New Program Proposal Brief

Master of Industrial Biotechnology Degree Program (MIBiotech)

One year (3 terms), course-based, self-funding program

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1. Introduction & Rationale:

1.1. The department of Biology is taking a lead on this cost-recovery proposal, based on the success of the HBSc/BSc Applied Biomolecular Science Program, recently renamed Applied Life Science. This undergraduate program has led to an enrolment increase in Biology, which has stabilized in the last 5 years at about 30 students. The Biology department also delivers a successful thesis-based MSc graduate program, bringing in about 10 new students annually. However, we have had difficulty attracting international students, who require substantially more resources for academic, research and personal support, especially if the thesis is based on experimental work. This proposal is designed to remedy this situation.

1.2. Brief description: The proposed program is designed for science and engineering graduates from non-Canadian universities, who wish to a) upgrade their qualifications, b) increase their understanding of biological principles underlying biotechnology, c) gain exposure to management and marketing strategies relevant to the biotechnology industry, d) develop specific research skills and e) learn industry standards for quality assurance and control. Such students will already have good mathematics and experimental design skills, which will be further honed in an advanced format. Emphasis will be placed on continuing to improve participants' communication and critical thinking skills, with the goal of preparing the candidates for entry into either research-based graduate programs or relevant jobs at home or elsewhere in the world where English is the primary medium of scientific communication. The proposed course-based program will consist of 6 FCEs taken over three semesters (one year); this structure will not stress the existing resources currently in place to support the traditional thesis-based MSc Biology.

1.3. Rationale: The program will be particularly suited to international students who wish to improve their understanding of the Canadian science establishment, as well as their science communication skills. Graduates will have broadened their knowledge and understanding of Industrial Biotechnology, particularly as it applies to sustainable natural resource utilization. This academic goal will be the primary achievement of the program. The MIBiotech program will also serve to pre-screen students wishing to continue into our thesis-based Master's programs. We hope this additional pool of MSc graduates will further bolster Lakehead's Biotechnology PhD program. An additional goal of the proposed program will be to increase enrolment in Biology and, ultimately, to support growth of the department, its resources and reputation.

1.4. Anticipated demand:

Annually, Biology receives about 40 applications for MSc positions from foreign students (many with scholarships). These students for the most part cannot be accommodated into typical thesis-based programs and therefore represents a large pool of potential candidates for MIBiotech. To our knowledge, there is only one other similar one-year Master's program, but it is geared toward medical biotechnology and offered through the University of Windsor. From discussions with administrators of this program, it is highly successful and has benefited the institution academically and financially. Our MIBiotech program is initially structured for International students only, however we are open to the possibility of expansion to domestic students should the market support it.

1.5. Program nomenclature

We recommend that the title "Master of Industrial Biotechnology" (abbreviated MIBiotech) be used. The name clearly differentiates this program from standard two-year MSc programs by excluding the term "Science" yet emphasizes science-based Biotechnology as the main subject. Abbreviating to Biotech (rather than just B) will differentiate the program from business degrees such as MB or MBA. The term "Industrial" will be essential in the program description in order to differentiate our program from medically-oriented ones such as the one at University of Windsor. The emphasis on resource-based industry will make the program relevant to our resource-rich region, and will make the program more difficult to duplicate.

2. Program Learner Outcomes and Consonance with University Planning

2.1. Learner Outcomes (course specific learner outcomes are described in Section 5, together with details of course evaluation methods. Program evaluation methods are described in Section 7 and to some extent within Appendix A - Program Coordinator job description).

Since entrants with various degrees of training and experience will be admitted, the program is intended to achieve a certain degree of "evening out" of basic science training and expanding training in the discipline of Biotechnology. By this we mean the correct application of basic principles learned in undergraduate programs. The development of communication and critical thinking skills will be one of the primary program outcomes. Students will gain deeper understanding and appreciation of the bio-resource industry and its connection to biotechnological applications in new product development and waste management. Newly emerging ideas of process integration will be stressed. Emphasis will be placed on compliance with pertinent legislation, regulations, quality control and assurance. Students will develop an appreciation of business practices, entrepreneurship and management and to link these to a critical evaluation of product development. Students will be expected to understand experimental methods employed toward the improvement of existing industrial processes. These skills will be honed, implemented and tested in the practical final project to a level where students will be able to independently recommend and implement improvements to and advances to current practice. Individual students will broaden their repertoire of skills with specific procedures and instruments, as well as analytical and reporting methods. Skills and habits will be established leading to the appreciation of the need for life-long learning, resulting in ongoing professional development and improved management skills.

Specific learner outcomes will be:

(a) As deep an understanding as possible, of bio-resource biotechnological processes used by industry and in research. Main focus will be on the organisms used and their biology in the context of novel product manufacture. This will include primarily microorganisms - bacteria, fungi, algae and, to a limited degree, higher plants and animals.

(b) Consonance with, and surpassing the Biotechnology Program Standard for Ontario College Diploma (MTCU, February 2012, Appendix C). These ten basic Biotechnology learner outcomes will serve as a teaching guide and will be surpassed at the graduate level by emphasizing independent thought, application of innovative ideas, independent ability to evaluate and improve existing standards. Students will continue to independently develop and enhance their work performance.

(c) Overview of the breadth of Industrial Biotechnology, including research performed by faculty members of the PhD Biotechnology program.
(d) Students will learn business management and marketing aspects of Biotechnology.
(e) Students will be guided through a cross-disciplinary environment and learn to communicate and function collaboratively with experts in different areas of application of biological knowledge. This will be achieved by having students from various academic backgrounds interacting with faculty in a range of fields: pure science, engineering, business and natural resource management.
(f) In the context of Biotechnology applications presented in core courses, internalize a thorough understanding of the scientific process based on interpretation of peer-reviewed information and critical evaluation of published materials.
(g) Practice all the skills acquired in the first two semesters in an independent (but guided) project to acquire and communicate new knowledge.
(h) International students will learn to deal with daily challenges of performing resource biotechnological science in a new and unfamiliar setting. Canadian culture, customs and science policies will be introduced.

