Teaching Portfolio Appendix

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Table of Contents

Appendix 1 - Teaching and Education Philosophy

Education has a broader focus than teaching because it includes the development of broad educational goals that are outside the scope of a single course. Education also includes support for the development of courses and programs, learning opportunities, an environment that supports and encourages student learning. My views on education and teaching are described throughout my CV and my Teaching Dossier. To provide a consolidated overview of my beliefs, I have created the following appendix.

I believe that the university has an obligation to foster learning environments where students can achieve their potential to be independent, discriminating life-long learners. I also believe that a university science education should foster disciplined thinking that endows students with the courage and tools to explore their curiosity, challenge ideas and create new knowledge. This learning can take place in many forms and styles, but all science students should develop a critical understanding of the scientific process. This awareness is crucial because it will help them construct a critical awareness of ideas and observations for the rest of their lives, wherever they are and whatever they are doing. I believe that the most effective way to develop this understanding is to include opportunities in every program to complete guided, independent, research-based inquiry during which the students practice and explore their skills in this form of reasoning. I am also convinced that students need informed advising and feedback to make appropriate choices of educational opportunities. The university has a responsibility to structure the goals of programs and courses such that students can see and understand the potential role of various programs and courses in their personal educational goals.

Effective teaching helps learners to learn. To facilitate authentic learning by my students I have included, adapted or invented many of the elements for effective learning that are promoted in publications such as "*Learning Development in Higher Education*" edited by Peter Hartley et al. (2011) and "*What the Best College Teachers Do*" by Ken Bain (2004). Several principles form the foundation of my approach to teaching and learning

Students

- Each student has a unique educational history, experiences and abilities that shape their individual ability to acquire and apply specific science concepts and facts.
- Students are well informed but need opportune assistance to develop skills that allow them to direct their expertise so that it is useful to them and to others.
- Students are more willing to argue details or explanations with their peers than the instructors or the teaching assistants.

Learning

- Critical engagement with concepts and observations in ways that involve analytical thinking or application or synthesis is necessary to develop comprehension.
- Understanding is the developed ability to apply the critical reasoning needed to infer rational opinions and solutions from available evidence or reasoning.
- Learning development is a cumulative activity that extends beyond the classroom

Teaching

- Effective teaching demands clear, relevant and achievable learning outcomes since student success is measured by the achievement of desired learning.

- Ideal teaching develops the reasoning and background applied by professionals in the field of the subject.
- Applying diverse pedagogical approaches is vital to encompass different learning styles.
- Providing consistent, constructive and timely feedback is essential to promote learning.
- Continually adapting courses to meet current learning needs is the key that compensates for the changing societal and cultural experiences that form the framework for successful learning.

I have engaged these principles in the lecture and lab courses that I have taught. When I started teaching I imagined helping students ascend a linear path of learning. As I matured I recognized that learning and learning opportunities are much more pervasive. Rather than a linear ladder, learning is multifaceted, multidimensional. Experts in one field are novices in other fields so that the roles of learner and teacher depend on the circumstance. I teach my students but I also learn from my students. Sometimes I learn extraneous knowledge. Sometimes I learn concepts and processes and views that I can use to strengthen my own expertise and teaching. Even opportunities that seem to be distinct and separate fields offer great potential to learn. For example, when I attended a kayak racing clinic I took lessons from an older teacher. He showed many skills for kayaking but he also stressed that you could not build and apply advanced technical skills without paying attention to the basic skills. If you slouched in the kayak seat instead of sitting upright you could not make the advanced techniques work. This was an important lesson that I have carried over and applied in my classes in molecular microbial genetics and physiology. If the students do not apply the basic skills that keep the cultures pure the outcomes from the advanced methods involving cloning and gene construction become much more difficult because the inevitable contaminants make it hard to interpret any of the outcomes.

In my current teaching I am attempting to foster a critical appreciation of the scientific research process by ensuring that all the undergraduate students in the six undergraduate specializations for Microbiology and Immunology have the opportunity to carry out actual research projects before they graduate. This interest is central to the teaching goals outlined in the Trek 2010 vision for UBC. It is also part of my personal belief that students begin to think like scientists when they need to develop and test their own explanations and ideas. Anecdotally, I have been aware of the "lost" students that other faculty members acclaim and regarded highly since I was a graduate student many years ago. These are the students with strong, independent analytical skills. They can see the important details in the chaff generated by research studies. They can make experiments work, but their grades are mediocre. Despite the weaker grades they seem to think differently because they seem to think more like professional scientists than most undergraduates. These "lost" students are important because they are closer to the desired learning outcomes than the students that write excellent exams but have not learned to think in broader concepts, and broader applications. I believe that real research can foster the skill to apply knowledge and think scientifically. To some extent this belief is supported by biological studies of the learning activities that suggest active involvement with learning causes different activity in different areas of the brain than simple talking or discussion.

To achieve my teaching goals, I apply a mixed mode of teaching that has included elements of problem based learning, Socratic questioning, student teams, peer feedback, individualized meetings, journaling, invention activities, reports, written feedback, detailed grading rubrics, learning outcomes and teaching outcomes. I develop lectures to address issues or background that need to be understood by many of the students in the class, then use smaller meetings with student teams or individuals to address specific issues. I use grades and other feedback to motivate desirable capabilities. To encourage this development I apply higher expectations as the course progresses and I provide extensive, constructive written, feedback explaining the strengths and weaknesses for every submitted assignment. I have also found that using examples of appropriate, anonymous student work is a valuable learning tool for presenting an

analysis and explanation of the problems and conceptual misunderstandings encountered by most students.

I also believe that teaching is an adaptive process rather than a fixed recipe that can be applied year after year. Students change, student ability and student backgrounds change. To accommodate these changes the teacher and the approaches to teaching need to be responsive. I also believe that student feedback is critical for course development so at the end of each term I solicit feedback to modify the future courses to better achieve the desired learning outcomes. All the suggestions are considered and one or two are chosen to test in the following year. To learn about other potential approaches I attend "Centre for Teaching, Learning and Technology" workshops (formerly "Teaching and Academic Growth"), "Science Supper Series" seminars on teaching topics, advising seminars, "Carl Wieman Science Initiative" lectures on learning, the annual "Teaching and Learning Conference" on teaching developments, some "Scholarship of Teaching and Learning Team" seminars. I also read relevant articles in *The Teaching Professor* and *Distant Education* journals. In my experience the single most productive approach for enhancing learning by my students is done by making the time to understand the problems that limit each individual student's understanding of the lessons and the goals of my courses.

Appendix 2 - UBC Journal of Experimental Microbiology and Immunology (JEMI)

The UBC Journal of Experimental Microbiology and Immunology (JEMI) is devoted to the publication of the results of undergraduate research projects undertaken in the MICB 421 (Experimental Microbiology) and MICB 447 (Experimental Research) research courses. These courses expect students to develop and carry out short independent hypothesis based research projects. The content of the journal covers preliminary studies in the areas of microbial physiology, molecular biology, enzymology, genetics, and phage biology. It is published at *http://www.microbiology.ubc.ca/JEMI/Volumes*

To demonstrate the recent content and the analytical expectations of the journal, I have included sections in the following pages that show:

- The table of contents for volume 15 from the 2010 – 2011 winter session to show the range of projects that are covered by the MICB 421 and 447 classes

- A sample page from an article in volume 15 to show the type of detail achieved by the students writing for this journal.

- An abridged version of the detailed instructions that I provide for the students to guide their writing and presentation

Example Table of Contents for JEMI

UBC Journal of Experimental Microbiology and Immunology

Volume 15 Fall 2010/Winter 2011

Physiology and Metabolism

Biofilms and Environment

Genetics and Molecular Environment

Example of Part of an Article for JEMI

Journal of Experimental Microbiology and Immunology (JEMI) Vol. 15: 96 – 102

Sub-Inhibitory Kanamycin Changes Outer Membrane Porin Ratios in *Escherichia coli* B23 by Increasing the Level of OmpC

Wei-Chieh Hu, Roderick MacDonald, Jean L. Oosthuizen, and Melanie van Soeren
Department of Microbiology & Immunology, University of British Columbia

Previous studies have shown that *E. coli* B23 cells pretreated with a sub-inhibitory concentration of the aminoglycoside kanamycin develop short term (1.5 hour) resistance against lethal concentrations of tetracycline, ampicillin, streptomycin and kanamycin, as well as long term (24 hour) resistance to streptomycin and kanamycin. Modulation of outer membrane porins such as OmpC and OmpF has been suggested as an early line of defense to antibiotherapy by provoking a decrease in membrane permeability. Given that OmpC and OmpF have been shown to be important for the uptake of antibiotics for which cross-resistance was observed, this study isolated and quantified their expression in outer membrane extracts from *E. coli* B23 treated with sub-inhibitory kanamycin. It was observed that upon exposure to sub-inhibitory concentrations of kanamycin, OmpC levels increased relative to the OmpA, while OmpF levels did not, concordant with our expectations as OmpC is the smaller of the two porins and excludes the passage of larger hydrophilic antibiotics capable of permeating OmpF. The results of this study help to further elucidate the mechanism(s) of adaptive resistance observed in *Escherichia coli* B23 following exposure to sub-inhibitory concentrations of kanamycin.

The use of antibiotics as therapeutic agents exemplifies some of the greatest successes and failures of medicine in the last half century. While efficacious in the treatment of a spectrum of infectious diseases, an equally diverse set of strategies have been evolved by bacteria to overcome these pharmaceuticals (5). Many mechanisms of antibiotic resistance have been well documented, such as intrinsic resistance due to outer membrane impermeability or efflux pumps (12) and acquired mechanisms of resistance like antibiotic modifying enzymes or alteration of the 30S ribosomal subunit (11). However, as of yet, little work has been done to identify mechanisms of adaptive resistance (9), which is defined as an environment dependent induction of transient resistance without observable changes in genotype (12).

It has previously been shown that *Escherichia coli* B23 cells pretreated with a sub-inhibitory concentration of the aminoglycoside kanamycin developed short term (1.5 hour) resistance against lethal concentrations of tetracycline, ampicillin, streptomycin and kanamycin, as well as long term (24 hour) resistance to streptomycin and kanamycin (3). Chen *et al* speculated that this resistance might be the result of outer membrane alterations, specifically through manipulating the ratio of OmpF and OmpC to favor the exclusion of drugs translocating through the larger porin (3). OmpC and OmpF have been shown to be important for the uptake of antibiotics for which cross-resistance was observed (15, 25) and may play a small role in the uptake of aminoglycosides (13, 20).

OmpC and OmpF are reciprocally expressed major outer membrane proteins in *E. coli* that form hydrophilic pores and participate in non-specific transport of solutes (7). OmpC has a channel size of 0.54 nm and molecular weight of 37 kDa, while OmpF has a channel size of 0.58 nm and a molecular weight of 38 kDa (21). Both are trimeric units consisting of three beta barrel channels formed by membrane spanning porin polypeptides. Due to its larger diameter, OmpF allows a greater flow rate, is more efficient in the uptake of sparse nutrients and allows the permeation of large hydrophilic molecules, such as aminoglycosides, whose passage is most likely excluded by the smaller OmpC (13, 21).

A decrease in membrane permeability through modulation of outer membrane porins could be an early line of defense to antibiotic therapy. Methods of regulation could include transcriptional and/or translational repression, or even a mechanistic closing of the porins as has been observed for OprM and TolC porins in *Pseudomonas aeruginosa* (23). OmpF expression has been

Guidelines for Producing Articles for JEMI

The final reports for project #2 will be published as an article in the UBC Journal of Experimental Microbiology and Immunology (JEMI) so these reports must use the style required by JEMI. This style is adapted from the style for the American Society for Microbiology (ASM) journals. The style is described below and in the "instructions to authors" section in the MICB 421 WebCT Vista site. The report for project #1 and the draft for project #2 will be done in the same style to provide practice with the requirements. In each report you are expected to concisely interpret the major observations in your data and then analyze the interpretations by relating them to your basic background knowledge and the specific objectives of the experiment.

The grade for the submitted reports will consider:

- grammar
- logic and accuracy
- formatting and style
- effectiveness of the presentation details (appropriate tables, graphs, graph choices)
- analysis and explanation of appropriate details within the data
- consistency and completeness of the analysis
- conciseness

Each report must include the title of the experiment, the names of the authors, the affiliation of the authors, an abstract, an introduction and labeled sections for material and methods, results, discussion, future experiments, acknowledgements and references. Examples of these features can be seen in recent copies of JEMI.

1. Title

   The intent of the title is to capture the reader's attention and allow potential readers to know whether the article might be relevant to their interests. The title should be a single sentence that should convey the essence of the study. Use the fewest possible words to accurately describe the paper and provide enough information for an indexing service such as Medline. There should be no jargon or abbreviations.

2. Abstract

   The abstract is a short form of the paper. It contains the objective, main method, summarized results and the main conclusion. It is intended to give potential readers a better idea of the objective of the study, the approach to the study, the main observations and the main conclusions. It is written in the past tense as a single, self-contained, short paragraph without references or abbreviations.

3. Introduction

   The intent of the introduction is to provide enough background to understand and evaluate the purpose and the results of the reported study and justify the purpose without further literature review. It is not intended to be a review but there should be sufficient literature information to orient the project by providing the essential details that allow the reader to understand the hypothesis being reported, the reason that anyone would study those details, the direction of the eventual discussion and a specific statement of the scientific purpose of the study. It must include a formal written statement that gives the scientific purpose that will be addressed and answered by the experimental results. It should define any specialized terms or abbreviations.

4. Material and Methods

   The details in this section must be written in paragraphs rather than point form but Tables and figures can be included to concisely present details that are too wordy to write out. It should be written in the past tense and should not include any results, just the details needed to know how the reported work was done.

   It should provide enough detail to understand how the assays were done. Where appropriate the operational details should be referenced to existing published articles or published books but there should be enough information that the reader can understand the specific approach without looking up a lot of references. If the materials and methods were identical to the descriptions in the references then you should make a short statement to that effect and cite the reference. If there were any significant changes then you can indicate that the materials and methods were a modified version of the protocol in the reference then cite the reference and briefly explain the modifications. Use the past tense. Provide catalogue numbers and supplier source for any significant chemicals, kits and supplies. Provide recipes or references to the recipes for the solutions used for growth or reactions. Give names and properties of constructs by taking the first letter of each surname on the team and linking it to the number of the winter session and a unique number for that strain (initials/session year/clone number, ie: AABF081 or KPST082). Use titles and labels for any Tables and figures.

5. Results

   a. The introduction and the methods explain how you got results. The results section is used to present the data and comment on the patterns. The results for Project 1 must include the tables and figures specified at the end of Project 1. The tables and figures for Project 2 will depend on what was done and seen in your project. In each report there should also be a few paragraphs that point out and comment on the main observations and problems in the presented results. These paragraphs should be succinct summaries that point out the meaning and patterns of the observations rather than simply re-describing the graphs and tables in words. You are expected to consider the experimental purpose and pick out what seems to be the most relevant observations, problems, paradoxes and quirks from the data. Then briefly compare those observed effects to your expected results. You should also comment on the quality of the result and the main observations and the main relationships of the trends but reserve the explanations of the trends for the discussion section. Similar effects should be considered together and treated as a single observation so that space is not wasted simply repeating the same thing. For example, imagine that you are examining the effect of drugs on polymerase activity and observe that one drug speeds up the activity and two drugs slow it down. In the report it is better to observe that different drugs have different effects since some decrease activity and some increase activity, instead of breaking the information into three totally separate and isolated observations. Since the results comment on measurements and observations done in the past they must be written in the past tense.

   b. Wherever possible, the observations should be related to each other and compared to the controls. All comparisons should be quantitative. For example, if something becomes two times bigger than the control values you should say that it is 2x bigger or 200% bigger or twice as big instead of just saying that the value got bigger.

   c. The tables and figures are intended to organize most of the data into a form that is easier for you to analyze, compare and examine for patterns. The tables and figures in Project 1 request more information than you would encounter in a normal published report. This extra information is intended to give you some indication of the steps involved in processing the data to the final form

and allow us to check whether you have problems in the logic at any of the different processing stages. You may include additional tables and figures, if you find them useful for either your discussion or analysis, but you should not include extra tables that simply repeat information already presented in the requested figures and tables.

d. Rules for making the figures are included in the "units, graphs and calculations" section in Appendix C of the lab manual. We will expect you to understand and apply those rules when you prepare and submit the reports.

e. Figures should be numbered in Arabic numerals and identified with relevant, informative titles at the bottom of the figure. A useful title is a sentence that indicates the purpose or intent of the information or trend in the graph rather than simply repeating the axis labels. For example: the title " Effect of carbon dioxide levels on the growth rate of *E. coli* in aerated minimal media" is more useful and informative than the title "Growth versus time" or "OD versus time". Figures should be identified by the capitalized abbreviation such as **FIG. 2** rather than Fig. 2 or Figure 2.

f. The tables should be identified with upper case letters, Arabic numerals and informative titles at the top of the table. For example, "**TABLE 2**. Strains and plasmids used in this study." rather than "Table II. Strains and plasmids used in this study."

g. When data from a particular experiment is referred to in the discussion, the relevant data should be clearly identified by referring to the appropriate figure or table number. This referencing can be done in a several ways, for example:
   - "Figure 12 shows that the growth rate doubled after the addition of the amino acids."
   - "The growth rate doubled after the addition of the amino acids (Fig. 12)."
   - "The affinity of *Listeria monocyogenes* to attach at different temperatures is shown in Fig.1"
   - "The amino acid uptake increased 3 fold after glucose was added (Table 2)."

h. You should note that even though the identification of the actual TABLE or FIG. is capitalized, the reference statements in the discussion and results use Table and Figure or Fig.

i. Good tables and figures are generally uncluttered and easy to read. Choose units and prefixes that try to avoid a lot of zeros or exponents that will clutter up the data and interfere with easy comparisons. In this regard, the units in the requested for tables and figures in Project 1 are just examples of the type of the unit that the data should be expressed in and you should not necessarily use that specific unit. For example, the table or figure might show units of mg/ml but if most of the measurements yield concentrations in the ug/ml range then you should express the data in units of ug/ml. Try to avoid a lot of zeros or exponents that will clutter up the data and interfere with easy comparisons.

j. The figures should include keys that correlate different graphed symbols to the appropriate reaction conditions. In these keys concisely identify the active component of the test condition rather than the arbitrary number given to that test during the experiment. Since the only intent of the key is to identify the datum points to correlate the result to the conditions identified in the title or the axis labels, the key should not repeat any unnecessary information that is already presented in the title or the labels. The keys should be boxed off or positioned so that the symbols in the key cannot be confused with actual data points. Frequently it is more convenient and effective to place the information about the symbols in the title rather than in a separate key.

k. It is also important to identify when something is added, if the addition is done after the observations begin. For example, if you plot the growth of a culture which grew on glycerol for

fifteen minutes and then was treated with lactose you should use an arrow to show when the lactose was added. This arrow will give you a direct visual reference to show how long any effects due to the addition take to occur and make any effects showing up prior to treatment more obvious.

6. Discussion

   a. The discussion is an analysis of the observations and interpretations in the results. You are not expected to review the experimental technique or theory in this section or repeat the results. You are expected to discuss what could cause the effect, explain what the effect indicates is probably happening, suggest alternate explanations, explain why the effect is important and judge whether the effect and interpretations seem reasonable. Comment on the principles demonstrated by the results. Point out items that do not make sense and provide an explanation. Show how your results and interpretations agree or disagree with results in previous publications. Discuss the implications/significance of your work. The observations and problems should be ranked so that the more important ones are discussed first and the less important ones last. Trivial observations and obvious minor problems should not be discussed.

   b. The final paragraph in the discussion should be a conclusion. Conclusions are different then summaries. For a conclusion, summarize the evidence then make **a brief statement about the general idea that your data has proved**, assuming that the data is correct. This statement must be based on the observed facts and should only be two or three sentences long. It must not include untested explanations of your results and must not be a discussion because facts do not need a discussion to explain them. If your tentative conclusion seems to be inconsistent with known facts you should bring that up somewhere in the earlier part of the discussion.

   c. The entire discussion for Project 1 should be done in less than four pages, the two sides of two pieces of paper. The entire draft report for Project 2 should normally be done in less than 4000 words. If your report is significantly longer then you are approaching the report wrong and doing unnecessary work.

   d. All abbreviations except for standard chemical abbreviations and the standardized symbols for units should be identified the first time that the abbreviation is used. Usually an abbreviation is identified the first time by writing out the word(s) in full then putting the abbreviation in brackets after the word(s). You can then use just the abbreviation for the rest of the report. If you do not use the abbreviation after the first time when it was defined then there was no need to include the abbreviation.

