FOR RECOMMENDATION **PUBLIC** **OPEN SESSION**

TO:	Committee on Academic Policy and Programs
SPONSOR:	Sioban Nelson, Vice-Provost, Academic Programs
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PRESENTER:	See Sponsor
CONTACT INFO:	
DATE:	April 28, 2017 for May 9, 2017
AGENDA ITEM:	4

ITEM IDENTIFICATION:

New Graduate Program Proposal: Master of Health Science in Medical Genomics (M.H.Sc.), Faculty of Medicine

JURISDICTIONAL INFORMATION:

The Committee on Academic Policy and Programs has the authority to recommend to the Academic Board for approval new graduate programs and degrees. *(AP&P Terms of Reference, Section 4.4.a.ii)*

GOVERNANCE PATH:

1. **Committee on Academic Policy and Programs [for recommendation] (May 9, 2017)**
2. Academic Board [for approval] (May 29, 2017)
3. Executive Committee [for confirmation] (June 13, 2017)

PREVIOUS ACTION TAKEN:

The proposal for the Master of Health Science in Medical Genomics received approval from the Faculty of Medicine on April 24, 2017.

HIGHLIGHTS:

The Master of Health Science in Medical Genomics is a 5 session, full-time professional master's degree program to be offered by the Department of Molecular Genetics, Faculty of Medicine. Students will complete 9.0 FCEs, including a capstone practicum in the last session of the degree program.

This proposed degree program will provide both laboratory and clinical-focussed students with the theory and practical knowledge necessary to incorporate genomics data into medical practice. It will appeal to potential applicants who are either working physicians or laboratory professionals. Genomics, the ability to read and interpret information contained within DNA, is a rapidly growing area with broad reaching implications from bench to bedside. The ability to generate and interpret genomic information will drive a new era of healthcare and patient management. This proposal responds to the growing knowledge gap between clinical practice and the discoveries stemming from genomescale research in human genetics as advances in systems biology, including genomics, proteomics, and metabolomics, are outpacing the ability of undergraduate medical and scientific teaching to prepare medical and technical staff.

Potential applicants will be working physicians and laboratory professionals. Applicants will either have a four year B.Sc. degree from a relevant discipline, such as biology, biochemistry, genetics analytical chemistry, or, an appropriate undergraduate medical degree from an accredited university.

The curriculum will consist of lecture, discussion, and project-based courses across five sessions. Lecture courses will be delivered by experts in the field comprising faculty from the Molecular Genetics department and cross-appointed clinical faculty in conjunction with the Faculty of Law and Dalla Lana School of Public Health. Students will proceed as a cohort through the program until the final practicum in the last session. Depending on their background, students will either choose the Practicum in Patient Management and Medical Genomics, geared to those in patient-facing medical fields, or Practicum in Modern Genomics, which focuses on the laboratory and state-of-the-art genomics techniques.

Consultation outside the Faculty of Medicine took place with the Dalla Lana School of Public Health and the affiliated McLaughlin Centre for Molecular Medicine and the Division of Clinical and Metabolic Genetics at SickKids.

The program was subject to external appraisal on December 12, 2016 by Professor David Lohnes, Department of Cellular and Molecular Medicine, University of Ottawa and Professor Douglas Marchuk, Vice Chair, Dept. of Molecular Genetics and Microbiology, Duke University. The external appraisers made a number of suggestions which resulted in changes to the program as is reflected in the Dean's response to the appraisal report. The proposal received approval from the Faculty of Medicine on April 24, 2017.

FINANCIAL IMPLICATIONS:

The new financial obligations resulting from this program will be met at the Faculty level.

RECOMMENDATION:

Be it Recommended,

THAT the proposed degree program, Master of Health Science in Medical Genomics (M.H.Sc.), as described in the proposal from the Faculty of Medicine dated August 1, 2016 be approved effective September 1, 2018.

DOCUMENTATION PROVIDED:

- *Proposal for the Creation of the Master of Health Science in Medical Genomics*

UNIVERSITY OF TORONTO

University of Toronto
New Graduate Program Proposal

This template is for all proposals for new graduate programs. It will help to ensure that all evaluation criteria established by the Quality Council are addressed in bringing forward a proposal for a new program. Separate templates have been developed for other types of proposals.

Full Name of Proposed Program:	Master of Health Science in Medical Genomics
Degree Name and Short Form:	Master of Health Science (M.H.Sc.)
Program Name:	Medical Genomics
Professional Program *(yes/no)*	Yes
Unit (if applicable) offering the program:	Department of Molecular Genetics
Faculty / Division:	Faculty of Medicine
Dean's Office Contact:	Allan Kaplan, Vice Dean, Graduate and Academic Affairs, Graudate and Life Sciences Education
Proponent:	Lean Cowen, PhD, Chair, Dept. of Molecular Genetics
Version Date*: (please change as you edit proposal)*	2016/08/01

New Graduate Program Proposal

MHSc in Medical Genomics

Department of Molecular Genetics

Faculty of Medicine

Table of Contents

1 Summary

Genomics, the ability to read and interpret information contained within DNA, is a rapidly growing area with broad reaching implications from bench to bedside. Technological advances are being pushed to the clinic, and the ability to generate and interpret genomic information will drive a new era of healthcare and patient management. With this progress, there is a growing knowledge gap between clinical practice and the discoveries stemming from genome-scale research in human genetics. Advances in systems biology, including genomics, proteomics, and metabolomics, are outpacing the ability of undergraduate medical and scientific teaching to prepare medical and technical staff. Many practicing clinicians and laboratory personnel were trained before the development of modern genomic technologies, yet are faced with the need to generate, integrate, and interpret genetic and genomic data. To address this acute educational need, the Department of Molecular Genetics within the Faculty of Medicine, proposes a new program and associated degree, a professional Masters in Health Sciences (MHSc) in Medical Genomics. This new degree will provide medical trainees, research scientists, and laboratory professionals with the theory and practical knowledge necessary to incorporate genomics data into medical practice.

The MHSc in Medical Genomics is a professional Masters degree that is focused on providing directly actionable skills and knowledge to enable graduates of our program to extend their professional practice. This new program complements the existing graduate programs within the Department of Molecular Genetics, and significantly extends our educational mission by reaching a previously untargeted student cohort. In contrast to the department's existing MSc/PhD graduate program, which is research and thesis-focused, the MHSc in Medical Genomics is a lecture and project-based curriculum. Although similar in title, the department's existing MSc in Genetic Counselling serves a much smaller student cohort with a programmatic focus on clinical genetic counselling and inborn genetic disorders. This MHSc in Medical Genomics is being developed for a new era of research and clinical science, providing professional and practical skills for a world where genetic and genomic data are routinely collected and analyzed across a wide range of patient populations and medical indications.

As a professional Masters degree, the MHSc in Medical Genomics is focused on teaching theory and practice, rather than the creation of new knowledge as is integral to research graduate degrees. This MHSc program's specific focus, orthogonal to existing curricula in the department, University, and across the province, will provide a means by which to provide professionally useful skills in Medical Genomics to students interested in immediate practical implementation.

The MHSc in Medical Genomics consists of a core set of lecture, discussion, and project based courses across a two year program duration. Lecture courses will be delivered by experts in the field comprising of faculty from the Molecular Genetics department and cross-appointed clinical faculty in conjunction with the Faculty of Law and Faculty of Public Health. In addition to lecture-based learning, students will participate in a capstone practicum during the final academic term of the program. For the practicum, students will be split into clinical (for

undergraduate or post-graduate M.D.) and laboratory professional (for post-bachelor's) streams, with unique course work focused on patient interaction and laboratory data generation, respectively.

This professional Masters degree will be the first of its kind in Canada, and will join several elite institutions leading the charge in the United States. This program developed organically from consultation with various stakeholders in Toronto, including clinical training programs, hospital affiliated laboratories, academic research departments, and other University Faculties of Public Health and Law.

The Department of Molecular Genetics, leveraging existing partnerships with the McLaughlin Centre and the Centre for Genetic Medicine at SickKids, is uniquely suited to serve the growing need for graduate-level training in Medical Genomics. This MHSc will leverage the academic strengths of the Department of Molecular Genetics, with direct teaching contributions to this program by more than 25 departmental faculty. Although few comparable programs currently exist in North America, the competitive landscape is expected to change rapidly over the next several years. We are proposing to start this program in Fall 2017, targeting an entering class of 20 students and steady-state of 20 entrants per year.

2 Effective Date

Start date of Fall 2018.

3 Program Rationale

The Department of Molecular Genetics has observed a growing, unmet need for practical training in genetic and genomic methods. Rapid progress in approaches to generate and analyze genetic data has outpaced the ability to cover these cutting-edge approaches in undergraduate (BSc) and undergraduate medical curricula. In response to an observed demand for advanced training in directly actionable medical genomics, the Department of Molecular Genetics began to examine the possibility of building a new course-based graduate program to teach theory and practical skills to students interested in genomic health. During this period of consultation, clinical faculty affiliated with the Department expressed parallel interest in developing a new residency program in clinical genomics for a subset of medical trainees. Following discussion among various faculty and University stakeholders, the Department of Molecular Genetics is proposing a new two-year (five session) MHSc degree targeted to both laboratory and clinically-focused students that provides a unique training and learning environment to teach practical and theoretical aspects of modern genetics and genomics with a strong focus on clinical application.

Professional Master's in Medical Genomics
This program is a course-based professional Masters targeted at students interested in building

academic expertise in actionable professional skills. Students will pursue coursework including genetics, genomic methods, and medical ethics that will enable graduates to generate and interpret genomic data. This degree is relevant whether students will be working as physicians or as laboratory professionals. The program will recruit students who are active clinicians, clinicians-in-training, and those holding Bachelor degrees working in or planning to work in clinical or research laboratory settings. These seemingly diverse student cohorts are each in need of training in medical genomics and, together, will provide orthogonal perspectives and a strong basis for dialogue. For clinicians and clinicians-in-training, the growing availability and visibility of direct-to-consumer genetic testing means that physicians are now at the front lines of assisting patients in interpreting genetic data. For laboratory professionals, genetic tests are a growing component of the data being generated to guide clinical treatment and research discovery.

This diverse student cohort will represent both the clinical and laboratory points of view in a single, shared training environment, allowing students to better appreciate the role of genetic testing on both medical practice and laboratory work. The intensive, full-time five-session program has been designed to provide students with graduate training of fixed duration and enable rapid return to full-time work.

We will draw on the diverse faculty already appointed to Molecular Genetics with strengths ranging from research in mechanisms of disease to oncology to clinical genetics. Courses will be built specifically for this program to provide a focused curriculum of interwoven modules. By including clinicians and clinicians-in-training as part of our student cohort, we will integrate clinical perspective and enable experience-based discussion. Courses delivered by research scientists will be built in consultation with clinical faculty. In addition to lecture-based learning, students will extensively participate in small-group and problem-based learning approaches and participate in interactive case studies. The integrated design of this program will enable delivery of concepts step-wise in a complementary "just in time" fashion; concepts and skills gained in one course will be expected and applied in subsequent modules.