2.2 Consonance with Strategic Mandate Agreement 2014-17(between LU and MTCU)
The SMA identifies the existing strengths of academic activities at Lakehead University and charts areas targeted for development. Lakehead University's areas of differentiation relate to our unique geographical situation and the existing institutional strengths. Particularly relevant to this proposal are: (a) the existence of the Biorefining Research Institute (Section 1.1), and (b) the close interactions of the members of the Faculties of Natural Resource Management and Science and Environmental Studies with local industries and the existing strong research and graduate teaching performance in these academic areas (Section 4.1). Both Faculties are involved in advancing this proposal. Our initiative also clearly links to the strategic objective of Lakehead University to increase international academic enrolment (Section 3.1), although the proposed MIBiotech program is hoped to be eventually available to Canadian students as well.

2.3 Consonance with Lakehead University Academic Plan 2012-2017

The proposed program is designed to continue Lakehead University's development of excellence in teaching, learning and research (**Priority 1**). Of particular concern to program faculty will be the development of metrics to demonstrate that desired goals are being achieved (Section 4). We are keenly aware that program quality will be closely associated with the resources available, and as clearly stated in the Academic Plan Appendix 2, enrolment growth will be linked to resources made available to the program. As shown in the budget (Section 8.3), some of the required resources will be allocated to research projects. This in turn will give participating students a positive experience in actual research, and will allow the selection of the best students for continuation into existing thesis programs, thus contributing to the growth of Lakehead's research capacity and the graduation of highly skilled graduates, empowered with good interpersonal and professional skills.

The program is also clearly designed to significantly contribute to the achievement of **Priority 5**, the expansion of the international reach of our institution. Great strides have been made

over the last few years, particularly at the undergraduate level. The proposed program will expand Lakehead's capacity to attract and fund additional graduate students. These students will be exposed to teaching of the highest calibre. In that respect, program proponents are keenly aware of the need to deliver an excellent program. An "ultimate" success metric in this respect will be the ability of program graduates to recommend Lakehead University to their home country peers.

3. Program Admission

3.1. Admission requirements

The program is intended for students holding four year HBSc/BSc degrees in Science, Engineering or a similar field, such as Biotechnology, Applied Biology, Natural Science or Resource Management. Students with post-graduate degrees will be also considered for admission. A minimum 70% average will be required for admission.

The standard language requirement for international students entering Lakehead University graduate programs will be followed.

3.2. Discussion

The admission requirements are in keeping with current university practice. We hope to attract students of the highest caliber, but in our experience some of the international students come with gaps in their undergraduate preparation. While we could only speculate on the reasons for this, in some cases this is due to a longer gap than usual (several years) between their basic training and their admission into graduate school (for this reason we include the option of one undergraduate course in the offered curriculum - see Section 4.) As with most international student admissions, we anticipate some degree of difficulty in evaluating translations of foreign transcripts. Fortunately sufficient expertise exists in the office of the Faculty of Graduate Studies to assist in such evaluations. To some extent the proposed program is structured in such a way to allow Lakehead instructors thorough evaluation of the academic abilities of participating students, the best of whom will then be considered for continuation into standard thesis-based Master's programs. Furthermore, participating students will be in a position to request reference letters for further academic work elsewhere, based on their performance in Canadian academic setting.

3.3. There are no alternative requirements.

4. Program structure and course outcomes

4.1. Structure

Course-based Master of Industrial Biotechnology (MIBiotech)

Students will be expected to complete the following course-based curriculum with 70% or B average.

Our proposal exceeds the minimum MTCU requirement of 2/3 of the program to be selected from graduate courses, since 5/6 of the program are at the graduate level.

Core of the program will consist of the first three FCEs on the list below. Biotechnology-specific theory and methodology will be introduced in the four Biotechnology-specific courses. Business-related issues, and to some extent laboratory management skills will be introduced in the Management and Marketing course. Understanding of specific analytical instruments and methods will be introduced through the modular Advanced Research Methodology course. Specific modules will be chosen depending on individual student's needs.
The two graduate seminar courses are designed to improve students' comprehension and delivery of scientific talks. The newly proposed continuation of Biol 5010 (Graduate seminar in Biotechnology 5xxC) will introduce students to the breadth of biotechnology as performed by members of the PhD Biotechnology faculty and by guest speakers.

The remaining elective courses will be selected in consultation between program co-ordinator and the individual student. The selection will be designed to complement and expand the student's academic background in Biology, and to further develop and apply some soft skills.

The final project during the Summer semester will put into practice previous learning - from planning to execution of a relatively basic (but biotechnology based) research project. This will conclude by a written report and an oral report to program participants and faculty.

Student performance and progress evaluation are described in Section 7.

3FCE Required Courses
0.5 FCE BIOT 5XXA Advanced Industrial Biotechnology (Christopher)
0.5 FCE BIOL/BIOT 5650 Advanced Issues in Biotechnology (Malek)
0.5 FCE NRM 5770 Management and Marketing Strategies (Shahi)
0.5 FCE BIOT 5XXB Integrated Biorefineries (Christopher)
0.5 FCE BIOT 5XXC Graduate Seminar in Industrial Biotechnology (Malek and guests, second semester)
0.5 FCE BIOT 5XXD Advanced Laboratory QA/QC Practices (Appoh - full term expansion of an existing module within Chem 5311)

1 FCE BIOT 5XXE Research project with report (Summer semester)

Elective Courses:
1 FCE required; select TWO OF:
0.5 FCE CHEM 5311 Advanced Research Methodology (Kinrade)
0.5 FCE BIOL 5730 Advanced Limnology (Lee) and
0.5 FCE NRM 5510 Research Methods I Philosophy and general methods (Shahi)
0.5 FCE NRM 5530 Research Methods II Experimental design (Shahi)
0.5 FCE NRM 5515 Research methods of scientific planning (Leitch)
0.5 FCE BIOL 5010 Graduate Seminar (Mallik)

1 FCE Selected from Biology (or possibly other science or NRM) undergraduate offerings in consultation with program co-ordinator, based on individual student background and needs

TOTAL 6 FCEs over 3 semesters

Discussion of program structure:
The academic year demands a standard of 5 Full Course Equivalents. Our proposal exceeds this standard by one full term course (Research project) taken in the third (Spring/Summer) semester of the academic year. This in our view compensates for the lack of thesis work, yet gives each student an opportunity to put into practice knowledge and skills developed in the standard academic year.

