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

TO: Academic Affairs Committee

SPONSOR: Amrita Daniere, Vice-Principal Academic and Dean
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DATE: April 30, 2018 for May 7, 2018

AGENDA ITEM: 3

ITEM IDENTIFICATION:

New Graduate Field: Master of Biotechnology, Digital Health Technologies

JURISDICTIONAL INFORMATION:

Under section 5.6 of its terms of reference, the Academic Affairs Committee is responsible for "major and minor modifications to existing degree programs. All major modifications shall be reported annually for information to the appropriate body of Governing Council".

GOVERNANCE PATH:

1. **Academic Affairs Committee [For Approval] (May 7, 2018)**

PREVIOUS ACTION TAKEN:

No previous action was taken on this proposal.

HIGHLIGHTS:

Institute of Management and Innovation (IMI) is proposing a modification to the existing Master of Biotechnology (MBiotech) Degree Program that will include a second field in digital health technologies. The modification proposes to capture the existing program into a Biopharmaceutical field and expand with a second field in Digital Health Technologies (DHT). This new field will focus on digital technology in medical devices, diagnostics, wearable technology (including implants), mobile health solutions and data analytics, as well as technologies that support drug development and that analyze and interpret the outcomes of drug treatments. Both the Biopharmaceutical and DHT fields within the MBiotech program will have similar learning outcomes that follow product progression but from a different perspective. Both fields rely on the existing strengths of the MBiotech program and are in-line with IMI's mission to foster innovation and management with a strong experiential learning component. The Biopharmaceutical student will focus on drug development (how drugs work), management of

clinical trials, and regulatory issues with new drugs, while DHT students will focus more on analysing data collection during clinical testing and current and emerging health technologies.

The proposed changes to the MBiotech program will not alter the original structure; rather, the existing program requirements will become the Biopharmaceutical field focus and the DHT field will incorporate developing strengths to expand the reach of the program. Both fields will share required courses, then each field will offer students a core curriculum in the Biopharmaceutical field and in DHT. Students in either field will also have the opportunity to take electives which are overlapping for both fields. The DHT field curriculum will include courses in data science, programming, data visualizations, digital tools, data analysis associated with patient experience with a drug or medical device as well as more integrated digital health courses.

The proposed DHT field will be unique to Canada, with few known programs offered at the international level or in the US. Current undergraduate and professional graduate students were polled; a third of respondents have signaled a very strong interest in the DHT field within the MBiotech program. Employers and industry in Mississauga and the GTA have expressed enthusiasm for the new field and have articulated keen interest in participating in internships/ co-ops and several have already committed to partnering to offer internships/co-op placements in their organizations.

FINANCIAL IMPLICATIONS:

With the exception of two lecturers required for DHT specific field courses, all other existing resources are available for the new offerings. The staffing needs are consistent with other professional master's programs in IMI and covered by the incremental net revenues that will flow to UTM from the proposed student enrolments. A 100% administrative staff position will be responsible for liaising with corporations and engage in business development for internship placements.

RECOMMENDATION:

Be It Resolved,

THAT the proposed graduate field in Digital Health Technologies for the Master of Biotechnology Program, recommended by the Vice-Principal Academic & Dean, Professor Amrita Daniere, and described in the proposal dated April 20, 2018, be approved, effective on May 1, 2019.

DOCUMENTATION PROVIDED:

Minor Modification: New Graduate Field: Master of Biotechnology, Digital Health Technologies

UNIVERSITY OF TORONTO

University of Toronto
Major Modification Proposal:
New Field or Concentration within an Existing Graduate Program

Program:	Master of Biotechnology (MBiotech)
Existing fields/concentrations:	None.
Proposed New Field / Concentration:	(1) Biopharmaceutical (Masters) (2) Digital Health Technologies (Masters)
Unit (if applicable):	Institute of Management and Innovation (IMI)
Faculty / Academic Division:	University of Toronto Mississauga (UTM)
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Version Date:	April 20, 2018

1 Summary

The Master of Biotechnology (MBiotech) degree program (www.mbiotech.ca) presently provides students with a world-class graduate education in the biotechnology and biopharmaceutical sectors, over the course of 24 months. The carefully selected combination of laboratory, science and management courses, combined with an 8-12 month paid internship opportunity, provides graduates with a unique and versatile skill set in the biotech arena. We propose to encapsulate the existing program (with a cohort consisting of 42 students) into a Biopharmaceutical field and augment this with a second field consisting of 16 students in Digital Health Technologies (DHT). This proposal will also change the program learning outcomes slightly to reflect the new field and streamline the existing program learning outcomes. The impetus for the development of the DHT field came from a Wearable Technology Symposium the MBiotech program hosted in 2015. The symposium's combination of topics within DHT, which reflected health, data science (analytics), big data, wearable technology and business, helped frame the content for this DHT proposal. We received a strong response from industry regarding the symposium, and as we explored the growth of this space further, we concluded there was opportunity for a new field.

The DHT field is intended to provide training and expertise to respond to emerging needs in medical devices, diagnostics, wearable technology (medical, health, fitness), mobile health solutions and data analytics. This has already been explored in the MBiotech program, and has been determined to be sufficiently specialized to warrant its own field (discussed below). While our current Biopharmaceutical students have a background in the biological sciences, we would seek to recruit engineers, biophysicists, statisticians, computer science students, and students with a strong quantitative focus in the domains of biology, epidemiology and public health for the proposed DHT field. Such students would have strong analytical skills at baseline prior to entering our program, allowing us to go further with our courses in data science, where data analytics is a key. In short, this new field would recruit students with strong quantitative training from various disciplines and who have some grounding in biology. DHT students would focus on technologies that work in conjunction with drugs, or that serve to support drug development and to interpret the outcome of drug treatments.

The US Food and Drug Administration (FDA) has identified topics in the digital health field such as: mobile medical apps, health IT, general wellness (devices that do not treat conditions but offer support for wellness), electronic medical records ("medical device data systems"), software (in a health context where it becomes a medical device) and cybersecurity (e.g., concerns about hacking of data transmitted from both consumer and medical devices), health information technology and wearable technology, to list a few. DHT is an area that invites a spectrum of expertise outside of engineering and design.

DHT involves the intersection of healthcare data analytics and digital technology and is currently in a sharp growth phase in the context of drug therapy. This can be seen with the renewed scientific interest exemplified by one of the world's top journals (*Nature*), which plans to publish a specialist journal dedicated to digital medicine in 2018. The FDA, a global leader in

regulation, has announced that it will create a new unit dedicated to digital health products, and in 2017 the Biotechnology Industry Organization (BIO) for the first time hosted its annual congress with the addition of a dedicated digital health segment. Healthcare in this context encompasses treatment, health and wellness, and preventative medicine. Examples of topics that are to be included in the proposed field include wearable health/medical technology, medical apps, medical devices that transmit data, electronic medical records, and an emphasis on "data science" with a focus on experiential learning and the use of computational tools for analysis of large data sets (which can be referred to as "big data" in a health context). The types of technologies examined for the DHT field would typically involve applications associated with a drug as part of patient therapy (e.g., smartphone apps to track / guide drug use; insulin pumps; ingestible sensors combined with a drug; wireless pill sized cameras that look at the effect of a drug in the body). The DHT and the Biopharmaceutical fields will share a close link as they focus on different aspects of therapeutic intervention in patients.

Both fields within the MBiotech program will have similar program learning outcomes (see **Appendix Ib** for a basic overview of what is discussed in detail in **Section VII**). A new product moves from discovery to testing and then to product launch so it is available to physicians or in the community. Both fields have a shared educational journey that conveys the process of product progression but through different lenses. Likewise, both fields consider drugs and medical devices, but they do so with different emphases. Students in the Biopharmaceutical field will focus on drug development and specific issues in commercialization (in particular the management of clinical trials and regulatory and regulatory issues with new drugs). DHT will focus on the analysis of data collected during clinical testing, and technologies used to support the drug experience of patients. Both fields have content that traces product development from inception to launch, but with different emphases on different topics appropriate for the field. Both learn technical skills that are appropriate to support the commercialization of these different product lines. DHT students are more focused on data analytics, and patient experience with the drug related technologies once on the market (e.g., technologies that tell us if the patient is using the drug at the right time and frequency), while Biopharmaceutical students are focused on how the drugs work, clinical trial design and marketing strategies.

The educational foundation for the MBiotech program is shared by both fields (**Appendix Ib** offers a basic overview). Such areas include basic marketing concepts, identifying a business case, critical evaluation of new technologies, applying the healthcare regulatory framework to new and controversial healthcare products, working in teams on projects, advanced technical training, presentations, experiential learning in industry and issues in market access and reimbursement for new health products. Each of these elements at the foundation of the MBiotech program involves variations in tools as appropriate for both fields. For example, students in the Biopharmaceutical field will learn the specific practices for market access and product regulation as it pertains to pharmaceuticals. DHT students, while they have basic exposure to such elements of the Biopharmaceutical field, will focus on medical device regulation (which covers digital health products) and market access practices that are specific for medical devices (conversely, biopharmaceutical students will have basic exposure to these areas). For advanced technical training, students in the Biopharmaceutical field experience

state-of-the-art laboratory courses to ensure they all have the same basic level knowledge of techniques in molecular biology and protein chemistry. Similarly, students in the DHT field will receive technical training in programming, advanced statistics and data visualization to provide them with the foundation to advance their training. Students in both fields will have options to complete courses in the other field if they meet course pre-requisites. Students in the Biopharmaceutical field will be able to complete elective elements of data science to build on their foundational training. Conversely, DHT students will be able to take electives from the Biopharmaceutical field that are more focused on drug mechanisms of action to build on their foundational training. Other foundational elements are identical between both fields. For example, both fields will learn how to communicate their respective domain areas effectively in presentations. Understanding a business case and applying basic marketing concepts are also identical for both fields (**Appendix Ib** for overview; **Section VII** for details).