7. Future experiments

   What is the next step that should be done? What are problems that should be avoided by future researchers? When you discussed your results you should have provided explanations of important observations and problems. Briefly outline an experiment that will test one of the most important explanations or paradoxes that you have actually proposed in your discussion section to account for some of your observed results or problems. Do not include operational details such as volumes, temperatures, times et cetera but give a brief statement of how the explanation will be tested and the expected results if the experiment supports or refutes your explanation. For example, if the test involved electrophoresis, explain how the result would test your explanation and what it would show if your explanation was correct or incorrect. It is not acceptable to merely repeat the experiment (even though this might be necessary).

8. Acknowledgments

   Indicate the financial support of the Department of Microbiology and Immunology, University of British Columbia.

9. References

   The references listed in the protocol for Project 1 are intended to give you some further background on the theory of the techniques and procedures. Newer relevant background can be located by using the library search programs. Web of Science, PubMed, Medline or Google Scholar are good starting places. At least **two newer, relevant journal citations** are expected for your formal project report **for Project 1.** Somewhere between **ten – to - thirty references** should normally be used **for Project 2**. The intent of a reference is to provide necessary background to understand your arguments or support one of your statements with facts. Any reference material that is used to expand or support arguments in the discussion section of the reports should be properly and completely cited in the style of the American Society for Microbiology journals such as Journal of Bacteriology and Journal of Immunology. If a reference is not cited or used in the introduction, methods or discussion it should not be included in the report because the information in it was not applied or needed.

   When citing references you must use the standard journal abbreviations available at
   - http://www.efm.leeds.ac.uk/~mark/ISIabbr/
   - http://home.ncifcrf.gov/research/bja/

   The formal abbreviation for the MICB 421 on-line Journal of Experimental Microbiology and Immunology (UBC) is **J. Exp. Microbiol. Immunol**. The informal abbreviation JEMI should not be used in the reports.

   The program RefWorks or analogous reference tracking programs can be beneficial for developing reference lists but you still need to ensure that the listed references are in the appropriate style and format.

   If you used a mutant strain of *Pseudomonas aeruginosa* from one of the libraries available from the Robert Hancock's lab in Project 2 then you must include the appropriate original reference to those strains in your report.

   The University of Washington PAO1 mutant library is described in:
   Jacobs, M. A., A. Alwood, I. Thaipisuttikul, D. Spencer, E. Haugen, S. Ernst, O. Will, R. Kaul, C. Raymond, R. Levy, C. R. Liu, D. Guenthner, D. Bovee, M. V. Olson, and C. Manoil. 2003. Comprehensive transposon mutant library of Pseudomonas aeruginosa. Proc. Natl. Acad. Sci. U. S. A. 100:14339-14344.

   The UBC (Hancock) PAO1 mutant library
   Lewenza, S., R. K. Falsafi, G. Winsor, W. J. Gooderham, J. B. McPhee, F. S. L. Brinkman, and R. E. W. Hancock. 2005. Construction of a mini-Tn5-luxCDABE mutant library in Pseudomonas aeruginosa PAO1: A tool for identifying differentially regulated genes. Genome Res. 15:583-589.

   The Harvard University PA14 mutant library
   Liberati, N. T., J. M. Urbach, S. Miyata, D. G. Lee, E. Drenkard, G. Wu, J. Villanueva, T. Wei, and F. M. Ausubel. 2006. An ordered, nonredundant library of Pseudomonas aeruginosa strain PA14 transposon insertion mutants. Proc. Natl. Acad. Sci. U. S. A. 103:2833-2838.

Three additional pages of additional directions provide a detailed description of the expected and required format for the draft and the final manuscripts. For example:

Title:

- No heading
- Capitalize first letter of each word (unless it is a gene name that should be lower case).
- Use 16 pt, bold, Times New Roman font
- Centered, single spaced
- Put one line space before authors

Authors names:

- No heading
- Alphabetical listing, each separated by a comma, "and" before last author
- 12 pt, Bold, Times New Roman font
- Centered, single spaced
- No space before institutions

Institutions of authors:

- No heading
- Use 10 pt, italics, Times New Roman
- Department, University
- Centered, single spaced
- Put one line space before abstract

Abstract:

- No heading
- Use 10 pt, bold, Times New Roman for writing
- Use 1.5" margins on right and left
- Make first line indent 0.13" (first notch on tab ruler)
- Put two line spaces before main body

Introduction:

- No heading
- Use 10 pt, Times New Roman for writing
- 1" margins on both sides
- 0.13" indents for beginning paragraphs
- Use "justify" alignment
- Put one line space before Material and Methods section

MATERIALS AND METHODS:

- Put in the heading name – All CAPS, 8 pt, bold Times New Roman, one line space before text.
- Subheadings are put in line with the text of the paragraphs to form the first sentence in the paragraph – Bold font, followed by a period. Make 0.13" indent
- Main text - 10 pt Times New Roman
- Use 1" margins on both sides
- Use 0.13" indents for beginning paragraphs.

Appendix 3 - Overview of the Biotechnology Specialization

In the following pages I have provided a description of the purpose of the Honours Biotechnology specialization and the course requirements to demonstrate the breadth gained by the students that choose this specialization. I have also included a summary of a survey of the career paths chosen by students after graduation to show the wide acceptance and potential of these graduates.

The Bachelor of Science, Honours in Biotechnology is a joint initiative of the University of British Columbia department of Microbiology and Immunology and the BCIT Biotechnology program. This unique Bachelor of Science program combines the extensive training in science theory available at UBC with the extensive laboratory training available in the BCIT Biotechnology program.

The joint program is intended to produce students with strong scientific and technical backgrounds and who are also well schooled in business and communications. As a new initiative, this unique Joint Degree program underwent extensive scrutiny to ensure that it met the technical and academic requirements mandated by both institutions. To ensure the excellence of the program, it is annually reviewed by a Program Advisory Committee.

The program addresses the documented need for people who can combine technical experience and training with expertise in other areas such as management, production, regulations and intellectual property. It provides a core set of skills required for all levels of employment in a typical biotechnology company.

The joint program recognizes the need for cross-discipline training and fosters collaborative interactions that will strengthen undergraduate education.

The program is specifically designed to:

- develop adaptable students with a strong foundation in skills that are relevant to the changing world of biotechnology
- provide students with practical training in the skills and techniques of biotechnology
- integrate the laboratory and lecture components of the program through the use of an experiential approach to learning
- uniquely combine BCIT's strength in providing practical, hands-on biotechnology training with UBC's strength in leading-edge biotechnology research and teaching.

Academic Calendar Description of the Biotechnology Specialization

The Department of Microbiology and Immunology at UBC and the Biotechnology Program at the BC Institute of Technology (BCIT) offer a five-year joint degree Co-operative Education Program that integrates academic study at both institutions with related and supervised work experience. Enrolment is limited. Entry into the specialization is at the second-year level and requires completion of the first-year prerequisites listed below with at least the minimum admission average set by the UBC Faculty of Science for transfer into second year Honours specializations.

Students must apply for the specialization. See www.bcit.ca/study/programs/8950bsc for details.

The first year of the specialization can be taken at UBC or another institution. The second and third years (taken at the BCIT campus) include two four-month work terms along with academic and technical studies. The fourth and fifth years (taken at the UBC campus) include two four-month work terms and advanced studies. Students must meet the Faculty of Science requirement to continue in this Honours specialization (see Honours specialization requirements). Completion of the requirements for the first three years of the specialization earns a Diploma of Technology in Biotechnology.

Completion of the requirements for the entire five-year specialization earns an Honours Bachelor of Science in Biotechnology. The credentials are awarded jointly by UBC and BCIT. Students who fail to maintain the Faculty of Science requirements for continuing in Honours specializations in their fourth or fifth year need to request transfer credit for their BCIT courses if they intend to enroll in other specializations such as the Microbiology and Immunology major.

Honours (1136): Biotechnology

First Year at any institution offering suitable courses

CHEM 121 - **Structural Chemistry, with Application to Chemistry of the Elements**
CHEM 123 - **Physical and Organic Chemistry**
PHYS 101 - **Energy and Waves**
One first year differential calculus course
Two of

- BIOL 111 - **Introduction to Modern Biology**
- BIOL 112 - **Unicellular Life**
- BIOL 121 - **Genetics, Evolution and Ecology**

Two first year writing intensive courses such as

- ENGL 112 - **Strategies for University Writing**
- SCIE 113 - **First-Year Seminar in Science**

One general elective

Second Year at the BCIT Campus

- BIOT 1371 - **Lab Safety**
- BIOT 3201 - **Microbiology 1**
- BIOT 3210 - **Introduction to Biotechnology**
- BIOT 3260 - **Principles of Animal Physiology**
- CHEM 3338 - **Organic Chemistry 1 for Biotechnology**
- COMM 3343 - **Communications for Biotechnology**
- MATH 2444 - **Information Technology for Biotechnology**
- BIOT 4201 - **Microbiology 2**
- BIOT 4230 - **Animal Cell Biotechnology**
- BIOT 4260 - **Plant Anatomy and Physiology**
- BIOT 4990 - **Co-op 1 Work Term**
- CHEM 4438 - **Organic Chemistry 2 for Biotechnology**
- COMM 4443 - **Communications Workshop**
- MATH 4442 - **Probability and Statistics for Biotechnology**

Third Year at the BCIT Campus

- BIOT 5220 - **Molecular Genetics** 1
- BIOT 5230 - **Advanced Plant Cell Biotechnology**
- BIOT 5240 - **Biochemistry 1**
- BIOT 5250 - **Introduction to Pharmaceutical Development**
- BIOT 5361 - **Process Systems**
- CHEM 5509 - **Analytical Chemistry 1**

- LIBS 7002 - **Applied Ethics**
- BIOT 6201 - **Microbiology 3**
- BIOT 6220 - **Molecular Genetics 2**
- BIOT 6240 - **Biochemistry 2**
- BIOT 6270 - **Management and Regulatory Affairs**
- BIOT 6990 - **Co-op 2 Work Term**
- BUSA 7250 - **Management Skills and Applications**
- CHEM 6609 - **Analytical Chemistry 2**
- LIBS 7001 - **Critical Reading and Writing**

Fourth and Fifth Years at the UBC Campus

MICB 405 - **Bioinformatics**
MICB 419 - **Industrial Biotechnology Laboratory**
BIOC 402 - **Proteins: Structure and Function**
BIOC403 - **Enzymology**
COMM 457 - **Fundamentals of Financial Accounting**
COMM 465 - **Marketing Management**
One of

- MICB 325 - **Microbial Genetics**
- MICB 425 - **Microbial Ecological Genomics**
- BIOC 410 - **Nucleic Acids-Structure and Function**

One of

- MICB 404 - **Topics in Molecular Bacterial Pathogenesis**
- MICB 406 - **Topics in Molecular Virology**
- MICB 412 - **Topics in Immunological Research**
- MICB 424 - **Cellular Dynamics of Pathogenic and Environmental Bacteria**
- MICB 430 - **Seminar in Microbiological Literature**

One of

- MICB 421 - **Experimental Microbiology**
- MICB 447 - **Experimental Research**
- MICB 448 - **Directed Research**

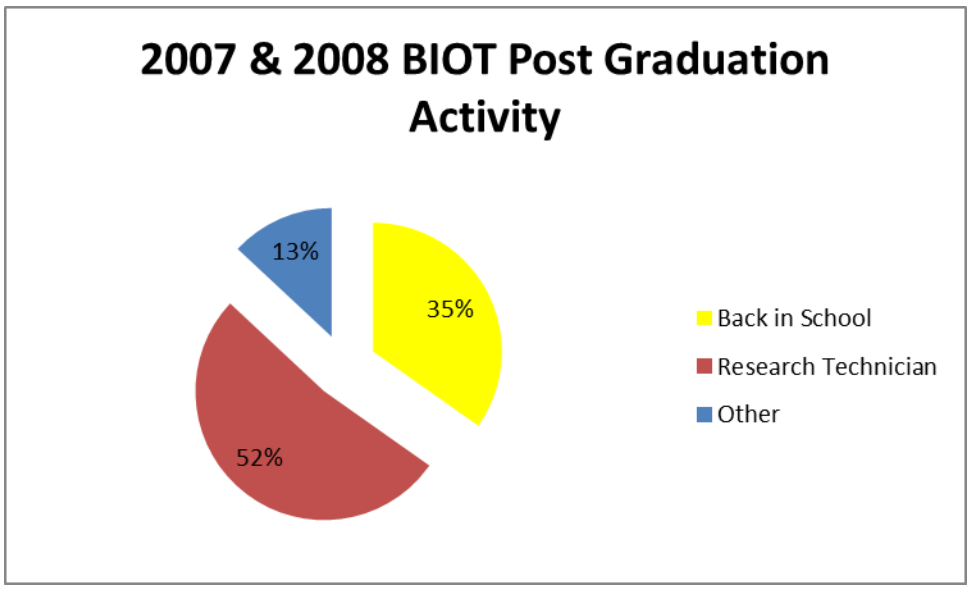
Two of

- BIOC 435 - **Molecular Biology Research on a Model Eukaryote**
- BIOL 436 - **Integrated Functional Genomics** BIOL 458
- BIOL 458 - **Developmental Neurobiology**
- BIOL 462 - **Ecological Plant Biochemistry**
- BIOL 463 - **Gene Regulation in Development**
- MEDG 420 - **Human Biochemical and Molecular Genetics**
- MEDG 421 - **Genetics and Cell Biology of Cancer**
- MICB 301 - **Microbial Ecophysiology**
- MICB 306 - **Molecular Virology**
- MICB 308 - **Paradigms in Bacterial Pathogenesis**
- MICB 402 - **Advanced Immunology**
- MICB 408 - **Advanced Bacterial Pathogenesis**

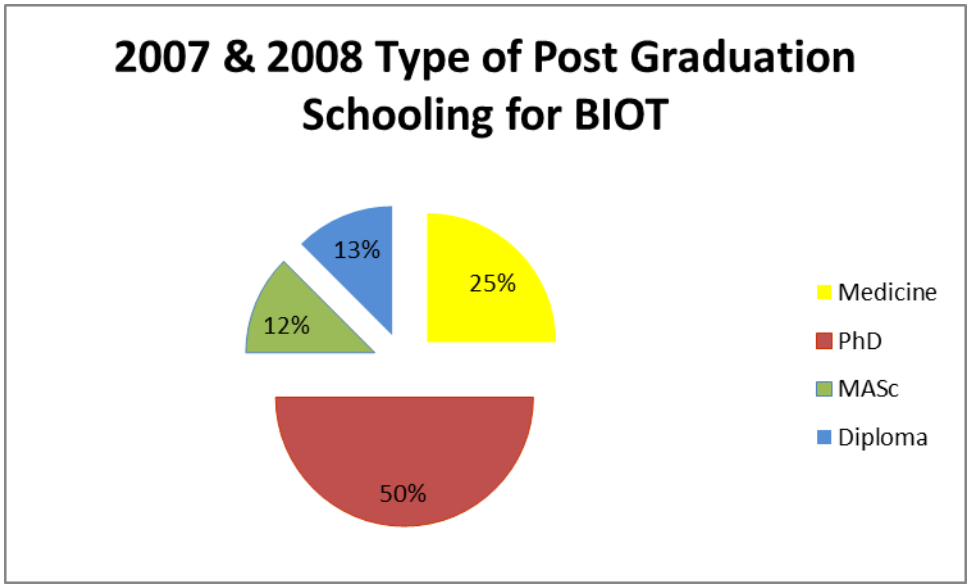
Three elective courses
MICB 498 – **Co-op Work Term**
MICB 499 – **Co-op Work Term**

Post Graduate Survey for Biotechnology Students

The following chart shows the general opportunities pursued by graduates one year after graduation.



The following chart shows the specific nature of the schooling pursued by the graduates in the preceding chart.



Appendix IV – Descriptions of the Combined Majors

The Department of Microbiology and Immunology has a Combined Major with the Department of Computer Science and a second Combined Major with the Department of Earth Ocean and Atmospheric Sciences called the Combined Major in Microbiology and Oceanography. In the following pages I have included abridged descriptions of these specializations to show the novel range of courses available for students working across these disciplines. I have also included a description of the program goals for the Microbiology and Oceanography major to show the general expectations of the specialization. Each specialization requires 120 credits over four years of study.

Academic Calendar Description of the Combined Major with Computer Science

Combined Major Computer Science and Microbiology & Immunology

First Year

BIOL 112 - **Unicellular Life**
CHEM 121 - **Structural Chemistry, with Application to Chemistry of the Elements**
CHEM 123 - **Physical and Organic Chemistry**
CPSC 110 - **Computation, Programs, and Programming**
CPSC 121 - **Models of Computation**
One first year differential calculus course
One first year integral calculus course
Two first year writing intensive courses such as

- ENGL 112 - **Strategies for University Writing**
- SCIE 113 - **First-Year Seminar in Science**

Second Year

BIOL 200 - **Fundamentals of Cell Biology**
BIOL 201 - **Introduction to Biochemistry**
CHEM 233 - **Organic Chemistry for the Biological Sciences**
CPSC 210 - **Software Construction**
CPSC 221 - **Introduction to Software Development**
MICB 201 - **Introductory Environmental Microbiology**
MICB 202 - **Introductory Medical Microbiology and Immunology**

Second or Third Year

CPSC 213
One of

- BIOL 300 - **Fundamentals of Biostatistics**
- MATH 200 - **Calculus III**
- MATH 221 - **Matrix Algebra**
- STAT 200 - **Elementary Statistics for Applications**

One course Electives

Third Year

CPSC 320 - **Intermediate Algorithm Design and Analysis**
MICB 301 - **Microbial Ecophysiology**
MICB 302 - **Immunology**
MICB 322 - **Molecular Microbiology Laboratory**

One of
- MICB 325- **Microbial Genetics**
- BIOL 335 - **Molecular Genetics**

Third or Fourth Year

CPSC 310 - **Introduction to Software Engineering**
One of
- CPSC 304 - **Introduction to Relational Databases**
- CPSC 313 - **Computer Hardware and Operating Systems**
- CPSC 420 - **Advanced Algorithms Design and Analysis**
- CPSC 421 - **Introduction to Theory of Computing**

One of
- MICB 323 - **Molecular Immunology and Virology Laboratory**
- MICB 401 - **Environmental Microbiology Laboratory**

One additional MICB at 300-level or higher
Two additional CPSC at 300-level or higher
Four additional electives

Fourth Year

CPSC 445 - **Algorithms in Bioinformatics**
MICB 405 - **Bioinformatics**
One additional CPSC at 400-level

Academic Calendar Description of the Combined Major with Earth, Ocean and Atmospheric Sciences

Combined Major (3144): Microbiology and Oceanography

First Year

BIOL 112 - **Unicellular Life**
CHEM 121 - **Structural Chemistry, with Application to Chemistry of the Elements**
CHEM 123 - **Physical and Organic Chemistry**
EOSC 112 - **The Fluid Earth: Atmosphere and Ocean**
PHYS 101 - **Energy and Waves**
One first year differential calculus course
One first year integral calculus course
One first year writing intensive courses such as

- ENGL 112 - **Strategies for University Writing**
- SCIE 113 - **First-Year Seminar in Science**

One elective course

Second Year

Communication Requirement1
BIOL 200 - **Fundamentals of Cell Biology**
BIOL 201 – **Introduction to Biochemistry**
CHEM 233 - **Organic Chemistry for the Biological Sciences**
EOSC 211 - **Computer Methods in Earth, Ocean and Atmospheric Sciences**
EOSC 270 - **Marine Ecosystems**
MICB 201 - **Introductory Environmental Microbiology**
MICB 202 - **Introductory Medical Microbiology and Immunology**
One first year writing intensive courses such as

- ENGL 112 - **Strategies for University Writing**
- SCIE 113 - **First-Year Seminar in Science**

Two elective courses

Third Year

EOSC 372 - **Introductory Oceanography: Circulation and Plankton**
EOSC 373 - **Introductory Oceanography: Climate and Ecosystems**
MICB 301 - **Microbial Ecophysiology**
MICB 306 - **Molecular Virology**
MICB 322 - **Molecular Microbiology Laboratory**
MICB 325 - **Microbial Genetics**
Four elective courses

Fourth Year

EOSC 472 - **Chemical Oceanography and Marine Geochemistry**
EOSC 475 - **Marine Microbiology**
MICB 425 - **Microbial Ecological Genomics**
One

- EOSC 470 - **Biological Oceanography**
- EOSC 471 - **Dynamic Biological Oceanography**
- EOSC 478 - **Introduction to Fisheries Science**

One of

- EOSC 448 - **Directed Studies**

- EOSC 473 - **Methods in Oceanography**

One of
- MICB 401 - **Environmental Microbiology Laboratory**
- MICB 323 - **Molecular Immunology and Virology Laboratory**

Two of
- MICB 405 - **Bioinformatics**
- MICB 418 - **Industrial Microbiology and Biotechnology**
- MICB 424 - **Cellular Dynamics of Pathogenic and Environmental Bacteria**

Two electives courses

Specialization Objectives and Learning Goals of the Combined Major Microbiology and Oceanography

Specialization Objectives:
Students completing this specialization will be able to:
- demonstrate mastery in microbiology/oceanography that will qualify them for graduate school in either microbiology or oceanography or environmental science (given a sufficient level of accomplishment)
- demonstrate basic laboratory skills useful for technician-level jobs in environmental sciences

Learning Goals:
Students completing this specialization will be able to:
- demonstrate basic knowledge about the chemical and physical ocean environment with emphasis on microbiological processes and chemical processes
- use mathematical knowledge including calculus and statistical techniques for experimental set-up and data analysis
- use numerical problem solving (using computer programming skills) both with models and with real data
- use basic field/laboratory skills for observation and experimentation in microbiological oceanography
- illustrate the distinction between data, experiment, theory, and model
- integrate concepts across multiple levels of microbiological complexity
- conduct independent study on a topic of their choosing
- write reports and communicate through oral presentations

Appendix V - Co-operative Education in the Microbiology and Immunology Specializations

The Department of Microbiology and Immunology has an optional Co-operative Education for students in the Microbiology & Immunology specializations and the combined specializations with Computer Science and with Earth Ocean and Atmospheric Sciences. It has obligatory Co-operative Education requirements for students in the Biotechnology specialization. I have included material from the Co-operative Education website and the academic description of the Microbiology and Immunology specializations to demonstrate the basic nature of this experience and demonstrate the number of life science specializations that now include a co-op option. I have also included chart to show where some of the students were recently placed and demonstrate the general success and acceptance of this opportunity.