Distinctiveness: Practically focused curriculum taught by leading researchers in medical genomics to train the next generation of genomics professionals

The Department of Molecular Genetics, leveraging existing partnerships with the McLaughlin Centre and the Centre for Genetic Medicine at SickKids, is uniquely suited to capitalize on the growing need for graduate-level training in Medical Genomics. The proposed faculty members include world leaders in clinical and research science genomics. This program will put the University of Toronto in a market leading position, and position the University of Toronto as the first in Canada to offer this degree. Although few competing programs exist worldwide, the competitive landscape is expected to change rapidly over the next several years. For instance, the US National Institutes of Health and National Human Genome Research Initiative has recently funded several pilot and scale-up training programs for Genomic Medicine[1]. The

[1] US National Institutes of Health / NHGRI RFA-HG-13-004: "Genomic Medicine Pilot Demonstration Projects"

proposed program presents the opportunity for the Department of Molecular Genetics to capitalize on its position as a leading hub for fundamental and clinical genomics research by translating this research expertise to this new program for training of laboratory and medical practitioners.

Medical Genomics: A program that will Promote Healthy People

By training professionals in genetics and genomics, students graduating from the program will be able to understand and use genomic information in their work. The growing availability and visibility of direct-to-consumer genetic testing means that physicians are now at the front lines of assisting patients in interpreting genetic data. In research and clinical laboratories, genetic tests are a growing component of the data used to guide clinical treatment and research discovery. These tests are rapidly progressing from single genes to panels of multiple genes and now to whole-genome data, with concomitant increases in the complexity of understanding and communicating results.

It is anticipated that the students will drive adoption and implementation of genomic healthcare in Toronto and across Canada, and that the largest demand by post-BSc students will be from those seeking, or currently working in, advanced clinical and research laboratories, where genetic and genomic techniques are a growth sector. This MHSc degree is a value-add for medical trainees and professionals as well: comprehension of genomic data and the ability to interpret and communicate genetic results will place our graduates at the forefront of practicing healthcare providers, and can be expected to provide wide-ranging benefits to clinical practice in Ontario.

Upon completion of this program, medical students and trainees will begin or return to clinical practice with the ability to implement and interpret genomic data. The clinical graduates will be at the forefront of "genomic medicine". The post-BSc students will be ideally suited for employment in clinical and research science labs implementing the tools of genomic medicine. They will also be highly attractive to publicly funded enterprises or private companies that are producing and interpreting genomic data for the health professions as well as for direct-to-consumer testing laboratories. This degree will distinguish graduates, enhance existing professional practice, enable new career paths, and help enable Ontario to lead the future of Genomic medicine.

This program is fundamentally different from our existing MSc in Genetic Counseling and we anticipate no internal competition between programs. Compared to our Masters in Genetic Counseling, this program targets a different student cohort with non-overlapping career prospects and trajectories. Our target of 20 students per year is 500% the size of our current genetic counseling program; from conception, we have designed this new MHSc to reach a larger and more diverse student population. This program will provide a distinguishing credential for students, and the training it provides is distinct from the clinical approach taught

in the Master of Science in Genetic Counseling program.

In addition to serving a presently unmet academic need for practical training in medical genetics and genomics, the proposed MHSc program is well aligned with the University of Toronto's strategic mandate to further academic excellence through practical graduate training. The Ontario Ministry of Training, Colleges, and Universities' Strategic Mandate Agreement (MTCU SMA, 2014) notes that the University of Toronto is "in a unique position to leverage our research strength into creating and delivering world-class, research-informed professional Masters programs." This proposed MHSc program is particularly aligned with the SMA's suggestion of an expansion of graduate enrolment and noted focus on growth of professional masters programs in biomedicine and health-related fields. This MHSc in Medical Genomics will further the Strategic Research Plan of the University of Toronto[2] to promote healthy people by translating research achievements from the University of Toronto and beyond into practical professional tools.

4 Fields/Concentrations

n/a

5 Need and Demand

The ideas of genetics are now part of common parlance. Companies tell us that features like quality, reliability, or good design are "in their DNA"; people joke with one another about whether they "have the gene" for a good hockey slap shot. Genetic analyses have moved beyond science fiction to everyday life. Paternity testing is advertised on billboards, and people discover forgotten ancestors using DNA testing with results served by online genealogy portals. *Post Baccalaureate education has lagged behind the emergence of genetics in our culture.*

A demonstrated need for additional genetics training:

Current undergraduate scientific and medical training does not provide competency in advanced genetics required to effectively order and interpret the growing range of genomic clinical data. During expansion of the Department of Molecular Genetics' undergraduate curriculum and informal surveys of alumni, an opportunity to provide masters-level coursework and practical training in genomics was identified. Faculty at the University of Toronto surveying practicing Ontario physicians have found a need for greater training in genetics, and have begun to identify actionable interventions for practicing medical professionals. Discussions with clinicians working metabolic genetics identified an opportunity for an MHSc degree to complement or replace a genomics residency that had been planned. The Professional Masters in Medical Genomics will train laboratory and medical professionals to understand and effectively communicate in the language of genetics and genomics, placing our graduates at the

[2] http://www.research.utoronto.ca/wp-content/uploads/2012/10/SRP-2012-web.pdf

vanguard of genomic medicine.

The proposed professional master's in Medical Genomics will be unique in Canada. We will capitalize on the leading role that the research and clinical community in Toronto plays worldwide in genomics through lecturing by world-leading clinical and data-analysis scientists and practical training in alliance with industry-leading clinical research facilities. Despite the absence of competition in Canada, the United States National Institutes of Health is actively funding pilot-scale "Genomics in Practice" initiatives[3] to bridge research and clinical practice. This MHSc program will place the University of Toronto at the forefront of this trend in biomedical practice.

Patient knowledge is outpacing that of practicing physicians. The cost of genetic testing is tumbling, and a flurry of medical research is demonstrating the use of whole genome sequences to guide clinical practice. In addition to clinical use, direct-to-consumer marketing of genetic tests is growing rapidly. In addition to large players like 23 and me, a diverse range of startups is appearing, including Geneyouin and Medsavant, two local companies started by department alumni and faculty members. We expect student demand to grow in parallel with increased clinical and direct-to-consumer deployment of genomic tools.

This MHSc will capitalize on a unique mixture of skills and previous experience provided by a combined program teaching both research- and clinically-focused trainees. The curriculum will include concomitant training of clinicians and laboratory professionals, paralleling the professional interaction between physicians and clinical laboratory personnel. The initial cohorts will include medical trainees (e.g., residents and fellows) and post-BSc professional students. As this program grows, we will refine elective courses with an aim of further specializing medical and technically focused sub-curricula to best engage our students.

6 Enrolment

Table 1: Graduate Enrolment Projections

Year of study	2017/18	2018/19	2019/20	2020/2021	2021/2022
Year 1	20	20	20	20	20
Year 2	0	20	20	20	20
Total	20	40	40	40	40

This is a new degree that does not supersede any existing offering from the Faculty of Medicine or other University of Toronto departments. As one of the first programs of its kind in the

[3] Implementing Genomics in Practice (IGNITE) http://www.genome.gov/27554264

world, we expect significant interest from both domestic and international students. Many facets of this curriculum incorporate legal and ethical aspects of medical genomics that will be implicitly and explicitly focused on Canadian practice. Following consultation with the office of the Faculty of Medicine Vice Dean of Graduate and Academic Affairs, we will initially focus our enrolment on domestic students (e.g., 90% domestic, 10% foreign) with the potential to expand to accommodate additional students, both domestic and foreign, as listed below. Students enrolled in this professional Master's program are responsible for their own tuition; foreign enrolees can be expected to pay a higher tuition (BIU offset).

Genomic medicine is a rapidly growing field; increased enrolment beyond our projected steady state is possible if required to serve a growth in demand. Requested administrative and space resources reflect our target of 40 students enrolled in the program at any given time; increased student number would require commensurate growth in support.

7 Admission Requirements

The professional Master of Health Science in Medical Genomics program is a content-dense degree program designed for highly capable students. We anticipate admitting students from diverse academic backgrounds and will prioritize potential for success in this program over any single axis of academic achievement.

Students are admitted under the General Regulations of the School of Graduate Studies.

Applicants must also satisfy the Department of Molecular Genetics additional admission requirements stated below.

- Successful completion of either:
    - an appropriate four year bachelor of science (BSc) degree with a B+ average from a relevant discipline, including, but not limited to: biology, biochemistry, genetics, molecular biology, laboratory medicine, analytical chemistry, or:
    - an appropriate undergraduate medical degree from an accredited university with a B+ average.
- Applicants will complete an application package including all previous university transcripts, full CV/resume, and a one to two page statement of interest describing how this degree program will have an impact on their career path.
- Applicants will be considered based on a combination of previous academic performance and preparation, three letters of reference, professional or research experience (if any), and the potential to immediately implement knowledge gained from

this master's program.

Prior to starting in the program, applicants will have obtained an appropriate BSc, or its equivalent, normally with at least a B+ average. Applicants will be evaluated in a holistic manner to build a well-balanced cohort combining exceptional academic abilities, professional perspective, and career prospects to enrich the out-of-class learning exercises and significant classroom discussion of this program. Applicants with relevant research and/or clinical experience, and those who will make immediate and substantive use of this new degree in professional practice are strongly encouraged to apply.

Students who are non-native English speakers and have received their most recent degree from a non-English speaking institution will be required to demonstrate mastery of written and spoken English prior to application. TOEFL (Test of English as a Foreign Language) and TWE (Test of Written English) scores must be submitted at time of application. Exams must have been written less than 12 months prior to application. Minimum scores for consideration are as follows and align with the School of Graduate Studies minimum:

TOEFL:

- Paper based test and TWE: Overall score 580, TWE 5
- Internet based test IBT: Overall score 93, writing/speaking 22

Applicants whose credentials warrant further consideration will be interviewed in person (for local applicants) or via phone or video interview (e.g., Skype) by no fewer than two program faculty. These interviews will be short (< 30 minutes each) and will be used to gauge the applicant's ability to engage in discourse consistent with this fast-paced program and to confirm student excellence as represented in other application materials.

Explanation

We anticipate that students admitted to this program will significantly exceed these minimum requirements. The desired student cohort will include applicants from diverse career and training backgrounds; no single evaluation metric is sufficient to assess student potential for this program. A fundamental challenge in the admissions process will be the identification of the *most* excellent students who have the potential to both benefit from and contribute to this educational experience. This will be facilitated by holding recruitment events for prospective students to enable faculty to interact with potential students, which has been a resounding success in the research masters and PhD programs in the Department of Molecular Genetics.

Although much of the coursework in this MHSc program is factual and technical in nature, successful students may come from a range of academic backgrounds. Typical candidates will have completed an undergraduate degree in biology with a working knowledge of genetics and molecular biology. A range of academic topics are covered in this program; prospective students are encouraged to examine the Graduate Calendar entry to determine if they feel sufficiently prepared to engage in fast-paced learning of the topics listed.

A key determinant of success in this program will be the ability of students to operate in a content-dense learning environment. Letters of reference and one-on-one interviews will be particularly important to identify self-motivated students who are equally able to work independently and in small-group environments. As a professional Masters degree, a major goal of this program is to provide immediately relevant knowledge and career-enabling experience. Students with a demonstrated interest and strong existing career prospects in genomic science or medical genomics will be given priority for admission.

8 Program Requirements

Students in the Medical Genomics program will be required to complete a total of 9.0 full-course equivalents (FCE) distributed as detailed below.

To build a cohesive student cohort, program content is fixed for the first four sessions. During the fifth and final session of the program, students will be tracked into one of two career-specific practica designed to provide information specific to their profession (physician or laboratory scientist).