Courses spanning business, digital tools, data science, experiential learning and healthcare will support the training of DHT students (see **Appendices Ia**, **Ib**, **II** and **III**). Two courses in data science will teach students advanced techniques in which to analyze large data sets associated with records of patient experience with a drug or medical device. The digital health course will take students through the regulation of drugs, medical devices and associated data transmission. To support these courses, students will also receive courses in programming and data visualization. Existing business courses in accounting and management will remain the core of both the Biopharmaceutical and DHT fields. For example, students will analyze customer experiences with medical devices (or drugs) from a large database to identify product issues and generate predictive algorithms for such health events.

As of the writing of this proposal, we have private sector interest in 15-21 internship positions across 13 companies, suggesting a need in industry for DHT students with the training we plan to provide. The experiential component of MBiotech, such as internships and company projects, strongly supports adding DHT as a field. In addition, every year the MBiotech program partners with two hospitals for projects (Sunnybrook Hospital and usually Toronto Western Hospital), half of which are in the DHT space. Adding DHT also allows MBiotech to expand the range of experiential opportunities for our students by engaging medical device companies; it is noteworthy that every medical device company we have contacted so far has expressed interest in offering internships in DHT (**Appendix IV**).

The rational for adding DHT to the MBiotech program follows from successful student projects observed over the past several years. DHT has overlapped with topics pertaining to biopharmaceuticals and projects have been created that included both elements. Students in the MBiotech program have done some outstanding work with DHT in the context of drugs (e.g., tackling electronic medical records in the context of biopharmaceuticals in blood transfusion care and presenting this to the Ministry of Health; tackling product design problems with medical data transmission for a large medical device company such as Medtronic). We have reached a point where there is now enough project activity in DHT that such projects would be better pursued and supported as a separate field within the program. In summary, MBiotech is a good home for DHT given that it has overlapping applications in biopharmaceuticals and there are existing and growing opportunities for student projects and

internships in this area.

The DHT field will ideally require a slightly different population of students than found in the current MBiotech program. While students in DHT may have less knowledge of biology upon entering the program than their Biopharmaceutical counterparts, they will have much stronger analytical (data) skills (e.g., statistics, programming, data visualization). This slight shift in recruitment criteria will allow us to select a population of students who will have the best foundation for their DHT training for both experiential and research opportunities.

Existing courses will make use of current academic staff who will provide 5.0 FCE of core MBiotech courses, including seminar and placement courses (**Appendix II**). In addition, two half courses (1.0 FCE) included in the proposed DHT field already exist in other programs and our students will be part of these environments (Information & Data Visualization in Science and Medicine MSC2019H; Introduction to IT Consulting and Web Design (BTC 1895H; cross listed). Program Directors and instructors for these courses have approved the participation of our students (see **Appendix I** and II). Six new courses (3.0 FCE) in the program will be offered largely through existing UTM faculty with two exceptions – a faculty member at the St. George campus will offer 0.75 FCE of the Data Science courses in collaboration with Jayson Parker, and a sessional lecturer will be hired for the Medical Device reimbursement course for the immediate future.

2 Effective Date

May 1, 2019.

3 Academic Rationale

Through the introduction of new digital health-specific courses and the adoption of existing courses from other programs, we are proposing to introduce a new Digital Health Technologies (DHT) field within the MBiotech program. The current MBiotech structure will remain unchanged and will be known as the Biopharmaceutical field. The proposed DHT field will allow us to build on our established core business and management courses to educate and train students with a strong quantitative background in the growing digital health area. It will also provide opportunities for existing Biopharmaceutical students to take some electives in the proposed DHT field, to build on topics for which they otherwise receive only a basic introduction (e.g., new courses in medical device reimbursement or in data analytics).

Digital Health Technologies apply to a wide range of product areas including medical apps, electronic medical records, wearable technology (health, fitness, medical), medical implants, mobile health, analytics of biometric data, and solutions and diagnostics that interact with external devices that can be used to support the use of a drug. Social media in a health and medical context displayed on these devices will also be included. While these are product area examples, the underlying skill sets rest in three main areas: data science, business and

health/regulatory. The proposed new DHT field will be different than the present M.Biotech program (the Biopharmaceutical field) in its focus on medical devices, especially those used with drugs, and on data analytics. The proposed field will recruit students with advanced quantitative training and provide additional advanced statistical training (e.g., machine learning). In addition, the new field will train students in advanced data visualization and programming to support their field. Lastly, while students in the Master of Biotechnology program are focused on life threatening and serious diseases, the new proposed field will extend this scope to include related areas such as health, wellness and physical fitness.

DHT is a recent development in our society and it is still evolving. The proposed field will build upon the trend of combining training in biology in a health and chronic disease context, with advanced statistical analytical tools such as machine learning tools. Currently, there is a tendency to keep these isolated in their respective silos, where biologists examine medical technology from a clinical perspective and statisticians analyze the data from these devices. The DHT field will combine biology with machine learning tools to tackle the problems posed by digitization of healthcare (e.g., drug use) and wellness. Data visualization is an emerging discipline and an immediate opportunity exists to build on the program's foundational training in displaying data for analysis. Data visualization training in the DHT field will build on the foundational training in the program to support the development of the student's ability to use analytical tools on vast complex data sets from the increasing digitization of both healthcare and health and wellness.

Appropriateness of field name. Digital Health Technologies encompasses a broad set of technologies. It gives us the flexibility to iterate the curriculum in step with changes in the field as they occur.

Distinctiveness – innovative aspects.

1. To our knowledge, Digital Health Technologies as a professional field has no equivalent at a university in Canada. Internationally, to our knowledge, there are very few programs. Tufts University in the US offers a certificate in Digital Health Communications; otherwise, there are various start-up incubators with similar titles but little by way of academic programs.
2. Advanced statistical training involving techniques in machine learning and neural network applied to a health setting will be distinctive to this professional program. Our students will combine domain knowledge of medicine and health with advanced data analytics tools to tackle large data sets.
3. While not unique, it is unusual for a program focused on "health" to simultaneously consider chronic conditions, health and wellness, aging at home and physical fitness. This is a shift from the Biopharmaceutical field in MBiotech which is focused on serious medical conditions, with some exposure to health and wellness. Exposure to these health topics will be through lectures, class projects, company internships and class discussion.
4. Product regulation in Canada and the US is reviewed not just in the context of medical devices, but also for a full range of health related software (apps, electronic medical records, wearable technologies).

5. Students in the proposed field will follow the current academic model for the MBiotech program – they will complete the same core courses as well as an 8-12 month industry internship, giving them valuable professional experience.
6. The overarching theme of the new field is also unique given the additional topics that support the focus of the field: privacy in data analysis, data cleaning, data visualization, programming and data governance.

Please see **Appendix I** for an overview.

Fit of DHT with Current MBiotech Academic Structure

The proposed DHT field is a good fit within MBiotech given the shared program learning outcomes with the existing Biopharmaceutical field (**Section VII** for program learning outcome details; **Appendix Ib** for basic overview from an industry perspective). Though the DHT field will share the same core program learning outcomes, the distinction will be in how some of these outcomes are achieved. The regulatory training in both fields will be very similar but DHT emphasizes content pertaining to life science software and medical devices, along with privacy protection. The critical thinking application for DHT students will be seen in the analysis of health data sets in the context of a health product; in contrast, for Biopharmaceutical students their critical thinking is applied to clinical trial design for drugs.

DHT professionals and their associates will place a great deal of emphasis on skills in data manipulation and analysis. Our training will position DHT students to not only achieve the program learning outcomes, but also to realize the expectations of DHT professionals. DHT students will learn to understand the health and medical context of a problem and demonstrate depth of knowledge in their capacity to work with data. This emphasis builds upon the foundational introduction students in the program currently receive in analyzing data.

The depth and scope of the training required for DHT students to achieve the DLEs and program learning outcomes necessitates new courses. For example, before our students can manipulate large health data sets, we must ensure that everyone is familiar with basic programming and advanced data visualization and statistical techniques. We will have a dedicated statistics course that will review programming in the context of data science in health. Such dedicated courses will provide students the opportunity to fully explore the depth of these DHT topics beyond the basic introduction that exists in the current program.

In summary, the goals of the MBiotech program will be supported by both fields as it pursues its brand of “science meets business” in a health context.

4 Need and Demand

Employment & Societal Need Trends:

1. An assessment of demand has been based in part on the interest of local companies in offering internships to students trained in DHT. So far, of the twelve companies in the Mississauga and GTA area we have approached on this topic, all of them have expressed some interest with the possibility of taking on at least one student internship for a period of

8-12 months (**Appendix IV**). We consider this a "focus group" that in part addresses demand for students trained in DHT as described in our proposal. It is important to note that even companies that were reluctant initially were interested once they heard the DHT curriculum. This also speaks to employment opportunities (**Appendix IV**).

2. In the US, revenues from digitally enabled health services rose more than 400% since 2010 compared to 2015, from 1.5 billion annually to over 5.5 billion annually. Such growth portents job creation and that speaks to employment opportunities for our students. https://www.parksassociates.com/blog/article/digitalhealthindustry-pr2011
3. Rock Health, a leading health incubator in the US, identified its top 6 funding categories of 2014 with three of these categories belonging to digital health: analytics/big data, digital medical devices and telemedicine. Trends within start-up companies are often a leading indicator of future employment trends. In this case, Rock Health suggests strong growth in employment opportunities in digital health. http://hitconsultant.net/2015/01/13/top-5-digital-health-categories-poised-for-growth-in-2015/
4. The US Centre for Disease Control (CDC) has reported that electronic medical record system use in physician offices has climbed from 18% in 2001 to 78% in 2013, representing a fourfold increase. Electronic medical records are a classic example of digital health technology and such growth is usually accompanied by job creation, another positive employment indicator for our DHT proposal. http://www.cdc.gov/nchs/products/databriefs/db143.htm
5. The wearable technology market (Fitbit, iWatch, etc.) more than doubled from 2012 to 2015 in terms of global revenues (now over 5 billion dollars). This growth demands experts with direct industry experience, such as the professionals produced by the MBiotech program. http://www.statista.com/statistics/302484/wearable-technology-market-value/
6. Over 80% of physicians (US) use smartphones at work. Smartphones are really "infrastructure" for our digital health age, an enabler of a myriad of digital health products that are here and coming. This trend again points to the need for experts in the digital health field, indicating a positive employment outlook for our DHT graduates. http://mobihealthnews.com/32232/in-depth-mobile-adoption-among-us-physicians.
7. The US Food and Drug Administration, the global leader in product regulation, has announced it will create a dedicated unit for digital health. http://www.raps.org/Regulatory-Focus/News/2017/05/04/27484/FDA-to-Create-Digital-Health-Unit/
8. Nature, one of the leading international science journals, is about to launch a sister journal in this area called Digital Medicine. https://www.nature.com/npjdigitalmed/

Below are a few examples of journals dedicated to different aspects of digital health, with their impact factors:

Description	Impact Factor
Telemedicine and e-Health	2.03

Journal of Telemedicine and Telecare	2.00
Journal of Medical Systems	2.50
Journal of Internet Medical Research (JMIR)	5.1
Journal of Internet Medical Research mHealth and uHealth (JMIR mHealth and uHealth)	(new journal)

In short, big data in health and the digitization of health systems and products is becoming part of the mainstream consumer experience. There are a number of indicators which show robust growth that point to expanding employment opportunities and increasing demand for experts in the digital health space such as the growth of electronic medical records, digital health revenue generation as an industry group, start-ups in digital health and wearable technology. Locally, we have engaged 9 companies regarding paid internships for our DHT students and all of them have expressed interest. Preparing students for employment (or research) in digital health will require a combination of dedicated courses that allow them to: work with big data in a health context, utilizing advanced machine learning techniques; acquire regulatory training focused on health & medical software; acquire basic data visualization and basic programming skills; and engage with projects that provide practice in combining these skills to address problems.