Co-operative education integrates the academic education (classroom-based learning) of interested and qualified students with relevant, supervised, and paid work experience (work-based learning) with employer organizations. Co-op students gain valuable skills that help guide them through their academic education, as well as prepare them for future job markets upon graduation.

The Faculty of Science offers co-operative education in the disciplines of atmospheric sciences, biochemistry and molecular biology, biology, biophysics, biotechnology, chemistry, computer science, cognitive systems, earth and ocean sciences, environmental sciences, general science, geographical biogeosciences, geophysics, geology, integrated sciences, mathematics, microbiology and immunology, pharmacology and therapeutics, physics and astronomy, physiology, psychology, and statistics. Students in other B.Sc. specializations are also able to participate in co-operative education.

Co-operative education is optional and supplementary to academic requirements of the degree. Students who wish to be considered for co-op will be selected on the basis of academic performance and suitability for the work environment. To enter and remain in co-op, students must be in Good Standing and be eligible for admission to and/or advancement in their specialization. Total enrolment is subject to the availability of appropriate work placements. Students admitted into the program will register in the appropriate co-operative education courses for each work term, once a suitable position is confirmed, and will be required to pay the co-operative education program fee. In addition, a co-op workshop fee is to be paid by all students accepted into the program. There will not be a tuition fee in addition to this.

Each successfully completed co-operative education course will be assigned 3 credits and will be recorded on the student's transcript. In order to graduate with the co-operative education designation, a student must have completed the required number of work terms in addition to the normal academic requirements of the specialization.

Students participating in co-op:

- **Gain industry work experience...**
  Learn new skills and cultivate professional work experiences. Build an impressive resume.
- **Build their career network...**
  Gather valuable employment contacts advantageous to future permanent employment.
- **Earn money while they build skills...**
  Help pay for their education or that backpacking trip they have always wanted to take!

- **Apply their classroom studies to real-life projects**
  Integrate learning in the classroom with related work experience and put themselves one step ahead of their peers.
- **Explore their career options...**
  Become more aware of specializations in your area through a variety of work experiences. Explore different career options.
- **Build life-long friendships...**
  Make lasting connections with like-minded, talented people through Co-op work placements.

The students in the Microbiology and Immunology Co-operative Education opportunity normally start an eight - month work term halfway through third year. They then return to academic studies to do the fall term of fourth year and then the winter term of third year. They then do another eight - month work term that starts in May and finish with a four – month academic term to complete the winter term of fourth year. We choose this pattern of work terms to ensure that the students could benefit from the experience. In particular, it provides enough remaining academic terms to allow each student to adjust their courses if their co-op experience has changed their career goals. It also increases the interaction of students across the years so that there is more communication and less stratification between classes. For example, the first time that students return from a co - op work term they take part in classes with the new third year students.

Co-operative Education Option
This option integrates academic study with relevant supervised work experience. The work placements are arranged by mutual agreement between the students and the employing organizations. Enrolment is limited. Admission is by application to the Science Co-op Office in February prior to third year (late applicants may be considered if they contact the Life Sciences Co-op Coordinator). Selection will be based on previous academic performance and general suitability to the work environment as assessed by resumé and interview. Admissibility to a third-year Microbiology and Immunology Bachelor of Science specialization is prerequisite for admission to the Co-op Option but applicants can apply to Co-op before admission to the third-year microbiology specializations. Graduation from the Co-op program requires completion of four work terms, the normal courses required for the specialization.

The following chart shows recent work placements for students in years 2, 3, and 4 of the Biotechnology specialization. Similar work placements are being made by the students in the other Microbiology and Immunology specializations. The range of placements for work in relevant industries and academic institutions around the world reflects the quality of the students participating in this experience and the general success of this initiative.

Work Place Employer	**Work Place Location**
Applied Biological Materials (ABM) Inc	Richmond
BC Cancer Agency	Vancouver
BC Cancer Agency	Vancouver
BCIT Biotechnology Department	Burnaby
BCIT Math Department	Burnaby
Bristol-Myers Squibb	US - New York
Cardiome Pharma Corp	Vancouver
Child & Family Research Institute	Vancouver

Children's Hospital	Vancouver
Chinese Academy of Sciences	Beijing, China
Federal Institute of Material Research	Germany
Jewish General Hospital	Montreal
Maxxam Analytics Inc.	Burnaby
Maxxam Analytics Inc.	Burnaby
Maxxam Analytics Inc.	Burnaby
Maxxam Analytics Inc.	Burnaby
McGill University	Montreal
Massachusetts General Hospital	Boston
MSL Bohlmann Lab	Vancouver
Northern Lipids	Burnaby
Provincial Health Services Authority	Vancouver
SignalChem	Richmond
UBC - Biochemistry & Molecular Biology	Vancouver
UBC - Faculty of Medicine	Vancouver
UBC - Medical Genetics	Vancouver
UBC - Medical Genetics	Vancouver
UBC - Pathology	Vancouver
UBC Biomedical Research Centre	Vancouver
UBC Fisheries	Vancouver
UBC Jack Bell Centre	Vancouver
UBC Medical Genetics	Vancouver
UBC Microbiology and Immunology	Vancouver
University of Saskatchewan	Saskatoon
University of Calgary	Calgary
University of Victoria	Victoria
University of Victoria - Water and Aquatic Research Program	Victoria
Vancouver General Hospital - The Prostate Centre	Vancouver
Vancouver General Hospital - The Prostate Centre	Vancouver
Vancouver General Hospital - The Prostate Centre	Vancouver
Xenon	Burnaby

Appendix VI - Science Curriculum Committee Activity

To demonstrate the significance of the material that is deliberated by the Faculty of Science Curriculum Committee that I chair, I have included a summary of the curriculum proposals that were considered and supported in the session from September 2011 to October 6, 2011. Similar types of proposals are considered each term. After these proposals are supported by Science Council they are reviewed by the appropriate Sub-Committees of Senate Curriculum Committee and then by the Senate Curriculum Committee where I represent the Faculty of Science. Similar types of material are also reviewed by the Faculty of Graduate Studies New Programs and Curriculum Committee where I representative.

There were 100 submissions with proposals to the Science Curriculum Committee for the fall term.

Many of the submissions involved tweaking descriptions, changing vectors and modifying prerequisites for courses. The Faculty of Sciences also submitted several proposals to clarify the promotion requirements for students, clarify the readmission process for students that have interrupted their studies and clarify academic requirements for students participating in the International Exchange Program (Go Global).

The major considerations were:

Creation of three new specializations:

- **Combined Major Oceanography and Biology**
- **Combined Major Oceanography and Physics**
- **Minor Astronomy**

Extensive redevelopment of existing specializations:

- **Major Biochemistry**
- **Honours Biochemistry**
- **Minor Biochemistry**
- **Major Biology**
- **Honours Animal Biology**
- **Honours Biology**
- **Honours Cell and Developmental Biology**
- **Combined Major Computer Science and Biology**
- **Honours Conservation Biology**
- **Honours Ecology**
- **Honours Evolutionary Biology**
- **Honours Marine Biology**
- **Honours Plant Biology**
- **Dual Degree Program: B.Sc. (Mathematics), B.Ed. (Secondary)**
- **Dual Degree Program: B.Sc. (Physics), B.Ed. (Secondary)**

Reactivation of a former specialization:

- **Major: Geology**

Creation of several new courses:

- BIOL 501 - **Quantitative Methods in Ecology and Evolution**
- CHEM 213 - **Organic Chemistry**
- CHEM 245 - **Intermediate Organic**
- CHEM 445 - **Projects in Experimental Chemistry**
- MATH 264 - **Vector Calculus for Electrical Engineering**
- MATH 358 - **Engineering Analysis**
- MATH 360 - **Mathematical Modeling in Science**
- MICB 424 - **Cellular Dynamics of Pathogenic and Environmental Bacteria**
- PHYS 333 - **Energy and Climate**

Several changes were broadly significant or unusual:

- The creation of CHEM 213 allows students that are outside the Chemistry and Biochemistry specializations to take a second lecture course on the topic of organic chemistry and access senior organic chemistry courses. This important opportunity has not been available for many years.

- The MATH 264 will be a course that is jointly offered with EECE 261 as an integrated complementary package where all students register in the MATH and EECE 261 and receive a single grade for the two courses even though the MATH covers the mathematical background and the EECE covers the applications.

- The two new specializations in Oceanography explicitly include the specialization objectives and the student learning goals as part of the academic calendar description. These are the second and third specialization at the University of British Columbia to include the student goals in the academic calendar. The first specialization to include learning goals in the academic calendar was the combined major for Microbiology and Immunology &Oceanography established in the last curriculum session.

Appendix VII - MICB 421 Project Course

To demonstrate the details needed to structure the MICB 421 project course I have included a copy of the course schedule; the grading schemes; a sample of the grading rubrics; and an abridged version of the project requirements.

Example of the MICB 421 Schedule

Date	**Activities on the specific date on the left**	**Activities on your lab day for that week**		
Jan 9	Lecture	Attend organizational meeting in registered lab period. Confirm teams, **start Project 1** day 1. Work on **P2D1 pre-assignment.**		
Jan 13	**Individual P2 proposal due**			**Submit individual project 2 proposals**
Jan 16	Lecture	P1 completed		P2D1 – discuss projects with TA and instructor
Jan 23	Lecture	Record book checked	Journal signed	P2D2 – discuss projects with TA and instructor. **Be able to describe team proposal.**
Jan 30	Lecture	Record book checked	Journal signed	P2D3 – discuss progress with TA and instructor
Jan 27	**P1 report due**			
Feb 6	Lecture	Record book checked	Journal signed	P2D4 – discuss progress with TA and instructor
Feb 13	**Submit detailed proposal for P2**			
Feb 13	Lecture	Record book checked	Journal signed	P2D5 – start general preparation. Discuss progress with TA and instructor.
Feb 17	Submit a separate list of chemicals, kits or strains that need to be ordered for P2.			
Feb 20	Reading break Feb 14 - 18. No scheduled classes			
Feb 27	Lecture	Record book checked	Journal signed	P2D6 – continue lab work. Discuss progress with TA or instructor.
Mar 5	**Mid-term**	Record book checked	Journal signed	P2D7 – continue lab work. Start preparing final report. Read more background.
Mar 12	Lecture	Record book checked	Journal signed	P2D8 – continue lab work. Discuss progress with TA or instructor.
Mar 19	Lecture	Record book checked	Journal signed	P2D9 – continue lab work. Discuss progress and content of the project report with TA and instructor.
Mar 26	Lecture	Record book checked	Journal signed	P2D10 – continue lab work P2D10 – Finish lab work
April 2	Lecture	Record book checked	Journal signed	P2D11 – – clean up lab space. Submit any strains.
Apr 9	**P2 draft report due**			
	The **April exam** will be scheduled in the exam schedule. Submit the optional **journal** on the day of the exam.			
By **April 26**	**P2 final revised report** and the record book due.			

Example of the MICB 421 Grading

The course considers a range of marks to develop different skills and emphasize different expectations. It has four potential grading patterns. The main differences in the opportunities depend on whether the student does the mid-term exam and chooses to keep a journal. In each pattern, approximately half of the grade is determined by the reports on the projects, approximately a third is determined by exams and the rest depends on the work in the lab and the team.

Potential Grading Schemes for the MICB 421

Graded Activity	Potential proportion of final grade for each activity in different grading schemes🔔			
Reflective weekly journal ♠	5	5	**NA**	**NA**
Project #1 ☼	10	10	10	10
Project #2 individual proposal	5	5	5	5
Project #2 team proposal☼	10	10	10	10
Weekly work, record book and progress meetings♠☼	10	10	10	10
Project #2 report♥☼	30	25	30	25
Theory exam #1 ☺	**NA**	10	**NA**	10
Theory exam #2	30	25	35	30
Team participation☼	The potential project grades will be prorated for those individuals that do not participate in proportion to lack of participation on their team.			
Lab preparation♣	Up to 10 penalty marks will be deducted from the possible final grades if there are observed problems.			
Lab etiquette	Up to 10 penalty marks will be deducted from the possible final grades if there are observed problems.			

Notes:

- 🔔 The potential grade for each student will be individually assessed in each of the four grading schemes. The student will be given the higher grade from the four different schemes. The patterns should be read vertically. The total in each vertical column is 100%. Entries with NA indicate that the category is not applicable for that pattern.
- ♠ An instructor or the **teaching assistant must initial the journal each week**.
- ♥ The draft report for P2 forms $9/10^{th}$ of the P2 report grade. The final report forms $1/10^{th}$ of the P2 grade but there is no grade for P2 until the final copy of the P2 report is suitably corrected and returned.
- ☼ If the contribution to the projects by some team members is less than $9/10^{th}$ of the expected average participation for the team then the project marks for the students with weak participation will be prorated in proportion to the apparent contribution to the project.
- ☺ The first theory exam is optional. Copies of the first exam will be made available to students that do not write that exam.

Grading Rubric for Lab record Books (Total of 20 points)

Expectations		Clearly meets expectations. Few, if any problems	Acceptable but definite weaknesses	Does not meet expectations. Significant weaknesses
Table of Contents updated at start of book		2	1	0
Date and page numbers on active pages		2	1	0
Purpose	Provides purpose of the work	2	1	0
Procedures	Provides details (could be cited or referred to earlier pages	4	2	0
Results	Tabulated or graphed. Complete and understandable	4	2	0
	Identifies details such as lanes in gels, controls, nature of samples	2	1	0
Comment/Conclusion	Comments on the result quality, outcomes, problems.	2	1	0
Participation Log	List of work times and effort in back of record book is up to date and adequate	2	1	0
Corrections	Problems noted on previous weeks must be corrected by the following week	0	0	Minus 10 from score from the preceding week

Grading Rubric for the Team Project 2 Proposal (Total of 44 Points)

Expected Detail	Clearly meets expectations. Few, if any problems	Acceptable but definite weaknesses	Does not meet expectations. Significant weaknesses	Criteria
Overview Chart	4	2	0	Brief overview that shows a diagrammatic relationship of the tests within the context of the experimental question.
Proposed Title	2	1	0	Suitable and relevant to proposal. Sufficient detail to be unique and complete with regard to the objectives
Introduction and Background	4	2	0	Clearly written. Addresses details needed to understand the explanation, approach and outcomes for your proposal.
Observation and Explanation	2	1	0	Clearly articulated explanation for the observation. Suitable relevance. Builds on an idea instead of dabbling with a method.
Experimental Question	2	1	0	Clearly written question (or part of a question) that will test the explanation.
Protocol	6	3	0	Explains what will be done. An overview of the work and how the methods fit together to address the objectives
Methods	4	2	0	Explains how the parts / tests will be done. Choice of suitable methods for the protocol and objective. Can be referenced but should give operational details.
Supplies and Equipment	4	2	0	List of supplies and chemicals needed. Include quantities and details of preparation of solutions such as solvation conditions for your actual experiment.
Weekly Time Frame for Completing the Work	4	2	0	Week by week staging of the work. Allow time to test/work with unfamiliar procedures or equipment, testing strains, determining preliminary values to assess ranges before attempting the main experiment.
Potential Pitfalls	2	1	0	Description of the main obstacles or difficulty that might be encountered in the protocol.
Known Hazards	2	1	0	Identifies unusual **significant** hazards (if any). Marginal if reasonable unusual problems missed. Inadequate if deadly problems are missed. Distinguishes routine, minor risks from real hazards.
References	2	1	0	At least four background references supporting the proposed explanation and protocol. Proper ASM style.
Overall	6	3	0	Demonstrates care and critical understanding throughout the proposal. Has been checked to eliminate most spelling, grammar and syntax problems. Clearly and concisely presented. Complete. Readily understood.

