PROPOSAL TITLE:

Feasibility Study for Life Sciences Undergraduate Collaborative Research Projects

SUBMITTED TO CLL:

March 1, 2010 by Dr. Kimberley Dej

ABSTRACT:

The opportunity to participate in independent research in a laboratory environment is considered a capstone experience for our undergraduate specializations in the Faculty of Science. Indeed, studies show a positive learning experience as reported by students that includes increased technical skills, the ability to act independently, increased confidence, and insight into graduate opportunities and career possibilities.[1, 2] In the various Life Science departments at McMaster University, this is typically a nine-unit thesis that is based upon research conducted within a lab. There are several problems associated with the current model, the primary one being the difficulty in providing enough thesis positions for all of the students who are interested in this opportunity.
The Honours Life Sciences program does not require a thesis for graduation, but many talented and enthusiastic students are seeking this valuable opportunity. Faculty are struggling to keep up with this interest and many students are turned away. Even within Departments, Faculty are finding it difficult to provide the time and space to accept undergraduate students from their own specialization programs into their labs.

This proposal suggests a new model that would allow more students the opportunity to conduct novel, independent research in association with a research lab with little increase in resources and time from a participating Faculty member. Within this model, a group of fourth year Honours students would collaborate on a common research project that is linked to current Faculty research. While the students would complete much of the research independently, they would support and assist each other in a peer-based, collaborative environment, in some cases guided by the expertise of a graduate student from the participating lab. Students would share their individual expertise and skills, but collect independent sets of data that would be accumulated at the end of the project for final analysis. The participating Faculty member would oversee the direction of the research, but the pedagogy would remain in the hands of the Life Sciences program. This would provide more students with the opportunity to complete self-directed research and would provide a new conceptual structure for undergraduate research at McMaster University that would appeal to students with diverse learning styles. In addition, these projects could tie together research projects from two or more labs and would have an interdisciplinary approach befitting the Life Sciences Program.

This project aims to show that a group of five fourth-year students can collaborate in a dynamic peer-based environment and contribute to a primary research study. The success of the proposal will be assessed from the perspective of the students completing the research and also from the response of Faculty members who will be asked to contribute projects in future years. This project could be used as a model for other projects associated with the Life Sciences Program and could also be used within Departments to increase the number of thesis opportunities.

WHAT IS THE LEARNING PROBLEM TO BE SOLVED?

The Honours Life Sciences (HLS) Program at McMaster University is a new interdisciplinary undergraduate program. Students have a lot of flexibility to design their own program, selecting courses taught by all of the Life Science Departments including Biochemistry and Health Sciences, Biology, Psychology, Chemical Biology, Kinesiology and Environmental and Earth Sciences. This allows students to assemble an interdisciplinary degree that is suitable to the changing face of the Life Sciences.

Students in the HLS Program are not required to complete a nine-unit research thesis that is typical of undergraduate Specializations in the Faculty of Science. As the Life Sciences program has been developing, there has been a dramatic increase in the number of students interested in pursuing an independent research project in their fourth year (40 Life Science students completed a Science 4CO9 project in 2009/10; over 120 Life Science students attended a thesis information night in November 2009 in preparation for 2010/11). Note that the Life Science Program is an undergraduate strictly an undergraduate program and does not have its own dedicated research Faculty

The problem can be summarized as follows:
1) As more Science students wish to complete a thesis, many are being turned away. Faculty are limited in the space they can provide for undergraduate students and the time to train students. This limits the total number of students that are given the opportunity to pursue self-directed research. This has a most dramatic impact on the students in the Life Sciences program who are not affiliated with a single Department and do not require a thesis for their degree. These students have the enthusiasm and skills, but are unable to access the opportunity.

As example, the Biology has about 30 Faculty members that take on thesis students each year. This is not including dips due to research sabbaticals. This year, there are about 120 Biology students completing thesis projects. Many Faculty are unable or unwilling to take on more than one or two thesis students. Immediately there is a a discrepancy between demand and access. If we now add on to this the Life Science students that wish to complete thesis projects, we can see that the capstone experience is unattainable for most.

2) Many students are unwilling or unable to commit nine units of their degree to a single thesis course, however, faculty tend to prefer to take students for a full nine-unit thesis project. The rationale is that the student will spend more time in the lab in proportion to the time invested in training. This proposal seeks to create a meaningful lab experience within a six-unit or three-unit project and to make this an appealing opportunity to faculty in the various Life Science departments.

3) Many students are more comfortable in a collaborative environment where they are working with a group of peers, and so choose not to complete a fully independent thesis. It is unfortunate that these students may miss out on this rare opportunity to work in a lab. Such an opportunity could actually increase the confidence and motivation of these students to continue on to graduate research.

This proposal suggests using the Life Science 4AO3 and 4BO6 courses to frame a new kind of fourth year research opportunity. A group of fourth year students would have the opportunity to complete original research in lab, but would be doing so in collaboration with other fourth year students.

PROJECT OBJECTIVES.

1) Increased access to capstone research experiences for Life Science students.