Student Interest

An online survey was sent out in Summer 2016 via "Survey Monkey" to students in various departments at UTM to assess interest in a Digital Health Technology field within the MBiotech program. Our current student survey results (n=100) across several departments indicate that 35% of respondents are definitely interested in enrolling in the field while 49% are "possibly" interested. More than 75% of respondents have a focus in quantitative training with at least 2 courses of statistics in their degree. Most respondents (64%) were senior undergraduates with 78% of total respondents from computer science. After computer science undergraduates, biology and statistics yielded 16% of the respondents.

Thus far, it appears this field will appeal to students outside the realm of biology and to other disciplines needed for this area of specialization (such as computer science). We do acknowledge that there are problems of sample bias, since those likely to take the time for this survey may be inherently interested in the subject matter.

Enrolment Projection

Each year the MBiotech program accepts 42 students. This proposed field would eventually add 16 students per year to the program. We anticipate that we will achieve three-quarters maximal enrolment in the first year of this new field (2018), with a steady state of 32 total DHT students reached in 2022 (116 total MBiotech students; see Table 1 below). At this juncture, we are not planning to expand the size of DHT beyond this level, as this would necessitate other changes to shared courses that would complicate the launch of this new field within the MBiotech program.

For courses that will host students in both MBiotech fields, we have confirmed there is not a capacity issue. The shared courses are Management courses and these departments and instructors have confirmed that the increased enrolment can be fully accommodated. The

number of internships being offered in the MBiotech program has increased to roughly 70 annually but MBiotech can only fill 42 of these positions. Moreover, 8-12 of these internships are already digital health positions. Thus, we feel that we can make use of existing internship demands to successfully launch the DHT field within the MBiotech program.

Table 1: Graduate Enrolment Projections*

Program Year	2018-19 Academic Year		2019-20 Academic year		2020-21 Academic year		2021-22 Academic year		2022-23 Academic year	
	Bio-pharma Students	DHT Students	Bio-pharma Students	DHT Students	Bio-pharma Students	DHT Students	Bio-pharma Students	DHT Students	Bio-pharma Students	DHT Students
1	42	0	42	12	42	14	42	16	42	16
2	42	0	42	0	42	12	42	14	42	16
International students	2		2		2		2		2	
Field Total	84	0	84	12	84	26	84	30	84	32
Program Total	84		96		110		114		116*	

**Steady State projected in 2022-23*

5 Admission Requirements

Admission requirements for the DHT field:

1. **A four year bachelor degree with a minimum "mid-B" (75%) average in the last 2 years of study.** This is the same as the current MBiotech program, Biopharmaceutical field.
2. **Undergraduate Degree program (or graduate degree) can be from a wide range of disciplines such as, but not limited to: biology, public health, statistics, computer science, engineering, chemistry, engineering, epidemiology, psychology or sociology.** This is a bit broader than the current MBiotech program, where sociology, statistics and psychology students would not have been considered. For our current Biopharmaceutical field, students in MBiotech are focused on drugs, and require academic training in cognate areas. The quantitative talent we are looking for in the digital health field for data science can be found across a wide range of disciplines. In addition, many of these disciplines bring content that, while not relevant for drug development, can be very relevant for aging at home, fitness, chronic illnesses and health and wellness.
3. **Strong quantitative training. This can be illustrated by at least 4 courses in the**

physical life sciences (e.g., chemistry, physics) or 2 courses in statistics or related quantitative disciplines such as econometrics or math. This can be judged on a *case-by-case* basis. This is a new requirement that is different for students in the current Biopharmaceutical field of the MBiotech program. Data science plays a central role in digital health technology. Cloud based technology (using remote rather local servers to store and analyze data) in health is there to support efforts in big data science.

4. **No prior knowledge of programming or business is assumed or required. Some exposure to biology is required (four courses in life sciences or related discipline).** This is different than the current Biopharmaceutical field of the MBiotech program in that we are not requiring a prior degree in biology or a related degree. There will be differences among students we recruit, but they will all share a common foundation of strong quantitative training. Students who possess an advanced background in biology may be a good fit for biopharmaceutical companies, while an analytical chemistry student may be a good fit for a firm that works with drug analog data. Engineering students are of interest to medical device companies. Computer science students, and those who excel at advanced statistical modelling, may be a good fit for firms looking to bridge needs across areas of their product lines through their customer database in both biopharmaceutical and medical device companies. Candidates must have demonstrable exposure in the *life sciences*. For greater clarity, life sciences shall include biochemistry, molecular biology, cell biology, biological chemistry, organic chemistry, immunology, genetics and other biological subjects at the discretion of the Program Directors.

The administration of entrance requirements to determine suitable background for entry to the proposed field can be done using academic transcripts. For #3 above, some cases will require closer scrutiny of the letter of intent and resumé of the applicant. As is done for the MBiotech program currently, applicants will be required to participate in an interview process to complete their application.

In-progress MBiotech Students at the time of potential DHT approval. If this proposal is approved, in-progress students in the MBiotech program would *not* have the option of switching from their current drug field to the DHT field. Students already in the program would have embarked on core courses for BioPh field and there would not be time for them to take core courses in the DHT field within the 2 year time period of this degree. In addition, a student in progress would not have the option of completing the degree and then embarking on an additional field (this may be possible in the future, but for now, to keep things simple administratively this is our approach).

Transcripts. Depending on which field students are in within the MBiotech program, would be denoted on their transcripts beside MBiotech (DHT or BioPh).

6 Program Requirements

Please see **Appendix II** for a full list of the course numbers and titles, including clear indications of whether courses are new or existing. Please see **Appendix V** for proposed calendar copy.

Program Requirements. Both fields will require completion of 9.0 FCE over the two year program. In the existing Biopharmaceutical field, required courses make up 8.0 FCE with the remaining 1.0 FCE being elective options. In the DHT field there will be 8.5 FCE of required courses and 0.5 FCE will be an elective chosen by the student. Electives include options for completion of courses in the other field from that being followed by a student. See below for a list of core and elective courses in the program (broken down by field). A full, detailed outline of the academic pathway for the DHT field is provided in Appendices II and III and is listed below.

The core courses for both fields cover related content. The Biopharmaceutical ("drug") field core and the DHT field core have in common most of the business courses, the internship requirements and the seminar series courses. The remaining content is presented in different courses for each field to reflect different emphases. The Biopharmaceutical field teaches stages of drug development, drug (emphasis) and medical device regulation, clinical trial design and drug action through the molecular biology laboratory, and courses in biotechnology in medicine and biomaterials and protein chemistry theory. The DHT field covers similar content by looking at regulation (with a medical device/software emphasis), drug development to provide a framework to understand major steps in medical device/software development, clinical trial design to provide the context for data output that will be analyzed (emphasis on data analysis), and drug action basics (not as technically detailed as the drug field), through courses in Digital Health Technologies, Data Science and Digital Ethnography in health. Technical training between the fields is different with Biopharmaceutical students learning laboratory technique in 2 courses (Molecular Biology Laboratory; Biomaterials and Protein Chemistry theory) while the technical training of DHT students involves programming and advanced statistics (Special Topics in Biomedical Communications; Data Science Part I and Part II). The differences in technical training converges in later subject matter as Biopharmaceutical field students look at problems with an emphasis on drug action while DHT students look at the same problem with an emphasis on the analysis of clinical data for the same drug.

Required Courses:

1. Core for the MBiotech Program (taken by students in both fields)

BTC 1600H	Biopartnering I
BTC 1610H	Biopartnering II
BTC 1900Y	Work Term I (Internship)
BTC 1910Y	Work Term II (Internship)
BTC 2000H	Effective Management Practices
BTC 2010H	Fundamentals of Managerial Concepts
BTC 2030H	Management of Technological Innovation

2. Core for Biopharmaceutical Field

BTC 1700H	Molecular Biology Laboratory
BTC 1710H	Biomaterials and Protein Chemistry Theory
BTC 1720H	Biomaterials and Protein Chemistry Lab
BTC 1800H	Biotechnology in Medicine
BTC 1810H	Biotechnology and Drug Manufacturing
BTC 1820H	Biotechnology in Agriculture and Natural Products
BTC 2020H	Society, Organizations, and Technology

3. Core for Digital Health Technologies Field

BTC 1842H	Medical Device Reimbursement (**New**)
BTC 1859H	Data Science in Health I (**New**)
BTC 1877H	Data Science in Health II (**New**)
BTC 1882H	Digital Ethnography in Health (**New**)
BTC 1895H	Introduction to IT Consulting and Web Design (**New**)
BTC 1899H	Data Science & Digital Health Technologies (**New**)
MSC 2011H	Introduction to Computer Programming for Non-Programmers (Special Topics in Biomedical Communications)
MSC 2019H	Information & Data Visualization in Science & Medicine

Elective Courses:

Electives are also listed in **Appendix VI** and are overlapping for both fields of study in the MBiotech program.