Session	Course Code	Course Title	Hours	FCE Weight
Session 1: Fall 1	MMG 0001 Y	Advanced Human Genetics	156 hours	
	MMG 0002 H	Biological Statistics	78 hours	1.0
Session 2: Winter 1	MMG 0001Y (continued)	Advanced Human Genetics	78 hours	2.0
	MMG 0003Y	Genomics Methodologies (classical molecular biology)	156 hours	
Session 3: Summer 1	MMG 0003Y (continued)	Genomics Methodologies (next-generation genomics)		2.0
Session 4: Fall 2	MMG 0004H	Communication of Genetic Information	78 hours	1.0
	MMG 0005H	Ethical and Legal Implications	78 hours	1.0

		of Genomics		
Session 5: Winter 2	MMG 0006H	Future Directions in Medical Genomics	78 hours	1.0
	MMG 0007H*	Practicum in Patient Management and Medical Genomics (Option A)	78 hours	1.0
	MMG 0008H*	Practicum in Modern Genomics (Option B)	78 hours	1.0

*Note: Students take either MMG0007 OR MMG0008H

This degree program consists of five full-time consecutive sessions in duration (Fall 1, Winter 1, Summer 1, Fall 2, Winter 2). Due to the cumulative nature of the program, students will proceed as a cohort and high enrolment retention is anticipated. Students are expected to graduate at the completion of term five. A three-year time limit enables students to complete a missed year under extenuating circumstances.

Explanation of the Proposed Requirements

Students will learn 1) fundamentals of the field, 2) principles underlying modern techniques and technologies, and 3) skills necessary to keep up to date with new advancements and communicate effectively with other knowledge users in the field. We anticipate no fewer than six hours of classroom time per week per course, consistent with the double-credit structure proposed.

We anticipate that students will arrive with range of factual knowledge and practical experience relevant to this program. It is therefore critical to simultaneously bring students to a common knowledge base while providing new material.

The unified structure of the program is designed to foster cohesion among students and to ensure that classes can be taught in a cumulative fashion. Learning objectives and concepts presented in the first courses will be expanded upon in subsequent terms. Tracking students in a common academic path enables the streamlining and integration of the program course material as a whole in a manner will ensure students of diverse backgrounds will benefit from each other and achieve the same learning outcomes.

Depending on student background and career path, the capstone fifth session (Winter 2) will include a required course in either patient management (medical track) or a practical laboratory course (professional track). Bifurcating our program at the final session enables the building of a cohesive student body during the bulk of the program while tailoring one of the courses offered during the final session for the present career needs of our students.

Please see Appendix [A] for a full list of the course numbers, descriptions and titles.

9 Program Description

Program delivery and duration:

Our Professional Masters in Medical Genomics will consist of five terms of study, spanning 20 months. Students will enrol on a full-time basis only.

Students will take two courses each consisting of 6 hours per week (for a total of 12 hours per week) for the fall and winter sessions of the first year. The summer of the first year will include a single course taught 6 hours per week. The fall and winter sessions of the second year will include two courses per session at 6 hours per week each term. Students will participate in the spring convocation following successful completion of all program requirements.

The program will be offered face-to-face, to allow for significant exchange between students. Class time will include lectures as well as hands-on, in-class learning activities. The course in Patient Management and Medical Genomics (elective for medical professionals) will include a structured practical component including patient contact. Our Practicum in Modern Genomics (elective for post-BSc students and practising scientists) includes hands-on laboratory exercises in which students generate and analyze genome-scale sequencing data, and will be delivered in the teaching lab facilities in the Faculty of Medicine Division of Teaching Labs.

We will augment lecture-based course delivery with a series of web-based information portals and extensive out-of-class learning and group projects. Course assignments will require students to use online resources, including research literature and databases, allowing them to build a hands-on fluency of genome analysis and statistical tools. Our blended lecture and student-driven delivery model has been selected to teach students theory and use of relevant techniques and data analysis approaches.

Unified and streamlined program structure:

The program has been designed to provide a maximum of practical and theoretical knowledge of advanced content with minimal repetition. Students will enter the program as a unified cohort each year and will progress through each of the required courses together. A single elective course is scheduled during the final session; students will finish the program with a career-specific practicum (MMG007H or MMG008H) in addition to a forward-looking capstone lecture course, Future Directions in Medical Genomics (MMG006H).

The unified approach enables significant synergy between individual courses, provides a unique opportunity for agglomerative learning within and across academic sessions, and ensures that all students have demonstrated competency in all program curriculum. This approach will also generate a cohesive student dynamic that facilitates group projects and learning outside of the classroom.

Whereas the Province's Quality Assurance Framework requires that students complete a

minimum of 2/3 of courses at the graduate level, the University of Toronto requires graduate students to complete all of their course requirements from amongst graduate level courses. This proposed program complies with this requirement.

10 Degree Level Expectations, Program Learning Outcomes and Program Structure

Table 2: Master's DLEs

MASTER'S DEGREE LEVEL EXPECTATIONS (based on the Ontario Council of Academic Vice Presidents (OCAV) DLEs)	**MASTER'S PROGRAM LEARNING OBJECTIVES AND OUTCOMES**	**HOW THE PROGRAM DESIGN AND REQUIREMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES**
EXPECTATIONS: ***This MHSc in Medical Genomics is awarded to students who have demonstrated:***		
1. Depth and Breadth of Knowledge A systematic understanding of knowledge, and a critical awareness of current problems and/or new insights, much of which is at, or informed by, the forefront of the academic discipline, field of study, or area of professional practice.	Depth and breadth of knowledge is defined in Medical Genomics as knowledge of a broad range of scientific and medical principles that allow the use of genetic information to assist in the diagnosis and treatment of human disease. This is reflected in students who are able to: **Depth** • Understand the molecular biology principles underlying genetic tests used in the clinic • Differentiate among statistical tests and their appropriate application. • Evaluate new genomic and genetic technologies with a particular focus on application to medical testing and patient care. • Identify research and clinical questions that would benefit from the inclusion of genomic data or analyses. **Breadth** • Explain the causes of genetic variation and recognize which genetic tests are suited to each type of variation.	The program design and requirements that ensure these student outcomes for depth and breadth of knowledge are: • MMG001Y, MMG002H, and MMG003Y will impart the foundational knowledge required for breadth and depth. These courses will build on one another and will contain exercises and projects designed to cumulatively develop and reinforce the fundamental principles of human genetics and the application of genetic testing to medicine. • The specialty-specific practicum courses (MMG007H Patient Management and Medical Genomics for clinicians, and MMG008H Practicum in Modern Genomics for scientists) will provide additional domain-specific depth.

MASTER'S DEGREE LEVEL EXPECTATIONS (based on the Ontario Council of Academic Vice Presidents (OCAV) DLEs)	**MASTER'S PROGRAM LEARNING OBJECTIVES AND OUTCOMES**	**HOW THE PROGRAM DESIGN AND REQUIREMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES**
	• Critically interpret research and clinical literature in the fields of genomics, personalized medicine, and medical genetics.	
2. Research and Scholarship A conceptual understanding and methodological competence that i) Enables a working comprehension of how established techniques of research and inquiry are used to create and interpret knowledge in the discipline; ii) Enables a critical evaluation of current research and advanced research and scholarship in the discipline or area of professional competence; and iii) Enables a treatment of complex issues and judgments based on established principles and techniques; and, on the basis of that competence, has shown at least one of the following: i) The development and support of a sustained argument in written form; or ii) Originality in the application of knowledge.	Research and Scholarship is defined in Medical Genomics as the ability to interpret and synthesize genetic information and medical findings to understand the biology of human disease. This is reflected in students who are able to: • Develop biological hypotheses and propose meta-analyses (analysis of existing data bases) or prospective (data collection) approaches to answering these questions. • Review the current research literature on a genetic disease and propose additional research avenues for diagnosis, prognosis, or treatment of that disease. • Interpret genetic and genomic test results with an understanding of the inherent biases and limitations of an individual assay. • Employ academic databases to determine the novelty of a given genetic finding and determine demonstrated or likely functional / health relevance of test results.	The program design and requirements that ensure these student outcomes for research and scholarship are: • As part of MMG001Y, students will write a comprehensive review of a genetic disease. This project will allow students to develop skills of scholarship and to gain practice reading and interpreting data in the genetic literature. • The specialty-specific practicum courses (MMG007H Patient Management and Medical Genomics for clinicians, and MMG008H Practicum in Modern Genomics for scientists) will include assignments that require the interpretation of original data and the application of these data to recommend diagnoses or courses of treatment.
3. Application of Knowledge Competence in the research process by applying an existing body of knowledge in the critical analysis of a new question or of a specific problem or issue in a new setting.	Application of Knowledge is defined in Medical Genomics as the use of genetic information and principles to guide diagnosis and treatment decisions. This is reflected in students who are able to: • Identify and list the causative genes and typical symptoms for	The program design and requirements that ensure these student outcomes for application of knowledge are: • The background information for these competencies will be presented in MMG001Y, Advanced Human Genetics, and MMG0002H, Biological

MASTER'S DEGREE LEVEL EXPECTATIONS (based on the **Ontario Council of Academic Vice Presidents (OCAV) DLEs)**	**MASTER'S PROGRAM LEARNING OBJECTIVES AND OUTCOMES**	**HOW THE PROGRAM DESIGN AND REQUIREMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES**
	major human Mendelian diseases • Describe the genetic risk factors for major genetically complex human diseases • Use patient medical reports and family history to prepare a pedigree and describe the likelihood of Mendelian disease presence • Interpret raw data to assess the validity of a test result • Identify the appropriate statistical test for different data types and scenarios to calculate patient disease risk • Recommend and justify the need for follow-up testing based on initial findings and patient history	Statistics. • Assignments in MMG003Y, Genomics Methodologies, will incorporate these activities. • Course assignments in MMG004H, Communication of Genetic Information, including group work and presentations, will further reinforce these concepts.
4. Professional Capacity/Autonomy a. The qualities and transferable skills necessary for employment requiring i) The exercise of initiative and of personal responsibility and accountability; and ii) Decision-making in complex situations; b. The intellectual independence required for continuing professional development; c. The ethical behaviour consistent with academic integrity and the use of appropriate guidelines and procedures for responsible conduct of research; and d. The ability to appreciate the broader implications of applying knowledge to particular contexts.	Professional Capacity/Autonomy is defined in Medical Genomics as the ability to apply the appropriate skills required for the interpretation and use of human genomic data in a laboratory and clinical setting. This is reflected in students who are able to: **Employment skills** • Demonstrate the ability to interpret and assess genetic data • Justify a course of follow-up testing and potential treatment, with discussion and appropriate weighting of other available options **Continuing professional development** • Use databases and information portals to identify current information related to genetic variants • Critically read and understand	The program design and requirements that ensure these student outcomes for professional capacity/autonomy are: **Employment skills** In most courses, students will be tasked with interpretation of actual (anonymized) genetic testing data. A significant component of group work throughout all courses will develop the collaborative skills of students. **Continuing professional development** All of the courses will require reading and interpreting research manuscripts and medical literature, imparting students with the skills required to add to their knowledgebase. MMG006H, Future Directions in Medical Genomics, will introduce students to the databases of human genetic data and train students to use these sources to

