### Research at the University of Ottawa

Located in the heart of Canada's capital, a few steps away from Parliament Hill, the University of Ottawa ranks among Canada's top 10 research universities. Our research is founded on excellence, relevance and impact and is conducted in a spirit of equity, diversity and inclusion.

Our research community thrives in four strategic areas:

- Creating a sustainable environment
- Advancing just societies
- Shaping the digital world
- Enabling lifelong health and wellness

From advancing healthcare solutions to tackling global challenges like climate change, the University of Ottawa's researchers are at the forefront of innovation, making significant contributions to society and beyond.

### Research at the Faculty of Medicine

"The Faculty of Medicine has a long history of conducting both basic and clinical research of the highest quality. Many of our high profile research projects are conducted in partnership with affiliated-teaching hospitals and research institutes. These partnerships lead

to biomedical discoveries that have a significant impact on health care. In the process they educate the next generation of Canadian scientists. Our research activity also attracts significant investment, which stimulates the Ottawa economy."

- Dr. Bernard Jasmin, Vice-Dean, Research

## Facilities, Research Centres and Institutes at the Faculty of Medicine

- Centre for Neural Dynamics (<https://neurodynamic.uottawa.ca/>)
- University of Ottawa Centre for Neuromuscular Disease (<http://med.uottawa.ca/neuromuscular/>)
- Centre for Research in Biopharmaceuticals and Biotechnology (<http://www.med.uottawa.ca/crb/b/eng/>)
- Canadian Partnership for Stroke Recovery (<https://canadianstroke.ca/>)
- Kidney Research Centre (<http://www.ohri.ca/centres/KRC/default.asp>)
- University of Ottawa Skills and Simulation Centre (<http://uossc.ca/>)
- Medical Devices Innovation Institute
- Ottawa Institute of Systems Biology (<http://med.uottawa.ca/oisb/>)
- University of Ottawa Brain and Mind Research Institute (<http://www.uottawa.ca/brain/>)

For more information, refer to the list of faculty members and their research fields on Uniweb (<https://uniweb.uottawa.ca/#!arts/themes>).

## Courses

Not all of the listed courses are given each year. The course is offered in the language in which it is described.

### CMM 5001 The Pathological Basis of Disease (3 crédits / 3 units)

Introductory course for non-medical graduate students in Life Sciences. This course will consist of a brief introduction to pathology describing the manifestation of disease at the macroscopic and microscopic level. This will be followed by (i) a description of various types of microscopy and methodology; (ii) concepts in flow cytometry, tissue/cell fractionation; (iii) histo-/cytochemistry and immunohisto-/cytochemistry; (iv) normal cells and tissues; (v) organs; (vi) the general pathology of cells and tissues including hypertrophy, aplasia, atrophy, hyperplasia, metaplasia, dysplasia, neoplasia, storage diseases, extracellular space pathologies, necrosis and apoptosis. Blood vessel and cardiac pathologies will be covered as well as concepts in neuropathology, organ/system specific pathologies and genetic diseases.

**Volet / Course Component:** Cours magistral / Lecture

### CMM 5101 Special Topics in Reproductive and Developmental Biology (3 units)

In-depth study of current topics in reproductive and developmental biology, with emphasis on state-of-the art molecular and cell biology techniques as well as their applications to reproductive diseases. Topics may include assisted reproductive technologies, embryonic stem cells, contraception, endocrine disruptors, reproductive toxicology, and transgenics.

**Course Component:** Lecture

Previously CMM 8300.

**CMM 5102 Ion Channels: Cellular and Molecular Aspects of Membrane Functions (3 units)**

A study of the diversity, molecular structure, structure-function relationship, electrophysiological characteristics and physiological roles of different ion channels in excitable and non-excitable cells. The channels that are studied include the sodium, potassium, calcium and chloride channels.