1. Electives for the MBiotech Program

BTC 1830H	Medical and Scientific Marketing
BTC 1840H	Patent Law for the Life Sciences
BTC 1850H	Creating Life Science Products
BTC 1860H	Generations of Advanced Medicine: Biologics in Therapy (GAMBiT)
BTC 1920Y	Work Term III
BTC 2040H	Change Management
BTC 2100Y	Topics in Biotechnology
BTC 2110H	Topics in Biotechnology
BTC 2120H	Topics in Biotechnology

7 Degree Level Expectations, Program Learning Outcomes and Program Structure

For brevity in the table below, the Biopharmaceutical field is abbrieviated as BioPh. Master's Degree Level Expectations in the first column are based on Ontario Council of Academic Vice Presidents (OCAV) Degree Level Expectations.

Table 2: Master's DLEs

MASTER'S DEGREE LEVEL EXPECTATIONS based on (OCAV) DLEs	**MASTER'S PROGRAM LEARNING OBJECTIVES AND OUTCOMES**	**HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES**
EXPECTATIONS: **This Master of Biotechnology is awarded to students who have demonstrated the following:**		
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.	In order to graduate from the MBiotech Program, students will have achieved the following primary Learning Objectives: a) Established a breadth of knowledge across the molecular life sciences, clinical research, data analysis, financial accounting and reporting, marketing, technology commercialization and entrepreneurship that cut across the science and business disciplines, and include a range of non-technical areas to facilitate successful networking and social awareness. b) Integrated skills and knowledge developed in a student's course of study through at least one internship placement, which involves the synthesis and application of course-based learning in the realistic context of a workplace environment that prepares graduates for a career in the biotechnology industry sector. c) Identified the value proposition created by science in industry and facilitate the commercialization of scientific discoveries. d) Developed ability to explain fundamental concepts across science and business disciplines, including molecular life sciences, clinical research, financial accounting and reporting, marketing, technology	The program design and requirement elements that ensure these student outcomes for depth and breadth of knowledge are as follows: — Both BioPh and DHT students hold 8-12 month internships in industry, with firms involved in various aspects of digital health; this provides experiential learning for students to consolidate course-based learning — Both BioPh and DHT students learn what business cases and value propositions are and how to be critical of a claimed business case in their core accounting and business courses (Fundamentals of Managerial Accounting and Society, Organization and Technology), where students develop and critique business cases. — Product safety concepts will be introduced and applied, for DHT students in the courses Data Science & Digital Health Technologies and Digital Ethnography in Health, and for BioPh students in Biotechnology in Medicine. Students in both fields are assessed on the ability to critique papers on this issue as well as formulate solutions to address problems in this area. — Product Regulation for drugs and medical devices is covered for both BioPh and DHT students as part of commercialization. This is assessed both in exams and in application in their major projects (knowledge interpretation; critical evaluation; sustained argument). This comes up in Digital Health Technologies (DHT) and Biotechnology in Medicine (BioPh) courses. — Commercialization stages of drugs and new technologies are assessed in exam

MASTER'S DEGREE LEVEL EXPECTATIONS based on (OCAV) DLEs	**MASTER'S PROGRAM LEARNING OBJECTIVES AND OUTCOMES**	**HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES**
	commercialization, drug and medical device commercialization and regulation and entrepreneurship. BioPh: Explain the fundamental concepts of drug commercialization and regulation. **DHT:** Explain the fundamental concepts of medical device and medical software commercialization and regulation. BioPh: Explain the fundamental concepts of drug reimbursement. **DHT:** Explain the fundamental concepts of medical devise reimbursement. BioPh: Access information about drug-related adverse events. **DHT:** Access information about medical device-related adverse events. BioPh: Analyze social media content for medical marketing insights **DHT:** Analyze social media content with software tools for medical marketing insights	settings, oral presentations and in major projects (knowledge interpretation; critical evaluation; sustained argument). This is covered in the core program Biopartnering course series Part I and Part II. Projects with hospitals and industry for DHT and BioPh students occur in the courses Digital Health Technology and Biotechnology in Medicine, respectively. — Health product reimbursement: BioPh students and DHT students learn about this in Biotechnology in Medicine and Medical Device Reimbursement courses respectively. They apply this knowledge in major projects and are tested in exams on this material (knowledge interpretation; critical evaluation; sustained argument). Both fields are exposed to both drugs and devices with different emphases. — Accessing safety events for products: DHT students learn this for devices in Digital Health Technologies and BioPh students in Medical Biotechnology courses, respectively. — Basic marketing concepts are introduced in the core program management course Fundamentals of Managerial Concepts (BTC2010). Assessment is through case study analysis and examination settings (critical thinking; originality). — Social media feed analytics are explored by both BioPh and DHT students at a foundational level in the core program course Biopartnering Part I. DHT students have additional training in the course Digital Ethnography in health. Assessment is in major project presentations for both courses (critical thinking; originality).
2. Research and Scholarship A conceptual understanding and	In order to graduate from the MBiotech Program, students will have achieved the following primary Learning Objectives: a) Competencies in learning and	The program design and requirement elements that ensure these student outcomes for research and scholarship are: — Critical and creative thinking assessed for both fields in core program course

MASTER'S DEGREE LEVEL EXPECTATIONS based on (OCAV) DLEs	**MASTER'S PROGRAM LEARNING OBJECTIVES AND OUTCOMES**	**HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES**
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.	applying knowledge to solve problems facing industry, and that are fundamental to responsible and effective participation in the workplace, in the community, in scholarly activity, and in personal life, including: • Critical and Creative Thinking • Quantitative Reasoning • Information Literacy b) Ability to explain and critique clinical and pre-clinical trial design and outcomes. BioPh FIELD: Interpret and analyze clinical data and clinical trial design and outcomes. **DHT FIELD:** Interpret and analyze clinical data with statistical modeling. c) Ability to access, select, summarize, and communicate data and information from different scholarly and business sources, and make evidence-based informed decisions. d) Ability to analyze and interpret data using a variety of quantitative methods, and interpret and critique published analyses. BioPh FIELD: perform foundational data analysis. **DHT FIELD:** analyze and clean large complex unstructured data sets in health. **DHT FIELD:** build statistical models with the aid of programming for data	Biopartnering Part I and Part II major projects with oral presentations. The BioPh field will have additional exposure in the courses Biotechnology in Medicine and Molecular Biology Laboratory, and the DHT field in the courses Data Science Part I and Part II and Digital Health Technology. Major projects and oral presentations part of the assessment (critical thinking; originality). — Quantitative Reasoning. Both DHT and BioPh field students engage in oral presentations and major projects involving quantitative reasoning in the core courses Biopartnering Part I and Part II. In addition, the core course Fundamentals of Managerial Concepts supports this goal. This is also supported for BioPh students in Biotechnology in Medicine, and for DHT students in Data Science Part I and Part II. — Clinical data analysis. For both fields, the core program course Biopartnering Part I supports this goal. For BioPh students Biotechnology in Medicine and for DHT students Digital Health Technology further support this goal. Both involve major projects that require quantitative reasoning with clinical data. — Accessing and selecting information from different scholarly courses. For both DHT and BioPh students this is supported by the core courses Biopartnering Part I and Part II. For BioPh students this supported by the courses Biotechnology in Medicine and Molecular Biology laboratory, and for DHT students by the courses Digital Health Technologies and Digital Ethnography in Health. Major projects, oral presentations and examinations take place in all these courses. — Analyze and interpret data with a variety of quantitative methods. For both BioPh and DHT fields, the core courses Biopartnering Part I and Part II support this goal. For BioPh students, the courses Molecular Biology laboratory,

MASTER'S DEGREE LEVEL EXPECTATIONS based on (OCAV) DLEs	**MASTER'S PROGRAM LEARNING OBJECTIVES AND OUTCOMES**	**HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES**
	analysis and predictive analytics in health.	Biotechnology in Medicine, and Biomaterials and Protein Chemistry help support this goal. For DHT students, the courses Data Science Part I and Part II, and Digital Ethnography in Health help support this goal. — Foundational data analysis for BioPh students is supported by the courses Biopartnering Part I and Biotechnology in Medicine. Major projects and examinations are used for assessment. For DHT students, analysis of large data sets by creating statistical models with programming is supported by the courses Data Science Part I and Part II, and Special Topics in Biocommunications (programming). Major projects, tutorials and presentations all are used for assessment.
3. Level of 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.	In order to graduate from the MBiotech Program, students will have achieved the following primary Learning Objectives: a) Accumulated a depth of experience working in a professional industry environment through the completion of internship opportunities. b) Demonstrate critical thinking and creative thinking through the solving of complex science-based problems facing industry. c) Apply and demonstrate quantitative reasoning **DHT FIELD:** apply a range of complex statistical tools for data analysis and decision making in health. d) Apply business concepts to scientific and technical content to make decisions at the	The program design and requirement elements that ensure these student outcomes for level and application of knowledge are: — Both BioPh and DHT students hold 8-12 month internships in industry with firms involved in various aspects of digital health, providing students with experiential learning to consolidate what they have learned in courses. — Students in both fields learn what business cases and value propositions are and how to be critical of a claimed business case in their core program accounting and business courses (Fundamentals of Managerial Accounting and Society, Organization and Technology). Students will develop and critique business cases in the core program course Biopartnering Part I. — Knowledge of commercialization stages of drugs and new technologies is assessed in exam settings, oral presentations and in major projects (knowledge interpretation; critical evaluation; sustained argument), in the core Biopartnering series courses Part I