2) A new format for independent projects that is based upon a collaborative, small group, peer-based lab experience. This allows students who lack the confidence to complete a full nine-unit thesis to gain the experience of working on novel, publishable research.

3) The establishment of interdisciplinary thesis projects that employ the various skills of the Life Science students.

4) Encourage undergraduate group projects that are interdisciplinary and collaborative between Life Science Faculty.

5) Enable Life Science Faculty to oversee more project students without straining the resource and space restrictions within their labs.

6) Develop a seminar series that would be partnered with the students' work in the lab that would include topics such as expectations within the lab culture, data collection, data analysis, and oral and written presentation skills. These seminars would alternate with group presentations from the participating students.

5) The project that follows is a sample that will be used as a feasibility study to assess the success of such a model in terms of:

(a) Student learning. Do students synthesize information from their Life Science degree in this research experience. Do students benefit from working in a small peer group? Are there students that complete this collaborative project that might not other wise have chosen a thesis? Are there students that complete this project that might not otherwise have had access to a project?

(b) Faculty interest. Do participating Faculty obtain valuable and publishable research from this project? Do Faculty perceive that students are receiving an experience comparable to a nine-unit independent thesis in the lab?

ALTERNATIVE SOLUTIONS CONSIDERED.

Given the essential problem of providing a capstone research experience for the Honours Life Science students, other solutions have been considered.

Current solutions:

1) Counselling Life Science students in their third year on thesis opportunities available outside of the three primary Life Science Departments (Biochemistry, Biology and Psychology) since there are already students within these Departments vying for positions. This includes opportunities in labs within McMaster Health Sciences and in research labs in McMaster-affiliated hospitals. In 2009/10, approximately 14 of 33 Honours Life Science students are completing thesis projects in labs within Health Sciences including Psychiatry, Pediatrics, and Pathology.

2) Providing alternative capstone experiences including fourth-year seminars that encourage inquiry-based learning and independent library-based research. For example, Life Science courses 4DO3 and 4LO3.

3) Encouraging students to seek independent projects that are not directly based in a lab and might instead include library-based research projects.

While we have not rejected these options, they are still limited in the number of students that they impact. In addition, evidence supports the advantages of hands-on laboratory experience in student learning. This includes the acquisition of research skills and an understanding of scientific research, but also clarification of career goals and aspirations. Students participating in undergraduate research may be more likely to pursue graduate research. Importantly, studies report personal gains that include increased self-confidence, improved communication skills, and enhanced career preparation.[1, 2, 3]

Examples of successful implementation of similar models include the course, Life Sciences 100r; Experimental Research in the Life Sciences at Harvard University. This is described in the Harvard academic calendar as follows "A laboratory course that immerses students in a dynamic project-based research environment. [Students] participate in experimental projects directly linked with ongoing faculty research. In a highly collaborative atmosphere, students form a fully-functional and diverse research group based on the sharing of ideas and progress reports between projects." (http://my/Harvard.edu/course/colgsas-2122).

In communications with Chairs of three contributing Life Science Departments (Biochemistry, Biology and Psychology), all agreed that there were constraints on the number of students that could be accepted into labs to complete thesis projects. All acknowledged that excellent and enthusiastic students from the Life Sciences program were competing for thesis positions, but that there was a sense of responsibility to students within Departmental specializations. In addition, all were intrigued by the description of the proposal presented here, but wanted to see evidence that students could be productive within such an environment.

METHODS AND SCHEDULE: PROPOSED PROJECT FOR 2010/11.

In order to demonstrate the feasibility of this project and convince research labs to participate in future years, I would like to have students complete a demonstration project in the academic year 2010/11. The proposed test project would be completed through collaboration between Dr. Bhagwati Gupta (Department of Biology) and myself, Dr. Kimberley Dej (Department of Biology and Director of the Life Sciences Program).

The proposed project involves the study of novel species of the nematode or roundworm. The nematode, *C.elegans*, is a valuable model organism. The genomes of this species and other related species have been sequenced in their entirety. While about 80 000 species have been identified, estimates suggest that there may be up to a million different species. Dr. Bhagwati Gupta's work includes research on the comparative developmental genetics in two species, *C. elegans* and *C. Brigsssae.*

We propose that five students would begin their study with a field component that sends them into various neighbouring ecosystems in order to obtain specimens of nematodes. Students would need to describe the habitat that is the source of the sample and use a global positioning system (GPS) to map the area. They would bring the specimens back to the lab for morphological analysis and description. Each student would select a distinct species for his/her studies. A thorough analysis of appearance and behaviour would be completed using a microscope. Then the students would proceed to complete some molecular analyses including DNA extraction, PCR reactions, and DNA sequencing of ribosomal genes. All of these elements of the project could be completed independently, but students would be encouraged to help and teach one another based upon their skill strengths. The students would then bring their data together at the end of the project to place the species into an evolutionary tree that represents the relationship of the specimens with one another.

The student projects would span two terms (and could be conducted within the summer months). A graduate student with the appropriate technical skills would assist the students. In addition, myself and the graduate student assistant would develop a series of seminars that would guide these and future project students in lab- and career-based skills. Topics would include the expectations of working in a group environment such as a lab, the development of research hypotheses and methods, maintaining a lab notebook, and the analysis and presentation of data. These would be partnered with presentations from the participating students. For example, if four such

projects were running in a given year, twenty or more students would actively participate in these seminars and present to the entire group of students. This would reduce the time required by Faculty in training these students in these skills.