Grading Considerations for Project 1 and 2 Reports

Category within Report	Consideration
Title	Concise, appropriate, single sentence to describe the study purpose and results
Abstract	Logical short version of the paper containing the objective, main method, main observation and conclusion. Past tense. No references or abbreviations (Except standard forms like DNA, PCR et cetera).
Introduction	Focused on providing the experimental purpose and background for the discussion.
	Concise and clear. Logical progression of ideas.
Results/Data Presentation and Structure	Appropriate and complete format for the presentation. Includes a separate section of written results to point out major observations and summarize trends.
	Suitable functional titles for figures or tables.
	Complete details in figures or tables (keys, legends, units, scales, titles *et cetera*).
	Appropriate listing of significant figures in tables, figures or comments. (Should be 2 or 3 comparable digits at most)
	Appropriate interpretive trend lines in graphs. (Must include at least $3/5^{th}$ of the points on trends). Consistent use of datum between graphs using the same observations and the written comments.
Discussion /Analysis	Attempts to explain the meaning of results and integrate the observations around a coherent idea. Explaining the meaning is different than explaining the cause or mechanism of the observations.
	Attempts to give either a plausible explanation of the cause of a problem or the reasons that an observation is a problem. Consideration of obvious alternatives to explain the observation.
	Discussion is focused on the observations and the experimental purpose. The reports must be research reports rather than reviews. Recognizes major observations that affect the conclusion.
Conclusion	Conclusion is based the tested observations rather than the explanations of observations or reports from other studies.
	Conclusion addresses the experimental purpose.
	Conclusion is a concise deductive statement of the idea “proved” or “indicated” by the facts.
References	Includes at least two novel journal references that are relevant to the discussion, the analysis.
	References are cited in the report (If they are not used to support an explanation or a fact in the introduction or discussion then they were not needed and should not be listed).
	Appropriate ASM formatting of the references. (Listing of authors, dates, titles)
Future Experiment	Proposed experiment addresses an explanation or a limitation or a paradox raised in the discussion.
	Suggested test and outcomes for the proposed experiment are relevant to the original, general experimental purpose.
Overall Evaluation	Has carefully proofread the report so any errors in grammar or spelling are minor.
	Concepts, arguments and explanations are accurately, clearly, concisely and logically developed throughout the report. Students seem to be intellectually involved in the report. Demonstrated understanding of the approach, the limitations of the observations and the methods and the conclusion. Applies literature. Has attempted a purposeful effort

Grading Rubric for the Draft Report of Project 2 (Total of 100 Points)

Report detail	Consideration	Clearly meets expectations. Few, if any problems	Acceptable but definite weaknesses	Does not meet expectations. Significant weaknesses	Criteria
Title	Clear and Accurate	2	1	0	Concisely conveys intent and outcome of project.
	Relevant	2	1	0	Relates to the study purpose.
Abstract	Clear and accurate. Appropriate format	2	1	0	Easy to read. Consistent with article. Includes purpose, main observations and main conclusion. No abbreviations or references.
	Relevant details	2	1	0	
Introduction	Clear and accurate	2	1	0	Easy to follow. Focused on the purpose of project. Proper coverage of background for the analysis and the discussion. Does not include parts that should be in Methods.
	Relevant details. Appropriate content.	4	2	0	
	Appropriate depth	4	2	0	
Materials and Methods	Complete and accurate	2	1	0	Mentions relevant details. Uses paragraph form. **Uses citations where appropriate**. Provides enough detail to follow approach.
	Appropriate format and content. Suitable abbreviations	2	1	0	
Results	Consistent and accurate processing	6	3	0	Consistent interpretation between uses. No processing errors.
	Appropriate format. Details are clear and accurate	12	6	0	Tables and figures processed with expected details. Suitable expressed comparable significance.
	Appropriate interpretation of the results	8	4	0	Interpretation of trends and observations is reasonable.
	Appropriate observations	4	2	0	Has recognized the major relevant observations.
	Appropriate comments	6	3	0	Integrated ideas and wrote about the ideas rather than simple descriptions.
Discussion	Clear and accurate	4	2	0	Statements are consistent with the results, help to understand the results and relate the results to the purpose. Statements show insight. Makes use of supporting knowledge. Covers all major observations.
	Relevant	4	2	0	
	Reasonable depth of analysis	4	2	0	
Conclusion	Accurate deductive statement	4	2	0	Deductive statement “proved” by the results rather than explanations.
	Addresses the experimental question	4	2	0	Conclusion addresses the experimental question.

Future experiments	Relevant and feasible	6	3	0	Addresses a significant problem or explanation raised in the discussion. Relevant to original purpose.
	Outcomes	2	1	0	
References	Additional and relevant	2	1	0	Four additional references that provide depth to discussion. Helpful. Relevant.
	ASM format	6	3	0	Cited by number. Correct ASM style in listing.
Overall	Overall impression	6	3	0	Demonstrates care and critical understanding throughout the report Correct language, tenses, and terms. Good insight into results.

The following section is an abridged version of the MICB 421 Experimental Research Project from the project manual to show the specific detail provided to develop this part of the course. The project description includes the purpose, references, instructions, day-by-day activities, materials and equipment, experimental sources, and general references. The part concerning experimental sources has been shortened by deleting all the entries in sections 2 through 10 except for the most recent article in that section. The fonts are taken from the corresponding parts of the project manual.

Experimental Research Project

Purpose:

The intent is to reinforce your understanding of the constraints of the scientific process by developing explanations of a supplied scientific observation, designing experiments to test the proposed explanations, preparing your supplies, identifying required equipment, doing your experiments and reporting your results as an article for a scientific journal. The specific experimental objectives will depend on the observations that your team chooses to explain and the manner in which your team chooses to test the explanation.

References:

Barker, K. 1998 "Chapter 4, How to setup an experiment", At the Bench, a laboratory navigator, p 69-87 Cold Spring Harbour Laboratory Press, New York, New York.

Barker, K. 1998 "Chapter 5, Laboratory notebooks", At the Bench, a laboratory navigator, p 89-99 Cold Spring Harbour Laboratory Press, New York, New York.

Instructions:

1. The project will be done by teams consisting of four students.

2. The general requirement is to examine data from the supplied sets of experiments and student research articles published in the UBC Journal of Experimental Microbiology and Immunology (J. Exp. Microbiol. Immunol. , JEMI) then devise an experiment to test a reasonable explanation(s) of the observation(s) in a chosen experiment or publication, prepare the supplies, carry out the tests and analyse the results. The compiled sources of available experiments and

published JEMI articles are too massive to bind with the lab manual. A list of the titles and a list of general references are included after the materials and methods section in this project outline. The actual articles and experiments are available as indexed pdf files in the JEMI section of the Microbiology and Immunology website at http://www.microbiology.ubc.ca/Volumes and the MICB 421 WebCT Vista site. There will be bound sets of experiments and articles in room 104 and 110. The bound sets should stay in room 104 and 110 but they are available for browsing. They may be taken out for short times for photocopying as long as there is a note indicating the time and the name of the person that has taken the material.

3. The proposed experiment may not be an exact duplicate of any other posted experiment but you may repeat a posted experiment in order to confirm the results before proceeding with your own experiment. You may develop and use a modification of a published experiment if the modification provides better insight into the problem and your explanation.

4. Acceptable proposals could involve changes of nutrient, environmental conditions, inhibitors, enzymes or strains. It could involve using different methods to test a hypothesis that has already been advanced by other students if the modification will overcome a limitation or weakness in the original tests. It is also acceptable to propose preliminary experiments or construct strains that would enable future students to test your hypothesis in future years. However, **each proposal must present a testable explanation of the chosen observation** rather than just dabbling with various experimental conditions. You should also **be aware that very few antibodies for bacterial proteins are commercially available and that strain construction or cloning a particular gene depends on serendipity**. Unless you are prepared to start strain construction by mid-February (or earlier) it is better to consider the available strains or clones in the MICB 421 Culture Collection or the Coli Genetic Stock Center or the Hancock Culture Collection to see if they can be used to test your hypothesis. Sometimes an available strain is not ideal but it will provide some initial evidence about whether it is worth the effort to make the ideal construct. Sometimes a mutant phenotype can be approximated by the use of selective antibiotics or inhibitors.

5. Since some types of equipment are limited, the number of teams choosing a particular approach or methodology might be restricted. Each proposal must be different. If two teams suggest the same proposal and same general approach then the first proposal received will be permitted to proceed and the second team will need to develop an alternative proposal (unless the second team provides evidence that the first team pirated their proposal). However, proposals that test similar ideas by significantly different approaches or methods are still acceptable. Similarly, proposals that bridge two or more experiments will be considered to be distinct from either of the original experiments.

6. Each team is encouraged to develop the details of their proposals. However, if you have a good idea but are unsure how to develop the idea into a testable explanation or develop a suitable protocol you should discuss the idea with the instructor or the teaching assistant to see if they have worthwhile advice. Similarly, if you are having trouble choosing an experiment or you think that you have a suitable experiment but are uncertain whether particular protocols could be attempted with the available equipment or supplies then you should discuss those concerns with the instructors or teaching assistants to get their advice. **The teaching lab is not equipped to deal with pathogens or eukaryote tissue cultures**.

7. Teams proposing projects involving a lot of samples should do a pretest with a few samples to ensure that the strain(s) have the correct phenotypes, the results are falling in the expected assay ranges and that the methods will work and give reproducible results.

8. The results will be presented as a research article suitable for publication in JEMI. Any major problems or technical errors in the submitted report will need to be corrected before the

manuscript is accepted for publication. The article must be accepted for publication before the mark for the project is added to your grade.

9. On Project 2-Days II, III, IV, VI, VIII, IX at least three team members must attend a scheduled meeting with the TA and / or the instructor during their registered lab period. At that time, the team must be prepared to discuss their progress, problems and planning for their project.

10. The instructor or the teaching assistant must approve proposals before you start significant technical preparation. Some basic preparation of media or buffers or glassware can be done in advance. Ask if you are in doubt about what could be done in advance.

11. The lab will normally be open between 9:00 AM and 5:00 PM to allow you to work on the project outside the scheduled lab periods if that work is necessary or helpful. However, we expect some of the work to be scheduled for your registered lab period when assistance will be available. Your team lab book must be signed each week by the instructor or the teaching assistant during your registered lab period. If you work in the lab outside your registered class there must be at least one other person present if the work involves any potentially hazardous procedures or equipment.

12. **Day I.**

    i. **Before** the scheduled Day I lab class each team member must **individually** select one problem that they would like to investigate for the project and prepare a brief report of approximately 300 – 500 words that explains their choice. **One electronic copy of these individual reports must be submitted to the MICB 421 WebCT Vista assignment drop box by 11:59 PM on the due date (See Appendix G). When you submit the report use your initials, surname, day and alphanumeric as the name for the file. For example, JohnSmithTuesA.** Other copies must be distributed to your team mates by the start of the lab session for your team.

    The report must include specific sections for:

    - **Identification**: your name and your team alphanumeric at the top right corner of the page.
    - **Source of the observation**: the source of the observation / problem in JEMI (or other permitted sources).
    - **Background**: the background necessary to understand / explain the relationship between the problem and the proposed explanation. (This section is not expected to be a full review of the topic but it needs enough detail for the reviewer to understand the logic for your subsequent explanation(s) and proposed experiment. In most cases this would take approximately 300 or 400 words)
    - **Observation**: a description of the observation / problem.
    - **Explanation / hypothesis**: a preliminary potential explanation(s) / hypothesis that might account for the observation.
    - **Experimental question**: state the actual question that will test the explanation. Include an explanation of how answering the question would assess the validity of the explanation.
    - **Approach**: the general experimental approach for testing your explanation. (What methods or combinations of feasible methods would be the key way of getting data to test your explanation? What would the results from that tests show if the explanation was correct or incorrect?)
    - **Feasibility**: the feasibility and outcomes of the proposed tests. (What are the main technical difficulties? What are the main details that need to be worked out

to know whether it would work? What are the limitations imposed on the analysis by these methods?)

Each student should think about additional project details and requirements and why they wanted to work on their particular proposal. This additional level of detail is not expected in the individual proposal for Project 1but the information might be helpful when the team chooses the topic for the project that they will develop as Project 2.

ii. During the lab class choose the coordinator for Project 2 and choose one or two projects to investigate further.

iii. To choose a project, compare and discuss the merits of the potential projects proposed by the different team members. Consider the pros and cons of different projects, the general interest of the team and alternative explanations that might account for the observation.

iv. If your team is sure about the intended project then one choice is sufficient. If the team is less certain it is better to choose two. For each of these projects the team should identify the major **specific information** or general background relevant to understanding the observations or the preliminary explanations. When the members draw up this list they should consider what they already know about the topic and how well they recall details. They should also consider whether their knowledge is superficial or detailed, whether the knowledge is dated or current *et cetera*. For example:

a. What is known about the process that formed the original experiment? Would knowing more about that process be beneficial? Is it known whether related processes give similar observations? Is anything known about those processes?

b. Are there known mechanisms involved in the biochemistry or physiology or genetics for any of the components involved in the experiments that might give rise to the observations that you want to test. Would a more detailed understanding of these mechanisms give more insight into potential explanations? Could any of these mechanisms be adapted to account for the effect? *Et cetera.*

v. Each team member should take responsibility for researching / checking some of the various sets of information that are necessary or helpful for choosing one project and refining the preliminary hypothesis by the your scheduled meeting with the TA and the instructor on Day II.

vi. The team should also consider whether anyone already has a source for some of the background. The web can sometimes provide some ideas and details but the quality of information is inconsistent. More reliable sources can be found by doing library searches for journal articles and compendiums of research facts and methods. The libraries provide workshops on the use of electronic indexes for finding relevant journal articles and searching for relevant key words. Some indexes that might be useful include:

- **Biosis** <http://resources.library.ubc.ca/551/ >
- **Medline** <http://resources.library.ubc.ca/139/ >
- **PubMed** <http://resources.library.ubc.ca/321 >
- **Web of Science** <http://resources.library.ubc.ca/277/ >

There are more sites at <http://toby.library.ubc.ca/subjects/subjpage1.cfm?id=283 >
And <http://resources.library.ubc.ca/ressubjtitles/S/129/ >

Google Scholar can also be helpful but is less complete than the dedicated research indexes. In addition, by accessing articles through the UBC library you go through the library subscriptions so more prepaid journal access is available for you.

vii. At this stage you can still consider other projects if the initial choices seem less suitable when you consider the details.

13. **Day II**

i. After considering the additional information reported by each team member, the team should decide which problem and which hypothesis will be investigated. **This will be your team project for the rest of the term**. When that choice is made each person on the team should consider the known facts and logic that support the proposed explanation. Each person should also bear in mind that the eventual evaluation of the project will consider:

a. Whether the experiment is testing an explanation of the observations or at least setting up the potential to test an explanation rather than dabbling with experimental variables.

b. Whether the proposal is practical. Can it be done within the constraints of time, expertise and available equipment and supplies?

c. Whether the experiment is worth doing. Some experiments are exciting and interesting. Some experiments are bland but the results are important to further understanding. Some experiments are not worth doing because the answers are either obvious or insignificant. For some experiments the distinctions are most obvious in retrospect.

ii. During the scheduled meeting with the TA and / or the instructor during the lab class the team should be able to:

a. State the observation they intend to investigate
b. Give preliminary explanation(s) of the problem
c. Explain what information was sought and discovered by each team member and how it applies to the potential projects.
d. Discuss the general feasibility of your project with the instructors.

iii. Consider any major additional details that the team will need to look up or work out in order to finish refining and designing the experiment. Examples of these details could include relevant strains, chemical requirements, potential hazards, necessary assays, potential equipment, recipes, scheduling *et cetera*.

iv. Assign particular team members specific duties to sort out by the following class.

14. **Day III**

During the scheduled meeting with the TA and / or the instructor during the lab class the team should be able to:

a. State the problem that has been approved in principle by the instructors
b. Provide the potential explanation(s) of the problem
c. Explain the evidence or logic for the explanation

d. State the experimental question that will be specifically addressed and how that question relates to the original hypothesis or explanation concerning the original observation.
e. Explain the experimental approach for testing the stated question and the probable outcomes if the hypothesis is true and the probable outcomes if the hypothesis is false.
f. Summarize any outstanding issues or changes to the original questions posed in the preceding week that that need to be addressed.
g. Explain your progress over the preceding week.

15. **Day IV**

i. During the scheduled meeting with the TA and / or the instructor during the lab class for Day IV the team should be able to explain the timeframe, the required amounts of supplies and equipment, the strains and the sources of strains that will be needed for the project.

ii. If strains must be acquired you will need to e-mail a **list of the desired strains** to the instructor **by the end of week**. The list should have "Required Strains for MICB 421" in the subject heading.

iii. The team can start to prepare basic supplies that will be needed for the project.

iv. By 11.59 PM on the Monday before mid-term break the team must submit a detailed written proposal. The expected amount of detail would be analogous to the details in the different sections of Project 1 with a bit less emphasis on the background. In 2500 – to – 5000 words the report must provide:

- **Identification**: the team alpha-numeric and the names of the team members
- **Overview Chart**: a chart that shows how the tests and work fit together as an overview of the project.
- **Title**: a relevant working title for your experiment (It might change by the final report).
- **Introduction and Background**: sufficient background to understand the explanation of the observation, the chosen approach to testing the question and the outcomes.
- **Observation and Explanation**: the experimental observation and the proposed explanation that the project is addressing.
- **Experimental Question**: the experimental question(s) that you are attempting to answer that will test your explanation / hypothesis of the observation. Include the potential outcomes if the explanation is correct or incorrect.
- **Protocol**: description of the project that **explains what will be done** and how the tests fit together. It would include details of sampling, number of samples, timing of sampling, types of assays for the different types of proposed measurements, controls, growth requirements.
- **Methods**: description of **how the assays and tests will be done**. It would include recipes or step by step explanations and details to make measurements, grow the cultures, and actually assay the samples. Include quantities and control conditions *et cetera*. It must be detailed enough to allow the team to make the supplies in appropriate quantities.
- **Supplies and Equipment**: provides quantities, and condition of the chemicals, equipment and strains. Any required chemicals or kits or strains that are not available in the inventories for the class must be clearly identified.
- **Weekly Time Frame**: the detailed schedule of the project work that will be done by the team each week in order to finish the project on time. Some work can be overlapped to allow testing of unfamiliar procedures, testing of strains, taking

preliminary measurements to assess response ranges *et cetera* before the final experiment is attempted.
- **Potential Pitfalls**: potential problems that might arise to put the work behind schedule.
- **Known Hazards**: any **significant unusual** hazards associated with the work and your means of controlling those hazards so the work is safe.

v. This report should be submitted on the MICB 421 WebCT Vista drop box. There should only be one submission for each team.
vi. The report will be graded for completeness, relevance and readability for each of the expected sections.
vii. **Submit a separate list of required strains, kits or chemicals** that are not in the class inventories **directly to the instructor**. Include sources, quantities and costs for each item. Strains that are not available locally can take weeks to arrive so they need to be requested early in the process.

16. **On Day V-through X**.

Over this time the team must finish preparing the required supplies (if they are not already available). Carry out the experiment. Examine the results. Then use the observations from your first experiment to re-design or refine the first experiment to improve or confirm the initial results. Sometimes the second experiment should use the same general approach with a better sampling strategy, additional controls or different input. Sometimes the second experiment should use a different approach to the initial hypothesis. In either version of the second experiment the intent is to refine your understanding of the initial observation and your proposed explanation of that observation. In all cases the second experiment must continue to test the idea or an explanation of the problem or observation made in the first round of testing.

17. **On Days VI and VIII**.

On Days VI and VIII each team must have a scheduled meeting during the registered class time with the TA and / or the instructor. During those meetings each team member must be prepared to explain:

a. Any observations or problems or progress from the preceding week.
b. Any new or modified procedures that were not described in the submitted proposal.
c. The schedule of the work that is being done for the following week
d. The name the team members that will participate in the work for each day and what they will do on that day

18. **On Day IX**.

On Day IX each team must have a scheduled meeting during the registered class time with the TA and / or the instructor. At the meeting, be prepared to discuss the remaining work and the content of the draft report. (What your tests have showed? What figures and tables are being considered for the report? What in missing?)

19. **On Day XI**.

All team members must attend the lab during their normal scheduled class time to clean up supplies and work places unless the cleanup was done the week earlier.

20. **Completing the project**

i. By the second Monday in April each team must submit a formal journal article that documents their hypothesis, their experiment, their results and their conclusions. The article must be written in the style prescribed in Appendix F of the lab manual. If this article is started in the last week of class it could be a large amount of work. However, much of the effort can be dispersed if the team coordinator assigns tasks that initiate the article by early - to- mid-March. For example, even though the final draft might require revisions to include the final results it is possible to make a draft version of the introduction as well as the materials and methods section. It is also possible to prepare preliminary graphs and tables that portray the preliminary results from the first round of the experiment before doing the second round. It is also possible to develop a written list of the major thoughts and provisional conclusions suggested by that data. Even though the final tables and figures need to be embedded at the end of the word document as pictures pasted into text boxes the preliminary tables and figures can be prepared in Excel (or an analogous spread sheet program) and saved so they are easy to update and use when the final experiments are completed.

ii. The final report is expected to include **at least** four journal article references aside from JEMI articles that are relevant to the explanation of the ideas being tested. To meet this requirement, it would be useful to continue the library searches and develop a provisional reference list well before the article is due. An early search might be helpful for interpreting the observations from the first experiment and designing the second experiment.

iii. **Streaked plates of all relevant bacterial strains, clones, constructs and plasmids used in your project must be prepared and submitted to the instructor so the strains can be preserved and accessible for any future students that wish to continue your project**.

19. The submitted draft reports will be reviewed in the order that they are received and the reviewers comments will be returned to the team that submitted the report (hopefully within a few days). The team must complete any required revisions and corrections then resubmit the report in electronic form before the end of April (hopefully sooner).

Materials and Equipment:

- Lists of inventories of the available equipment, strains and chemicals are available in the resources section at the MICB 421 WebCT website. There are bound paper copies of this information in room 104 and 114 Wesbrook.