MASTER'S DEGREE LEVEL EXPECTATIONS based on (OCAV) DLEs	**MASTER'S PROGRAM LEARNING OBJECTIVES AND OUTCOMES**	**HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES**
	intersection of science and business.	and Part II. Projects with hospitals and industry for DHT and BioPh students occur in the courses Digital Health Technology and Biotechnology in Medicine, respectively. — Health product reimbursement. BioPh students and DHT students learn about this in Biotechnology in Medicine and Medical Device Reimbursement courses, respectively. They apply this knowledge in major projects and are tested in exams on this material (knowledge interpretation; critical evaluation; sustained argument). Both fields are exposed to both drugs and devices with different emphases. — Accessing safety events for products. DHT students learn this for devices in Digital Health Technologies and BioPh students in Medical Biotechnology courses. — Basic marketing concepts will be introduced in the core program management course Fundamentals of Managerial Concepts (BTC2010). Assessment is in case study analysis and examination settings (critical thinking; originality). — In the DHT field, knowledge of application of statistics to problems in health is supported by the courses Data Science Part I and Part II and Digital Ethnography in Health. — Critical thinking to solve science based problems in industry/hospitals, is covered for both fields in the core program course Biopartnering Part I. For BioPh students this also occurs in the course Biotechnology in Medicine. For DHT students this occurs in the course Digital Health Technologies and Digital Ethnography in Health.
4. Professional Capacity/Autonomy a. The qualities	In order to graduate from the MBiotech Program, students will have achieved the following primary Learning Objectives:	The program design and requirement elements that ensure these student outcomes for professional capacity/autonomy are:

MASTER'S DEGREE LEVEL EXPECTATIONS based on (OCAV) DLEs	**MASTER'S PROGRAM LEARNING OBJECTIVES AND OUTCOMES**	**HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES**
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 behavior 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.	a) Competencies in learning and applying knowledge to solve problems facing industry, and that are fundamental to responsible and effective participation in the workplace, in the community, in scholarly activity, and in personal life, including ethical thinking and decision-making. b) Ability to apply the concepts of liability, confidentiality, obligations of employment contract, privacy, and intellectual property. c) Ability to effectively mentor, coach, and critique peer performance. d) Ability to perform professional duties with integrity and in accordance with ethics. e) Ability to develop and demonstrate professional workplace practices in both science and business contexts, including privacy, confidentiality, transparency, data governance and scholarship. BioPh FIELD: Demonstrate professional workplace practices regarding privacy. **DHT FIELD:** Demonstrate professional workplace practices regarding data governance.	— Mentoring and critiquing peers occurs for both fields in Biopartnering Part I and Biopartnering Part II. BioPh students are also exposed to this in Biotechnology in Medicine. DHT students will be exposed to this in the Digital Heath Technologies course. The methodologies used in major projects for assessment also supports this learning expectation. — Ethical thinking, understanding of privacy, and decision-making processes related to both are supported for both fields by the core program courses Effective Management Practices and Biopartnering Part I. For BioPh students this is also supported by the course Biotechnology in Medicine, and for DHT students by the course Digital Ethnography in Health. Methods used in the major projects for both fields additionally form part of the evaluation process that supports this learning expectation. — Integrity and professional workplace practices. This is supported by their internship placements for both fields. This expectation is supported by employer feedback and site visits by our corporate liaison for the program. Training in best practices is provided through faculty (Revers & Parker). — Data governance for DHT students will be supported by the courses Data Science Part I and Part II. This knowledge will be tested in examinations and assessed in major project work.
5. Level of Communications Skills The ability to communicate ideas, issues and conclusions	In order to graduate from the MBiotech Program, students will have achieved the following primary learning objectives: a) Competencies in learning and applying knowledge to solve problems facing industry, and	The program design and requirement elements that ensure these student outcomes for level of communication skills are: — Team work. For both fields this is supported by the core program courses Effective Change Management and

MASTER'S DEGREE LEVEL EXPECTATIONS based on (OCAV) DLEs	**MASTER'S PROGRAM LEARNING OBJECTIVES AND OUTCOMES**	**HOW THE PROGRAM DESIGN AND REQUIREMENT ELEMENTS SUPPORT THE ATTAINMENT OF STUDENT LEARNING OUTCOMES**
clearly.	that are fundamental to responsible and effective participation in the workplace, in the community, in scholarly activity, and in personal life, including: • Oral and Written Communication • Team work b) Ability to communicate scientific knowledge, technical knowledge, and business cases to diverse audiences and stakeholders in written, oral, and visual forms. c) Ability to present and visualize complex data and/or results in creative ways to communicate data effectively to diverse stakeholders. **DHT FIELD:** display and Visualize and increasingly complex data sets using a range of tools. d) Ability to work both independently and collaboratively in teams across different science and business contexts.	Biopartnering Part I and the internships. For BioPh students this is also supported by the Molecular Biology Laboratory and Biotechnology in Medicine courses. For DHT students this is supported by the courses Digital Ethnography in Health and Digital Health Technologies. Major project presentations have various milestones providing assessments of team effectiveness and difficulties. — Oral and Written Communication. For both fields this is supported by the core courses Biopartnering Part I and Part II and Effective Management Practices. For BioPh students this is supported further by the courses Molecular Biology Laboratory, and Biomaterials and Protein Chemistry laboratory. For DHT students this is further supported by courses in Digital Health Technologies, and Data Science Part I and Part II. All courses have written assignments and oral presentations for assessment. — Presenting visual data in creative ways. For both fields, the core program course Biopartnering Part I supports this learning expectation. For BioPh students this is also supported by the course Biotechnology in Medicine, and for DHT students this supported by the course Information and Medical Data Visualization. Oral presentations and written assignments provide the means for assessment. — Working independently and collaboratively in teams across fields. This is supported for both fields by courses Effective Management Practices; Management of Technological Innovation and internship courses. Written assignments, major projects and oral presentations are used for assessment.

8 Assessment of Teaching and Learning

1. Tutorials. A series of problem sets will be used in several courses. These tutorials would be done in both teams and as individual tasks. The problem sets will test the ability of the student to: program in both R and Java, analyze small and large data sets, visualize data, critically evaluate misleading conclusions about data and compose text that conveys a complex subject matter to a lay person. Most often these are take home problem sets, which will be evaluated a week or so later in the tutorial session for the course. The tutorials will be graded by the course instructor but also may be subject to peer evaluation in the class setting, as appropriate for the course. These assessments apply to Application Level Knowledge and Research and Scholarship in the DLE categories above. This evaluation supports learning objectives of analyzing clinical data, application of statistics, application of programming, critical thinking, data visualization and working with large data sets.

2. Major projects. Major projects in a number of courses will expose students to some basic research skills. There will be large data sets that they must tackle, and in this process, generate and identify trends/ patterns in the data. Students will take this further by framing hypotheses about what to expect as the data set expands, based on the trends identified. These data sets will be novel and will originate both from an academic research setting and from industry partners. The combination of massive data sets derived from both academic research settings and from industry, helps foster application of program concepts. Evaluation will be through a panel of both faculty and industry partners, each with their respective expertise with the data sets. These assessments apply to Application Level Knowledge, Research and Scholarship, Depth and Breadth of Knowledge and Professional Capacity DLEs. Given the role of critical thinking, data analysis, sourcing of research material, data visualization, application of quantitative reasoning in these major projects, these two Degree Learning Expectations are well supported by this category of assessment. Professional capacity develops from the integrity and professionalism with which students gather opinions from experts in the field, how they work with hospital and industry stakeholders and their conduct as a team. As major projects in commercialization, there is a large body of material that the students must formulate into a coherent picture, supporting the Depth and Breadth of knowledge DLE.

3. Presentations. This form of evaluation looks at the ability of the student to communicate both orally, and with data visualization techniques. The talks are a distillation of formal written reports that are also submitted, which cover content in much more depth. The emphasis for the talks themselves is on the capacity to present and engage the audience. A question period follows that involves both peers and a panel of experts from both faculty on campus and industry. The internship placements have their own presentations. This category of assessment applies to Professional Capacity and Communication DLEs. Communication is critical here both in written format and in oral presentations, providing ample means for assessment of student ability to fulfill the learning objectives. Professional capacity is demonstrated in oral presentations through the conduct of the student team in dealing with criticisms and how they portray themselves in the process of gathering information from experts.

4. Program self-evaluation. All stakeholders play key roles here. Students in our program are very vocal and there is ample opportunity to get feedback on the effectiveness of meeting our learning objectives. Program feedback from students comes in the form of course evaluation surveys, global surveys about the overall program and town hall styled feedback from the entire class in an open oral forum. Instructors provide feedback that lets us know if the students have been suitably selected in the first place, updating our interviewing techniques. In addition, instructor feedback informs us whether earlier foundational courses in the program are as effective as they should be in setting up the more specialized courses. Internship stakeholders (firms and public-sector institutions) provide direct feedback regarding student conduct and performance. In addition, our annual board meetings tap into student alumni, industry experts and internship companies, all of whom provide feedback on the success and weaknesses of our program and its fields.

9 Consultation

The following departments were consulted during the development of this field and proposal:

- Mathematical and Computational Sciences (UTM);
- Computer Science (St. George campus);
- Institute of Communications, Culture, Information and Technology (UTM);
- Psychology (UTM);
- MSc in BioMedical Communications Program (UTM);
- Faculty of Information;
- Master of Health Informatics (MHI) Graduate Program. Institute of Health Policy, Management and Evaluation;
- UTM Library Services;
- Department of Biology (UTM);
- Biomedical Communications (UTM);
- MD Program University of Toronto/Mississauga Academy of Medicine;
- Institute of Biomaterials and Biomedical Engineering (St. George Campus);
- Institute of Medical Science (St. George campus);
- Translational Research in the Health Sciences Program (St George campus); and
- Institute for Management and Innovation (UTM).

No concerns have been expressed about the program overlapping with any initiative ongoing or planned but some have expressed interest in seeing the latest draft of this proposal (e.g. Translational Medicine). A detailed inventory of consultations is available from the UTM Program and Curriculum Officer.

DHT has emerged organically from ongoing efforts in the MBiotech program over the past several years. Each year the MBiotech program partners with two hospitals to work on early stage technologies and problems in patient care. Most of the projects we have received in the course of these collaborations have involved medical devices and digital health. As a result,

some of our best success stories of student impact come from DHT topics. For example, when MBiotech students worked on the problem of creating a viable electronic record system, they received unanimous support from transfusion medicine directors across the Greater Toronto Area, and subsequently presented their proposal to the Ministry of Health. A private sector example involved finding a new application for portable ultrasound that would have proper reimbursement in our healthcare system. This caught General Electric's attention and they hired one of our students as a result. While more examples exist from MBiotech, these success stories illustrate what we can do in the absence of deeper training in DHT through dedicated courses. DHT gives us a chance to build upon company and hospital interest in our program, and better position our students to successfully address real problems supported by a curriculum that provides content to support such projects. DHT is a natural fit for MBiotech that builds upon a pre-existing trajectory of success in this area.