4.2. Program outcomes
These were already described in Section 2.1 for the entire program, and individual course LO's are described in Section 5. Student progress evaluation is described in Section 6.

4.2.1. Depth and Breadth of Knowledge
This will be attained through all program courses, and greatly expanded by contact with researchers from the PhD Biotechnology program and outside of the university via the seminar course (BIOL/BIOT5XXC).

4.2.2. Research and Scholarship
Eight (of the ten) graduate courses are designed to increase the comprehension and application of Biotechnology-relevant techniques and knowledge creation. Examples of critical evaluation of presented outcomes of biotechnology research will form the basis of most lectures, literature reviews and essays. In essays in particular, comparisons of successful and failed product development projects will train students in applying good judgment and reliance on established and well tested principles. The ultimate project course (BIOL/BIOT5XXE) will put into practice the learned skills by presenting newly acquired original knowledge orally and in a written paper. In both cases, the main expectation will be the students' ability to develop sustained argument defending the newly attained data.

4.2.3. Level of Application of Knowledge
Several written submission, and primarily the final project report, will demonstrate students' competence in understanding the research process and critical analysis of existing knowledge. In a majority of cases this will be from the perspective of addressing a problem from a new angle.

4.2.4. Professional Capacity/Autonomy
The core "Issues" course (BIOL/BIOT5650) and the four elective research management courses (BIOL 5010, NRM 5510, 5530 and 5515) will emphasize various aspects of professional development and research ethics issues, framed by the concept of tolerance of alternate viewpoints and stringent evaluation of evidence. Most assessments in the program will be based on individual, not group, work. This will provide instructors with ample opportunity to evaluate and guide the individual student's ethical and professional development. The "Issues" course in particular will address industrial biotechnology in the broader societal context.

4.2.5. Level of communication skills
The ability to communicate ideas, methods, processes, conclusions and recommendations clearly is going to be stressed in all components of the program. This is particularly important since we will be dealing with students whose native tongue will likely not be English.

4.2.6. Awareness of Limits of Knowledge
The "Issues" course (BIOL/BIOT5650) will address this specifically, but this theme will emerge in the majority of the offered graduate courses. By working at the cusp of obtaining new knowledge, students will develop an appreciation of the fluid nature of rationally acquired knowledge and understand the dangers of dogmatic application of scientifically obtained knowledge.

4.3. Program duration and scheduling
One academic year consisting of three semesters is adequate to achieve the above goals. By extending the program into the Spring/Summer semester with the one FCE Research Project (BIOT 5XXE), students will be taking only the normal load expected of undergraduates in the Fall and Winter, i.e. 5 half courses in each term. Scheduling across two Faculties may present a problem, but enough flexibility can be introduced by offering some of the Biotechnology-specific courses in the evening.

5. Program content

CORE courses (each 1/2 FCE unless indicated otherwise)
BIOT 5XXA Industrial Biotechnology (Christopher)
Students will be introduced to the biotechnology fundamentals and the role industrial biotechnology plays in the advancement of product and process technologies of modern bioeconomy. Special emphasis will be given to classical and advanced approaches to screening for new metabolites, strain development, methods for fermentation and product recovery as the key processing steps in product development in Industrial Biotechnology. To help reinforce understanding, students will be exposed to a range of topics from various sectors of Industrial Biotechnology supported by examples and literature reviews.

Learner outcomes:
- Acquire solid knowledge of the principles of Industrial Biotechnology
- Gain understanding of the classical and modern methods of Industrial Biotechnology.
- Develop and expand competences on how Industrial Biotechnology can be used in various sectors of manufacturing for advancement of quality of human life and health.
- Develop abilities to critically evaluate advantages and disadvantages of biotechnological methods and their usefulness in new product development.
- Develop presentation skills and abilities to analyze, discuss and interpret information presented during the course in the form of lectures and published literature.

Evaluation: Grading will be based on: 1) 70% class work (presentations 15%; quizzes 20%; final exam 35%); and 30% home work (learning modules 15%; paper assignments 15%).

BIOL 5650 Advanced Issues in Biotechnology (Malek)
Graduate students will critically evaluate published materials and lead discussions of current technical and ethical issues in industrial biotechnology with emphasis on plant biotechnology and genetically modified foods, implications of interspecies gene transfer, plant-derived drug development and approval processes and bioremediation using cloned organisms. Some emphasis will be placed on the interpretation and presentation of scientific information for general audience.

Learner outcomes:
- Acquire specific knowledge based on the scientific content and principles emerging from selected scientific primary literature.
- Using the framework of lectures based on current and potentially controversial research publications in industrial biotechnology, students will learn to (re-) interpret and critically evaluate scientific evidence.
- Students will learn to accept, and deal with, alternative views on scientifically obtained information.
- Appreciation of the limits of scientific knowledge will be developed.
- Students will gain knowledge of the structure and politics of Canadian research establishment.
- Skills leading to ethical use of available information and ethical professional behaviour will be internalized.
- In addition to the standard knowledge of communicating scientific information to other scientists, some popular science writing skills will be developed.