MASTER'S DEGREE LEVEL EXPECTATIONS (based on the Ontario Council of Academic Vice Presidents (OCAV) DLEs)	**MASTER'S PROGRAM LEARNING OBJECTIVES AND OUTCOMES**	**HOW THE PROGRAM DESIGN AND REQUIREMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES**
	scientific and medical literature **Ethical behaviour** • Understand current ethical standards for genetic testing • Appreciate the guidelines for communication of incidental genetic findings in paediatric and adult populations • Be respectful of patient belief systems that affect the use of genetic information **Broader Implications** • Recognize how the growing availability of genetic information is changing the practice of medicine • Use risk information to assess the impact of new genetic findings	interpret new genetic findings. MMG001Y, Advanced Human Genetics, and MMG003Y, Genomics Methodologies, will emphasize how the rapid progress in genomic technologies requires the continual assessment of the best current approaches to problem solving. **Ethical behaviour** All students will complete a MMG005H, Ethical and Legal Implications of Genomic Information, taught by members of the Faculty of Medicine, Faculty of Public Health and Faculty of Law. This course will communicate the current ethical and legal standards for genetic information. Students will learn to sensitively communicate with patient populations from varying belief systems. **Broader Implications** MNG006H, Future Directions in Medical Genomics, will explicitly address how the growing availability of genetic information is expected to transform clinical practice. This course will also address new technologies on the near-term horizon for adoption into genetic and genomic technologies.
5. Communications Skills The ability to communicate ideas, issues and conclusions clearly.	Communications Skills is defined in Medical Genomics as the ability to communicate genetic information in a clear, easily understood manner tailored to the level of training of the audience. This is reflected in students who are able to: • Work closely with other laboratory and medical professionals to interpret	The program design and requirements that ensure these student outcomes for communication skills are: • The diverse student class will create interaction between clinicians and laboratory researchers. In addition to formal collaborative projects in class, dedicated learning space will encourage informal

MASTER'S DEGREE LEVEL EXPECTATIONS (based on the Ontario Council of Academic Vice Presidents (OCAV) DLEs)	MASTER'S PROGRAM LEARNING OBJECTIVES AND OUTCOMES	HOW THE PROGRAM DESIGN AND REQUIREMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES
	genetic testing results and collaboratively develop follow-up and treatment plans • Prepare and present clearly understandable and supported written and oral summaries of genetic testing results for both patient and professional audiences, including a statistically supported description of disease risk	interactions among students. • Evaluation of student performance in several courses will include written and oral presentations, performed individually and as teams. This will be a particular focus of MMG0004H, Communication of Genetic Information.

11 Assessment of Learning

Assessment of Learning:

Mechanisms for student evaluation:

Program coursework will include a variety of assessment modalities in which students are required to demonstrate acquired knowledge and apply these concepts to both theoretical and practical problems in medical genomics. The program is designed to be cumulative; successful completion of assignments in later courses will require the application of knowledge and methods learned in earlier courses.

Student performance will be quantified through a variety of mechanisms including written quizzes and examinations, oral presentations, and written projects (e.g. case reports). Students will receive a letter grade for each course in addition to a written mid-term performance evaluation.

	Quizzes and Examinations	*Written projects*	*Oral Presentations*
1. Depth and Breadth of Knowledge			
Understand the principles underlying genetic / genomic testing methods	*X*	*X*	*X*
Critically assess statistical methods and justify most appropriate techniques	*X*	*X*	*X*

Describe and explain genetic variation and association with disease risk	*X*	*X*	
2. Research and Scholarship			
Develop biologically sound hypotheses and propose approaches to test the same		*X*	*X*
Demonstrate mastery of research literature to provide support for diagnosis, prognosis, and treatment planning of genetic variation and disease	*X*	*X*	*X*
3. Application of Knowledge			
Interpret raw genomic / genetic data to assess the validity of a reported result	*X*	*X*	
Identify and implement the appropriate statistical methods for diverse genomic tests	*X*	*X*	
Recommend and justify follow-up testing based on patient history and existing data		*X*	*X*
4. Professional Capacity / Autonomy			
Integrate information from databases and scientific publications to assess genetic test results	*X*	*X*	
Critically assess new genomic tools and understand primary and research literature		*X*	*X*
Understand and follow current ethical standards for genetic testing and evaluation		*X*	*X*
Use risk information to assess the impact of new genetic variants		*X*	*X*
5. Communication Skills			
Work with laboratory and medical professionals to interpret genetic testing results and collaboratively develop follow-up and treatment plans		*X*	*X*
Generate understandable and supported summaries of genetic / genomic test results for both professional and patient audiences	*X*	*X*	*X*

Evaluation of program effectiveness:

A key component of this program is provision of career-enabling skills. We will actively follow our program graduates using a combination of post-completion surveys at several points post graduation (six months, one year, three years), phone and in-person follow-up interviews. Student feedback will be combined with targeted surveys of employers of our graduates to enable head-to-head comparison of program participants and their peers.

We will establish a program steering committee consisting of lead instructors from each course, the departmental chair, program director, and at least two external knowledge users from local hospitals and clinical laboratories. This committee will meet at least once per year to discuss the effectiveness of course content, foster greater integration between course modules, and identify program strengths and focal areas for improvement. Our course content is intentionally

flexible to enable dynamic response to changes in state-of-the-art technologies and to rapidly respond to feedback from program participants. This structured evaluation and course-planning approach will ensure that students are being provided with effective and relevant content.

Medical genomics exists in a fast-changing regulatory environment. While there are not at present any relevant certifications available for the program, we will monitor and aggressively pursue any certifications and professional accreditations that may arise.

12 Consultation

This proposed program has been developed following discussions both inside the Faculty of Medicine and with local stakeholders and knowledge users, including the Dalla Lana School of Public Health, the McLaughlin Centre for Molecular Medicine, and the Division of Clinical and Metabolic Genetics at SickKids.

Preliminary meetings began in 2013 within the Department of Molecular Genetics (Faculty of Medicine)and the Donnelly Centre, a multidisciplinary, an Extra Departmental Unit A cross-faculty research institute comprised of more than 40 research groups across different faculties (Medicine, Engineering and Applied Sciences, Arts and Sciences, and Pharmacy). The impetus for developing this program has been the desire to translate knowledge and research excellence of these two units into a clinically relevant professional Masters program. Upon extremely positive feedback from stakeholders in both departments, we proceeded to engage the greater faculty and surrounding community.

Discussions within the Faculty of Medicine in early 2014 centred around the viability of a new professional Masters program for medical genomics, through consultation with clinical faculty. Feedback from these meetings was strongly positive, and significantly expanded our target student population to include physicians in training at the undergraduate medical and resident levels. Dennis Daneman (Chair, Department of Paediatrics, U of T & Physician-in-Chief, SickKids) and Ronald Cohn (Chief, Division of Clinical & Metabolic Genetics, SickKids) provided valuable insight from the clinician and clinician-scientist perspectives. *Dr. Cohn, in particular, was excited at the potential to leverage our MHSc program in lieu of a separate clinical genomics fellowship.*

We consulted with Steven Scherer, Director of the McLaughlin Centre for Molecular Medicine, to gauge interest from knowledge users and potential employers of our prospective graduates. Dr. Scherer was strongly positive about the program in general, re-affirmed our assessment that this program will provide a novel and timely contribution to genomics education, and suggested the potential for direct externship possibilities in the McLaughlin Centre for professional-track students. As a leader in genomics, Dr. Scherer underscored the importance of our program in providing genomics education to both clinicians-in-training and post-BSc students likely to join genomics research or commercial enterprises.

Further discussions inside the Faculty of Medicine focused on defining our target student population. In mid-2014, we engaged Norm Rosenblum, Associate Dean in charge of the

physician-scientist training program in the Faculty, who supported our targeting of clinical trainees and recent graduates as part of our student cohort. Echoing previous stakeholders, Dr. Rosenblum was extremely positive about our proposal, and the potential for the University of Toronto to take a leadership position in this field.

In mid-2015, we engaged Barbara Secker and Michael Szego of the Joint Centre for Bioethics, an Extra-Departmental Unit C within the Dalla Lana School of Public Health for collaboration on one of our proposed course modules. The Centre for Bioethics delivers the MHSc in Bioethics and the graduate Collaborative Program in Bioethics. Drs. Secker and Szego saw significant strategic fit with their teaching efforts, and offered support for the genetic ethics components of MMG 0005H. Prof. Trudo Lemmens of the Faculty of Law already holds a cross-appointment in the Department of Molecular Genetics to teach in its M.Sc. Program in Genetic Counselling. Drs. Szego and Lemmens will participate in the M.H.Sc. course MMG 0005H on Ethical and Legal Implications of Genomic Information.

In June 2015, a draft version of this proposal was presented in a full faculty meeting of the Department of Molecular Genetics and received uniformly strong support. Members of the Department will be largely responsible for program content, with portions of one course, MMG005H, delivered with assistance from Drs. Szego and Lemmens as described above.

13 Resources:

13.1 Faculty Complement

The Department of Molecular Genetics includes faculty members at the University of Toronto both on campus (~50 faculty members) and in two nearby hospitals (SickKids, Mt. Sinai; ~90 faculty members). The Department's scientists and clinician-scientists recruited to teach in this program are world leaders in the generation, interpretation, and clinical use of genetic and genomics information. Over 25 of our faculty members have been tapped to contribute to the program, allowing students to benefit from expertise in specific areas. These faculty members include several Fellows of the Royal Society of Canada, multiple Canada Research Chairs (both Tier 1 and Tier 2), and include recipients of awards for teaching and research. Their accomplishments are detailed in Appendix A.

As a major medical centre of the province of Ontario, clinicians and medical students enrolled in the program will have the opportunity to interact with patients presenting with a wide range of genetic diseases with clinical data representing the latest in genomic medicine.

Table 3: Faculty Complement (please list alphabetically)

Name	**Home Department / Unit** *(who holds primary budgetary appointment)*	**University Rank**	**Graduate Faculty Membership Status** *(e.g., Associate/ Full privileges)*	**Commitment to other programs** *(please list other programs in which the person routinely teaches / supervises)*	**Nature of contribution to this program** *Course Instructor (CI)*
Tenured					
Andrews, Brenda	Donnelly Centre	Professor	Full	Molecular Genetics	CI
Bader, Gary	Donnelly Centre	Associate Professor	Full	Computer Science, Molecular Genetics	CI
Blencowe, Ben	Donnelly Centre	Professor	Full	Molecular Genetics	CI
Emili, Andrew	Donnelly Centre	Professor	Full	Molecular Genetics	CI
Fraser, Andrew	Donnelly Centre	Professor	Full	Molecular Genetics	CI
Hughes, Tim	Donnelly Centre	Professor	Full	Molecular Genetics	CI
Kim, Philip	Donnelly Centre	Associate Professor	Full	Molecular Genetics, Computer Science	CI
Lemmens, Trudo	Law	Professor	Associate	Molecular Genetics	CI
Moffat, Jason	Donnelly Centre	Associate Professor	Full	Molecular Genetics	CI
Morris, Quaid	Donnelly Centre	Associate Professor	Full	Molecular Genetics Computer Science	CI
Roth, Fritz	Donnelly Centre LTRI	Associate Professor	Full	Computer Science, Molecular Genetics	CI
Zhang, Zhaolei	Donnelly Centre Molecular Genetics	Professor	Full	Computer Science	CI
Tenure-Stream					
Caudy, Amy	Donnelly Centre	Assistant Professor	Full	Molecular Genetics	CI