Our current student survey results (n=100) across several departments indicate that 35% of respondents are definitely interested while 49% are "possibly" interested. More than 75% of respondents have a focus in quantitative training with at least two courses in statistics in their degree. Most respondents were senior undergraduates (64%). 78% of total respondents are from computer science. Departments responding included, but were not limited to, computer science, engineering, biology and psychology.

10 Resources

With the exception of two lecturers (one instructor for Data Science in Health Part I and as co-lecturer for Data Science in Health Part II; and the second lecturer for Medical Device Reimbursement) all other resources are present at UTM and are already in place or involve new offerings via Jayson Parker (Dept. of Biology), who has teaching capacity for these new courses. Data science in Health Part I will be taught Nicholas Mitsakakis from the St George Campus and he would then proceed to co-lecture the next data science course (Data Science in Health Part II) with Jayson Parker (full appointment in MBiotech). Data Science in Health Part I and Part II are two different courses (Part I; Part II) each worth half a credit.

A new full-time administrative staff position (100% FTE) is required as a corporate liaison and/or business development officer for this initiative to deal with co-op placements and arrangements of academic interactions with companies. In addition, there will be a need for an Associate Director to specifically focus on the DHT program. Jayson Parker has recently been promoted to Associate Director in MBiotech, and is meant to transition his responsibilities from the current program and work on the proposal of DHT, to one focused on DHT if this proposal is approved.

The proposed new Digital Health Technologies field will not affect any current existing agreements with other institutions and will not require the creation of any new agreements.

We requested and have been granted a new research-stream hire in the Department of Management, cross-appointed to IMI, and specializing in the emerging field of digital health.

This would add to the domain knowledge of our program and help establish its credibility and provide management with resources to help deliver this field. This new hire would start July 1st 2019 and would teach Fundamentals of Managerial Concepts and Management of Technological Innovation (second session dedicated to DHT students in both cases).

10.1 Faculty Complement

Please see **Appendix II** for a table that outlines current and proposed teaching assignments and faculty associated with the new field. Existing graduate courses will be used in combination with a few newly developed courses specifically for this field, as shown in **Appendix II**.

This new field will help enrich the existing program by offering new courses and bringing in new related content that allows us to expand in far more structured way into medical devices and medical software. Until now these have been peripheral topics, and we have lacked critical mass to develop these topics properly in the program and give real field options to prospective students for their training.

Table 3: Detailed Listing of Committed Faculty for the MBiotech Program (Biopharmaceutical & Digital Health Fields)

Faculty name and rank	Unit of Primary Budgetary Appointment	Unit of Other Budgetary Appointment	Unit of Graduate Faculty Membership	Area(s) of Specialization
Ann ARMSTRONG, Lecturer	Rotman School of Management; IMI		Leadership, Higher and Adult Education	Organization behaviour, team practices
Micheal CORRIN Assistant Professor, Teaching Stream	Biology, IMI, UTM		Biotech	Design of optimized virtual environments for teaching
Jodie JENKINSON, Assistant Professor, Tenure Stream	Biology, IMI, UTM		Medical Science	Data visualization, Web based health communication
Ulrich KRULL, Professor, Tenure Stream	Chemical & Physical Sciences, IMI, UTM		Chemistry, Management of Innovation	Biological and Bioanalytical Chemistry
Nicola LACETERA, Associate	Management, IMI, UTM		Management, Tri-campus	Strategic Management

Faculty name and rank	Unit of Primary Budgetary Appointment	Unit of Other Budgetary Appointment	Unit of Graduate Faculty Membership	Area(s) of Specialization
Professor. Tenure Stream				
Rhonda MCEWEN, Assistant Professor Tenure Stream	Culture Communications Information and Technology (CCIT), UTM		Information Studies	User interface design, social/new media, mobile communication, tablet computing
Nicholas MITSAKIS, Assistant Professor, Tenure Stream	Institute of Health Policy, Management and Evaluation, and Division of Biostatistics, Dalla Lana School of Public Health, University of Toronto Biostatistician, Biostatistics Research Unit, Toronto General Hospital		Health Policy, Management & Evaluation	Machine learning, biostatistics
Jayson PARKER, Associate Professor, Teaching Stream	Biology, IMI, UTM		Biotech, Management of Innovation	Medical Product regulation, data science, patents
Scott PROSSER, Professor, Tenure Stream	Chemical & Physical Sciences, IMI, UTM		Chemistry	Biophysics & Physical Chemistry
Leigh REVERS, Associate Professor, Teaching Stream	Biology, IMI, UTM		Biotech, Management of Innovation	Biotechnology Entrepreneurship
Mihkel TOMBAK, Processor, Tenure Stream	Management, IMI, UTM		Management	Strategic Management

Faculty name and rank	Unit of Primary Budgetary Appointment	Unit of Other Budgetary Appointment	Unit of Graduate Faculty Membership	Area(s) of Specialization
Kevin YOUSIE, Assistant Professor (LTA)	Management, IMI, UTM		Management of Innovation	Strategy, accounting

10.2 Space/Infrastructure

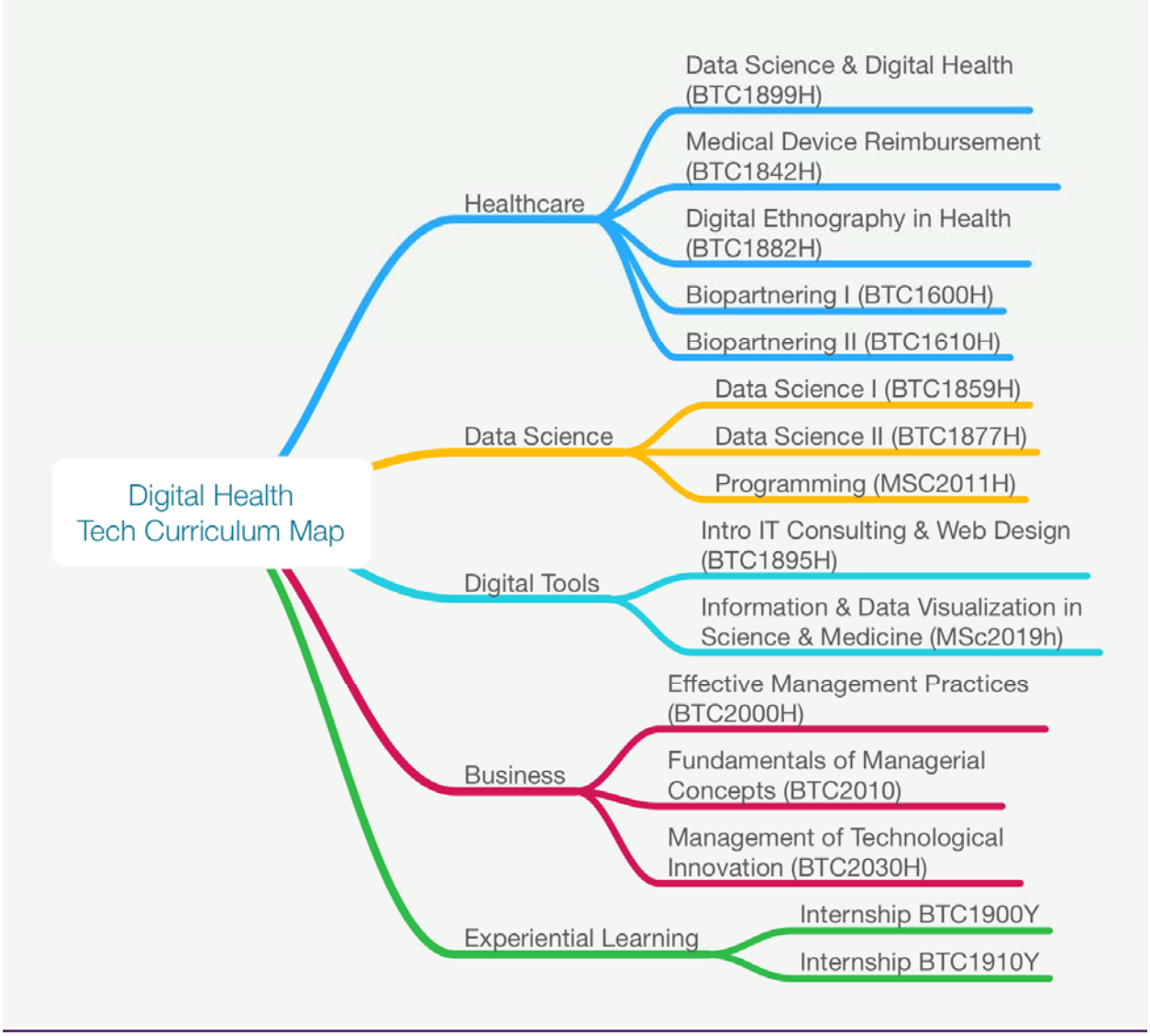
All current space and infrastructure needs for the DHT field and its students can be accommodated within our current MBiotech structure and setup.

New software will be used in the program and so far we see that software of interest is free to academic institutions. If there are some charges we expect to cover this through ancillary fees.