Evaluation: Student presentation content and delivery (20%), critical evaluations of presentations given by lecturer and class participants (20%), mini-review paper (20%), popular article on biotechnology topic (20%), final examination - short answers (20%).

NRM 5770 Management and Marketing Strategies (Shahi)
A study of the fundamental principles of marketing management and an in-depth understanding of the present national and international market of forest products and equipment. Techniques of conducting market research and developing marketing intelligence for the forestry sector will be explored. A firm's marketing environment will be explored to develop a market coverage strategy over a value-added forest product's life cycle by using market segmentation, market targeting, and market positioning theories. Concepts of pricing decisions, distribution channels, integrated logistics management and marketing communication will be introduced.

Learner outcomes:
- To learn the skills involved with scientific research*/critical inquiry*, including experimental design, experimental techniques, data gathering and data analysis.

- To develop the skills enabling them to stay abreast of the current literature in their field, enabling them to use the published literature and to interact with other researchers and professionals.
- To develop the skills enabling them to present their thesis research*/critical inquiry* to the scientific community by the medium of publications in technical journals, and*/or* talks and posters at scientific conferences and meetings

Evaluation: Mid-term examination (20%), final examination (30%), case studies analysis (30%), presentation/poster (20%).

BIOT 5XXB Integrated Biorefineries (Christopher)
Students will be introduced to the Integrated Biorefineries as one of the major pillars of the growing Bioeconomy where oil is inevitably replaced by plant biomass, the most abundant and renewable resource on earth. They will learn how biotechnology, science, engineering could maximize the value extracted from lignocellulosic fibers for sustainable production of biofuels and value-added bioproducts. Focus will be given to the major research needs, production and conversion platforms, technological challenges and opportunities of the Biorefineries that can bring about socio-economic and environmental benefits to the biobased industry. To help solidify knowledge and skills, students will examine and discuss practical examples for biomass Biorefining from published literature.

Learner outcomes:
- Provide learners with thorough understanding of the Biorefinery Concept for the complete waste-free utilization of plant biomass for value-added products.
- Acquire knowledge and appreciation of the various chemical, biochemical and thermochemical conversion methods for biomass processing and opportunities for their integrated use.
- Develop abilities to critically evaluate the global challenges and opportunities that stand in front of Integrated Biorefineries to help transform the industry sector and provide significant benefits to society.
- Develop communication skills and abilities to analyze, interpret and present research data from lectures and published literature.

Evaluation: Grading will be based on: 1) 70% class work (presentations 15%; quizzes 20%; final exam 35%); and 30% home work (learning modules 15%; paper assignments 15%).

BIOT 5XXC Graduate Seminar in Industrial Biotechnology (Malek, guest speakers, students, second semester)
Current topics in Industrial Biotechnology will be covered in research seminars. Scientific content and presentation style will be analyzed and critically evaluated in the form of brief written and graded paragraphs. Written review essays and discussions will follow some seminars.

Learner outcomes:
- Students will get an understanding of the breadth of scientific endeavour related to industrial biotechnology.

- Students will further hone their communication skills and critical thinking skills.
- Students will apply not only their knowledge of the specific biotechnology science, but also the skills needed to effectively and ethically interpret the facts presented.
- Students will be asked to re-interpret science content at a level suitable for the general public.

Student evaluation:
Critical reviews of each weekly presentation (40%), discussion participation - based on submitted prepared points dealing with previous week's presentation (20%), mini-review based on one of the presentation topics (20%), presentation delivery and content (20%).

BIOT 5XXD Advanced Laboratory QA/QC Practices (Appoh)
This course discusses the importance of Total Quality Management together with Good Manufacturing Practices (GMPs) and Good Laboratory Practices (GLPs). It demonstrates the development of a quality management system based on various International Organization for Standardization (ISO) series standards, emphasizes the importance of Quality Control and Quality Assurance, and teaches laboratory management practices appropriate for a biotechnology facility.

Learner outcomes:
- Acquire a fundamental understanding of the multidisciplinary components that define the field of Quality Assurance
- Learners understand and describe the differences between Quality, Quality Assurance, Quality Control and Quality Management System
- Describe the Canadian and International agencies that establish regulations and standards and explain their interdependencies.
- Learners acquire expertise in Validation Equipment & analytical methods as required by GMP/GLP operations and by accredited laboratories.
- Write Standard Operating Procedures.
- Realize and understand the importance of Good Laboratory Practices and accreditation process.

Student evaluation:
Quizzes (10%), Exams (30%), Term Project/Paper-Written report & Presentation (20%), Final Exam (40%).

BIOT5XXE Research Project with Report (1 FCE, Summer semester)
A supervised practical project in a research area relevant to Industrial Biotechnology, based on independently developed research plan, execution and analysis of results. Final reports will be in the form of a publishable paper and a final oral presentation to program members.

Learner outcomes:
- Student will test their ability to independently survey the state of current knowledge in a specific area of biotechnology and develop a project leading to the attainment of new knowledge.

- Students will test and hone their ability to put into practice research management and reporting skills learned in the entire program.
- Further specific practical skill development, perhaps in areas if investigation not previously encountered.

Evaluation (by program coordinator and project supervisor):
Final report on project in the form of a short scientific paper (50%), final seminar presentation - based on input from class members, supervisor and self evaluation (50%).

ELECTIVE COURSES

CHEM 5311 Advanced Research methodology (Kinrade)
A cross-disciplinary course in instrumental analysis and research methodology. Students choose three modules from a series of offerings that can include scanning electron microscopy, nuclear magnetic resonance spectroscopy, x-ray diffraction spectroscopy, infrared spectroscopy, mass spectroscopy, optical microscopy, paper testing, chromatography, and DNA sequencing.
Two additional modules will be developed of specific relevance to the MIBiotech program: bioreactor operation and batch culture of algae.