Name	**Home Department / Unit** *(who holds primary budgetary appointment)*	**University Rank**	**Graduate Faculty Membership Status** *(e.g., Associate/ Full privileges)*	**Commitment to other programs** *(please list other programs in which the person routinely teaches / supervises)*	**Nature of contribution to this program** *Course Instructor (CI)*
Status-Only					
Awadalla, Philip	Molecular Genetics OICR	Professor	Full	Molecular Genetics	CI
Cohn, Ronald	Paediatrics Hospital for Sick Children	Associate Professor	Full	Molecular Genetics Paediatrics	CI
Dirks, Peter	Surgery Hospital for Sick Children	Professor	Full	Molecular Genetics	CI
Gingras, Anne-Claude	Molecular Genetics LTRI	Professor	Full		CI
Hudson, Tom	Molecular Genetics OICR	Professor	Full	Medical Biophysics	CI
Meyn, Steve	Paediatrics Hospital for Sick Children	Professor	Full	Molecular Genetics	CI
Parkinson, John	Biochemistry Hospital for Sick Children	Professor	Full	Molecular Genetics	CI
Pearson, Christopher	Molecular Genetics Hospital for Sick Children	Associate Professor	Full		CI
Rommens, Johanna	Molecular Genetics Hospital for Sick Children	Professor	Full		CI
Scherer, Steve	Molecular Genetics Hospital for Sick Children	Professor	Full	IMS	CI

Name	**Home Department / Unit** *(who holds primary budgetary appointment)*	**University Rank**	**Graduate Faculty Membership Status** *(e.g., Associate/ Full privileges)*	**Commitment to other programs** *(please list other programs in which the person routinely teaches / supervises)*	**Nature of contribution to this program** *Course Instructor (CI)*
Stein, Lincoln	Molecular Genetics OICR	Professor	Full		CI
Szego, Michael	Joint Centre for Bioethics	Adjunct Professor			CI
Wilson, Michael	Molecular Genetics Hospital for Sick Children	Assistant Professor	Full		CI
Wrana, Jeff	Molecular Genetics LTRI	Professor	Full		

13.2 Learning Resources

Please see the following Appendices:

Appendix [D]: Library statement confirming the adequacy of library holdings and support for student learning

Appendix [E]: Standard statement concerning student support services

13.3 Financial Support for Graduate Students

As with all professional Masters programs at the University of Toronto, professional Masters students are not eligible for a graduate funding package. Students will be eligible for scholarships and loans typically available to professional Masters graduate students.

13.4 Space/Infrastructure

We anticipate 40 students enrolled across two academic years at steady state. The Department of Molecular Genetics has access to classrooms of appropriate size and configuration in the Medical Sciences Building. Several of these rooms can be used for both small group discussion and general lecture while others are best suited for a single purpose. Rooms have built-in projection systems, microphones, and blackboards or whiteboards. All rooms have internet

access suitable for the use of online tools for data analysis.

The Faculty of Medicine has agreed to identify and renovate a space within MSB to provide a study area for program participants. Funds for this renovation are in the approved 2017/2018 Departmental budget. This learning area would be furnished with cubicles and a group study areas. The proposed space will foster communication and enable on-campus work on team projects and team study among program participants.

The elective laboratory component of the will use Department of Teaching Laboratories in the Faculty of Medicine, which have appropriate equipment and layout to accommodate the students. Multiple laboratories are available for concurrent use, though a single room will be sufficient for the anticipated program size.

A new Program Assistant (0.5 FTE) will be recruited to administer the degree program. The assistant will be housed in existing office facilities in the Department of Molecular Genetics. The inaugural Program Director will remain in his existing office, located in the Donnelly Centre.

14 Quality and Other Indicators

The Molecular Genetics faculty members participating in the program span a range of disciplines from fundamental to clinically relevant genomics using experimental or computational methods. Students in the program will benefit from interacting with these leaders; several salient highlights follow. Drs. Ronni Cohn and Steve Meyn, Co-Directors of the SickKids' Genome Clinic, a project that is the first of its kind in Canada, are working to implement whole genome sequencing in the routine clinical care of children. Dr. Steve Scherer, director of The Centre for Applied Genomics and the McLaughlin Centre for Molecular Medicine, has been leading multiple genome sequencing efforts for mapping diseases including autism. Dr. Tom Hudson, President and Scientific Director of the Ontario Institute for Cancer Research, chairs the International Cancer Genome Consortium's Executive and Scientific Steering committees. Dr. Lincoln Stein, Director of Informatics and Bio-computing, Ontario Institute for Cancer Research (OICR), is leading the Cancer Genome Collaboratory, a $7.3 M project to process and make available the data from the International Cancer Genome Consortium. Drs. Gary Bader and Quaid Morris are instructors in Canadian Bioinformatics Workshops and are leaders in the development of the Cytoscape application for viewing high dimensional systems biology data. Appendix F contains the CVs of the more than 25 faculty involved in the program present potential faculty for the program who are each at the frontiers of genome medicine, making discoveries and tools to better connect genetic data with patient outcomes.

15 Governance Process:

	Levels of Approval Required
Consultation with Provost	
Decanal and Provostial Sign-Off	
	Faculty/Divisional Governance
Submission to Provost's Office	
	AP&P
	Academic Board
	Executive Committee of Governing Council
Program may begin advertising as long as any material includes the clear statement that "No offer of admissions will be made to the program pending final approval by the Quality Council and the Ministry of Colleges Training and University (where the latter is required)."	
	Ontario Quality Council
	Submitted to MTCU (in case of new graduate degrees and programs, new diplomas)

Appendix A: Courses

Title	Description	FCEs
MMG0001Y: ***Advanced Human Genetics***	This two-session course will bring all students to a common knowledge base and introduce advanced concepts including quantitative trait genetics and epigenetics. Students will learn human genetics from the perspective of phenotype / clinical presentation toward genotype in addition to a semester-long focus on molecular genetics and underlying mechanisms of human disease. This fundamental course will provide a knowledge framework for the entire program and will introduce key concepts that will be examined in detail in subsequent courses.	2.0
MMG0002H: ***Biological Statistics***	The ability to effectively translate genomic test results into clinical plans and to interpret the literature of genomic medicine requires a strong foundation in advanced statistics. This course will use example-based teaching of frequentist and Bayesian statistics. Students will be taught statistical theory and be required to actively employ modern statistical methods and software in the analysis of genomic data. Students will learn how to identify the appropriate statistical methods for a given data set, apply these methods, and critically interpret these results. This course will focus on practical knowledge, with interspersed discussions of how biological statistics integrates into the larger fields of computer science, applied math, and biology.	1.0
MMG0003Y: ***Genomics Methodologies***	While next-generation techniques are making headlines, many deployed clinical assays are predicated on "last-generation" molecular biology tools. We will teach the theory and practice of molecular biology relevant to genetic and genomic testing. This two-session course will consist of classic methods during the first (spring) term, followed modern and emerging methods during the summer term. The second half of the course will include a strong component of computational techniques in genomic assays, reflecting the lock-step development of new molecular biology and data-analysis techniques. Students will complete this course understanding the scientific principles underlying genomic tests, be able to examine the limitations and applications of current tests, and with the necessary background to understand new assays	2.0
MMG0004H: ***Communication of Genetic Information***	This course will teach students the terminology and jargon relevant to genomic research to enable access of medical and scientific literature. In addition, we will train students to effectively and bi-directionally translate clinical information into patient-accessible language. Lectures will be complemented with group projects in which students will prepare written and oral presentations with the goal of building the skills necessary to communicate genomic information to a variety of audiences.	1.0

MMG0005H: ***Ethical and Legal Implications of Genomics***	This course will explore the current social and legal landscape of human genetic analysis, with a focus on the application of genome-science on patient care. Students will explore the manifold legal and ethical implications of genomic science, including the cost and complexity of counselling patients in the face of new clinical data types. We will use a combination of lecture and project-based learning to train students on current requirements for obtaining patient consent, ethical implications and protocols for use of patients in research studies, and emerging issues reporting of incidental findings. Particular focus will be made on communication of genetic findings for patients with religious beliefs or value systems that affect clinical care.	1.0
MMG0006H: ***Future Directions in Medical Genomics***	Ongoing learning is essential in this fast-growing field. This course will train students about the available resources in genomic medicine and develop an information portal for students for continued learning. We will deliver a series of complementary lectures highlighting new techniques in allied fields such as proteomics, metabolomics, and gene expression analysis. Students will extend their understanding of genomic medicine with topics including tumour and prenatal diagnostic sequencing, molecular pathology, and learn how new assays are deployed to the clinic.	1.0
MMG007H: ***Practicum in Patient Management and Medical Genomics***	Genomic medicine is enabling a range of clinical interventions. This course will explore the current and future tools for genomics-driven patient management. Students will engage in hands-on practical exercises designed to prepare them for clinical practice from patient intake through consultation and post-testing counselling. We will focus on current best practices for patient management in Canada and the US, with units focusing on patient intake, the current and future actionability of genetic information, implications of direct-to-consumer genetic testing, and management and notification of potentially affected kin. Students will prepare and present case studies based on actual primary data from collaborating research institutes.	1.0
MMG0008H: ***Practicum in Modern Genomics***	We have developed a hands-on laboratory curriculum for teaching state-of-the-art genomics techniques. This course will be delivered as a hybrid of lecture, hands-on laboratory exercises, and extensive computer-based analysis of genomic samples. Students will be tasked with applying much of the knowledge gained throughout the preceding four terms as they generate, analyze, and follow up genomic testing data. Students will complete this course with the ability to perform a range of classic and next-generation genetic and genomic assays, and be “shovel ready” for employment in clinical or research laboratories.	1.0

Appendix B: Graduate Calendar Copy

Medical Genomics

Master of Health Science

Overview: The professional Master's in Medical Genomics program is a fast-paced, content-dense degree program delivered over five continuous sessions. This program will provide medical trainees, research scientists, and laboratory professionals with the theory and practical knowledge necessary to incorporate theory and practical aspects of generating and analysing genomics data into research and medical practice.

Minimum Admission Requirements

- Applicants are admitted under the General Regulations of the School of Graduate Studies.
- Applicants must also satisfy the Department of Molecular Genetics additional admission requirements stated below:
    - An appropriate Bachelor of Science (BSc) degree with high academic standing from a recognized university, with a B+ average or better. Applicants would normally possess an undergraduate degree displaying competence in genetics, molecular biology, or related fields.
    - OR
    - An appropriate MD degree with high academic standing from a recognized university, with a B+ average or better.
- Applicants will complete an application package including:
        - All previous university transcripts
        - Curriculum vitae (CV)
        - Statement of interest (1 to 2 pages maximum), including how this program will have an impact on future career path
        - Three letters of reference from professional, academic, or other qualified referees
- Preferred applicants will have relevant research and/or clinical experience, and who can demonstrate an immediate and substantive use of this degree in professional practice.
- Interview (30 minutes).