- Major equipment that could be available include:

:- a variety of **centrifuges** for microcentrifugation, high-speed centrifugation and ultracentrifugation. Some of this equipment has restricted access but it can be used as long as you have suitable instruction in the use.

:- a variety of **spectrophotometers**. Some machines like the Spectronic 20 are suitable for working with larger volumes and are well suited for following growth, measuring the results of chemical assays and enzymatic assays but lack the capacity to measure ultraviolet light. Others work well in the ultraviolet light. These spectrophotometers generally have a maximum volume of approximately one millilitre but special cuvettes are available to measure 100 microlitre volumes. Another one has a carousel that can be programmed to rotate in order to automatically read the absorbance of samples in successive cuvettes. Some of the instruments that read at ultraviolet wavelengths can be set to scan multiple wavelengths of light and give a reading at the specified wavelengths. Some of the spectrophotometers can be linked to the SpecX data acquisition

program to automatically collect digitized data that can be imported into spreadsheet programs. The SpecX program can also be adapted to give automatic readings of temperature and ion-probe measurements

:- a variety of **electrophoresis** equipment. There are gel systems for working with protein gels and nucleic acids. The nucleic acid systems are mostly for submerged agarose gels. The agarose gel systems are available in a range of sizes. The bigger boxes can hold more samples than the smaller boxes and the samples can be run further to improve the resolution between bands. However, the smaller boxes run a lot faster and use less agarose so they are much better for tests that involve fewer samples with well-resolved bands. There is also a **Western Blotting** apparatus and a special **pulse-field gel** apparatus that is used to electrophorese and isolate large molecules such as whole genomes, chromosomes and viruses.

:- a variety of **incubators, air-shakers, tube rotators and waterbaths** to grow cultures. Some incubators are stationary and are suitable for static incubations of flasks and plates. Some move to allow agitation or aeration of flasks or tubes or other containers. Some work at ambient temperature. Some have thermostats to work above room temperature. Some of the waterbaths can be hooked to cooling systems to work below ambient temperature. Some work can also be done in cold rooms to lower the ambient temperature.

:- **ovens** for higher temperature incubations.

:- **digital cameras**, an **Alpha Imager** (geldoc) system and a **scanne**r to create electronic files that store data and images. The digital cameras can be used in freestanding mode or stabilized in box stands or hooked to some microscopes.

:- a **fluorimeter** that measures fluorescence. It is analogous to a spectrophotometer but measures the intensity of light created by the sample rather than transmitted light. It can be more sensitive than spectrophotometry and has wide application for a variety of chemical and enzymatic assays.

:- a **spectrofluorimeter** that is analogous to the fluorimeter but allows a broader range and combination of excitation and emission wavelengths.

:- a **luminometer** to measure light emitted by luminescent assays.

:- small capacity **bead beaters, large capacity bead mills, grinders**, a **sonicator** and other equipment for breaking cells.

:- an **electroporator** to shock and transform cells.

:- a **gas chromatograph** (GC) for separating and measuring volatile molecules such as acetic acid, butyric acid and other metabolic wastes. It can also be used to measure some types of storage products.

:- a variety of **gas tanks** and **pressure regulators** to adjust and control the atmosphere in cultures and reactions.

:- a variety of **ion-probes** for measuring **pH, oxygen, ammonium and re-dox**.

:- a **scintillation counter** for quantifying tritium and carbon-14 isotopes. There is also an x-ray developer system for working with autoradiographs.

:- two **hybridization ovens** for working with nucleic acid hybridizations or protein blots.

:- an **ultraviolet light chamber** for mutagenesis and binding molecules to specific activated membranes.

:- **polymerase chain reaction machines** (PCR).

Sources for Experiments:

Sources are listed under eleven categories. Some articles potentially fall in two or more categories but are listed in the category reflecting the dominant aim of the project.

1. Metabolic Effects of Antibiotics

JEMI 2:103-108. Effects of kanamycin and streptomycin on the macromolecular composition of streptomycin-sensitive and resistant *Escherichia coli* strains

JEMI 7:43-48. Potential synergistic effects of rifampicin resistance and *rec* mutations on growth rate in *Escherichia coli*.

JEMI 3:41-49. The antimicrobial effects of magnolol on the intracellular pH of *Bacillus subtilis* WB746 and *Escherichia coli* B23

JEMI 7:82-88. The effects of sub-inhibitory levels of chloramphenicol on pBR322 plasmid copy number in *Escherichia coli* DH5a cells

JEMI 9:11-15. Secondary effects of streptomycin and kanamycin on macromolecular composition of *Escherichia coli* B23 cell.

JEMI 9:31-38. Effects of kanamycin on the macromolecular composition of kanamycin sensitive *Escherichia coli* DH5∝ Strain.

JEMI 11:54-59. Effects of streptomycin and kanamycin on the production of capsular polysaccharides in *Escherichia coli* B23 cells.

JEMI 11:103-111. The effects of gratuitous heterologous gene expression on the amplification of ColE1-related plasmids in cultures of *Escherichia coli* BL21 (DE3) in the presence of sub-inhibitory levels of chloramphenicol.

JEMI 12:14-20. The effects of the antimicrobial honokiol on the intracellular pH of *Bacillus subtilis* WB746 and *Escherichia coli* B23.

2. Enzymology

JEMI 11:14-22. The relative release of alkaline phosphatase and beta-galactosidase of *E. coli* C29, in exponential and stationary phases, through different lysis methods.

3. Gene Expression and Physiology

JEMI 15:125-129. Dps augments LexA autocleavage after UV-C-induced DNA damage in stationary phase *Escherichia coli*

4. Effects of Environment on Growth and Apoptosis

JEMI 15:71-78. Role of alginate in gentamicin antibiotic susceptibility during the early stages of *Pseudomonas aeruginosa* PAO1 biofilm establishment

5. Virology and Surface Recognition

JEMI 15:47-51. Capsular polysaccharide has a minor role on streptomycin-induced reduction of T7 phage adsorption to *Escherichia coli*

6. Genetic Transformation

JEMI 15:130-135. Genotyping *Escherichia coli* isolates from duck, goose, and gull fecal samples with phylogenetic markers using multiplex polymerase chain reaction for application in microbial source tracking

7. Autoinducer, Growth and Survival

JEMI 15:111-116. Transcription of katG is enhanced in *Escherichia coli* exposed to UV-A and might enhance cell survival

8. Cell Disruption and Enzyme Purification

JEMI 14:1-6. Assessment of periplasmic enzyme isolation methods: isolating L-asparaginase from Escherichia coli using microwave irradiation and potassium phosphate-hexane permeabilization methods

9. Molecular Biology and Genetics

JEMI 15:136-141. Construction of pBAD-clones using the TOPO TA cloning system

10. Mutagenesis

JEMI 15:142-147. Troubleshooting the single-step PCR site-directed mutagenesis procedure intended to create a non-functional *rop* gene in the pBR322 plasmid

11. Additional Potential Novel Experiments:

D1. A number of recent studies have shown that stationary phase cells are metabolically active and that growth appears to occur in the stationary phase (Microbiol. Molec. Biol. Rev. 61, 305 - 318 (1997)). Is the range of protein synthesis at that time comparable to the range of synthesis during exponential growth phase? Are all forms of stationary phase equivalent with regard to residual metabolic activity? What is the nature of the small fraction of cells that are alive but metabolically inactive in crowded cultures?

D2. There is a growing interest in nanotechnology. Some of this technology involves growth in nanospaces (J. BioSci. Bioeng. 98, 304-305 (2004)). This confined growth might be analogous to bacterial biofilm growth. Does bacterial growth and metabolism behave differently in spaces similar to the size of a bacterium?

D3. For over 100 years researchers studied nitrifier populations by using Most Probable Number (MPN) assays. The bacteria grew up in these assays over several weeks. Recent molecular studies have shown a wide diversity of nitrifiers. Are the nitrifiers that develop later in an MPN assay the same species as the nitrifiers that developed early?

D4. The suppression of galactosidase induction by glucose has been well established. Some studies have shown that lactose or serine will also strongly, suppress induction. The lactose effect is probably due to enhanced binding by the repressor but the effect of serine is less clear.

D5. The induction of inserts cloned into the pBAD plasmid cloning sites results in greater expression of the insert when the concentration of the arabinose inducer is increased. The effect has been attributed to limited induction of each cell when the arabinose is limiting. The effect could also be explained if the number of induced cells in the population is limited even though each induced cell is fully induced. It is important to know the difference between these explanations in order to interpret the effects of the expression of the cloned inserts on the cells. Is either model correct?

D6. Other potential proposals might be permitted as long as they deal with the physiology or genetics of bacteria, bacterial plasmids or yeasts. (**The teaching lab is not equipped to deal with pathogens, virulence factors, eukaryote cell cultures or eukaryote viruses**).

General References that might be Useful to find Project Background:

1. Books

At the Bench ; a Laboratory Navigator, K.Barker (1998) A guide to many basic laboratory research skills and functions.

Biochemical Methods, Pinoud, P., C.Urbanke, J.Hoggett and A.Jeltsch, (2002) Theory and application of biochemical techniques.

Difco & BBL Manual , Manual of Microbiological Culture Media , Zimbro, M.J. and D.A.Power, (eds.) (2003) A manual discussing the history, properties and uses of the Difco and BBL media that are commonly used in microbiological work.

Escherichia coli and Salmonella typimurium : Cellular and Molecular Biology (1996) Reference text concerning physiology, genetics, cell biology and biochemistry of *Esherichia coli* and *Salmonella*

Experimental Biochemistry, Dryer, R.L. and G.F.Lata, (eds.) (1989) Basic biochemical procedures, explanations of methods and experimental design.

Manual of Methods for General Bacteriology, Gerhardt, P. et al., (eds.) (1981) A manual of basic microbiological, biochemical and basic molecular biological techniques.

Manual of Methods for General Bacteriology, Gerhardt, P. et al., (eds.) (1994) An updated manual of basic microbiological, biochemical and basic molecular biological techniques.

Methods in Enzymology, Kaplan, N.O.and S.P. Colowick (eds.) 1955-present. An encyclopedia with detailed descriptions of a wide range of assays for enzymes as well as isolation procedures and the measurement of a wide range of biochemical molecules.

Molecular Approaches to Environmental Microbiology, Pickup, R.W. and J.R. Saunders (eds.) (1996) A manual of basic microbiological and basic molecular biological techniques.

Molecular Cloning, 2nd ed., J. Sambrook, E.F.Fritsch and T.Maniatis (1989) A manual molecular biological techniques.

Molecular Biology of Bacteriophage T4, Karam, J.D. and J.W. Drake (eds.) (1994) Reference text concerning T4 properties.

Principles and Techniques of Practical Biochemistry, 5th ed., Wilson, K. and J.Walker (1999) Theory and application of biochemical techniques.

Short Protocols in Molecular Biology, 4th ed., F.M.Ausubel, et al. (1999) A manual of molecular biological techniques.

The Lac Operon: A Short History of a Genetic Paradigm, Benno, M., (1996) Reference text concerning galactosidase and lac operon properties.

2. Catalogues

Aldrich Information on chemicals.

Bio-Rad Life Science Research Products Information on molecular biology reagents and methods.

Fermentas Extensive information on restriction enzymes, reaction conditions and applications.
Fisher Biotech Collection Information on molecular biology reagents and methods.
Fisher Catalogue Information on general laboratory equipment and chemicals.
Invitrogen Information on molecular biology reagents and methods.
Nalgene Information on plastic properties such as chemical resistance and temperature stability.
New England Biolabs Information on molecular biology reagents and methods.
Promega (Fisher Scientific) Information on molecular biology reagents and methods.
Roche Molecular Biochemicals Information on molecular biology reagents and methods.
Sigma Catalogue Information on chemicals.
VWR Catalogue Information on general laboratory equipment and chemicals

3. Websites

UBC Library at http://www.library.ubc.ca
Search for journal articles related to topics by using
Biosis <http://resources.library.ubc.ca/551/ >
Medline <http://resources.library.ubc.ca/139/ >
PubMed <http://resources.library.ubc.ca/321 >
Web of Science. <http://resources.library.ubc.ca/277/ >

The following sites are good places to find journal articles in the topics and to search whether published authors have published more recent studies.

Google Scholar at http://scholar.google.ca/schhp?sourceid=navclient&ie=UTF-8
Search for research articles and scholarly books
Google at www.google.com
General information search site

The following sites are good sources of information on bacterial molecular biology, genetics and techniques respectively

EcoCyc and **MetaCyc** at http://ecocyc.org and http://metacyc.org
Information on metabolic pathways and enzymes in hundreds of different organisms including *Escherichia coli* and *Bacillus subtilus*.
Coli Genetic Stock Center at http://cgsc.biology.yale.edu/
Data base and source for mutant strains of *Escherichia coli* including the single gene knockout strains in the Keio Collection.
Hancock Laboratory Methods at http://cmdr.ubc.ca/bobh/methodsall.html
Extensive collection of common assays for molecular and cellular work.

Appendix VIII - MICB 447 Project Course

To demonstrate the nature of the MICB 447 course I have included an abridged copy of the course outline.

MICB 447- Experimental Research

Purpose: The purpose of the course is to carry out a research project involving aspects of molecular biology in order to:

- demonstrate your ability to apply your skills in this area of science.
- expand your background in this area of research.
- learn additional molecular biology skills.

Learning Outcomes:

- be able to define a research problem.
- be able to examine a research problem and suggest reasonable experimental explanations and solutions.
- be able to locate information and background for designing an experimental protocol.
- be able to critically evaluate experimental results to modify experiments.
- be able to maintain records and communicate results in a formal scientific presentation.

Course Operation:

The majority of the course is concerned with designing and carrying out a research project but each Wednesday there will be a scheduled class meeting. During that part of the class we will discuss/review different aspects of project design and advanced molecular biology background in nucleic acid isolation, restriction enzymes, hybridization and gels. Towards the end of term we will also talk about the final report and the characteristics of the final report. The actual content of these classes will depend on general needs for the different projects in the class. Individual weekly meetings at other times will be scheduled to discuss details of their projects with individual students or teams. By the start of your weekly meeting you should have an idea of the work that you are intending to complete in the following week and how you will do that work.

An original copy of your records must be maintained in a bound lab book or binder when you are working in the laboratory. This book must include all important laboratory details such as your working hypotheses, ideas, data, explanations of observations, and conclusions as well as significant discarded ideas, relevant references, equipment names and models, chemical sources and catalogue numbers. Each week at your scheduled meeting you must ask the instructor to sign the completed pages in the book. The first page of the book must be reserved for an index that is updated each week. Each page in the book must be numbered and dated as it is used so that the important pages can be identified in the index.

The final report must be a formal journal article written in the style of the Experimental Journal of Microbiology and Immunology described in the JEMI file in the undergraduate student folder of the Microbiology and Immunology website www.microbiology.ubc.ca This style is adapted from the style used in the American Society for Microbiology journals such as J.Bacteriol and J.Immunol. Examples can be seen in recent volumes of the Journal of Experimental Microbiology and Immunology (JEMI) in the undergraduate student section at www.microbiology.ubc.ca

Grading expectations:

If students wish there can be a written final exam based on the concepts of experimental research covered in the scheduled class meeting. Otherwise the grading will be a subjective evaluation that considers:

- The demonstrated understanding of your attempted work and your demonstrated effort to achieve results.
- Your progress.
- Effective participation in the class discussions.

- The written proposals and the completeness of the lab record book.
- The project reports.
- Lab etiquette.

Activity	Due Date	Fraction of Grade (%)
Experimental record book*	Each week throughout the term. Final record book is due when the final report is submitted.	10
Weekly progress and demonstrated effort and lab etiquette	Observed each week throughout the term	10
Preliminary proposal	5 PM September 15	5
Final proposal	5 PM October 6	20
Progress report	5 PM November 3	5
Draft report*	December 12 or January 12	40
Final report*	February 14	10

Tentative Schedule:

a. Sept 7, week 1– select a problem and research background about the problem and the methods normally used to work with the problem.
b. Sept 14, week 2 – limit experimental problem, define the problem as an objective, start to develop an experimental plan, check sources of additional information, consider specific resource requirements (are the types of supplies and equipment available?), safety constraints.
c. Sept 21, week 3 – refine experimental plan, justify the details and submit a written copy of the proposal to the course coordinator. Prepare specific supplies that will be needed to do the project. Common supplies may be shared. Request any chemicals or supplies that will likely be needed but are not available in the class inventory. Start preparing general supplies that will be needed. Common supplies may be shared.
d. Sept 28, week 4 – Finish proposal. Begin experiments, report progress / problems / changes to proposals. Submit the proposal by October 6.
e. Oct 5, 12, 19, 26, Nov 2, 9, 16, 23, 30 – continue experimental work. Each week discuss progress of the results, observations and problems at the weekly individual meeting. Bring a printed copy of the results and experimental proposals to each meeting.
f. On Nov 3 submit a progress report to the course instructor that summarizes the results up to that time and outlines the remaining work to complete the project.
g. Nov 23, week 12 – continue work if necessary. Begin writing the introduction, methods and references for the final report. (Some of these details could be started sooner by writing them out as you encounter them in the project).
h. Nov 30. Be able to provide an outline of the available results and general outline of the discussion at the weekly meeting. Clean up lab, stabilize useful cultures and supplies, and discard other materials.

i. If the initial draft is submitted by Dec 12th it will be reviewed, graded and available to be picked up later that week to do final revisions. If the initial report is submitted by Jan 12th it will be reviewed, graded and available to be picked up by Jan 31st to do final revisions.
j. Tuesday, Feb 14th – submit the final corrected report (paper copy and an electronic copy) and the lab record book for final grading. If you are away from UBC on a work term make arrangements before you leave to submit eh record book.

Details:

A. Effort and Etiquette

a. Other research courses such as directed studies expect approximately 15 hours of lab work per week, your individual workload should be similar.

b. Your lab work affects other people in the department that either share the same equipment, clean equipment, prepare media or instruct. There are six rules that you will be expected to follow in order to minimize problems with other people.

- Clean up balances, centrifuges, and spectrophotometers each time you use them.

- Clean up your working area including the sinks and balances before leaving the lab. Put the capped tubes that need to be autoclaved and the uncapped tubes in separate discard racks in room 112. Remove tape labels and felt pen labels from flasks and beakers. Use cold water to rinse out all flasks and tubes that contained dangerous chemicals before you put the flasks on the discard cart for washing.

- Place working equipment back in the storage areas when you finish.

- Tell the instructors about malfunctioning equipment so that it can be repaired.

- Tell the instructor if any particular bottles of chemicals are running low so that the chemicals can be ordered before there is a shortage.

- Discard your cultures from the incubator and the refrigerator when the lab work is completed.

- Prepare your own project supplies unless you have made formal arrangements to borrow supplies from another team. Respect other student's spaces and supplies.

B. Experimental Record Book

The record book must be brought to each lab to keep it up to date and be a record of all raw experimental details. **It is your responsibility to ensure that it is** reviewed and **marked each week by the instructor.** At that time the book will be initialed and graded for completeness and accessibility of information. Any deficiencies noted when the book is initialed must be corrected before the book is examined on the following week.

The grading for the record book will consider:

a. Whether you had the record evaluated for completeness and signed by the instructor **each week during the scheduled meeting.**

b. A complete a table of contents on the first page at the front of the book that must be **updated each week before the record is marked**. At that time the table of contents must list the abbreviated work

titles for the recorded work in each experiment or assay, the starting page numbers of the corresponding work and the date of the work.

c. A date on every completed page.

d. A page number on every completed page.

e. A participation log of the work that was done each day. This should be a simple, ongoing, series of consecutive entries **at the back page of the record book**. These entries should show the date, the approximate length of time that the work took place and five-to-ten words that describe the nature of the work (ie. Inoculated cultures for overnight growth; measured enzyme kinetics of samples; prepared acrylamide gels and ran samples).

f. The following entries in **labeled sections for each time you are working in the lab**. The labeled sections should normally include the purpose, procedures, results and conclusions. If you are just doing routine work such as preparing supplies or setting up inocula then you only need the first two sections but should comment on whether the results of that work were reasonable and give an explanation if they were not reasonable. Since some results might take a few days to sort out or complete before making a conclusion, the results and conclusion statements only need to be updated to the end of each preceding week at the time the record is marked.