Learner outcomes:
- Each module is designed to develop thorough understanding of the use and application of specific technique(s) in material analysis.
- Any of the above listed techniques are relevant to Biotechnology skill set.
- Students will gain an understanding of the breadth of techniques available to biotechnologists, and the need for continued (life-long) learning.
- Data analysis and reporting will be emphasized.

Evaluation:
Reports on the methods and results obtained in each of the three modules. Module-specific exercises and assignments for a total of 100%.

NRM 5510 Research Methods. I Philosophy and general methods (Shahi)
A wide variety of philosophical and practical topics will be covered. These include the nature, origin, and limits of scientific knowledge; the scientific literature; library research methods; research problem analysis; research proposals; project management and reporting research results.

Learner outcomes:
- Thorough understanding of the process of critically evaluating and editing reports on new research results
- Ability to effectively and critically identify, obtain, and interpret scientific reports

- Thorough understanding of the peer review process and it's value in detecting and avoiding plagiarism
- Ability to develop plausible and ultimately fundable research proposal

Evaluation: Literature searching exercises (20%), short report writing exercises (30%), research problem analysis exercise (20%) and mini-grant proposal (30%)

NRM 5530 Research Methods. II Experimental design (Shahi)
The design, execution and analysis of forestry experiments. Four basic design structures are treated: completely randomized, randomized complete blocks, split-plot, and nested. One way, factorial and nested treatment structures are discussed. Additional topics include incomplete block designs, fractional factorial designs and response surface designs. Students learn how to decide whether a proposed design is well suited to their purposes and how to make ill-suited designs better. As a term project, students execute, analyze and report on an experiment of their own design.

Learner outcomes:
- Thorough understanding of experimental design approaches
- Good understanding of the adoption of a particular experimental design to a specific research problem
- Understanding of the pitfalls of applying inappropriate design to a specific problem

Evaluation: Term project (60%), quizzes (4 x 10%)

NRM 5515 Research Methods of Scientific Planning (Leitch)
Further development and understanding of the design of research, building on hypotheses and theories, including principles presented in Natural Resources Management 5510. Emphasis on development of scientific communication skills within the context of a research program.

Learner outcomes:
- Ability to formulate testable scientific hypotheses
- Interpretation and critical evaluation of scientific data as published in peer reviewed literature
- Development of presentation and poster presentation skills

Evaluation: Oral presentations on selected topics (2x30%), presentation and evaluation of posters (40%)

BIOL 5010 Graduate Seminar (Mallik)
An overview of scientific writing, critical appraisal of research seminars, scientific reviews and group discussion as well as effective methods to prepare and present research proposals, short oral presentations and formal seminars. This required course must be taken in the first year of a student's program.

Learner outcomes:

- Thorough understanding of the process of critically evaluating and editing reports on new research results
- Ability to effectively and critically identify, obtain, and interpret scientific reports
- Thorough understanding of the peer review process and it's value in detecting and avoiding plagiarism
- Ability to develop plausible and ultimately fundable research proposal

Evaluation: Literature searching exercises (20%), short report writing exercises (30%), research problem analysis exercise (20%) and mini-grant proposal (30%)

BIOL 5730 Advanced Limnology (Lee)
A practical and seminar course on current topics in Limnology. Initial emphasis is on phytoplankton and zooplankton identification and ecology, and quantification of limnological data. Students then select a subject of interest in Limnology, present critiques of important papers on the subject and prepare a detailed literature search. The emphasis is on preparing the student to conduct practical investigations on lakes and rivers.

Learner outcomes:
- Thorough and hands-on understanding of protocols used in the identification of phytoplankton and zooplankton
- Ability to calculate the concentrations of specific plankton components
- Ability to apply statistical methods to determine the quality of the obtained data
- Understanding of, and the ability to interpret and critically evaluate limnological literature
- Ability to develop a research proposal based on thorough literature search

Evaluation: Species identification and quantification exercises (40%), limnological problem presentation (40%), research proposal (20%)

1 FCE Selected from Biology Undergraduate Offerings (in consultation with program co-ordinator, based on individual student background and needs)

Learner outcomes:
In the experience of the Biology MSc program, many international students come with good theoretical knowledge, but tend to be deficient in specific hand-on skills and the desire for independent work. Undergraduate courses will be selected in a way to enhance this aspect of learning. Emphasis will be placed on courses with significant laboratory component, but with sensitivity to individual student background and future needs.

6. Mode of Delivery
Delivery will be course-specific: seminars followed by discussions in seminar courses, instructor lectures and student presentations in lecture-based courses, and hands-on experimental "experiential learning" in the modular and project courses. All courses will have some degree of scientific oral (presentations, discussions) and writing (short paragraphs, essays) skill development.
The ultimate, and arguably the best mode of delivery is the personal mentorship approach, which will be used in the project course. Ideally most of the instruction will be from the

specific supervisor of the course, but in practice all members of a particular research laboratory contribute new ideas and skills. This approach engenders the development of mutually respectful, goal oriented, and creative learning environment, which will inspire further participation in life-long learning in later academic or industrial setting.

These four standard modes of instruction are standard at the graduate level. The essential component in all modes is the use of discussions and evidence evaluations in the development of skills to critically judge the presented material.

7. Assessment of Teaching and Learning

Specific methods for individual courses are described in Section 5, but to summarize our general approach:
In seminar courses, evaluation will be based on standardized evaluation sheets (Appendix B) focusing on (1) content - i.e. the understanding of scientific principles presented, accuracy, relevance and (2) soft skills, i.e. delivery development. Peer- and self-evaluation forms will be developed and used for instruction.

In lecture courses, examinations will be administered as described for each individual course (in Section 5).

The Research project course (BIOT 5XXE) will culminate in a "brief-report" type of publication, describing a piece of original research performed by the student. An oral presentation to program participants and instructors will be expected in the last weeks of the course as well.