Program Requirements

- Within this two-year, five-session program, students must complete a total of 9.0 full-course equivalents (FCEs) as follows:
    - Year 1:
        - MMG 0001Y *Advanced Human* Genetics (2.0 FCE, Fall and Winter)
        - MMG 0002H *Biological Statistics* (1.0 FCE, Fall)

- MMG 0003Y *Genomics Methodologies* (2.0 FCE, Winter and Summer)

- Year 2:

  - MMG 0004H *Communication of Genetic Information* (1.0 FCE, Fall)
  - MMG 0005H *Ethical and Legal Implications of Genomics* (1.0 FCE, Fall)
  - MMG 0006H *Future Directions in Medical Genomics* (1.0 FCE, Winter)
  - MMG 0007H Practicum in *Patient Management and Medical Genomics* [Elective for students and trainees patient-facing medical fields] (1.0 FCE, Winter)
    OR
  - MMG 0008H *Practicum in Modern Genomics* [Elective for students in laboratory / research science careers] (1.0 FCE, Winter)

Program Length

5 sessions full-time (F/W/S/F/W)

Time Limit

3 years

Course List

Required

MMG 0001Y	Advanced Human Genetics
MMG 0002H	Biological Statistics
MMG 0003Y	Genomics Methodologies
MMG 0004H	Communication of Genetic Information
MMG 0005H	Ethical and Legal Implications of Genomics
MMG 0006H	Future Directions in Medical Genomics

Required Elective (chose one)

MMG 0007H	Practicum in Patient Management and Medical Genomics
MMG 0008H	Practicum in Modern Genomics

Graduate Faculty

Full Members

Andrews, Brenda – PhD
Awadalla, Philip – PhD
Bader, Gary – PhD
Blencowe, Ben – PhD
Caudy, Amy – PhD
Cohn, Ronald – PhD, MD
Dirks, Peter – MD
Emili, Andrew – PhD
Fraser, Andrew – PhD
Gingras, Anne-Claude – PhD
Hudson, Tom – PhD
Hughes, Tim – PhD
Kim, Philip – PhD
Meyn, Steven – MD
Moffat, Jason – PhD
Morris, Quaid – PhD
Parkinson, John – PhD
Pearson, Christopher – PhD
Rommens, Johanna – PhD
Roth, Fritz – PhD
Scherer, Steve – PhD
Stein, Lincoln – PhD
Wilson, Michael – PhD
Wrana, Jeff – PhD
Zhang, Zhaolei – PhD

Associate Members

Lemmens, Trudo – DCL
Szego, Michael - PhD

Appendix C: Library Statement

University of Toronto Libraries Report for

Professional Masters in Medical Genomics, Faculty of Medicine, 2015

Context: The University of Toronto Library (UTL) system is the largest academic library in Canada and is currently ranked third among academic research libraries in North America, behind Harvard and Yale.[4] The research and special collections, together with the campus and college libraries comprise almost 12 million print volumes, nearly 5.5 million microform volumes, more than 17,000 journal subscriptions, in addition to a rich collection of manuscripts, films, and cartographic materials. The system provides access to more than 1.5 million electronic books, journals, and primary source materials and increasingly supports access via personal handheld devices.[5] There are numerous collection strengths in a wide range of disciplines reflecting the breadth of research and instructional programs at the University. The University of Toronto Library system has an annual acquisition budget of $28 million. The strong collections, facilities and staff expertise attract unique donations of books and manuscripts from around the world, which in turn draw scholars for research and graduate work.

Major North American Research Libraries[6]					
	2009-10	**2010-11**	**2011-12**	**2012-2013**	**2013-2014**
ARL RANK	**UNIVERSITY**	**UNIVERSITY**	**UNIVERSITY**	**UNIVERSITY**	**UNIVERSITY**
1	Harvard	Harvard	Harvard	Harvard	Harvard
2	Yale	Yale	Yale	Yale	Yale
3	**Toronto (3rd)**	**Toronto (3rd)**	**Toronto (3rd)**	**Toronto (3rd)**	**Toronto (3rd)**
4	Columbia	Michigan	Columbia	Columbia	Columbia
5	Michigan	Columbia	Michigan	Michigan	Michigan

[4] Chronicle of Higher Education, "Library Investment Index at University Research Libraries, 2013 – 2014." In the Almanac of Higher Education, 2015.
[5] Figures as of 2013 taken from UTL's 2012-2013 Annual Report. http://onesearch.library.utoronto.ca/sites/default/files/UTL%20Annual%20Report%202012-2013_FINAL_reduced%20size_0.pdf
[6] Association of Research Libraries Statistics, 2014

Top 5 Canadian Universities in the ARL Ranking of Major North American Research Libraries					
	2009-10	**2010-11**	**2011-12**	**2012-2013**	**2013-2014**
	RANK/ UNIVERSITY	**RANK/ UNIVERSITY**	**RANK/UNIVERSITY**	**RANK/UNIVERSITY**	**RANK/UNIVERSITY**
	3/Toronto	**3/Toronto**	**3/Toronto**	**3/Toronto**	**3/Toronto**
	11/Alberta	11/Alberta	10/British Columbia	18/Alberta	22/British Columbia
	24/British Columbia	16/British Columbia	15/Alberta	24/British Columbia	26/Alberta
	31/Montreal	32/Montreal	18/McGill	30/McGill	35/McGill
	37/McGill	38/McGill	32/Montreal	35/Montreal	36/Montreal

Space and Access Services: The Library system provides a variety of individual and group study spaces for both undergraduates and graduates in the 10 central and 23 divisional libraries on the St. George, Mississauga, Scarborough and Downsview campuses. Study space and computer facilities are available twenty four hours, five days per week at one location, Robarts Library. Web-based services and electronic materials are accessible at all times from campus or remote locations, through the U of T based Scholars Portal and other leading edge digital services.

Instruction & Research Support: The Library plays an important role in the linking of teaching and research in the University. To this end, information literacy instruction is offered to assist in meeting Faculty of Medicine degree level expectations in the ability to gather, evaluate and interpret information. These services are aligned with the Association of College and Research Libraries (ACRL) Information Literacy Competency Standards for Higher Education.[7]

Program Specific Instruction: Instruction occurs at a variety of levels for Faculty of Medicine students and is provided by the faculty liaison librarians for the many departments in the Faculty of Medicine. The Gerstein Science Information Centre facilitates formal instruction integrated into the class schedule and hands-on tutorials related to course assignments. Librarians at Gerstein provide one-to-one consultations in person, by phone, email or Skype with graduate students who are conducting literature, scoping or systematic reviews for their theses. he Library, through its liaison librarians, customizes feeds of library resources. These appear prominently in Portal/Blackboard course pages. For example Undergraduate Medical Education at http://guides.library.utoronto.ca/UME or Evidence-Based Medicine at http://guides.library.utoronto.ca/evidencebasedmedicine.

[7] Association of College & Research Libraries. *Information Literacy Standards*. ACRL, 2006.

Collections: All college and campus libraries collect materials in support of programs in the sciences and health sciences; the largest collection of materials is centrally located in the Gerstein Science Information Centre. Collections are purchased in all formats to meet the variety of preferences and styles of our current students and faculty. The University of Toronto Library is committed to collecting both print and electronic materials in support of Medical Genomics at the University of Toronto.

Journals: Journals for the degree program in the department of Medical Genomics are listed in the Journal Citation Reports (JCR)[8] in the subject areas of Genetics and Heredity, Microbiology, Biotechnology and Applied Microbiology, and Medical Informatics. The table below summarizes what the Library subscribes to of the top 25 journals listed in the JCR and which titles are available electronically to staff and students of the University.

Subject Area	e-Journal subscriptions	Print subscriptions	Open Access
Genetics & heredity	22		3
Microbiology	23		2
Biotechnology and Applied Microbiology	21	1	3
Medical Informatics	20	2	3

Monographs: The University of Toronto Library maintains comprehensive book approval plans with 53 book dealers and vendors worldwide. These plans ensure that the Library receives academic monographs from publishers all over the world in an efficient manner. For Medical Genetics monographs are purchased in electronic form where possible. The Library currently receives all current e-books directly from the following publishers: Springer, Elsevier, Taylor & Francis, Cambridge Books Online, Karger, and Wiley.

Preservation, Digitization, and Open Access: The University of Toronto Library supports open access to scholarly communication through its institutional research repository (known as T-Space), its open journal and open conference services, and subscriptions to open access publications. In addition to acquiring materials in support of Medical Genomics, the Library is also, in cooperation with the Internet Archive, digitizing its monograph holdings published before 1923. These books are available without charge to anyone with access to the Internet through the Scholar's Portal e-Book platform.

Key Databases: The Library subscribes to major databases that support the Medical Genomics programs: Medline and Embase in the health sciences, BIOSIS Citation Index in the life sciences, and Web of Science and Scopus that index all science disciplines and the smaller but specific database Genetics Abstracts.

[8] 2008 Journal Citation Reports® (Thomson Reuters, 2009)

Special Collection Highlight: To support program commitments in Medical Genomics the Library subscribes to a variety of online methods and protocols. E.g. Springer Protocols with titles like Developing and Evaluating Genomics- or Proteomics-Based Diagnostic Tests and Introduction to Genomics (http://link.springer.com.myaccess.library.utoronto.ca/search?facet-content-type=Protocol). Also, to support online and blended learning the Library subscribes to the Biomedical and Life Science collection of Henry Stewart Talks, a series of streaming lectures from world experts. The Genetics category includes 580 talks organized into 31 series like Molecular Genetics of Human Disease and The Genetic Basis of Neurological Disorders (http://hstalks.com.myaccess.library.utoronto.ca/main/index_category.php?c=252).

Prepared by:

Gail Nichol

Selector for Life and Health Sciences

September 3, 2015

Submitted by:

Larry Alford

Chief Librarian, University of Toronto Libraries

Date

Appendix D: Student Support Services

All University of Toronto undergraduate and graduate students have access to student services on all three campuses, Mississauga, St. George (downtown Toronto), and Scarborough, regardless of their 'home campus'. The services and co-curricular educational opportunities provide a complement to the formal curriculum by engaging and challenging students to reach their full potential as learners, leaders and citizens. At the University of Toronto (St. George Campus) these services are organized by Student Life Programs and Services, the academic division registrar offices, and the School of Graduate Studies, and support the success of our students from the time they are admitted through degree completion and beyond.

Students have access to comprehensive **physical and mental health care** on campus including a medical clinic, travel medicine services, immunization, contraception and sexual health education. Counselling and treatment options for psychological and emotional concerns include psychotherapy, group therapy and pharmacotherapy, as well as specialized assault counseling services.

Housing needs, including off-campus housing listings and resources for students living independently, are met through the Student Housing Service.

Coaching and education in the development of key **learning skills** – from time management to overcoming exam anxiety – is provided through the Academic Success Centre. The ASC also partners with faculty to integrate success strategies and support into the curriculum.

Students' career exploration and employment services are provided through a **Career Centre** offering resume and interview coaching, workshops, career resources, on and off-campus employment and volunteer listings, job shadowing, and career counseling.

Specialized services are provided for **international students** (orientation, advising, cross-cultural counselling), students with **disabilities** (academic accommodations, advising), students with **children or other family responsibilities** (advising, resources, subsidized child care), **aboriginal students** (academic support, financial counselling) and **lesbian, gay, bisexual and transgender** students (counselling, referrals, equity outreach and engagement).

Participation in **campus life** and **experiential learning** are facilitated through Hart House (clubs, committees, events), the Centre for Community Partnerships (service learning), the Multifaith Centre (interfaith dialogue, events), and the Office of Student Life (leadership development, orientation, recognition and support for student groups, activities.) **Sport and recreational facilities and programs** are provided to all students through both Hart House and the Faculty of Kinesiology and Physical Education.

Students will have access to on-campus departmental meeting and discussion spaces, including the InteractHome housed in the Department of Molecular Genetics, a space which provides flexible study and meeting space, a kitchenette, and provision for data presentation.

School of Graduate Studies, Student Services

All graduate students at the University of Toronto have access to registrarial services and co-curricular programs at the School of Graduate Studies that assist students in meeting their academic goals.

Administrative staff at the School of Graduate Studies (SGS) provide **registrarial** services to graduate students including but not limited to recruitment, admission, orientation, registration, fees, program progress, awards/financial assistance and graduation.

The **Grad Room** is an accessible space on the St. George campus which provides University of Toronto graduate students with a lounge area and a multi-purpose space for academic, social and professional graduate student programming.