The **purpose** is a brief specific statement that explains the experimental intent of the work, even if it is just to make media.

The **procedures** are a section that clearly explains how the work is being done. The description must include details on the growth conditions, calculations, company names and catalogue numbers for chemicals, brand names for equipment, the sources where materials such as plasmids, cultures and chemicals originated (this will usually be the UBC Department of Microbiology and Immunology teaching labs) and the properties of any strains or plasmids or primers or probes or antibodies. You may reference recipes, assays, procedures, protocols, strains *et cetera* as long as you note any modifications or discrepancies between the actual work and the referenced description. If there is no reference then provide the details in the record book.

The **results** section should be organized into tables and figures. The tables must show all the raw data such as the actual start and stop times for "timed experiments", actual dilutions and measured concentrations such as turbidity, absorbance or pH. Other data such as photographs, blotting membranes and autoradiographs should be clearly and completely labeled and taped into the appropriate location in the book.

The **conclusion** for each day's work must state what the work demonstrated. A following statement should consider whether the results were expected or unexpected and indicate the next step? If the results were unusual then there should be an attempted explanation, especially if a variation in the procedure could be responsible.

Any other information that might be useful when you review your results.

Within reason the neatness of the book and the records is up to you but the book will be more useful if the data is recorded in appropriate tables that were prepared and organized in the book before the experiment. The entries should be complete, understandable and readable. The entries will be graded for completeness and ease of finding experimental information.

C. Project proposals

The preliminary proposal should be a short written report that provides the:

a. The problem category that you are planning to work on.
b. A summary of the current state of that problem. Describes what work has been done and what are the conclusions and problems in that work.
c. You're the experimental aspect of your potential explanation(s) or approaches to the problem with demonstrated awareness of the prior work and how your work will differ to make successful.
d. Explains the evidence or logic for your explanation or approach.
e. Explains why your approach is relevant to the original hypothesis or explanation concerning the original observation.
f. Summarize any outstanding issues that you will need to be sort out.
g. References

The final proposal should be a detailed written report that provides the:

a. Proposed Title
b. Observation and Explanation
c. Experimental Objective
d. Background
e. Protocol
f. Methods
g. Supplies and Equipment
h. Weekly Time Frame for Completing the Work
i. Potential Pitfalls
j. Known Hazards
k. References

D. Weekly meetings

Be prepared to discuss your progress and understanding of your results. Bring your updated record book for grading. Be able to explain what you will be attempting during the following week and what difficulties you might encounter. Be aware of any pending experimental needs for chemicals or equipment so that required supplies can be ordered if they are not present in the lab.

E. Progress Reports

The progress report is a two - page, written summary that describes the major accomplishments in the work to that time. Explain any major problems in the project, point out significant changes in the aim or approach for the project, describe readjustments of the time frame and outline the remaining works that you expect to complete before writing up the final project report.

F. Project Reports

In a formal report you are expected to concisely interpret the major observations in your data and then analyze the interpretations by relating them to your basic background knowledge and the specific objectives of the experiment. A formal report must include the title of the experiment, the author's name, an abstract, an introduction and labeled sections for material and methods, results, discussion, future experiments and references.

a. Title

The intent of the title is to capture the reader's attention and allow potential readers to know whether the article might be relevant to their interests. The title should be a single sentence that should convey the

essence of the study. Use the fewest possible words to accurately describe the paper and provide enough information for an indexing service such as Medline. There should be no jargon or abbreviations

b. Abstract

The abstract is a short form of the paper. It contains the objective, main method, summarized results and the main conclusion. It is intended to give potential readers a better idea of the objective of the study, the approach to the study, the main observations and the main conclusions. It is written in the past tense as a single, self contained, short paragraph without references or abbreviations.

c. Introduction

The intent of the introduction is to provide enough background to understand and evaluate the purpose and the results of the reported study and justify the purpose without further literature review. It is not intended to be a review but should be sufficient literature information to orient the project by providing the essential details that allow the reader to understand the hypothesis being reported, the reason that anyone would study those details, the direction of the eventual discussion and a specific statement of the scientific purpose of the study. It must include a formal written statement that gives the scientific purpose that will be addressed and answered by the experimental results. It should define any specialized terms or abbreviations.

d. Material and Methods

No results, just the details to do the experiments. Use the past tense. Provide catalogue numbers and supplier source for any significant chemicals, kits and supplies. Provide recipes or references to the recipes for the solutions used for growth or reactions. Give names and properties of constructs (initials/year/clone #, ie: AF081 or PS082). Write sub-headings as the first line of the sentence. Use titles and labels for all Tables and figures.

The details in this section must be written in paragraphs rather than point form. Where appropriate the operational details should be referenced to existing published articles or published books but there should be enough information that the reader can understand the specific approach without looking up a lot of references. If the materials and methods were identical to the descriptions in the references then you should make a short statement to that effect and cite the reference. If there were any significant changes then you can indicate that the materials and methods were a modified version of the protocol in the reference then cite the reference and briefly explain the modifications.

e. Results

Use appropriate tables and figures to show the results and use a few paragraphs to point out and comment on the main observations and problems in the presented results. These paragraphs should be succinct summaries that point out the meaning and patterns of the observations rather than simply re-describing the graphs and tables in words. You are expected to consider the experimental purpose and pick out what seems to be the most relevant observations, problems, paradoxes and quirks from the data. Then briefly compare those observed effects to your expected results. Similar effects should be considered together and treated as a single observation so that space is not wasted simply repeating the same thing.

Present the results without repeating the methods. A few details of the methods can be presented to clarify the context but the main details should be in the methods section. Process the data in tables and figures. Comment on the quality of the result and the main observations and the main relationships of the trends. The discussion explains why you got the results. The introduction and the methods explain how you got results.

Wherever possible, the observations should be related to each other and compared to the controls. All comparisons should be quantitative. For example, if something becomes two times bigger than the control values you should say that it is 2x bigger or 200% bigger or twice as big instead of just saying that the value got bigger.

The tables and figures are intended to organize most of the data into a form that is easier for you to analyze, compare and examine for patterns. You should not include extra tables that simply repeat information already presented in other figures and tables.

Figures should be numbered in Arabic numerals and identified with relevant, informative titles at the bottom of the figure. A useful title is a sentence that indicates the purpose or intent of the information or trend in the graph rather than simply repeating the axis labels. For example: the title " Effect of carbon dioxide levels on the growth rate of E. coli in aerated minimal media" is more useful and informative than the title "Growth versus time" or "OD versus time". Figures should be identified by the capitalized abbreviation such as **FIG. 2** rather than Fig. 2 or Figure 2.

The tables should be identified with upper case letters, Arabic numerals and informative titles at the top of the table.. For example, "**TABLE 2**. Strains and plasmids used in this study." rather than "Table II. Strains and plasmids used in this study."

When data from a particular experiment is referred to in the discussion, the relevant data should be clearly identified by referring to the appropriate figure or table number. This referencing can be done in a several ways, for example:

> "Figure 12 shows that the growth rate doubled after the addition of the amino acids." or
> "The growth rate doubled after the addition of the amino acids (Fig. 12)."or "The affinity of *Listeria monocyogenes* to attach at different temperatures is shown in Fig.1" or "The amino acid uptake increased 3 fold after glucose was added (Table 2)."

You should note that even though the identification of the actual TABLE or FIG. is capitalized, the reference statements in the discussion and results use Table and Fig or Figure.

Good tables and figures are generally uncluttered and easy to read. Choose units and prefixes that try to avoid a lot of zeros or exponents that will clutter up the data and interfere with easy comparisons.

The figures should include keys that correlate different graphed symbols to the appropriate reaction conditions. In these keys concisely identify the active component of the test condition rather than the arbitrary number given to that test during the experiment. Since the only intent of the key is to identify the datum points to correlate the result to the conditions identified in the title or the axis labels, the key should not repeat any unnecessary information that is already presented in the title or the labels. The keys should be boxed off or positioned so that the symbols in the key can not be confused with actual data points. Frequently it is more convenient and effective to place the information about the symbols in the title rather than in a separate key.

f. Discussion

The discussion is an analysis of the observations and interpretations in the results. You are not expected to review the experimental technique or theory in this section or repeat the results. You are expected to discuss what could cause the effect, explain what the effect indicates is probably happening, suggest alternate explanations, explain why the effect is important and judge whether the effect and interpretations seem reasonable. Comment on the principles demonstrated by the results. Point out items that do not make sense and provide an explanation. Show how your results and interpretations agree or disagree with results in previous publications. Discuss the implications/significance of your work. The observations and problems should be ranked so that

the more important ones are discussed first and the less important ones last. Trivial observations and obvious minor problems should not be discussed.

The final paragraph in the discussion should be a conclusion. Conclusions are different then summaries. For a conclusion summarize the evidence then make **a brief statement about the general idea that your data has proved**, assuming that the data is correct. This statement must be based on the observed facts and should only be two or three sentences long. It must not include untested explanations of your results and must not be a discussion. However, you may include a short separate qualifying statement if your tentative conclusion seems to be inconsistent with known facts.

The entire draft report should normally be done in less than 4000 words. If your report is significantly longer then you are approaching the report wrong and doing unnecessary work.

All abbreviations except for standard chemical abbreviations and the standardized symbols for units should be identified the first time that the abbreviation is used. Usually an abbreviation is identified the first time by writing out the word(s) in full then putting the abbreviation in brackets after the word(s). You can then use just the abbreviation for the rest of the report. If you do not use the abbreviation after the first time when it was defined then there was no need to include the abbreviation.

g. Future experiments

What is the next step that should be done? What are problems that should be avoided by future researchers? When you discuss your results you should provide explanations of important observations and problems. Briefly outline an experiment that will test one of the most important explanations or paradoxes that you have actually proposed in your discussion section to account for some of your observed results or problems. Do not include operational details such as volumes, temperatures, times *et cetera* but give a brief statement of how the explanation will be tested and the expected results if the experiment supports or refutes your explanation. For example, if the test involved electrophoresis, explain how the result would test your explanation and what it would show if your explanation was correct or incorrect. It is not acceptable to merely repeat the experiment (even though this might be necessary).

- Acknowledgments

Indicate the financial support of the Department of Microbiology and Immunology, University of British Columbia.

- References

Include suitable references in suitable format. Web of Science, PubMed and Medline are good starting places for finding published references. At least four newer, relevant published journal citations are expected for your project report. The intent of a reference is to provide necessary background to understand your arguments or support one of your statements with facts. Any reference material that is used to expand or support arguments in the discussion section of the reports should be properly and completely cited in the style of the Journal of Bacteriology. If a reference is not cited or used in the introduction, methods or discussion it should not be included in the report because the information in it was not applied or needed.

When citing references you must use the standard journal abbreviations available at http://www.efm.leeds.ac.uk/~mark/ISIabbr/ or http://home.ncifcrf.gov/research/bja/

The formal abbreviation for the MICB 421 on-line Journal of Experimental Microbiology and Immunology (UBC) is J. Exp. Microbiol. Immunol**.** The informal abbreviation JEMI should not be used in the reports.

The program RefWorks or analogous reference tracking programs can be beneficial for developing reference lists but you still need to ensure that the listed references are in the appropriate style and format.

Potential Molecular Biology Projects for MICB 447

The potential projects fall into ten categories. Projects can be done by individuals or pairs of students. Separate projects within each category must be different but could be sufficiently related that students can compare results arising from different approaches or slightly different techniques.

Category 1 projects are concerned with the role of heat shock or cold shock cascades in the bacterial transformation process. During the standard transformation process the bacteria are mixed with DNA in the cold then rapidly shocked at 42ºC. It is easy to imagine how this procedure might alter the membrane fluidity and allow movement of the large DNA molecules across the cell surface. However, both cold shocking and heating shocking activate separate but overlapping cascades that lead to the expression of unique gene products. Many of the gene products in these cascades affect DNA replication, transcription and membrane structure. The types of projects would focus on whether these cascades or individual proteins activated or inactivated by the cascades play a significant role in the transformation process?

Some references relevant to this project include:

Bork, P., C. Sander and A. Valencia. 1992. An ATPase domain common to prokaryotic cell cycle proteins, sugar kinases, actin, and hsp70 heat shock proteins. Proc.Natl.Acad.Sci.USA 89: 7290-7294.

Han, M.-J. and S.Lee. 2006. The Escherichia coli proteome: past, present and future prospects. Microbiol. Molec. Biol. Rev. 70: 362-439.
(See pages 421-428 for details of the temperature induced cascades).

Sambrook, J. and D. Russell. 2001. Molecular Cloning: A Laboratory Manual 3rd Ed., vol 1.
(pages 1.105 – 1.111 has details of the transformation procedure.

Yoo, L. 2009. The effect of rpoH for heat shock gene expression on plasmid transformation. J. Exp. Microbiol. Immunol. 14: 108-111.

Category 2 projects are concerned with the observation that transformation is more efficient in the D23 strain with the *mre*B11 and *slo*B1 mutations than it is in wild type *Escherichia coli*. The mreB gene at 73.24 units in the genome was originally called envB. It is thought to be associated with actin analogues that affect chromosome segregation in growing cells. The mutation is associated with resistance to the penicillin mecillinam and causes a change in cell shape that is probably associated with changes of peptidoglycan structure and surface penetration. The sloB1 mutation around 75 units is associated with slow growth. The specific identity is unknown but that general region of the chromosome encodes several genes involved in energy metabolism, membrane and transcription regulation. The focus of this project would be to identify the sloB1 gene by isolating and sequencing potential candidates or mutating potential candidates to distinguish the roles of *mre*B and *slo*B in the enhanced transformation. Supplentary Table 6 in the Baba reference lists several essential genes in the general region of the where the *slo*B mutation was genetically mapped. Some genes might appear to be essential in an assessment of single gene knockouts if a second gene needs to be mutated to allow the cell to survive.

Some references relevant to this project include:

Baba, T., T.Ara, M. Hasegawa, Y. Takai, Y. Okumura, M. Baba, K. Datsenko, M. Tomita, B. Wanner and H. Mori. 2006. Construction of *Escherichia coli* K-12 in-frame, single – gene knockout mutants:the Keio collection. Molec. Systems Biol. Doi:10.1038/msb4100050.

Chan, E., L. Kuang, A. Lau and J. Wang. 2010. Antisense mRNA method as an alternative to generate a catalase double knockout phenotype in a Escherichia coli *kat*G mutant. J. Exp. Microbiol. Immunol. 14: 127 - 134.

Doi,, M., M. Wachi, F. Ishino, S. Tomioka, M. Ito, Y. Sakagami, A. Suzuki, and M. Matsuhashi. 1988. Determinations of the DNA sequence of the mreB gene and of the gene products of the mre region that function in formation of the rod shape of Escherichia coli. J. Bacteriol. 170: 4619 – 4624.

Habibi, M., P. Liem, W. Luong and E. Netchaeva. 2009. Comparison between transformation efficiencies in rod-shaped and spherical-shaped *Escherichia coli* strains", J. Exp. Microbiol. Immunol. 13: 75 - 78.

Kruse, T., J. Bork-Jensen and K. Gerdes. (2005). The morphogenetic MreBCD proteins of Escherichia coli form an essenetial membrane bound complex. Mol. Microbiol. 55: 78-89.

Westling-Haggstrom, B. and S. Normark. 1975. Genetic and physiological analysis of an *env*B spherelike mutant of *Escherichia coli* K-12 and characterization of its transductants. J. Bacteriol. 123: 75-82.

Category 3 projects are concerned with the observation that pUC19 plasmid is preferentially selected when Escherichia coli DH5α is simultaneously transformed with equal quantities of pUC19 and pBR322 plasmids. This type of an effect might arise because the pUC19 plasmid lacks the *rop* gene that is involved in the regulation of plasmid copy number while the pBR322 has a wild type *rop* gene. The effect might also arise because the pUC19 is a smaller plasmid than the pBR322. These explanations could be examined by re-constructing the plasmids to either increase the size of pUC19, decrease the size of pBR322 or switching the *rop* genes between the plasmids. The modified plasmids could then be mixed with the normal plasmids to determine whether transformations with the new combinations produced the same results.

Some references relevant to this project include:

Chu, V. 2004. Attempts to construct a completely *Rop*$^-$ pUC19 by using *NdeI* and *EcoO1901* restriction endonucleases and blunt-end ligation. J.Exp. Microbiol. Immunol. 6: 67-71.

Fang, D. 2004. Attempts to use PCR site-directed mutagenesis to create a non-functional *rop* gene in the plasmid pBR322. J.Exp. Microbiol. Immunol. 6: 45-51.

Jew, L. (2010). Troubleshooting the Single-step PCR Site-directed Mutagenesis Procedure Intended to Create a Non-functional *rop* Gene in the pBR322 Plasmid). J. Exp. Microbiol. Immunol. 15: 142 – 147.

Komljenovic, I. 2005. Construction of a mutant pBR322 using site-directed mutagenesis to investigate the exclusion effects of pBR322 during co-transformation with pUC19. J. Exp. Microbiol. Immunol. 8: 27-32.

Lin-Chao, S.,W.-T.Chen and T.T.Wong, 1992. High copy number of the pUC plasmid results from a Rom/Rop suppressible point mutation in RNA II. Mol. Microbiol. 6: 3385-3393.

Ng, I. 2005. Attempt to construct a Rop+ pUC19 by using NdeI, AatII, and AfeI restriction endonucleases with separate blunt and staggered-end ligations. J. Exp. Microbiol. Immunol. 8: 40-46.

Plaa, N. 2010. Determining the Importance of a Specific *rom* Mutation in Plasmid Exclusion of pBR322 During pUC19 Co-Transformation. J. Exp. Microbiol. Immunol. 14: 112-115.

Sabaiduc, S. and A. Lo. 2008. Determination of exclusion effect in wild type and rop deficient mutant pBR322 co-transformations. J. Exp. Microbiol. Immunol. 12: 118 - 122.

Sozhamannan, S., J.G.Morris and B.L.Stitt. 1999. Instability of pUC19 in *Escherichia coli* transcription termination factor mutant rho026. Plasmid 41: 63-69.

Category 4 projects are concerned with the characterization of the conditions necessary for efficient and effective ligation by the T4 ligase commonly used in molecular biology. Some reports suggest that the efficiency of the ligation might be affected by the position of the restriction sites forming the fragments, the type of restriction site, the sequence of the restriction site and the enzymes that restricted the site. An important study showed that some small ends were not detected when NdeI cut fragments were end-labeled with biotin but it was not clear whether the ends were not detected because of lack of labeling or lack of binding to the membrane used for detection.

Some references relevant to this project include:

Cheng, E., B. Ge, M. Lee, M. So and W. Wang. 2005. Investigation of the ligation efficiency of *Nde*I digested fragments. J. Exp. Microbiol. Immunol. 7: 68-72.

Choi, C. 2006. Exploring the availability of the NdeI cut ends for additional molecular reactions. J. Exp. Microbiol. Immunol. 10: 46-49.

Chow, P., 2005. Cloning of λ DNA fragments into pUC19 vector to study the ligation efficiency of NdeI-digested pUC19 and HindIII-digested pUC19 by T4 DNA ligase. J. Exp. Microbiol. Immunol. 8: 8-13.

Liao, L., 2009. Investigating whether NdeI-Cut ends are available to incorporate deoxynucleotides. J. Exp. Microbiol. Immunol. 13: 100 - 103.

Wong, J., 2005. Generation of intermediate plasmids for the investigation of sequence- dependent ligase activity due to location of sequences relative to the restriction endonuclease nick site. J. Exp. Microbiol. Immunol. 8: 54-59.

Category 5 projects are concerned with the observation that inactivating the outer membrane protein ompA reduces conjugation efficiency. This reduction might be due to consequent changes in the membrane structure rather than due to the ompA. To try to assess whether ompA plays a direct role, the gene was cloned into a plasmid and over expressed. The strain with the over expressed ompA had a conjugation efficiency similar to wild type strains. However, this similarity might have been caused by uncontrolled over expression of the gene. The intent of this type of study would be to construct a clone that allowed controlled expression of the ompA gene in order to test a range of expression on conjugation efficiency.