Standard Lakehead University requirement for MSc program graduation will be followed: "Graduate students must maintain at least a B overall average in their courses with no more than one full course equivalent (two half courses) graded C. A mark of less than 60% in a graduate course, or in an undergraduate course used towards a graduate degree, constitutes failure. Graduate students with a mark of 50 to 59% in an undergraduate or graduate course used towards the degree may repeat the course once; however, no more than one full course equivalent may be repeated. "

Alternatively, students failing to attain the above MIBiotech program requirement will be offered the opportunity to receive a "Certificate of completion - Industrial Biotechnology Program", provided the grades in any of the program courses are not lower than a C (60%).

8. Resources for Graduate Programs

8.1. Faculty and Staff (see Appendix D for CVs)

Core:
Lew Christopher, PhD, Director of Biorefining Research Institute
Ladislav Malek, PhD, Professor of Biology
Chander Shahi, PhD, Associate Professor and Chair, Forest Management Program
Francis Appoh, PhD, Director of LUCAS
Mathew Leitch, PhD, Associate Professor, Natural resources Management Faculty

Associate:
Azim Mallik, PhD, Professor of Biology
Stephen Kinrade, PhD, Professor and Chair, Chemistry
Peter Lee, PhD, Professor of Biology

Elaboration on staffing
Dr. Christopher will co-ordinate the program as a tenure-track professor in a cognate department (Biology) and will deliver 2 new courses, based on his existing salary and a supplement equivalent to 3 sessional instructor salaries
Dr. Malek will assist with co-ordination of the program and the seminar course, as well as continue delivering Bio 5650 post-retirement, based on 2 sessional instructor salaries.
As described in the Budget, strategic hire to be considered, once certain enrolment conditions and targets are met.

8.2. Funding Support for Students

No direct support for students is requested. I.e., no graduate teaching assistantships are requested. However, we are proposing that a scholarship fund will be developed as described in the Budget.

8.3. Physical & Financial Resources

Proposed budget and its justification are presented on the following pages.

1	**Revenue**	Year 1	Year 2	Year 3	Year 4	Year 5	MaxTarget
2	Enrolment projection	4	8	12	16	20	30
3	International tuition (estimate $20,000 per student)	80000	160000	240000	320000	400000	600000
4	*University (70%)**	*56000*	*112000*	*168000*	*224000*	*280000*	*420000*
5	Faculty of SES (30%)	24000	48000	72000	96000	120000	180000
6							
7	**Revenue MIBiotech Program (15%)**	12000	24000	36000	48000	60000	90000
8	**Expenses - Program operating**						
9	Seminar speakers and lecture honoraria	7000	8000	9000	10000	10000	10000
10	Research and lab supervisor incentive ($2000 per student)**	8000	16000	24000	32000	40000	60000
11	Program promotion and administrative costs	5000	5000	5000	5000	5000	5000
12	MIBiotech program subtotal (surplus/deficit) Deficit in the first three years to be made up from SES budget, subsequent savings to scholarship fund	-8000	-5000	-2000			
13	**Revenue Faculty of SES (15%)**	12000	24000	36000	48000	60000	90000
14	**Expenses Faculty of SES**						
15	1/4 PhD Biotech program administrator	7500	8000	8250	8500	8750	9000
16	Scholarship fund (flowing back to LU)****	-3500	11000	25750	40500	56250	96000
17							
18	**Revenue University portion (70%)**	*56000*	*112000*	*168000*	*224000*	*280000*	*420000*
19	***Expenses - teaching (University 70%)***						
20	*3 FCE sessionals for core courses (1.5 after year 2)*	*54250*	*24000*	*24750*	*25500*	*26250*	*27000*
21	*Strategic hire in year 2*****		*100000*	*103000*	*106000*	*109000*	*112000*
22	*University Sub-total*	*1750*	*-12000*	*40250*	*92500*	*144750*	*281000*

*Italics indicate university revenue and expense stream

**needed to give incentives to potential summer project supervisors

***deficit in the first three years to be made up from SES budget

****Criteria for disbursement of scholarship to be developed by SES Faculty

*****If position is filled by the existing BRI director, only three sessional salary top-up is needed rather than full salary

8.3.1. Budget rationale:

Proposed budget for this **self-funding program** was developed in discussion with Biology Department Chair and SES Faculty Dean.

Summary:
The tentative budget is predicated on revenue sharing between Lakehead University and the SES Faculty at a 70:30 ratio. **This breakdown ensures that the program, which is intended for international clientele, will result in the delivery of the highest possible quality of instruction**. This will be achieved not only by the high quality of instruction, but also by providing resources and enticements to guest lecturers, as well as financial resources to support summer research projects by faculty members who are not necessarily core members of the program. The proposed budget will increase the likelihood of potential supervisors retaining students into full thesis MSc or PhD programs. A small portion of the budget will be for software and instruments, which will aid student training and development. A significant portion of the budget in later years is dedicated to scholarships, which will allow the SES Faculty to support academically strong candidates with limited resources to participate in the program. Even though the scholarships are presented as a cost, it must be emphasized that these funds will be returned to the university in the form of tuition fees.

The budget model is based on a modest increase in enrolment of 4 students per year, a target we hope to exceed. The expenditures are divided into three segments, with operating costs borne by SES Faculty and the program (30%), and the majority of staffing achieved by expenditures from revenue to the institution. The net results of the proposed budget are: (a) stable and predictable annual resources for operating the program, (b) stable and predictable resources to the SES Faculty budget, ultimately translating into scholarship funds flowing back to LU and (c) significant revenue accruing to Lakehead University as a whole, while contributing to the strategic hiring in Biology.