11 UTQAP Process

Steps	Approving Body	Approval Date
Development/consultation within Unit	Leigh Revers Director, MBiotech Program	November 20, 2017
	Soo Min Toh Director, IMI	January 11, 2018
	IMI Graduate Curriculum Committee	January 11, 2018
Consultation with Dean's Office (& VP,AP)	Rosa Ciantar Acting Program and Curriculum Officer Jeremy Packer Associate Dean, Graduate Heather M.-L. Miller Vice-Dean, Teaching and Learning	April 20, 2018
	UTM Academic Affairs Committee	
Submission to Provost's Office		
Report to AP&P		
Report to Ontario Quality Council		

Appendix Ia – Field Overview within the MBiotech Program



Appendix Ib – Field Overview within the MBiotech Program

	PHARMACEUTICAL INDUSTRY KNOWLEDGE DOMAINS	
PROBLEM SOLVING DOMAINS	**Drug field**	**DHT field**
How does a drug work?	Drug mechanism of action	Drug mechanism of action basics
Safety frameworks for new medical products	Science of safety events	Science of safety events
	Regulatory requirements for safety reporting & archiving	Regulatory requirements for safety reporting & archiving
Intellectual property law – what protections does it give us in health?	Drug & medical device patents	Drug & medical device patents
	Copyright compliant use of health & medical data	Copyright compliant use of health & medical data
How are new medicines developed?	Drug and medical device testing requirements (emphasis on drugs)	Drug and medical device testing requirements (emphasis on technologies used with drugs)
	Drug (emphasis) & medical device regulatory	Drug & medical device (emphasis) regulatory

	PHARMACEUTICAL INDUSTRY KNOWLEDGE DOMAINS	
	paths	paths
How can we analyze clinical data to address drug problems?	Question formulation based on product knowledge the data set can answer	Question formulation based on product knowledge the data set can answer
	Presentation of clinical data basics	Presentation of clinical data (data visualization)
	Gathering research data from patient surveys and regulatory websites	Gathering of research data from patient surveys, regulatory websites and social media feed analytics
	Normalizing data and basic statistics	Statistical modeling & programming
PROBLEM SOLVING DOMAINS	**Drug field**	**DHT field**
What regulatory issues exist in gathering & analyzing medical data?	Privacy regulation and data governance basics	Privacy regulation and data governance
Will a new medicine be covered by	Drug (emphasis) and medical device	Drug and medical device (emphasis)

	PHARMACEUTICAL INDUSTRY KNOWLEDGE DOMAINS	
insurers?	products reimbursement	products reimbursement
Presentation skills for managerial and scientific audiences	Full formal lecture talks and short pitches for a new idea	Full formal lecture talks and short pitches for a new idea
What restrictions exist in talking about unapproved & new medical products?	Medical marketing and regulation	Medical marketing and regulation basics
Critiquing a peer reviewed paper in medicine	Peer review paper critiques based on study design & analytics (basics)	Peer review paper critiques based on study design (basics) & analytics
Understanding a business case	Accounting & finance	Accounting & finance
Understanding marketing	Marketing basics	Marketing basics
Leading and working in a team	Managing team dynamics	Managing team dynamics

Appendix II – Course Overview (new & existing courses; all required)

Course	FCE	Code	Instructor	Program	Status
Biopartnering I & II	1.0	BTC1600H; BTC1610H	Jayson Parker	MBiotech	Existing MBiotech courses
Medical Device Reimbursement	0.5	BTC1842H	Stephen Dibert	MBiotech	New course.
Data Science in Health Part I	0.5	BTC1859H	Nicholas Mitsakis	MBiotech	New course.
Data Science in Health Part II	0.5	BTC1877H	Nicholas Mitsakakis & Jayson Parker	MBiotech	New course.
Digital Ethnography in Health	0.5	BTC1882H	Jayson Parker	MBiotech	New course.
Introduction to IT Consulting and Web Design	0.5	BTC1895H	Rhonda McEwen	ICCIT	New course (cross listed).
Data Science & Digital Health Technologies	0.5	BTC1899H	Jayson Parker	MBiotech	New course.
Internships	2.0	BTC1900Y; BTC1910Y	Leigh Revers & Jayson Parker	MBiotech	Existing MBiotech courses
Effective Management Practices	0.5	BTC2000H	Ann Armstrong	MBiotech	Existing MBiotech course
Fundamentals of Managerial Concepts	0.5	BTC2010H	Kevin Yousie	MBiotech	Existing MBiotech course
Management of Technological Innovation	0.5	BTC2030H	Rubin Gaetani	MBiotech	Existing MBiotech course
Programming Fundamentals	0.5	MSC2011H	Micheal Corrin	BMC	
Information & Data Visualization in Science & Med	0.5	MSC2019H	Jodie Jenkinson	BMC	
ELECTIVE	0.5				

* **Yellow** – existing MBiotech courses.
* **Blue** – adopting existing or proposed course from another dept/program for this new field in MBiotech.
* **Green** – new courses specific for this field (but will be open to some students external to the program).

Total FCEs for DHT field: 9.0 credits
FCE in Required courses: 8.5 FCEs
FCE for electives: 0.5 FCEs

Appendix III - Course Descriptions

BTC1842H **Medical Device Reimbursement** (**NEW)**
How medical devices are paid for by government and insurance companies, is called reimbursement. Without reimbursement, most patients would not be able to afford access to a wide range of medical technology. This course introduces how medical devices are evaluated for reimbursement, the steps taken by different stakeholders for reimbursement and now medical devices fit into the Canadian healthcare landscape. The path and criteria for medical device reimbursement can often be vague or undisclosed, and this poses a real challenge for those outside this area who wish to understand the pathway for their own product. Students will work a series of small cases in class to understand these nuances, in addition to their team based major project.

BTC1859H **Data Science in Health Part I** (**NEW**)
This graduate course equips students with a basic background in statistics to tackle massive data sets in health. This is a key step in enabling students to work within big data issues in health. The focus will be on univariate statistics and learning to program in the language R, a common tool used in statistics today. Students will also learn about web scraping, working with unstructured data, data cleaning and data governance. The course will emphasize creative approaches to analyzing data and how to be critical of misleading analysis. Each class will involve both lecture and weekly tutorial assignments. The major project for the course will involve a large health data set that teams will compete to analyze. Students must have a taken at least 2 courses in statistics or come from a strong quantitative background to enrol in the course.

BTC1877H **Data Science in Health Part II (NEW)**
This graduate course takes students with a basic background in statistics and equips them to tackle massive data sets in health. The focus will be on advanced statistical tests in machine learning and assemble such tests by accessing and validating publicly available code in the R programming language and creating their own code as needed. Students will also learn additional techniques pertaining web scraping, working with unstructured data, data cleaning and data governance building upon the course Data Science in Health Part I. The course will emphasize creative approaches to analyzing data and how to be critical of misleading analysis. Each class will involve both lecture and weekly tutorial assignments. The major project for the course will involve a large health data set that teams will compete to analyze.

BTC1882H **Digital Ethnography in Health (NEW)**
This graduate course examines how social media feeds can be analyzed to provide insight into health-related products. Various software tools (e.g. Sysmos™, Youtube analytics™, Google Analytics™, Affino™) will be introduced that can be used to analyze social media feeds to build a profile of the kinds of participants interested in the product, and the network of interactions between them. For example, what kind of demographic is following a medical product and what kind of experts appear to be influencing the perceptions of the product? The course will

also introduce some basic health and regulatory concepts that will impact how data is analyzed in the digital world in a health context. The course will involve team-based learning and students will work on a major project that will define their experience in the course. This course is only available to students in the Digital Health Technology field, within the Master of Biotechnology program.

BTC1895H **Introduction to IT Consulting and Web Design (New) (Cross listed)**
Information Technology (IT) Consulting is a growing profession that embodies the use of computer-supported collaborative tools in the execution of business functions. In this course students engage with the principles of Computer Supported Co-operative Work (CSCW) through an experiential opportunity to work with a real client. Students create an IT Consulting company and take on the role of consultants, learning core skills (soft and hard) necessary for this profession, including client management, communication, ideation, analysis and solution development, project management, presentation skills, and web design. Using case studies we discuss consulting lessons learned and problems to avoid within the context of industry best practices. Student teams will also advance their case by citing relevant best in class examples.

BTC1899H **Data Science & Digital Health Technologies (NEW)**
Digital health technologies is a broad area that refers to the transmission and storage of both medical and health related data (e.g. fitness trackers, medical & health apps, electronic medical records, medical device implants with telemetry). This course will explore current products in this space and review concept behind them as they pertain to: big data in health, regulation of medical devices and drugs, privacy regulation, product safety, usability and hazard analysis. Areas of application discussed include aging at home, dementia, diabetes and physical fitness. The major project will involve a massive health data set analyzed by teams of students. The course is open to graduate students from other departments who have some background in health or biology.

BTC2000H **Effective Management Practices**
Effective Management Practices introduces students to the basic skills and concepts needed to become an effective member of an organization, and to fundamentals of organizing technical and commercial work. It allows students to explore various structures, to learn about issues of cooperation, teamwork, leadership and goal- orientation. Key topics include:

-Basic people skills: Understanding interpersonal differences, motivation, leadership;
-Basic communication skills: Written and oral;
-Basic team working skills: Team roles, dynamics;
-Basic organizational skills: Organizational structures, cultures.

This course serves as a platform for identification of leadership skills by the students, and provides the first opportunity for a team approach to problem solving.

BTC2010H **Fundamentals of Managerial Concepts**
This foundational course introduces a number of the critical managerial concepts required to operate successfully in today's botechnologically focused organizations. Topics covered include: financial statement analysis, financial management, marketing management, as well as some

aspects of organizational behaviour and strategic management. Theory and application are combined through the use of readings, case studies and a group project.

MSC2011H **Introduction to Computer Programming for Non-programmers (Special topics in Biomedical Communications)**
This course teaches basic programming skills to non-programmers and introduces them to the value of those skills. Students will learn about the various roles of programming languages and participate in discussions about the purpose of programming including task automation and interactive Web design. Students will use the language of the Web, JavaScript. Students will be introduced to elementary data types, control flow, functions, as well as functional and object oriented programming. Students will practice approaches to problem solving with computer programs and learn debugging strategies. By the end of the course, students are expected to create a program that helps them solve a reasonable problem or perform a task in their own domain of study.

MSC2019H **Information and Data Visualization in Science and Medicine**
This 24-hour course addresses the fundamental principlesof information visualization, including a discussion of human visual perception, cognition, and approaches to graphic representation. This course will include weekly lectures and seminars, required readings, student presentations, and a term paper. Topics will include the accurate representation of numerical and statistical data, innovative approaches to visual representation, and appropriate use of design elements for clarity and legibility. Practical application of course material will require students to develop visualizations that yield insight into complex biomedical subject matter and successfully communicate to a range of audiences.