Some references relevant to the project include:

Adair, S., J. Boyd, D. Hancock and A. Suo. 2008. Proposed construction of pBAD24-*omp*A for the differential expression of OmpA in conjugation efficiency studies. Exp. Microbiol. Immunol. 12: 100-105.

Carson, J. and A. Lee, 2010. Determination of the relative OmpA expression and membrane integration in an ompA-deficient Escherichia coli strain complemented with a plasmid containing an ompA Gene. J. Exp. Microbiol. Immunol. 14: 48-50.

Chambers, C., B. Chang, K. Fehrmann and G. Quan. 2007**.** Investigating the Sex Life of *Escherichia coli:* The effect of OmpA expression on Hfr conjugation efficiency**.** J. Exp. Microbiol. Immunol. 11: 98-102.

Chan, C., T. Chiu and R. Kang. 2005**.** Construction of a plasmid that increases the level of ompA gene expression in Escherichia coli for the study of its effect on bacterial conjugation. J. Exp. Microbiol. Immunol. 9**:** 102-107.

Han, J., F. Latulippe, S. Rai and E. Yim. 2010. Troubleshooting for the proposed construction of pBAD24-ompA. J. Exp. Microbiol. Immunol. 14: 146-152.

Lo, B. 2010. Construction of pBAD24-OmpA for modulating ompA expression in Escherichia coli to assess role in conjugation. J. Exp. Microbiol. Immunol**.** 14: 142-145.

Tong, K. 2010. Construction of pBAD-clones using the TOPO TA Cloning System. J. Exp. Microbiol. Immunol. 15: 136-141.

Category 6 projects are concerned with the construction of catalase deficient strains of E. coli in order to test the effect of catalase on the death induced by exposing cells to UVA. Previous studies have suggested that UVA kills by a mechanism involving active oxygen. This suggestion could be tested by exposing strains that lack catalases to UVA. However, the available strains have two catalases and only one catalase has been mutated.

Some references relevant to this project include:

Chan, E., L. Kuang, A. Lau and J. Wang. 2010. Antisense mRNA method as an alternative to generate a catalase double knockout phenotype in a Escherichia coli katG mutant. J. Exp. Microbiol. Immunol. 14: 127 - 134.

Cheng, M., Anna Chow, Julie Ho and Beryl Luk. 2009. *katE* Complementation Fails to Protect Against UV-A-Mediated Killing in Catalase-Deficient *Escherichia coli.* J. Exp. Microbiol. Immunol.13: 63 - 66.

Gerami, O., L. McLaughlin, J. Valle-Rivera, and S. Yeung. 2010. Attempted transformation of catalase-deficient *Escherichia coli* with pBAD24 vector containing *katE.* J. Exp. Microbiol. Immunol. 14: 135 - 141.

Gong, L., K. Takayama and S. Kjelleberg. 2002. Role of spot-dependent ppGpp accumulation in the survival of light-exposed starved bacteria. Microbiol. 148: 559-570.

Gordon, R., B. Livingstone and V. Pho. 2010. Transcription of *katG* is Enhanced in *Escherichia coli* exposed to UV-A and might enhance cell survival. 15: J. Exp. Microbiol. Immunol. 15: 111 - 116.

Lee, Y. 2010. *katE* Complementation on *katG* Background has Negative or No Effect on the Ability to Protect against UV-A-Mediated Killing in *Escherichia coli.* J. Exp. Microbiol. Immunol. 15: 108- 110.

Makhijani, P. 2010. The Role of Catalase HPII Levels in Protection against UV-A Damage in a Catalase Knockout *Escherichia coli* Strain. J. Exp. Microbiol. Immunol. 15: 103 - 107.

Mulvey,M., J. Switala,A. Borys, and P. Loewen. 1990. Regulation of Transcription of katE and katF in Escherichia coli. J.Bacteriol 172: 1990, 6713-6720

Category 7 projects are concerned with the construction of Escherichia coli strains that are deficient in both spot and relA in order to test the role of stringency in acquired physiological antibiotic resistance. Previous work has tried to look at the role but the available isogenic strains have multiple uncharacterized mutations that might limit the comparability. The intent would be the construction and characterization of isogenic strains by using site specific recombination.

Some references relevant to this project include:

Baba, T., T.Ara, M. Hasegawa, Y. Takai, Y. Okumura, M. Baba, K. Datsenko, M. Tomita, B. Wanner and H. Mori. 2006. Construction of *Escherichia coli* K-12 in-frame, single – gene knockout mutants:the Keio collection. Molec. Systems Biol. Doi:10.1038/msb4100050.

Chenne, W., L. Ng, and M. Pambid. 2010. Assessing the Role of SpoT and RelA in Capsular Polysaccharide Synthesis After Treatment with Sub-lethal Concentrations of Kanamycin to Confer Decreased Antibiotic Sensitivity in *Escherichia coli.* J. Exp. Microbiol. Immunol. 15:52 - 58.

Chiang, V., B. Wong, C. Wong and J. Yu On the Limited Role of *relA* in kanamycin and Amino Acid Starvation Induced Stringency and Subsequent Antibiotic Cross-protection in *Escherichia coli.* J. Exp. Microbiol. Immunol. 15:59 - 63.

Category 8 projects are concerned with the observation over-expressed proteins are frequently insoluble and biologically inactive. In the pET 32a plasmid from Novagen, fusion with thioredoxin has been used to enhance solubility of overexpressed protein. The enhanced solubility could be due to net changes of solubility chemistry in the fused proteins or the reduction of thiols within the proteins. The observation suggests that other re-dox proteins such as the highly soluble *Escherichia coli* NADH : flavin oxidoreductase (Fre) might also be useful for overexpressing fusion proteins.

This project has been approached with several different constraints and several different inserts. All of the projects attempted to clone the Fre into a high expression vector. An additional relatively insoluble protein could then be to cloned Fre gene to assess the potential value for enhancing solubility of overexpressed proteins.

Some references relevant to this project include:

Cameron, A., S. Gray, A. Sribnaia and T. Withrow 2009. Attempted Construction of a pET32a(+) Vector Containing EDTA Monooxygenase A. J.Exp. Microbiol. Immunol. 13:
119 – 124

Fam, H.-K. 2009. Subcloning emoA into pET32a(+), pET32a(+)□trxA/+fre and pET32a(+)□trxA to Assess the Relative Effect of Thioredoxin A and Flavin Oxidoreductase on emoA Solubility. J.Exp. Microbiol. Immunol. 13: 114 – 118

Honeyman, G., A. Moore, E.Rurak and A. Shamlou 2008. PCR Amplification of *emo*A from the pEmoA Plasmid. J.Exp. Microbiol. Immunol. 12: 106 – 112

Kazem, M. 2004. Cloning EDTA monooxygenase as a model protein to characterize the effects of flavin oxidoreductase on solubility of proteins in protein overexpression systems. J.Exp. Microbiol. Immunol. 6: 26-34.

Kartono, A. 2004. Construction of a pET32a expression vector lacking the TrxA fusion protein. J.Exp. Microbiol. Immunol. 6: 39-44.

Kwok, W. 2004. Attempted Cloning of *Escherichia coli csg* into flavin reductase or thioredoxin in the pET32a (+) vector to assess disulfide bond effects on amyloid deposits formation. J.Exp. Microbiol. Immunol. 6: 72-76.

Shah, N. 2004. Preparing plasmid constructs to investigate the characteristics of thiol reductase and flavin reductase with regard to solubilizing insoluble proteinase inhibitor 2 in bacterial protein overexpression systems. J.Exp. Microbiol. Immunol. 6:20-25.

Woo, A. 2004. Characterizing a Lambda red recombinase induced presumptive partial deletion of *lacI* in *Escherichia coli* C29 that affects regulation of β-galactosidase production. J. Exp. Microbiol. Immunol. 6: 1-8.

Wong, J., N. Cai, C. Tanaka, W. Vensel, W. Hurkman, and B. Buchanan. 2000. Thioredoxin reduction alters the solubility of proteins of wheat starchy endosperm: an early event in cereal germination. Plant and Cell Physiol. 45: 407-15.

Wong, S-H. 2005. Cloning of flavin reductase into pET32a(+) expression vector lacking the thioredoxin A tag to study solubility of EDTA monooxygenase A in overexpression systems. J. Exp. Microbiol. Immunol. 8: 59-66.

Category 9 projects are concerned with the characterization of a population of *Esherichia coli* isolated from lake water to determine the probable fecal source of these bacteria. *Esherichia coli* is widely used as an indicator of fecal contamination. However, in order to remedy the contamination it would be useful to understand whether the contamination arose from septic fields, dog waste or other natural sources such as birds. Some researchers have attempted to distinguish these sources by using molecular biology to distinguish the *Escherichia coli* subtypes that reside in different types of hosts. The intent of this type of study would be to apply molecular biology tools to determine the probable source of the Escherichia coli in an existing collection and assess the reliability of the method used to distinguish the strains of Esherichia coli.

Some references relevant to this project include:

Dombek, P., L. Johnson, S. Zimmerley and M. Sadowsky. 2000. Use of repetitive DNA sequences and the PCR to differentiate Escherichia coli isolates from human and animal sources. Appl. Environ. Microbiol. 66: 2572-2577.

Girao,D., V. Girao, K. Irino, and T. Gomes. 2006. Classifying Escherichia coli. Emerg. Infect. Dis. 12: 1297-1298.

Hamilton, M., T. Yan and M. Sadowsky. 2006. Development of goose- and duck-specific DNA markers to determine sources of Escherichia coli in waterways." Appl. Environ. Microbiol. 72: 4012-4019.

Lee, A. and E. Wong. 2009. Optimization and the robustness of BOX A1R PCR for DNA fingerprinting using Trout Lake E. coli isolates. J. Exp. Microbiol. Immunol. 13: 104 - 113.

Lee, C. 2010. Genotyping Escherichia coli Isolates from Duck, Goose, and Gull Fecal Samples with Phylogenetic Markers using Multiplex Polymerase Chain Reaction for Application in Microbial Source Tracking. . J. Exp. Microbiol. Immunol. 15: 130 – 135.

Mehta, S. 2010. Testing the efficacy of PCR for DNA fingerprinting avian isolates of E. coli from Trout Lake using the rpoS Gene. J. Exp. Microbiol. Immunol. 14: 48-50.

Zhu, J. 2010. Comparison of four template preparation methods and optimization of BOX A1R PCR for DNA fingerprinting of Escherichia coli isolates. J. Exp. Microbiol. Immunol. 14: 48-50.

Category 10 projects are concerned with the identification of filamentous organisms in the foam in wastewater bioreactors. Some reactor configurations cause extensive foam development. This foam can be an asset because it concentrates the reactor solids. It can also be a problem because the foam limits nutrition and aeration by separating the organisms from the media. Since different operating conditions give rise to different populations of filamentous organisms it is useful to identify the organisms in order to have insight into the cause and control of the foam development. Historically most of the identification was done microscopically but this type of identification id difficult to quantitate and consistently assess. More recently several molecular probes have been developed to identify foam associated filaments. The types of projects would involve testing the reliability of the probes and the relationship of the organisms to the reactor conditions.

Some references relevant to this project include:

Eikelboom, D., 2000. Process Control of Activated Sludge Plants by Microscopic Investigation. IWA Publishing.

Jenkins, D., M. Richard, and G. Daigger. 2004. Manual on the Causes and Control of Activated Sludge Bulking, Foaming, and Other Solids Separation Problems. IWA Publishing.

Seviour, R., and P. Nielsen. 2010. Microbial ecology of Activated Sludge. IWA Publishing.

Category 11 projects are concerned with nitrifiers. The lithotrophic nitrifiers are difficult to isolate. Most nitrifiers have never been grown in pure culture. Many have slow growth rates and undefined growth requirements. The standard MPN method for quantifying them is to inoculate diluted samples into nitrifying medium then incubate the tubes. By recording the proportion of non-nitrifying tubes the Poisson equation can be used to predict the average number of nitrifiers that were probably present in the original dilution. The method does not distinguish between species. It takes about four to six weeks and requires a minimum of fifteen culture tubes for each tested dilution of each sample. In recent years, researchers have applied molecular methods such as DDGE, RNA or DNA hybridization with nitrifier specific probes, as well as PCR enrichment of genes associated with nitrifiers to allow cloning, probing or direct sequence analysis. In some studies the activity in nitrifying bioreactors is not consistently correlated to the extent of binding by probes directed towards the 16sRNA of known nitrifying bacteria. For example, during some tests the presence of *Nitrobacter* and *Nitrospira* can be barely detected by the Nb1000 probe and the Ntspa 685 probe respectively even though the reactor is forming large amounts of nitrate from ammonia and nitrite. Similarly the level of ammonium converted to nitrite can remain high even when the apparent population of

organisms responding to the Nso 190 probe (that is supposed to detect all characterized ammonia-oxidizers in the β-subdivision of the proteobacteria) is decreased by 50%. The discrepancy might arise if the probes are incorrectly matched with the nitrifying organisms present in the reactor or the organisms contain multiple gene copies that could be amplified if they grew at faster growth rates. When the ribosomal genes from the reactors were cloned and probed, only one of the five clones that reacted with the probe corresponded to a known Nitrosomas sequence.

The reactors that showed the initial discrepancies have been dismantled. Other nitrifying reactors are available that are rich in nitritifier populations (convert ammonium to nitrite) and nitratifier populations (convert nitrite to nitrate). A large scale MPN growth assay has been done on one of these reactors. Some of the MPN positive tubes have been diluted and maintained to form additional cultures. We have a pure culture of Nitrosomas. A variety of different projects could be considered. For example, What is the relationship between the MPN assay and the results of the probe assays? Does an MPN assay enrich for a diversity of nitrifiers? Are different nitrifiers enriched at different times during an MPN assay? Do nitrifying bacteria have multiple rRNA genes that are differentially enriched by different growth conditions? Are different nitrifiers enriched at different times during the assay? What is the impact of specific probe mismatches on the strength and fidelity of the binding by probes? What is the detection limits for the nonradioactive probe system? There are references for a number of primers for different groups of nitrifying organisms (i.e. ammonia or nitrite oxidizers).

Some references relevant to this project include:

Burrell., P., C. Phalen and T. Hovanec. 2001. Identification of bacteria responsible for ammonia oxidation in freshwater aquaria, Appl. Environ. Microbiol. 67: 5791-5800.

Finlay, J. 2003. Complete Detection of the β-subclass of the Ammonia-Oxidizing Proteobacteria in a Sequence Batch Reactor Requires a Multi-Probe Approach", J. Exp. Microbiol. Immunol. 4: 1-6.

Gieske, A., U. Purkhold, M. Wagner, R. Amann and A. Scramm. 2001. Community structure and activity dynamics of nitrifying bacteria in a phosphate-removing biofilm", Appl. Environ. Microbiol. 67: 1351-1362.

Hiorns, W., R. Hastings, I. Head, A. McCarthy, J. Saunders, R. Pickup and G. Hall, 1995. Amplification of the 16S ribosomal RNA genes of autotrophic ammonia-oxidizing bacteria demonstrates the ubiquity of nitrospiras in the environment. Microbiology 141: 2793-2800.

Ng, C. 2004. An evaluation of the relationship between the Most Probable Number (MPN) assay and 16S rRNA hybridization technique in characterizing and quantifying Nitrosomonas species in sludge wastewater. J. Exp. Microbiol. Immunol. 6: 52-58.

Purkhold, U., A. Pommereng-Roser, S. Juretschko, M. Schmid, H.-P. Koops and M. Wagner. 2000. Phylogeny of all recognized species of ammonia oxidizers based on comparative 16S rRNA and amoA sequence analysis: implications for molecular diversity surveys. Appl. Environ. Microbiol. 66: 5368-5382.

Schmid,M., U. Twachtmann, M. Klein, M. Strous, S. Juretschko, M. Jetten, J. Metzger, K.-H. Schleifer and M. Wagner. 2000. Molecular evidence for genus level diversity of bacteria capable of catalyzing anaerobic ammonium oxidation. System.Appl.Microbiol.23: 93-106.

Seviour, R., and P. Nielsen. 2010. Microbial ecology of Activated Sludge. IWA Publishing.

Ward, B., D. Arp, and M. Klotz. 2011. Nitrification. ASM Press.

Ward, W., and G. O'Mullan. 2002. Worldwide distribution of *Nitrosococcus oceani*, a marine ammonia-oxidizing γ-proteobacterium, detected by PCR and sequencing of 16S RNA and *amo*A genes. Appl. Environ. Microbiol. 68: 4153-4157.

Yu, R. 2004. An evaluation of the relationship between the most probable number (MPN) assay and the 16S rRNA hybridization technique in characterizing and quantifying *Nitrobacter* and *Nitrospira* species in wastewater. J. Exp. Microbiol. Immunol. 6: 59-66.

Appendix IX - MICB 430 Seminar Course

The MICB 430 seminar course handouts that I have prepared include detailed descriptions of the expectations of the presentation and suggestions on how to effectively present material. I have included a copy of the course outline and an evaluation form that I designed to give convenient feedback to the students after each seminar that they present.

Course Outline for MICB 430

The goal of the course is to develop your ability to read, critically analyze, present, explain and discuss contemporary research papers from a range of microbiological and immunological publications. Each term includes three distinct segments. During each segment, pairs of students are expected to read one published research article and work together to explain that paper to the rest of the class and the faculty facilitator. That seminar must present the work and explain the global context of the work.

The facilitator will be responsible for either assigning a specific paper for each pair of students or assigning a general subject area or journal that each pair of students can use to select a recent paper to present to the rest of the class. The facilitator is also responsible for evaluating the strengths and weaknesses of each presentation, but students are encouraged to provide constructive feedback to their peers and learn by analyzing the presentation styles of other students. The faculty facilitators are switched every four weeks to expose you to a broad range of subject areas.

1. Teaching schedule for the Winter term MICB 430A

	Facilitator	**General Area of Interest**	**Dates**
Segment 1	Marc Horwitz	**virology, innate immunity**	**Sept 13 - to – Oct 4.**
Segment 2	Jim Kronstad	**mycology, fungal pathogenesis**	**Oct 4 - to – Nov 1.**
Segment 3	Wilf Jefferies	**immunology, cell biology**	**Nov 1 - to – Nov 29.**

2. The class is scheduled for **WOOD B76** from 2:00 to 5:30 on Tuesday for the Fall term

3. The class will normally be about three hours long each week. This time allows each scheduled pair of students to have 35 minutes to present their paper and put the paper into a global context plus another 15 - to - 20 minutes to discuss the paper with the audience and answer audience questions.

4. After segment #1 each pair will present and explain two papers in each segment but everyone must still attend each class and participate in the discussions following presentations by other students. Part of the mark depends on participation in discussions of the papers presented by other students.

5. The presentation of the paper should address:

    a. The question(s) addressed by the paper and the reason(s) the question(s) were important.

    b. The approach the authors used to answer the question(s).

    c. The essential results and conclusions from the results.

6. The commentary on the global context of the paper should assess the scientific significance of the paper for that area of science. It should consider :

    a. Whether the work was novel compared to other work in that area of science.

    b. Whether there were significant flaws or weaknesses in the design of the experiment or the interpretation of the results.

c. Whether the conclusions were justified by the results.

d. Whether there were other experiments that should have been done to strengthen the conclusion(s).

e. Whether new work has been published that either extends or contradicts the conclusions.

7. Each pair of students will be expected to work together to understand the experiments in the paper, research the background and think about the significance of the paper. Sometimes the boundary between the details that should be considered in the presentation and details that should be considered in the commentary on the global context is fuzzy. If that problem arises you will need to consider how to divide up the presented comments to allow a logical development of the talk but still avoid significant repetition of unnecessary detail between the parts.

8. For each seminar you should consider and apply the specific ideas in the following guideline for presenting seminars and the orientation seminar in September.

9. The grade will consider the quality of the presentation of the paper, the quality of the presentation of the global context and a demonstrated participation in most of the discussions. The expected split is 40% for the presentation of the paper, 35% for putting the presentation into a global context and 25% for participation in the discussions. Participation for each class will be assessed on a scale of 0-to-10 by judging the quality and number of the questions asked during the discussions following each presentation.