Justification and explanation of specific budget lines:
Lines 1-5 Revenue: The model is based on anticipated erollment increases of 4 students per year, with revenue income based on current international fees. The revenue is to be shared between SES Faculty (at 30%) and Lakehead University (70%). We justify the slightly increased contribution to the Faculty and MIBiotech program (compared to the current 25%) by the need to deliver a fiscally stable and academically strong program, which will be well appreciated by participants and reported on positively in their home countries. Specifics of how this will be achieved are described below. Based on the target optimal goal of attracting between 20 and 30 students per year, ample revenue (line 4, $300,000 to 400,000 annually) will accrue to the institution beyond the fifth year of operation.

Lines 7-12 Revenue to the MIBiotech program (administered by SES Faculty): Three main operational components will ensure the delivery of a strong and internationally recognized program:
Line 9. The inclusion of a strong set of seminar speakers from North American biotechnology industrial and academic community in the seminar course BIOT5XXC will introduce participants to the most current trends in the science and business of biotechnology. The seminar series will be open to the rest of the LU community, general public and in particular to

the Biotechnology PhD students and their supervisors. We hope to work closely with the PhD Biotechnology program, and bring speakers who may also serve as PhD thesis examiners. We anticipate budgets of about $600 per speaker from nearby provinces and states and $1000 per speaker from the rest of North America. Occasional speakers from other continents may be brought in if supplemental funding can be secured. Speakers from industry or those well established on the speaker circuit may expect honoraria, in addition to travel expenses.
Line 10. The research and lab supervisor incentive is intended to ensure that supervisors of the Spring/Summer semester 1FCE project course (BIOT 5XXE) will be in a position to support participating students, particularly since there will be no additional compensation for faculty members supervising the student. The allowable purchases will be for disposables, small equipment, office supplies, safety equipment and chemicals related to the project. Limited operating funds are a persistent obstacle to accepting students into Biology project courses. We are certain the situation is similar in other departments and faculties. Availability of this fund, established at $2,000 per student project, will ensure that all MIBiotech students will find suitable supervisors not only in Biology, but also Chemistry and the Faculty of Natural Resource Management, as well as among the Biotechnology PhD supervisory faculty. This funding will also directly contribute to our ability to evaluate students for their suitability to transfer into other graduate programs at LU or elsewhere (see learner outcomes and evaluation of the course for details).
Line 11. A steady budget of $5000 is needed for office supplies for the program (increasing over time) and for promotion of the program (decreasing over time). The former category is self explanatory - paper, printer supplies, long distance calls, office equipment replacements. The promotion costs will be the greatest in the first 2 years of operation. While collaboration with Lakehead International office will provide the main avenue for promoting the program, some funds will be dedicated to the development of web site and promotional pamphlets. Some travel will be necessary to relevant educational or biotechnology conferences.
Line 12. It is prerogative that a stable and predictable budget is established for the MIBiotech program from the start in year one. This will result in some shortfall in the initial projected revenue and will be made up from other SES resources in the first 3 years of operation. Positive residuals from this line in years 4 and beyond will contribute to the scholarship fund described in line 16.

Lines 13 - 16 Revenue and expenses indirectly contributing to MIBiotech and relevant SES activities.
Line 13. The other 15% of the income to SES will be used to:
Line 15. Partly support (1/4 of cost) the activities of the administrative assistant for PhD Biotech and other large SES graduate programs (about $30,000 PA). This individual will assist the MIBiotech academic program coordinator with record keeping and communications in respect to student admission and graduation. For example, we anticipate the need for good record keeping during the final oral presentations and examinations.
Line 16. Scholarship fund is proposed to be built up from the 30% of the total program revenue going to SES Faculty that is not required for day-to-day operation. Significant amounts will not be available until the 3rd year of operation, at which time SES faculty will decide on appropriate mechanism for the disbursement of the fund. Since the MIBiotech program will rely to a large degree on a limited supply of students supported by their governments' scholarships (income which may not be as secure as expected), we would like to dedicate majority of the fund to attracting academically strong international students with partial, or full support for tuition fees. In other words, the tuition scholarship funds will flow back into

university's general revenue stream. Significant added benefit will be the ability of SES to attract international students from other countries, than those providing our current international clientele.

Lines 19 - 22 Expenses for teaching

As indicated by the Italics typeset, the resources for instruction costs are to come from the 70% university revenue.

Line 20. The program requires the delivery of 3 FCE of **required** courses, all of which require new funding. The program is to be supported by 0.5FCE equivalent for the academic coordinator of the program, for a total of $54250 in the first year. This budget is anticipated to increase by about 3% annually.

As indicated in course descriptions, these sessional assignments are tentatively allocated to the following instructors:

Dr. Lew Christopher, program co-ordination, BIOT 5XXA and BIOT 5XXB (3 sessional equivalents)

Dr. Lada Malek, Biol 5650 and BIOT 5XXC (2 sessional equivalents)

Dr. Francis Appoh BIOT 5XXD (1 sessional equivalent)

The remaining optional 2 FCEs will be covered by existing faculty and their 3FCE optional graduate courses. This means that (for example) of the 20 students in the 5th year there will be on average 3.3 additional students per graduate course, a number that can be easily accommodated by the volunteer faculty members offering these existing graduate courses. The required 0.5 FCE undergraduate Biology course(s) are numerous, and MIBiotech students will be dispersed among six or so of these, again not adding more than 3-5 students per undergraduate course.

As mentioned before, there will be no teaching compensation for the participation in the Project course in the third semester, only a budget for supplies.

Line 21. Strategic hire in year 2 of the program.

Given the need to place the core teaching in the program on a solid academic base AND the projected long-term potential for revenue generation, we propose that a strategic hire be made in year 2 of the program, thus eliminating 3 of the 6 sessional salaries. An individual with strong background in industrial biotechnology teaching and research is required for this position.