Appendix IV – Companies Expressing Internship Interest

Company	Possible Internships	Comment
Johnson & Johnson (drug and device divisions)	2-3	Two different business units - drug and device; take 6 per year - could get all.
GE Health	1-2	Company just formed Digital Health Solutions group and their needs here are growing.
Medtronic	1	
Cortex Design	1-2	A need for both engineers and marketing analytics support for health related projects.
Telus Health	1-2	Varies - at least this number. Some management say they have a critical need for machine learning/biology
Celestica	1-2	Yes manufacturing optimization of sensors for DHT
Zymewire	1-2	General interest in DHT students
Tornado Medical Systems	1	DHT students with analytical chemistry background
Express Scrips Inc.	1	Data science angle of DHT of interest to analyze drug data trends
Klick Health	1-2	Needs in both their product research area and in their marketing analytics area for health related products.
Astrazeneca	1-2	They have an interest in applying data science to health and this need is emerging from a number of different areas.
Exponential Exchange Group (e2) Inc.	1	A need for someone with analytics and healthcare knowledge to analyze data. Programming an asset.
Swiss Re-insurance (health)	?	In discussion – 2 meetings so far.
Shoppers Drugmart	2	Positions would be around both business development and the deployment of new technologies

Appendix V – SGS Calendar Entry

Current calendar description with changes

Management & Innovation: Introduction Faculty Affiliation

University of Toronto Mississauga (UTM)

Degree Programs

Biotechnology

MBiotech

Fields:
Biopharmaceutical
Digital Health Technologies

Forensic Accounting

MFAcc

Management & Professional Accounting

MMPA

Management of Innovation

MMI

Sustainability Management

MScSM

Concentrations:

Management

Science

Diploma Programs

Investigative & Forensic Accounting

DIFA *(Admissions to this diploma program have been suspended.)*

Collaborative Specializations

The following collaborative specialization is available to students in participating degree programs as listed below:

1. **Environmental Studies**
- Sustainability Management, MScSM

Overview

The Institute for Management & Innovation (IMI) is the centre for management education at the University of Toronto Mississauga (UTM). This collaborative institute provides students with access to professional master's programs in biotechnology, accounting, innovation and sustainability, and undergraduate programs in accounting, finance, marketing and human resource management.

IMI is a cross-disciplinary institute producing mission-focused managers and future leaders with a combination of management skills and depth in their chosen field. IMI also provides an academic platform to foster close interactions and sharing of expertise between the faculty, staff, and students in these programs, along with our community partners.

Contact and Address

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Biotechnology

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Master of Biotechnology Program
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Management & Innovation: Biotechnology MBiotech

Program Description

The MBiotech is an interdisciplinary course-based professional degree program. Students come from various science and/or engineering backgrounds with the common goal of pursuing a career in the biotechnology, medical device, and pharmaceutical industries.

The program meets the evolving needs of students and this global industry sector. Lecturers from various University of Toronto Faculties, biotechnology and pharmaceutical industries, and governmental agencies provide a truly interdisciplinary learning experience. Introductory laboratory courses and a year-long work internship round out the broadly based learning environment.

The program is a full-time, course-based master's degree which is launched in May each year.

Field: Biopharmaceutical

Admission Requirements

- Applicants are admitted under the General Regulations of the School of Graduate Studies. Applicants must also satisfy the Institute for Management & Innovation's additional admission requirements stated below.
- An appropriate bachelor’s degree from a recognized university in any area of biological sciences, chemistry, engineering, or related field with a minimum mid-B standing in the final two years of study.
- Applicants who have completed their studies outside of Canada must also submit their Graduate Record Examination (GRE) Subject Test scores and meet the SGS minimum standards for English proficiency.
- The MBiotech program also evaluates applicants on their letter of intent, CV, three references, and both a science and business interview.

Program Requirements

- The program is a full-time, course-based master's degree which is launched in May each year.
- Students are required to complete 9.0 graduate full-course equivalents (FCEs) over a 24-month period:
  - 4.5 FCEs MBiotech courses (includes credits for Seminar and Placement)
  - 3.5 FCEs Biopharmaceutical courses
  - 1.0 FCE elective course
- An ongoing seminar series led by university, industry, and government specialists links all the participants with the academic, practical, and applied aspects of the program.

Program Length

6 sessions full-time (typical registration sequence: S/F/W/S/F/W)

Time Limit

3 years full-time

Course List

Required Courses

A general description of each required course is posted on the website.

BTC 1600H	Biopartnering I
BTC 1610H	Biopartnering II
BTC 1700H	Molecular Biology Laboratory
BTC 1710H	Biomaterials and Protein Chemistry Theory

BTC 1720H	Biomaterials and Protein Chemistry Lab
BTC 1800H	Biotechnology in Medicine
BTC 1810H	Biotechnology and Drug Manufacturing
BTC 1820H	Biotechnology in Agriculture and Natural Products
BTC 1900Y[0]	Work Term I
BTC 1910Y[0]	Work Term II
BTC 2000H[+]	Effective Management Practices
BTC 2010H	Fundamentals of Managerial Concepts
BTC 2020H	Society, Organizations, and Technology
BTC 2030H	Management of Technological Innovation

[0] Course that may continue over a program. The course is graded when completed.
[+] Extended course. For academic reasons, coursework is extended into session following academic session in which course is offered.

Elective Courses

BTC 1830H	Medical and Scientific Challenges in Marketing Therapeutics
BTC 1840H	Patent Law for the Life Sciences
BTC 1850H	Creating Life Science Products
BTC 1860H	Generations of Advanced Medicine: Biologics in Therapy (GAMBiT)
BTC 1920Y	Work Term III
BTC 2040H	Change Management
BTC 2100Y	Topics in Biotechnology
BTC 2110H	Topics in Biotechnology
BTC 2120H	Topics in Biotechnology

Other graduate courses approved by Program Directors.

Field: Digital Health Technologies

Admission Requirements

- Applicants are admitted under the General Regulations of the School of Graduate Studies. Applicants must also satisfy the Institute for Management & Innovation's additional admission requirements stated below.
- An appropriate bachelor’s degree from a recognized university in any area of biology, public health, statistics, computer science engineering, chemistry, sociology, psychology, epidemiology , or related field with a minimum mid-B standing in the final two years of study.
- A minimum 1.0 credit of university level statistics (or equivalent) with at least mid-B standing
- Applicants who have completed their studies outside of Canada must also submit their Graduate Record Examination (GRE) Subject Test scores and meet the SGS minimum standards for English proficiency.

The MBiotech program also evaluates applicants on their letter of intent, CV, three references, and both a science and business interview.

Program Requirements

- The program is a full-time, course-based master's degree which is launched in May each year.
- Students are required to complete 9.0 graduate full-course equivalents (FCEs) over a 24-month period:
  - 4.5 FCEs MBiotech courses (includes credits for Seminar and Placement)
  - 4.0 FCEs Digital Health Technologies courses
  - 0.5 FCE elective course
- An ongoing seminar series led by university, industry, and government specialists links all the participants with the academic, practical, and applied aspects of the program.

Program Length

6 sessions full-time (typical registration sequence: S/F/W/S/F/W)

Time Limit

3 years full-time

Course List

Required Courses

A general description of each required course is posted on the website.

BTC 1600H	Biopartnering I
BTC 1610H	Biopartnering II
BTC 1842H	Medical Device Reimbursement
BTC 1859H	Data Science in Health I
BTC 1877H	Data Science in Health II
BTC 1882H	Digital Ethnography in Health
BTC 1895H	Introduction to IT Consulting and Web Deisgn
BTC 1899H	Data Science & Digital Health Technologies
BTC 1900Y[0]	Work Term I
BTC 1910Y[0]	Work Term II
BTC 2000H[+]	Effective Management Practices
BTC 2010H	Fundamentals of Managerial Concepts
BTC 2030H	Management of Technological Innovation
MSC 2011H	Introduction to Computer Programming for Non-Programmers
MSC 2019H	Information & Data Visualization in Science & Medicine

[0] Course that may continue over a program. The course is graded when completed.
[+] Extended course. For academic reasons, coursework is extended into session following academic session in which course is offered.

Elective Courses

BTC 1830H	Medical and Scientific Challenges in Marketing Therapeutics
BTC 1840H	Patent Law for the Life Sciences
BTC 1850H	Creating Life Science Products
BTC 1860H	Generations of Advanced Medicine: Biologics in Therapy (GAMBiT)
BTC 1920Y	Work Term III
BTC 2040H	Change Management
BTC 2100Y	Topics in Biotechnology

BTC 2110H	Topics in Biotechnology
BTC 2120H	Topics in Biotechnology

Other graduate courses approved by Program Directors.

Appendix VI – Electives

The elective options are the same between the two fields. Students are also free to go beyond the electives listed here, with permission from the Director.

Courses	**FCE**	**DHT**	**BioPH**
BTC1830H Medical and Scientific Challenges in Marketing Therapeutics	0.5	Yes	Yes
BTC1840H Patent Law for the Life Sciences	0.5	Yes	Yes
BTC1850H Creating Life Science Products	0.5	Yes	Yes
BTC1860H Generations of Advanced Medicine: Biologics in Therapy	0.5	No	Yes
BTC1920Y Work Term III	0.5	Yes	Yes
BTC2040H Change Management	0.5	Yes	Yes
BTC2100Y, 2110H, 2120H Topics in Biotechnology	0.5	Yes	Yes

Appendix VII – Time Table of Courses in DHT

Year One

Course		May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Effective Management Practices	BTC2000H												
Introduction to Computer Programming for Non-	MSC2011H												
Medical Device Reimbursement	BTC1842H												
Data Science in Health I	BTC1859H												
Fundamentals of Managerial Concepts	BTC2010H												
Information & Data Visualization in Science & Medicine	MSc2019H												
Data Science in Health II	BTC1877H												
Data Science & Digital Health Technology	BTC1899H												
Introduction to IT Consulting	BTC1895H												
Seminar I (Biopartnering I)	BTC1600H												

Year Two

Course		May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Internships	BTC1900Y; BTC1910Y												
Management of technological innovation	BTC2030H												
Digital Ethnography in Health	BTC1882H												
ELECTIVE													
Seminar II (Biopartnering II)	BTC1610H												