**Course Component:** Lecture  
Previously CMM 8350.

**CMM 5103 The molecular and pathophysiological basis of kidney disease and hypertension (3 units)**

Lecture and seminar course with emphasis on translational aspects of biomedical research towards a better understanding of the molecular and pathophysiological mechanisms of human kidney disease as related to vascular dysfunction. Topics to include: basic structure and physiology of the kidney; the endothelium in hypertension and chronic kidney disease; aldosterone in hypertension and kidney disease; acute kidney injury – impact on the renal vasculature; the sympathetic nervous system in patients with hypertension and chronic kidney disease; preclinical models of renal diseases - towards translation to humans; the glomerular filtration barrier - hemodynamic & non-hemodynamic mechanisms of injury.

**Course Component:** Lecture  
Previously CMM 8355.

**CMM 5105 Introduction to Cancer Biology (3 units)**

An introduction to the biology of cancer. Major topics in cancer biology include the following: tumor suppression/oncogenes; apoptosis in cancer; cell immortalization and senescence; genomic instability; multistep tumorigenesis/inflammation in cancer; biology of angiogenesis; rational therapies.

**Course Component:** Lecture

**CMM 5111 Computational Cell Biology (3 units)**

Emphasis is on providing students with the background knowledge and the tools needed to develop and analyze models of cellular processes. Topics include modelling enzyme kinetics, signal transduction pathways, and gene regulatory networks, using differential equations, nonlinear dynamics, and stochastic processes.

**Course Component:** Lecture  
Permission of the Department is required.

**CMM 5210 Mammalian Physiology (6 units)**

**Course Component:** Lecture

**CMM 5302 Comprehensive Pharmacology I (3 units)**

Extensive coverage of pharmacodynamics, pharmacokinetics, and the pharmacology of the autonomic and central nervous system. Courses CMM 5301, CMM 5302 cannot be combined for units.

**Course Component:** Lecture

**CMM 5303 Comprehensive Pharmacology II (3 units)**

Extensive coverage of the pharmacology of antibiotic and anti-inflammatory drugs, of chemotherapeutic agents, and of the cardiovascular and gastro-intestinal systems. Courses CMM 5301, CMM 5303 cannot be combined for units.

**Course Component:** Lecture

**CMM 5304 Introduction to Developmental Biology (3 units)**

Concepts in development and signalling pathways during development including formation of the germ layers; establishment of the body axis and principles of segmentation; patterning and homeobox genes; neurogenesis; axonal and neuronal guidance; stem cell concepts; germ cells; animal models in developmental biology.

**Course Component:** Lecture

**CMM 5311 Physiology and Pathophysiology of Energy Metabolism and Muscle Functions (3 units)**

Advanced comprehensive training in mammalian and human physiology with emphasis on pathophysiology. Topics include: neural and endocrine control of the hypothalamus-hypophysis axis; role of pancreas, adipose tissue and skeletal muscle in carbohydrate and lipid metabolism; cellular and molecular aspects of muscle contraction and fatigue in cardiac and skeletal muscle.

**Course Component:** Lecture

**CMM 5313 Physiology and Pathophysiology of the Reproductive, Renal and Gastrointestinal Systems (3 units)**

Advanced comprehensive training in mammalian and human physiology with emphasis on pathophysiology. Topics covered include reproductive physiology, molecular and bulk transport processes in the renal system, enteric control of the gastrointestinal tract.

**Course Component:** Lecture

**CMM 5315 Cellular and Molecular Basis of Cardiovascular Function/ Dysfunction (3 units)**

Mechanism of failing heart and cardiovascular system, its associated functions and associated conditions. Therapies for restoring function. Topics include: regulation of heart development, cell signaling, cellular and molecular mechanisms of atherosclerosis and heart disease, hormonal regulation, hypertension, bioenergetics, cardiovascular genomics and genetics, cell therapy, and regenerative medicine.

**Course Component:** Lecture

**CMM 5326 Experimental Preparations and Animal Models (3 units)**

Applied and theoretical course intended to give the potential researcher basic surgical skills. Lectures followed by demonstrations and/or practical exercises.

**Course Component:** Lecture

**CMM 5341 Stem Cells (3 units)**

Topics in stem cell biology which will include an in-depth look at the properties of embryonic and adult stem cell populations, tissue-specific stem cells (muscle, skin, neural, etc.), differentiation and reprogramming, the stem cell niche, induced pluripotent stem cells, and therapeutic advances using stem cell therapy.