Grad Room is home to the **Graduate Professional Skills Program** (GPS). GPS is a non-academic program presented by SGS consisting of a variety of offerings that provide doctoral stream students a range of opportunities for professional skills development. The program focuses on skills beyond those conventionally learned within a disciplinary program, skills that may be critical to success in the wide range of careers that graduates enter, both within and outside academe. GPS aims to help students communicate effectively, plan and manage their time, be entrepreneurial, understand and apply ethical practices, and work effectively in teams and as leaders.

The Office of **English Language and Writing Support** (ELWS) provides graduate students with advanced training in academic writing and speaking. By emphasizing professional development rather than remediation, ELWS helps students cultivate the ability to diagnose and address the weaknesses in their oral and written work. ELWS offers four types of instruction designed to target the needs of both native and non-native speakers of English: non-credit courses, single-session workshops, individual writing consultations, and website resources.

Appendix E: Compendium of Curricula Vitae

Appendix F: External Review

UNIVERSITY OF TORONTO
FACULTY OF MEDICINE

EXTERNAL APPRAISAL REPORT | New Program Proposal

The external reviewers are asked to evaluate the standards and quality of the proposed program undergoing external review, commenting on the points below. This interactive form is based on the terms of reference and highlights the critical elements that must be considered. Please make note of any recommendations on any essential and/or desirable modifications.

Proposed Program	MHSc, Medical Genomics, Department of Molecular Genetics
Commissioning Officer	Prof. Trevor Young, Dean
External Reviewers	Prof. David Lohnes – Chair, Dept. of Cellular and Molecular Medicine, University of Ottawa Prof. Douglas Marchuk – Vice Chair, Dept. of Molecular Genetics and Microbiology, Duke University
Date of Appraisal Visit	December 12, 2016

EXTERNAL APPRAISAL SUMMARY *(Please provide a summary of your findings*

The impact of genomics in medical practice is increasing at an exponential pace, and yet, currently there is a dearth of trained professionals capable of interpreting the vast genomics data available on patients, and then clearly translating this information in layman's terms, whether the recipient is a patient or a non-scientist dealing with administrative or business issues. The MHSc in Medical Genomics program is poised to fill this significant void with professionals that are trained in these very skills. The Molecular Genetics faculty of the University of Toronto is uniquely qualified to lead Canada in this emerging area. The objectives of the program are very clear, and completely consistent with the educational mandate of the University and the Department of Molecular Genetics. The admission requirements are clearly spelled out and it is anticipated that as the program grows in stature, it will compete for the very best students from across Canada. The program is highly structured in order to ensure that every graduate possesses all the varied skills required of a professional in this area. The courses are well aligned with the objectives and plans to modify the content of the courses with input from stakeholders and graduates of the program will allow the curriculum to adapt in response to the rapid evolution of this emerging area of medicine. The mode of delivery is appropriate and the practicum in the final year will provide valuable hands-on experience. The heterogeneous composition of the cohort (e.g. BSc, MD, MSc backgrounds) offers an important value-added learning environment, with interactions between students with such diverse backgrounds anticipated to enhance the educational experience. Resources requested are appropriate and the will benefit from the addition of a common room for the students to conduct group-based work; this common room should also be equipped with an adequate number of workstations. Means for ongoing learning, such as on line portals and self-directed learning, were articulated. These are appropriate means for keeping graduates current in this fast-paced area. A clear strength of the proposal rests in the outstanding quality of the faculty to be engaged in the delivery of the curriculum. Important to the success of this program is the appointment of a Director. Such an individual should, ideally, have the relevant academic background as well as the requisite time to develop, and contribute to, the curriculum. There are a number of qualified individuals currently holding appointments to the Department. Alternatively, this may offer an opportunity to recruit new talent to the Department. Finally, the reviewers were most impressed with the energy and vision of the Department Chair, Dr. Leah Cowen, and the Associate Chair and Graduate Coordinator, Dr. Julie Claycomb. The program will be successful in large part due to their considerable talents and efforts.

1. OBJECTIVES

- ***consistency of the program with the University's mission, and Faculty's and Department's academic plan***
- ***clarity and appropriateness of the program's requirements and associated learning outcomes in addressing the academic division's graduate Degree Level Expectations***
- ***appropriateness of the degree or diploma nomenclature***

- The MHSc in Medical Genomics is completely consistent with the University of Toronto mission to meet the practical training of students in an emerging and critical area of heath care.
- As the leading institution in Canada in the field of Molecular Genetics, University of Toronto is uniquely situated to provide this training for the entire nation (and beyond). UT may be the only University in Canada capable of successfully establishing this critical program.
- The Department has made a commitment to increase training in the area of human genetics/genomics, and this professional Masters degree is perfectly aligned with that commitment.
- All requirements are clearly spelled out and are appropriate for the needs of the students.
- Similarly, the learning outcomes are clear and appropriate.
- The engagement with diverse stakeholders, especially leaders in this field who will become the future employers of the students, is a brilliant idea to continue to fine-tune the program requirements and learning outcomes.
- The MHSc is the correct and entirely appropriate degree for this program. As a research degree, the PhD would be focused on the wrong skill set, require too many years of training, and thus would be inappropriate.

EXTERNAL APPRAISAL REPORT | New Program Proposal

2. ADMISSION REQUIREMENTS

- ***appropriateness of the program's admission requirements to the learning outcomes of the program***
- ***appropriateness of any alternative requirements for admission into the program such as minimum grade point average or additional languages or portfolios, along with how the program recognizes prior work or learning experience***

- The requirements at the BSc level are appropriate.
- The pre-requisite course requirements in biology and chemistry disciplines are appropriate and will ensure that classes can be taught at the correct level without the need for remedial courses.
- The computer programming skills of the entering students will necessarily vary (in some cases, widely) from student to student. It would be inappropriate to require in advance such training for admission, as doing so would exclude admission to otherwise highly qualified and motivated students with the BSc degree in the biological sciences. The plan to instead provide computer programing training as part of the program curriculum makes the most sense, as articulated to the reviewers during the site visit.
- The minimal grade point average is entirely appropriate. Indeed, as the program gains in stature, it might become a highly competitive program that will be able to admit only the very best of students.
- The plan for recognizing prior work and learning experiences (such as prior clinical experience) is also appropriate.

3. STRUCTURE

- ***appropriateness of the program's structure and regulations to meet specified program learning outcomes and Degree Level Expectations***
- ***rationale for program length in order to ensure that the program requirements can be reasonably completed within the proposed time period***

- The program is highly structured with the curriculum of each year clearly laid out.
- The number of courses is appropriate for a professional degree.
- The course requirements match the learning outcomes and expectations of the degree. As stated earlier, these requirements may change as the professional needs evolve.
- The length of the program appears sound, especially for those students entering with a BSc. This fits the expectations of such students.
- The plan to include medical students or physicians was thought to be innovative and have the potential to greatly enhance the program by providing a different viewpoint for course projects, etc.
- To reiterate, including students coming from the BSc and the M.D. paths is considered one of the best and most innovative parts of the program.
- This innovation listed above necessarily creates some logical issues- issues that are well worth trying to resolve. The main issue is that it is unclear to the reviewers whether students entering the program while still in medical school, or already having finished and now in residency or advanced training, would prefer an accelerated program (less than 2 years).
- This issue was discussed at length during the site visit and Deans Kaplan and Young thought a half-year to possibly a year could be shaved off of the program for medical students in the MHSc Medical Genomics program while concurrently in Medical School. If possible, we anticipate this program would become very popular.

4. PROGRAM CONTENT

- ***ways in which the curriculum address the current state of the discipline or area of study***
- ***identification of any unique curriculum or program innovations or creative components and their appropriateness***
- ***clarity of the nature and suitability of the major research requirements for degree completion***
- ***evidence that each graduate student in the program is required to take all of the course requirements from among graduate level courses***

- Each of the courses is clearly articulated and represents the state of the art in medical genomics.
- The content of each course can be modified in subsequent years to meet the needs of the students as the field of medical genomics evolves.
- Such evolution of course content is necessary in an emerging and rapidly changing field such as medical genomics. Thus, it is no criticism of the program to point out the need of such evolution. Indeed, a strength of this training plan is that the even before day one, the authors realize the need for this evolution to occur.
- Since the MHSc degree is not (and should not be) a research degree there are no research requirements.
- The practicum in the second year is a critical component of the program and arguable represents the best part of the program training. In this regard, the practicum substitutes for the research requirement.
- The course requirements for the entire program are clearly laid out. The program coursework is (nearly) invariant, providing consistent training for all of the students. For such a professional degree, uniformity of training is appropriate and even absolutely essential for the success its students as they enter the workforce.

EXTERNAL APPRAISAL REPORT | New Program Proposal

5. MODE OF DELIVERY

- ***appropriateness of the proposed mode(s) of delivery—distance learning, compressed part-time, online, mixed-mode or non-standard forms of delivery, flex-time options—to meet the intended program learning outcomes and Degree Level Expectations***

- This course-based curriculum offers an appropriate mode of delivery and a defined time line for completion which is desirable for a Professional degree such as offered thorough this program.
- The application of blended-learning approaches through classroom instruction and student-directed (e.g. web-based portals and other online resources; group projects) is an excellent means of instruction. This is especially true given that online applications are commonly used in genomics/genetics, and this aspect of the curriculum is a judicious means to develop this important skill set.
- The use of 'just-in-time' cumulative instruction is an appropriate and logical pathway to objectives of the program. This is especially important given the anticipated diverse background of the learners.
- The heterogeneous composition of the cohort (e.g. BSc, MD, MSc backgrounds) offers an important value-added learning environment, with interactions between students with such diverse backgrounds anticipated to enhance the learning experience.
- Such interactions should be encouraged at every opportunity throughout the program by, for e.g., small group problem-based learning modules, co-presentations and other group-based activities.
- The final practicum offers an excellent modality for learning, entirely appropriate for the degree. Under future iterations of the program, it may be beneficial to expand this to other experiential learning opportunities. In an ideal situation, such experiential learning could occur in collaboration with relevant partners in the community, including potential future employers.
- As the program evolves, it may be beneficial to explore opportunities to offer greater flexibility to the curriculum in order to maximize opportunities to MD-stream students.
- An ongoing learning portal, as well as self-directed learning, was proposed for continuing professional development genetics. These are appropriate means for keeping graduates current in this fast-paced area.

6. ASSESSMENT OF TEACHING AND LEARNING

- ***appropriateness of the proposed methods for the assessment of student achievement of the intended program learning outcomes and Degree Level Expectations***
- ***completeness of plans for documenting and demonstrating the level of performance of students, consistent with the academic division's statement of its Degree Level Expectations***

- Student achievement will be assessed through examinations and quizzes, written projects and evaluation of oral presentations. This is an appropriate means to monitor student achievement. The incorporation of oral presentations is especially important, as verbal communication skills are an essential part of the requisite skill set in the profession.
- In addition to letter grades for coursework, students will also receive midterm written evaluations. The latter should offer a more in-depth feedback of performance. While not articulated, this could be coupled with individual meetings to discuss progress and to provide additional feedback.
- The plans for documentation and demonstration of student performance are clearly articulated. Each domain (depth and breadth of knowledge; research and scholarship; application of knowledge; professional capacity/autonomy; and communication skills) has clearly laid out areas (and modes) for evaluation. These performance criteria are directly relevant to the degree, and are concordant with Degree Level Expectations for the Department of Molecular Genetics.
- Plans for tracking the success of graduates is noted through surveys of graduates as well as their employers. This is an essential component to ensure that the Program is delivering on expectations for this Profession.
- Curriculum oversight by a Steering Committee, which will include two knowledge users, provides an additional means for adapting to changes in the field. This includes any future needs for certification of graduates.