Assessment would be based in part upon individual lab work and the oral and written presentation of their results, but the final project would be presented by the group in a written and oral format. This would more accurately represent a typical research environment.

The students would have exposure to a large number of techniques that span ecological field studies, morphological analyses, molecular genetic techniques and evolutionary biological analyses. This cross-disciplinary research is in the spirit of the Life Sciences program. It gives students the opportunity to complete independent work, but also to benefit from a collaborative environment. The students would also have multiple opportunities to present their work to faculty and peers.

EVALUATION OF PROJECT SUCCESS.

Project success would be evaluated upon the following criteria:

1) An evaluation of the student experience. Through interviews and questionnaires, we will assess the perceived benefits of the project by the student. A similar assessment will be conducted among Life Science students completing nine-unit independent thesis projects. In comparing the two groups, we will see if there are advantages or disadvantages to the group-based project.

2) The productivity of the students working in a peer-based environment on a novel research project. This would be evaluated by the successful isolation and analysis of new nematode species, in particular those closely related to the model organism, *C.elegans*. This is required to demonstrate to Faculty that such projects can be a valuable source of data for their labs.

3) The ability to convince Faculty on McMaster campus to support similar projects in the following year. While this pilot project involves 5 students, we would like to see about four such projects running each year. We propose that Faculty would submit brief proposals for projects each Winter to the Life Sciences program that would be supported through TA positions. In particular, we would encourage projects offered jointly by collaborating labs that draw together skills from various fields in the Life Sciences.

DISSEMINATION OF RESULTS.

Primarily the results will be presented to Departmental Chairs and interested Faculty members in order to encourage future participation in similar projects. In addition, seminars would be presented through McMaster's Centre for Leadership and Learning CLL that summarize project effectiveness.

WHO WOULD BENEFIT?

If this project is successful, four or more group projects could run in a single year giving about twenty students the opportunity to conduct research in their fourth and final year of the Honours Life Science Program. While this may seem like a small number of students, these are students that would otherwise miss out on this independent experience during their career at McMaster.

In addition, this course has the promise of benefiting multiple different Life Science Departments and may provide a model for similar specialized courses within each Department. In communications with the Chairs of Biochemistry, Biology, Kinesiology, and Psychology, it is apparent that all Life Science Departments are struggling to provide a capstone research experience to their students.

Furthermore, this would be an opportunity to encourage research and pedagogical collaboration within the Faculty of Science and perhaps even between Faculties.

PROPOSED BUDGET:

Technical support and equipment would be provided for this pilot project by Dr. Bhagwati Gupta (Department of Biology) in addition to the equipment that I (Kimberley Dej) can provide in my Biology 4CO9 teaching lab. The items listed are those required for the project to run for about two years, but also include the establishment of the seminar series that would run annually. While this exact project would not run indefinitely, the investment is in the proof of principle. By demonstrating the success of the model, different Faculty in various Life Science Departments would be interested in participating each year.

Detailed Budget:

Technical Resources:		
	Platinum Taq polymerase	188
	High Fidelity Taq	364
	Primers for PCR	20
	Agarose	160
	DNA ladder	178
	dNTPs for PCR (nucleotides)	78
	RNAse/DNAse free water	20
	Sequencing (Mobix)	300
	DNA extraction buffer	60
	Gel extraction kit	100
	Plates for worms	500
	microscope (borrowed)	0
	Software (sequence analysis-freeware)	0
	PCR machine (borrowed)	0
	GPS (borrowed)	0
	Misc. Equipment (tips, tubes, etc)	200
	SUBTOTAL	2168
Conference/presentations (Ontario Biology Day)		
	Poster/Presentation preparation (5x40)	200
	Registration (5X50)	250
	Transportation	250
	Accommodation and Board	350
	SUBTOTAL	1050
Project support salary:		
	½ graduate TA	2750
	(65 hour includes benefits)	
	SUBTOTAL	2750
	TOTAL	5968

FUTURE PROJECT SUPPORT:

If this project is successful from the perspective of student learning and Faculty interest, the Life Sciences program would support the infrastructure of the projects in the following way: (note that the "participating Faculty member" would be the lab's primary investigator who provides the research proposal)

1) The seminar series would be run through the Life Sciences program to support student learning without requiring the input of the participating Faculty member.

2) TA support for the projects would be built into the Life Sciences budget.

3) While the participating Faculty member would be asked to contribute a small amount of research funds and share necessary equipment , the Life Sciences program could in the future provide a small grant each year to support a project. For example, the model proposed here could run for a year within the established structure on a resource budget of about $1000. This is a relatively low amount for a lab to invest in a research project that could generate a great deal of data.

REFERENCES:

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3. Ward, C. Bennett, J., & Bauer, K. (2002) Content analysis of undergraduate research student evaluations. http://www.udel.edu/RAIRE/Content.pdf

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