**Course Component:** Lecture

**CMM 5360 Imaging in Cell Biology (3 units)**

Microscopy, biological imaging, and image generation. Overviews of common transmitted light, electron microscopic and epifluorescent techniques. Discussion of enhanced fluorescence microscopy and live cell imaging techniques, including image acquisition, processing and analysis with focus on quantitative and ethical issues.

**Course Component:** Lecture

**CMM 5372 Cell Signalling and Hormone Action (3 units)**

Topics will include the major cell signaling pathways and the action of steroid and non-steroid hormones. These signaling pathways will be discussed in the context of biological function and pharmacology.

**Course Component:** Lecture

**CMM 7301 Directed Studies (3 units)**

A program of study designed for a given student according to the student's educational requirements.

**Course Component:** Seminar

**CMM 8103 Epithelial Cell Polarity (3 units)**

Cell polarity with emphasis on tight junctions and Claudins (tight junction molecules). Topics include: the molecular basis of cell polarity and permeability barrier during development, organogenesis and disease including inflammatory disease and cancer.

**Course Component:** Lecture

**CMM 8105 Advanced Topics in Cancer Biology (3 units)**

Advanced study of recent developments in the field of cancer biology with emphasis on cellular and molecular aspects. Specific topics to be covered include: angiogenesis, apoptosis, cancer genetics, cell signaling, genetic instability, oncogenes and tumour suppressors.

**Course Component:** Lecture

**CMM 8310 Current Topics in RNA Molecular Biology (3 units)**

Properties, mechanisms associated with regulation and the function of RNAs and Ribonucleoprotein (RNPs) as well as RNA organisms. Current knowledge on RNA expression (synthesis, processing, transport and localization), the structure-function relationship and molecular mechanisms associated with RNAs and RNA genomes, RNA in evolution and in the origin of life, and RNA as therapeutic agents. Courses BCH 8310 and CMM 8310 cannot be combined for units.

**Course Component:** Lecture

Courses BCH 8310 and CMM 8310 cannot be combined for units.

**CMM 8311 Current Topics in Transcriptional Regulation (3 units)**

Topics will include chromatin structure and its impact on gene expression, protein: DNA interactions, the assembly of transcriptional complexes, and the control of gene expression in mammalian systems.

**Course Component:** Lecture

**CMM 83241 Seminars I (Part 1 of 2)**

Compulsory for one year for all students enrolled in the master's program. Presentation of two seminars or one seminar and one poster required during the year as well as regular attendance at the departmental seminar series. (Part 1 of 2)

**Course Component:** Seminar

**CMM 83242 Seminars I (Part 2 of 2) (3 units)**

Compulsory for one year for all students enrolled in the master's program. Presentation of two seminars or one seminar and one poster required during the year as well as regular attendance at the departmental seminar series. (Part 2 of 2)

**Course Component:** Seminar

Prerequisite: CMM 83241

**CMM 8324S Seminars I (3 crédits / 3 units)**

Compulsory for one year for all students enrolled in the master's program. Presentation of two seminars or one seminar and one poster required during the year as well as regular attendance at the departmental seminar series.

**Volet / Course Component:** Séminaire / Seminar

**CMM 83251 Seminars II (Part 1 of 2)**

Compulsory for all students enrolled in the doctorate program. Presentation of two seminars or one seminar and one poster required during the year as well as regular attendance at the departmental seminar series. (Part 1 of 2)

**Course Component:** Seminar

**CMM 83252 Seminars II (Part 2 of 2) (3 units)**

Compulsory for all students enrolled in the doctorate program. Presentation of two seminars or one seminar and one poster required during the year as well as regular attendance at the departmental seminar series. (Part 2 of 2)

**Course Component:** Seminar

Prerequisite: CMM 83251

**CMM 8325S Seminars II (3 crédits / 3 units)**

Compulsory for all students enrolled in the doctorate program. Presentation of two seminars or one seminar and one poster required during the year as well as regular attendance at the departmental seminar series.