7. RESOURCES

- ***adequacy of the administrative Department's planned utilization of existing human, physical and financial resources, and any institutional commitment to supplement those resources to support the program***
- ***participation of a sufficient number and quality of faculty who are competent to teach and/or supervise in the program***
- ***adequacy of resources to sustain the quality of scholarship and research activities of graduate students, including library support, information technology support, and laboratory access***
- ***recent research or professional/clinical expertise of faculty to sustain the program, promote innovation and foster an appropriate intellectual climate***
- ***sufficiency of financial assistance for students to ensure adequate quality and numbers of students***
- ***supervisory load distribution and the qualifications and appointment status of supervisors***

- Adequate space for class-based instruction currently exists. This will be augmented with a projected addition of a common room for the students to conduct group-based work. Assuming a steady-state cohort of 40 students, this common room should also be equipped with an adequate number of workstations.

- Recruitment of a 0.5 full time administrative support staff is noted. Due to the unique nature of the proposed program, and the work required to initiate it, this position will be important, and is clearly justified.
- Equally important to the success of this program is the appointment of a Director. Such an individual should, ideally, have the relevant academic background as well as the requisite time to develop, and contribute to, the curriculum. There are a number of qualified individuals currently holding appointments to the Department. Alternatively, this may offer an opportunity to recruit new talent to the Department.
- The Faculty who have been noted as potential contributors to the program are remarkable both in terms of quantity and especially quality. There is a most impressive breadth of relevant expertise from world-class leaders ranging from bioinformatics and genetics to ethics. As regards the latter, appropriate collaborations have been forged with the Faculty of Law and Faculty of Public Health.
- Adequate support is articulated on other fronts. The University of Toronto boasts a world-class library, and is positioned to provide relevant support for this program, including on-line access to contemporary publications. Access to relevant bioinformatics and other tools will also be provided. Adequate and appropriate laboratory space is currently available.
- As a professional degree, MHSc students are not eligible for grant funding. Support will be available in the form of scholarships and loans appropriate for this degree type.
- As a course-based program, there is no consideration needed for supervisory loads or related matters.

8. QUALITY AND OTHER INDICATORS

- ***quality of the faculty (e.g., qualifications, research, innovation and scholarly record; appropriateness of collective faculty expertise to contribute substantively to the proposed program)***
- ***program structure and faculty research that will ensure the intellectual quality of the student experience***

- As noted above, a clear strength of the proposal rests in the outstanding quality of the faculty to be engaged in the delivery of the program.
- Many of the Faculty are International leaders in their respective field, with appropriate expertise ranging from clinical genetics/genomics to bioinformatics and computation to ethics.
- The collective Faculty members to be engaged in this program ensure an outstanding student experience of the high intellectual quality.

Appendix G: Dean's Response to External Appraisal Report

UNIVERSITY OF TORONTO
FACULTY OF MEDICINE

L. Trevor Young, MD PhD FRCPC
Dean
Vice Provost, Relations with Health Care Institutions

February 21, 2017

Prof. Sioban Nelson
Vice-Provost, Academic Programs
University of Toronto
Simcoe Hall
27 King's College Circle, Room 225
Toronto, ON M5S 1A1

Dear Professor Nelson,

Re: External Appraisal Report
New Program Proposal - MHSc Program for Medical Genomics

On behalf of the Faculty of Medicine, University of Toronto, I would like to thank Professor David Lohnes Chair, Dept. of Cellular and Molecular Medicine, University of Ottawa, and Professor Douglas Marchuk, Vice Chair, Dept. of Molecular Genetics and Microbiology, Duke University, for their thorough expert in- depth analysis of the proposal and for their excellent report. I would also like to thank the administrative staff of the Department of Molecular Genetics and all those who contributed to the preparation of the comprehensive new program proposal. I also extend many thanks to all the faculty members and students who met with the external reviewers. Your input was invaluable for this review.

The Faculty of Medicine and the Vice Dean, Graduate and Academic Affairs fully support the proposal for a new Professional Master's degree in Medical Genomics. We are very pleased to see that the two external appraisers are also highly supportive of this new program. They state in their review: "The impact of genomics in medical practice is increasing at an exponential pace, and yet, currently there is a dearth of trained professionals capable of interpreting the vast genomics data available on patients, and then clearly translating this information in layman's terms, whether the recipient is a patient or a non-scientist dealing with administrative or business issues. The MHSc in Medical Genomics program
is poised to fill this significant void with professionals that are trained in these very skills. The Molecular Genetics faculty of the University of Toronto is uniquely qualified to lead Canada in this emerging area."

The following highlights the key findings of the appraisers that represent challenges and opportunities for this new Program.

1. Admission Requirements

   In response to the fact that computer programming skills of entering students will vary considerably, the reviewers endorse the plan not to require training in this area for admission. Instead the Program will provide computer programming training as part of the program curriculum. Competency in foundational computer programming skills to enable analysis of genomic data will be provided in part through course work and in part through the practicum. Programming skills will be developed in multiple courses including Biological Statistics, Advanced Human Genetics, and Genomics Methodologies. Students will further develop programming skills through participation in a capstone

practicum during the final academic term of the program, with unique course work focused on patient interaction and laboratory data generation and analysis. The Department of Molecular Genetics has phenomenal strengths in bioinformatics and computer programming with world-class faculty, and multiple related graduate programs. The Quantitative Biology in Molecular Genetics track provides quantitative scientists who have backgrounds in physics, computer science and math, with a foundation in modern biology and mentors them towards leadership in cutting-edge interdisciplinary research. The Computational Biology in Molecular Genetics track provides biologists with an immersive curriculum towards leadership in the new discipline of computational molecular genetics. The expertise and training environment for computer programming in Molecular Genetics is outstanding and will support this new program.

2. Program Structure/ Recruitment and Length of the Program

The reviewers state that including students coming from the BSc and the MD paths is considered one of the best and most innovative parts of the program. This innovation necessarily creates some logistical issues - issues that are well worth trying to resolve. The main issue is that it is unclear to the reviewers whether students entering the program while still in medical school, or already having finished and now in residency or advanced training, would prefer an accelerated program (less than 2 years). The reviewers felt it would be worthwhile to shorten the length of the Program for students enrolled in the undergraduate medical program and that this would make the program extremely popular with medical students. The program has not been designed currently to be completed while students are also in another degree program (i.e. undergraduate medical program). This is currently being presented as a full time program and at this point there are no immediate plans to create different pathways. Plans for alternate pathways may be considered in the future after the core program has been in place for a few years.

3. Program Content

This is a research informed program; however, the reviewers recognize that the MHSc is not a research degree. They emphasize that the practicum component in the second year is a critical component of the program.

The Practicum in Modern Genomics includes hands-on laboratory exercises in which students generate and analyze genome-scale sequencing data, and will be delivered in the teaching lab facilities in the Faculty of Medicine Division of Teaching Labs. The Practicum will augment lecture-based course delivery, and will provide rigorous training in research techniques that are foundational to medical genomics. Students will also be exposed to cutting-edge research in the area of medical genomics through their courses. Courses will leverage important research papers and advances to illustrate current technologies and approaches for data analysis.

4. Mode of Delivery

The reviewers recommend expanding the experiential components of the curriculum, including in the community and with future employees. There are exciting opportunities in this area that would add value for the Practicum. Molecular Genetics has strong relationships with hospital partners and with the public and private sector through faculty members and the alumni community. The current Molecular Genetics MSc in Genetic Counselling provides an avenue for developing opportunities for experiential components of the curriculum in the clinical space, and alumni from the diverse Molecular Genetics programs provide key connections to build additional opportunities for experiential components with future employees.

5. Assessment of Teaching and Learning

   The reviewers recommend in depth feedback of performance for midterm evaluations, including individual meetings to discuss progress and provide feedback. We will incorporate individual meetings as part of the midterm evaluation. In addition, program coursework will include a variety of assessment modalities in which students are required to demonstrate acquired knowledge and apply these concepts to both theoretical and practical problems in medical genomics. The program is designed to be cumulative; successful completion of assignments in later courses will require the application of knowledge and methods learned in earlier courses. Student performance will be quantified through a variety of mechanisms including written quizzes and examinations, oral presentations, and written projects (e.g. case reports). Students will receive a letter grade for each course in addition to a written mid-term performance evaluation. An individual mid-term meeting with the Program Director associated with the performance evaluation will promote effective learning and maximize the educational experience for students.

6. Resources

   The reviewers refer to the projected addition of a common room for students to conduct group- based work. The Faculty of Medicine anticipates that this space would be in the Medical Sciences Building, which is the academic home of Molecular Genetics. A review of space allocation for the Medical Sciences Building is currently underway. Funds are committed in the Molecular Genetics budget to support the renovations. The reviewers refer to the recruitment of a .5 FTE administrator and the appointment of a Director. Necessary approvals are already in place to initiate the search for a Teaching Stream Assistant Professor to serve as Program Director, and this is expected to move forward in March 2017. Recruitment of the .5 FTE administrator is expected to occur during the summer of 2018, prior to the launch of the MHSc program in the fall.

Summary

This external review was highly favorable. The review has been very helpful in identifying and discussing the strengths of the new program proposal and ways to improve it. Several of the reviewers' suggestions have been incorporated into the proposal. The Faculty of Medicine will continue to work with the Department of Molecular Genetics to establish this innovative and important new graduate program.

Sincerely,

Trevor Young

cc. Allan Kaplan, Vice Dean, Graduate & Academic Affairs, Faculty of Medicine
Daniella Mallinick, Director, Academic Programs, Planning and Quality Assurance
Cora McCloy, Acting Coordinator, Academic Planning and Reviews
Anastasia Meletopoulos, Academic Affairs Specialist, Office of the Dean

Appendix H: Vice-Provost Response

UNIVERSITY OF TORONTO

OFFICE OF THE VICE-PROVOST,
ACADEMIC PROGRAMS

February 9, 2017

Trevor Young
Dean, Faculty of Medicine and
Vice Provost, Relations with Health Care Institutions
Faculty of Medicine
University of Toronto

Re: Appraisal Report, Proposed new Master of Health Sciences in Medical Genomics

Dear Trevor,

I am very pleased to receive the appraisal of the proposed Master of Health Sciences in Medical Genomics. Your administrative response provides an excellent summary of the appraisal report and highlights the specific suggestions made by the reviewers.

In response to the report's suggestion that an accelerated path be created for students with a medical degree, you indicate alternative pathways in the program may be considered in the future, after the program has been in place for a few years and there has been adequate time to assess the demand. The report praises the practicum as a critical component of the program and suggests in the future it could expand its experiential opportunities. You agree with the appraisers' suggestion and indicate how pursuing this might be accomplished. The report recommended that the mid-term written evaluations of students include in-depth feedback of performance, and the program organize individual meetings to discuss progress. I note that the program will incorporate this suggestion. In terms of resources, the appraisal report emphasizes that the appointment of a director is critical to the program's success and your response confirms that a search for a program director will likely begin in March 2017.

The reviewers were very impressed with the program proposal and stated the program is positioned to fulfill a significant void in this emerging area. I will be very pleased to recommend this new professional master's program to governance for approval, following approval at the divisional level.

Sincerely,

Sioban Nelson
Vice-Provost, Academic Programs

cc.

Amy Lee, Executive Secretary to the Dean, Faculty of Medicine
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