In view of the proposed core requirement of Biotechnology-specific courses, we are fortunate to already have on staff Dr. Lew Christopher, current Adjunct to the Department of Biology and the Director of the Biorefining Research Institute. As a major proponent of, and contributor to, the proposed MIBiotech program, Dr. Christopher is in a strong position as a candidate for this strategic position. In this case, only a top up of his existing salary would be required, equivalent to the three sessional salaries already budgeted for in Year 1 of the program. Hiring him would result in significant ADDITIONAL savings to the proposed budget, eliminating the projected deficit in year two. This eventuality would essentially result in saving Lakehead University the projected $100,000+ annual expenditure.

8.3.2. Quality indicators and program review

Given that strategic hire becomes a reality in year 2, we propose that a review of the program be performed after 4 years, based on the following indicators:

1. Enrolment targets.
The program should show a steady increase in enrolment over the first 4 years, reaching ±20% of the projected goal, i.e. minimal enrolment of 13 students in year 4.

2. Conversion rate into other graduate programs.
The program will keep track of the numbers of students retained for Lakehead's MSc and PhD programs, as well as numbers of students continuing their graduate studies elsewhere, with a target of about 1/3 of the students retained.

3. Statistics on the overall graduation rate from the program, and supporting evidence for reasons of failure.

4. "Soft" data on student perceptions of the program, based on questionnaires collected on exit from the program.

8.3.3. Classroom, Laboratory and Research Equipment and Facilities

Since we are dealing with upper levels of instruction, the relatively small numbers of students can be accommodated in existing classrooms and specialized laboratories. The department of Biology is in the process of converting a room used as offices into a seminar room, which will be available to house about 24 students. Some of the new and program-specific courses could be delivered at this location, especially since we anticipate that some of these courses will have to be taught in the evening, due to potential scheduling conflicts between Biology and courses offered by NRM Faculty.

The program will not rely on teaching laboratory space, since it is primarily lecture-based. The only exception is possibly if a lab-based undergraduate course is identified as deficient in the student's background. For example, the Laboratory Biology 2910 course can likely accommodate additional 20 students or so. However, we don't anticipate more than additional 10 students per course in later years of the program, as the potential 30 students will disperse into about 10 undergraduate laboratory and lecture-only courses, adding about 3 students per course on average.

Research equipment and facilities of core faculty, as well as additional faculty in Biology, Chemistry, Physics and Engineering (primarily those supporting PhD Biotechnology students) should be more than adequate in the early stages of the program. However, should research space demand exceed the capacity and ability of existing staff to supervise summer research projects, alternative projects may need to be developed, so they are less demanding on research facilities. These are envisaged for the weakest of students, and will be based on library and Internet research. Alternatively, collaborative projects may be developed with local industry, and the best students allowed to work on industrially oriented projects.

8.3.4. Office Space for Faculty and Students

The program is proposed by existing LU staff, all of who have existing office space. It is hoped that if the strategic hire is made from within the university, there will not be additional demand on office space. The program is to a large extent supported by the activities of the LU Biorefining Research Institute and with its development, there will likely be additional space available.

Student office space is not an issue during the academic year. Students will primarily use the library graduate student space currently under development. Additionally, students will likely be able to use the Biology Seminar room, when not used for teaching or meetings. Biology student lounge is also available, although in need of updating. During the summer research projects, space will have to be found in the individual supervisors' labs, or the common university spaces (Library) will be used as described above.

Appendix A

Program Coordinator job description:

The incumbent will have a doctoral degree and full academic credentials related to the program content. Initially volunteer position, but ultimately to be selected by program and Faculty of Science, committee structure TBA. Activities of the coordinator in this capacity shall constitute one half FCE course equivalent. Once established as Tenure Track appointment, additional duties will include teaching a standard course load in the Biology Department.

Responsibilities will include:
In consultation with the faculty of Graduate Studies, screen student applications; participate in student selection and admission process.

Working with the International office, will assist students in settling in Thunder Bay.

Working with the International office, will organize welcome activities at the beginning of each Fall semester. This will include a lecture outlining the program expectations and services such as the learning assistance center, the library and computing facilities. Will deliver the Entrance Quiz and with occasional participation from other MIB faculty, conduct bi-weekly one hour meeting with program students.

Will act as interface between (1) program faculty and administration on academic and budgetary matters; (2) program students and program faculty, on academic and disciplinary issues and (3) MIBiotech program and the department of Biology.

Will be responsible for the delivery of the seminar course and organization of guest speakers for this course. Names of potential visitors will be solicited from program faculty and from Biotech PhD faculty.

Will organize and schedule the seminars resulting from Summer research projects. In consultation with individual project supervisors, shall evaluate the project seminar and final report.

Will deliver the exit oral discussion with the participation of two additional faculty members.

Will deliver the Exit Questionnaire, collate the information gathered on individual students. Shall prepare an annual written report summarizing the performance of individual students and the achievements of the program. Shall identify shortcomings and seek possible ways to rectify these.

Will organize a minimum of two MIBiotech faculty meetings per year, aimed at reviewing and improving the program.

Appendix B.
Seminar evaluation form.
Seminar evaluation form (comment on each point):
PRESENTER NAME:

Evaluator NAME:

1. Clarity - Was the presentation clear, understandable, meaning was grasped?

2. Precision - Was the presentation given at a required level of detail and geared to audience? Were results exact?

3. Were results accurate? Free from errors and distortions? True? (Statistics)

4. Relevance - Did presentation relate to issue at hand? title, content relevant? did results advance understanding of the issue?

5. Fairness - Was presentation justifiable, not self-serving or one-sided?

6. Depth - Did presentation deal with complexities and multiple interrelationships? Additional complexities? How can these be dealt with?

7. Breadth - Should this be looked at from another perspective, from any other points of view?

8. Logic - Was the presentation organized well? Did the parts fit together? Contradictions?

9. Significance - Did presentation focus on the important, not trivial? What is the central idea here?

10. What are the implications of this work in a broad context?

11. Presentation skills