**Volet / Course Component:** Séminaire / Seminar

**CMM 8340 Neuromuscular Function and Dysfunction (3 units)**

Topics to be covered include factors controlling muscle and synapse-specific gene expression, regulation of myogenesis and muscle cell growth, formation of the neuromuscular junction, motor neuron - muscle interactions, the role of the cytoskeleton in organization of post-synaptic domains, functional role of ion channels in muscle, molecular genetics of neuromuscular disease.

**Course Component:** Lecture

**CMM 8341 Cell Stress (3 units)**

Topics will include cellular responses to cell stress and will include hypoxia, oxidative stress, ER stress, autophagy, apoptosis and aging.

**Course Component:** Lecture

**CMM 8345 Special Topics in Gastroenterology (3 units)**

Lectures, tutorials and seminar-discussion sessions, designed to provide advanced training in gastrointestinal function. Emphasis on pathophysiological mechanisms.

**Course Component:** Lecture

**CMM 9998 Examen de synthèse (doctorat) / Comprehensive Examination (PhD)**

**Volet / Course Component:** Recherche / Research

**BNF 5104 Bioinformatics Laboratory (3 units)**

Principles of organization, retrieval, manipulation, and analysis of molecular data in genomics, proteomics and transcriptomics. Hands-on analysis of these data to solve biological questions using quantitative and computational methods. This course is equivalent to BIOL 5104 at Carleton University. Prerequisites: Graduate standing and permission of the instructor

**Course Component:** Laboratory

**BNF 5106 Bioinformatics (3 units)**

Major concepts and methods of bioinformatics. Topics may include, but are not limited to: genetics, statistics & probability theory, alignments, phylogenetics, genomics, data mining, protein structure, cell simulation and computing.

**Course Component:** Lecture

**BNF 5107 Applied Bioinformatics (3 units)**

Computational knowledge discovery in and the dynamic nature of cellular networks. Includes, but is not limited to, knowledge representation, large scale data integration, data mining and computational systems biology. This course is equivalent to BIOL 5516 at Carleton University.

**Course Component:** Lecture

**BNF 5504 Laboratoire de bioinformatique (3 crédits)**

Principes d'organisation, de récupération, de manipulation et d'analyse de données moléculaires en génomique, protéomique et transcriptomique. Analyses pratiques de ces données pour résoudre des questions biologiques en utilisant des méthodes quantitatives et computationnelles.

**Volet :** Théorie et laboratoire

Les cours BPS 4504 et BNF 5504 ne peuvent être combinés pour l'obtention de crédits.

**BNF 5506 Bioinformatique (3 crédits)**

Concepts et méthodes en bioinformatique. Les sujets abordés peuvent inclure, entre autres, la génétique, les statistiques et les théories des probabilités, les alignements, la phylogénétique, la génomique et la structure de protéines.

**Volet :** Cours magistral

**BNF 6100 MSc Seminar (3 units)**

Current topics in bioinformatics presented by program professors and invited speakers. Oral presentation and written report required. Graded S (Satisfactory) / NS (Not satisfactory).

**Course Component:** Lecture

**BNF 6500 Séminaire de maîtrise (3 crédits)**

Sujets courants en bioinformatique présentés par des professeurs membres du programme et des conférenciers invités. Présentation orale et rapport écrit requis. Noté S (satisfaisant) ou NS (non satisfaisant).

**Volet :** Cours magistral

**BNF 8166 Seminar in Bioinformatics (3 units)**

Current research topics in bioinformatics presented by PhD students and invited speakers. Oral presentation required. Graded S (Satisfactory) / NS (Not satisfactory).

**Course Component:** Seminar

**BNF 8301 Evolutionary Bioinformatics (3 units)**

Fundamental concepts in molecular evolution and hands-on experience with computer analysis of DNA sequences. Topics may include molecular sequence databases, multiple alignments and phylogenetic trees. This course is equivalent to BIOL 5201 at Carleton University.

**Course Component:** Lecture

Prerequisite: Graduate standing plus basic courses in genetics and evolution.

**BNF 8766 Séminaire en bioinformatique (3 crédits)**

Sujets courants en bioinformatique présentés par des étudiants en PhD et des conférenciers invités. Présentation orale requise. Noté S (satisfaisant) ou NS (non satisfaisant).

**Volet :** Séminaire