MICB 430 Presentation Assessment Student name:_____
Paper _____ Partner name: _____
Date:_____

Needs improvement(1)_____Average(2)_____Well done(4)
Posits/understands experimental question
Comments:

Needs improvement(1)_____Average(2)_____Well done(4)
Explains/understands background and assays (to the extent necessary)
Comments:

Needs improvement(1)_____Average(2)_____Well done(4)
Explains/understands/presents results and expected outcomes
Comments:

Needs improvement(1)_____Average(2)_____Well done(4)
Understands and presents the critical and relevant parts of the paper
Comments:

Needs improvement(1)_____Average(2)_____Well done(4)
Summarizes the key reults/observations and makes an appropriate conclusion.
Comments:

Needs improvement(1)_____Average(2)_____Well done(4)
Overall presentation style and time were suitable
Comments:

Total: /24

Appendix X - MICB 449 Thesis Course

The MICB 449 course handouts that I have prepared include detailed descriptions of the expectations of the processes in the course. I have included a copy of the course outline and a copy of a real evaluation that I received and decided to make available to faculty members that want more guidance for assessing grades in the course.

MICB 449 – Research Thesis

The MICB 449 is the graduating research thesis that is required by all the MBIM honours programs. The six – credit MICB 448 is the same course but it is an elective of the MBIM majors program. In either course the students make arrangements to work in a research lab headed by a Microbiology and Immunology research faculty member. The intent of the courses is to provide formal research experience in a research environment and develop skills for doing scientific research in that field. To develop these skills the student should have regular meetings with the faulty supervisor and/or the project supervisor.

The major learning outcomes of the course are:

- Student researchers should be able to apply critical thinking skills to a research problem by:
    - Formulating research questions as the project proceeded.
    - Understanding the design of experiments to answer research questions.
    - Integrating observations and explanations to understand the results and relate the results to each research question.
    - Link experimental results to experimental questions to draw accurate conclusions, recognize the limitations of the results and recognize future significant directions of the research.
- Student researchers should be able to effectively communicate their research in oral and written form.

To complete the course the students must:

- Contact eligible faculty members in the Department of Microbiology and Immunology to discuss the possibilities of working in the lab of that faculty member. When there is a mutual agreement between the faculty member and the student then the student reports that agreement to the program coordinator and registers for the course.
- Submit a written outline of the proposed research project to the supervisor and the course coordinator.
- Submit a written progress report to the supervisor and the course coordinator.
- Finish lab work and submit a research article that analyses the project and the results to the supervisor and the course coordinator.
- Defend the project and the report in a formal oral exam attended by the faculty supervisor and another faculty member.

Successful completion of the course will typically require 15 hours of project work each week for six months or 20 hours per week for sixteen months. The grade will consider:

- The demonstrated critical understanding of the project and the results.
- The effort to get results.
- The intellectual contribution of the student toward the development of the project.
- The quality of the written report and analysis.

A first class mark (>80%) should represent a first class achievement in each of the four preceding categories. A more detailed grading rubric is at the end of this outline.

Eligible faculty supervisors include:

Faculty member	Summarized research interests of the Faculty member: (see the research folders of the departmental website at www.microbiology.ubc.ca for more details)
N. Abraham	Lymphocytes, cytokines, molecular biology, proteomics, interleukin
T. Beatty	Molecular biology, photosynthetic bacteria,genetic regulation, site directed mutagenesis
W. Bingle	Molecular biology, biotechnology
J. Davies	Antibiotics, secondary metabolites
L. Eltis	Bacterial physiology, enzymes, organohalide degradation, *Mycobacterium* drug targets, *Nocardia* genomics
R. Fernandez	Molecular pathogenesis, molecular biology, bacterial disease
B. Finlay	Microbial pathogenesis, molecular biology, cell biology
E. Gaynor	Bacterial molecular pathogenesis, gene expression, gene array
M. Gold	Molecular immunology, signal transduction
R. Hancock	Antibiotic resistance, transport, molecular biology
K. Harder	Innate immunity, tumour immunology, dendritic cell development
M. Horwitz	Innate immunity, virology, immunology
F. Jean	Virology, antiviral antibiotics, viral proteases
W. Jefferies	Molecular immunology, MHC antigen properties
P. Johnson	Molecular immunology, signal transduction
J. Kronstad	Mycology, genetics, pathogenicity, plant-microbe interactions, fungal molecular genetics
W. Mohn	Bacterial physiology, microbial diversity, drug targets
M. Murphy	Protein engineering, denitrification, iron transport, crystallography
W. Ramey	Microbial physiology, applied microbiology
J. Smit	Surface gene expression, biotechnology, molecular biology
C. Suttle	Marine viruses, marine ecology
G. Weeks	Ras, *Dictyostelium discoideum* differentiation,cell cycle

Winter Session Schedule for MICB 449

1. The course involves lab work, a written project proposal, a progress report, a written report, an oral presentation of the work and an oral exam. You will be expected to spend a minimum of 15 hours per week on the project lab work during September, October, November, January and February and should arrange your schedules to carry out at least that much work.

2. By the second Friday in September you should arrange to work in a lab supervised by a member of the Faculty of Microbiology and leave a message for the Undergraduate Program Advisor which names the supervisor that you will work under.

3. Before the first Friday in October submit copies of your project proposal to your project supervisor and the Undergraduate Program Advisor. This brief (one or two pages!) project proposal should state or explain your understanding of:

   i) The aim of your project (the idea that you are testing).
   ii) The significance of your project (why is it interesting or important).
   iii) The approach you will use to test the project (the general procedure).

iv) The time frame for the work (the steps or progress you expect to complete each month).
v) The potential problems or difficulties you might encounter in the project.

4. On the second Friday in January submit a brief (one or two pages!) progress report to the project supervisor and the Undergraduate Program Advisor. This report should state:

   i) Major accomplishments in the work to that time.
   ii) Major problems in the project.
   iii) Significant changes in the aim or approach for the project.
   iv) Remaining experiments that you expect to complete before writing up the final project report.

5. Complete the lab work for the project by the third week of March. By the second Friday in April, before the start of the formal examination schedule, submit the written report of your work to your project supervisor, the Undergraduate Advisor and the member of the Faculty of Microbiology chosen to examine your work. This written report should be in the style of the Journal of Bacteriology or Journal of Immunology or the Journal of Virology. It is normally fifteen to twenty printed pages including tables and figures.

6. Your supervisor will schedule your oral exam and submit your mark to the Undergraduate Program Advisor by the end of April. The exam will be scheduled sometime after the second Friday in April to allow your examiner adequate time to read your report.

7. Once you know the date and time for your exam you should book a departmental seminar room for the two hours needed to present the results.

8. The oral exam will require you to formally explain your project and results to the supervisor and the chosen examiner for 10 to 20 minutes. This presentation will be followed by 20 to 30 minutes questioning by your supervisor and your examiner to assess your understanding of the intent of the work, the presented results, the relationship of your work to other work in that field, and your understanding of the techniques involved in your work.

9. The formal presentation at the beginning of your exam should consist of an organized oral seminar presentation covering the salient ideas, experiments, results and conclusions of your thesis work. It does not need to include all your work and should present the major points of the work rather than simply giving a chronological description of the results of each experiment. It usually includes 8 to 12 slides of the major graphs, tables or design features that you have presented in the written report and will talk about in the seminar.

10. The mark submitted to the Undergraduate Program Advisor by the supervisor will be a cumulative grade determined by your effort in the lab, your understanding of the work and procedures, the quality of each draft of the written report, and your performance in the oral exam. The grading rubric that should be applied is at the end of this outline.

11. The final mark will usually be the mark submitted by the supervisor but up to 20 percent of the mark will be penalized unless there are punctual submissions of an adequate project proposal, an adequate progress report and a suitable final report. Each mark, proposal or report submitted late will be penalized unless a prior exemption has been requested to delay the report or extend the project.

12. If you are having difficulties with your project that are hard to describe in writing please discuss the problem with the supervisor or the Undergraduate Program Advisor.

Grading Rubric for MICB 449

The **A+ grade between 95 - to - 100%** represents outstanding work. To fall in this range the student and the work must demonstrate all of the following features. The student did not need to complete the entire original proposal but should have made some progress.

- The **student could work relatively independently**. The student demonstrated that they knew the limitations of the study, the place that the work fits in the field, the significance of the project and the next steps in the project.
- The student consistently participated in the development of the project by researching background outside the original references provided by you. Throughout the project the student contributed significant insight into the results and technical problems rather than passively expecting you or their immediate lab supervisor to interpret their results, provide explanations and solve their problems. If there was no dialogue concerning the meaning of the results during the meetings of the supervisor and the student then the student was probably not an active participant in the ongoing development of the project.
- The student put in at least 15 hours of active work per week on the project in an attempt to get results and complete the proposal. The student was technically competent. The student kept adequate records and did not need to keep returning to get instructions repeated. The work areas were organized and safe.
- The first copy of the final report was organized so that it had a professional appearance and excellent flow. There were no significant spelling or grammatical errors, all the important observations and controls were included and the irrelevant observations were omitted. Critical thought and accurate consistent analysis was evident. The discussion clearly referred to the observations and clearly related the observations to the field of study by citing relevant references. The conclusion was an accurate statement that was based on the observed experimental results. The conclusion addressed the experimental purpose.
- The style was appropriate for an ASM journal submission and the content placed in the title, abstract, methods, results, discussion and reference sections was appropriate.

The **A / A+ grade between 85 - to - 94%** represents very good work. To fall in this range the student and the work has the following features. The student did not need to complete the entire original proposal but should have made some progress.

- The student demonstrated that they knew the limitations of the study, the place that the work fits in the field, the significance of the project and the next steps in the project.
- The student consistently participated in the development of the project by researching background outside the original references provided by you. Throughout the project the student has been contributing significant insight into the results and technical problems rather than passively expecting you or their immediate lab supervisor to interpret their results, provide explanations and solve their problems. During meetings between the student and the supervisor there was significant dialogue concerning the results.
- The student put in at least 15 hours of active work per week on the project in an attempt to get results and complete the proposal. The student was technically competent. The student kept adequate records and did not need to keep returning to get instructions repeated. The work areas were organized and safe.
- The first copy of the final report was organized so that it had reasonable flow. There might have been **a few significant spelling or grammatical errors, but the important observations and controls were included** and the irrelevant observations were omitted. **Some critical thought and analysis is evident and there were adequate references to relate the observations and conclusions to the field**. **The conclusion was an accurate statement that was based on the observed experimental results.** The conclusion addressed the experimental purpose.
- The style was appropriate for an ASM journal submission and the content placed in the title, abstract, methods, results, discussion and reference sections was appropriate.

The **A⁻ grade between 80 - to - 84%** represents good work. To fall in this range the student and the work has the following features. The student did not need to complete the entire original proposal but should have made some progress.

- The student demonstrated that they knew the limitations of the study, the place that the work fits in the field, the significance of the project and the next steps in the project.
- The student interpreted the observations and contributed some insight into the results and technical problems **but tended to rely on you or their immediate lab supervisor to provide explanations and solve their problems. There was some dialogue but the dialogue was limited.**

- The student put in at least 15 hours of active work per week on the project in an attempt to get results and complete the proposal. The student was technically competent. The student kept adequate records and did not need to keep returning to get instructions repeated. The work areas were organized and safe.
- The first copy of the final report was organized so that it had reasonable flow. **There might have been be a few significant spelling or grammatical errors**. **Most** of the important observations and controls were included but **the coverage was uneven so that one or two important observations might have been deemphasized or some irrelevant observations might have been included**. **Some critical thought and analysis was present and there were adequate references to relate the observations and conclusions to the field**.
- The style was appropriate for an ASM journal submission and the content placed in the title, abstract, methods, results, discussion and reference sections was appropriate.

The **B+ grade between 76 - to - 79%** represents reasonable work. To fall in this range the student and the work has the following features. The student did not need to complete the entire original proposal but should have made some progress.

- The student demonstrated that they knew the limitations of the study, the place that the work fits in the field, the significance of the project and the next steps in the project.
- The student interpreted the observations and contributed some insight into the results and technical problems **but tended to rely on you or their immediate lab supervisor to provide explanations and solve their problems. There might have some dialogue but it was limited.**
- The student put in at least 15 hours of active work per week on the project in an attempt to get results and complete the proposal. The student was technically competent. The student kept adequate records and did not need to keep returning to get instructions repeated. The work areas were organized and safe.
- The first copy of the final report **was a bit difficult to follow because the presentation did not flow logically or some key points were not very clear**. **There might have been a few significant spelling or grammatical errors**. Most of the important observations and controls were included but **the coverage was uneven so that one or two important observations were missing or several irrelevant observations were included**. **The critical thought and analysis was limited but there was some integration of the observations and adequate referencing was used in an attempt to relate the observations to the field of research**.
- The style was **mostly** appropriate for an ASM journal submission but the content placed in the title, abstract, methods, results, discussion and reference sections **was not consistently appropriate**.

The **B grade between 72 - to - 75%** represents adequate work. To fall in this range the student has done the work but had two or more of the following limitations. The student did not need to complete the entire original proposal but should have made some progress.

- The student interpreted the observations and contributed some insight into the results and technical problems but **tended to rely on you or their immediate lab supervisor or other students to provide explanations and solve their problems.**
- The student put in at least 15 hours of active work per week on the project in an attempt to get results and complete the proposal. The work was technically competent and the student kept records and did not need to keep returning to get instructions repeated. The work area was organized and safe.
- The first copy of the final report **was sloppy and poorly organized so it did not flow. Some key observations were missed**.
- **Critical thought and analysis was present but was very limited so the work tended to be descriptive rather than analytical. Documented relationships between the field and the research were limited to one or two novel references. The analysis was difficult to follow because the arguments were not consistently related to the observations or contradictory observations were not recognized or the conclusion was inappropriate for the evidence**.
- The style was generally appropriate for an ASM journal submission but the content placed in the title, abstract, methods, results, discussion and reference sections was not consistently appropriate.

Grades below 72% represent poor work or effort. They are appropriate if

- The student did not understand the significance of the project in relation to the field.
- **The student put in less than 15 hours per week and did not get results.**
- **The report is difficult to read because it was not focused on the research question or it had numerous grammatical problems or it missed many key observations or it was mostly just descriptions with no significant critical thought and analysis.**

Grades of 50- 55% represent marginal work or understanding.

- The student did adequate technical work, completed the report and the exam but did not understand the project or the meaning of the results.

Grades below 33% indicate that the student might have done good technical work but did not complete the report or the oral exam.

SAMPLE
of a useful MICB 449 Evaluation

Student:
Supervisor:
Title of project:

Overall grade: /100

Student evaluation *(40% of final grade)*

Work and effort: *43 /50*
Initiative, Problem solving, understanding: *39 /50*

Comments (Provided as example): The student was hard-working and motivated. The student began working on the project in September, and continued to work regularly throughout the year: the student worked diligently and put in additional hours whenever the student reasonably could (i.e., during holiday breaks and when not busy with other courses). The work at the bench was careful and precise. However, the student did not always display the best comprehension of the project and the techniques involved. To be fair, I think that the student is capable of better. I believe that during this project, the student was often overworked and frazzled with other unrelated jobs and volunteer responsibilities.

Thesis evaluation *(30% of final grade)*

Thesis Mark: *78 /100*

The thesis was carefully prepared and is properly formatted. Each section had the appropriate content yet was fairly concise.

The overall quality of the writing is high and the overall flow of the ideas is good. The thesis contains a remarkably low number of grammatical, typographical and stylistic errors. Perhaps the most notable exception was the use of protein names to identify DNA fragments in the agarose gels (Figs. 3 and 4). Also, it was unclear what is meant by "Peptides were sequenced against the MASCOT DB".

The Abstract and Introduction were very clear, quite comprehensive and concise.

The Materials and Methods section contained all of the relevant information. Relevant experimental techniques were clearly described with the exception of the description of the purification of cell extracts over affinity resins: exactly how were the extracts handled?

The Results and Discussion sections were logically organized. The cloning results were well documented and described, although it was not necessary to describe unsuccessful cloning experiments (Fig. 5). The main weaknesses are the lack of some controls and the lack of some data. Among the controls, it would be good to know whether the unidentified affinity-purified bands were detected in cells transformed with empty vector. With respect to the data, the changes in the in vitro cleavage assay should have been stated with reference to the data (Fig. 10) instead of simply stating that no cleavage was observed. Similarly, the gel bands should have been identified, even if they were not viral proteins.

Conclusions were reasonable, and the future directions were good.

The references were appropriate and correctly formatted but some were incorrectly cited in the text.

***Oral presentation** (30% of final grade)*

Presentation:	*86 /100*
Questions:	*74 /100*

The student provided a 30 minute oral presentation of the work. This was clear, logical and of better overall quality than the thesis. In the presentation, the student demonstrated a clear understanding of the project.

In the subsequent oral examination, the student fielded questions from the examiner for 20 minutes, followed by a further 15 minutes of questions from myself. Together, the questions covered most aspects of the student's project. Overall, the student's handling of the questions was deemed to be adequate: while the student handled some questions correctly, the student seemed to be lacking some important knowledge and could have shown a better ability make a quick decision and give an answer quickly. For example, the student did not know the rationale for using certain strains. Similarly the student did not deduce the inherent advantage of using insect cells to express the viral replicase.

Appendix XI – Teaching and Learning Conferences

The First Annual UBC Learning Conference, May, 2001, Vancouver had a conference theme of *inquiry-based learning*. It was hosted by the Centre for Teaching and Academic Growth (TAG). I have included the outline for my presentation at that conference as an indication of the starting point for the design that led to the development of the MICB 421 project course.

Talk for UBC Learning Conference , May 2001

What I want to talk about is **Experimental Science in Large Advanced Laboratory Classes.**

I hope to discuss the **advantages and disadvantages of traditional laboratory courses and experimental science laboratory classes**. I also hope to get some feedback and solutions about limitations in our approach for introducing experimental science in laboratory classes.

About three years ago, the Faculty of Science and the University released reports that stated that **undergraduate students should experience research during their undergraduate careers.** This view has recently been re-enforced by comments in the **draft version** of the **Academic Unit Plan** for the Faculty of Science.

Experimental Science should seem to be the natural consequence of laboratory courses in science. However, there are **important differences between traditional laboratory exercises and experimental laboratory exercises**. Each form teaches aspects of hands-on-laboratory-science, but the **emphasis of each form is different.**

To appreciate the difference, it is important to clearly define the process of the **Scientific Method** that is the paradigm of modern science. Everyone has heard the term, everyone uses the term, but several months ago when I was interviewing undergraduate science students I asked each of them to explain what the words Scientific Method meant to them and only half of them could put the concept into words.

Since you might have a better definition than me, I would like each of you to take a minute to write down **your definition description of the Scientific Method**, then show the description to one or two of your neighbours and compare statements.

WAIT "MINUTE" for responses

ASK for DEFINITIONS

EXPECT

- Observation Testable Explanation Test Data Analysis Conclusion

Within this description
Traditional Laboratories focus on

- **Test Data Analysis Conclusion**
- **EXAMPLE**
- Usually include a **description of the objectives**

- Usually have a **recipe leading the student through the experiment** so students can complete the work without understanding either the purpose or the procedure until after the work is completed

- Sometimes ask students to **use the results to find answers**

- Sometimes ask students for a **follow-up**

- Are usually **limited to the experimental test provided** by the instructors because the process is constrained to fit limited times and spaces.

Some Laboratory Courses such as **directed studies courses** and **thesis** courses allow students to work on **actual research projects** in research laboratories. These courses are great vehicles for exposing students to a more complete process of experimental science.

However, this style of research course has several constraints that make them difficult to widely apply.

- They typically take **3 to 6 months of labour at 15 - 20 hours per week** if the student is working on a real research problem

- They are usually done by placing students in research laboratories and most researchers can only **fit one or two students at a time** into their laboratories

- Some **students are not suited to the work** and disrupt the routines of the laboratory

- Sometimes there are exceptions, but the teaching tends to be **highly focused, individualized and intuitive** so there is **less chance of developing general background theory of the methods** or learning from the problems encountered and solved by other students in the class

These problems mean that even though research courses are good exposure for teaching students about the process of science, we cannot use them to expose all the students in our program to experimental science. Therefore, we are currently redeveloping our fourth year lab course in order to provide a more balanced and complete research experience as well as increase student involvement and interest in the labs. This course is a requirement for all students in our program. It usually has 65 to 70 enrolled students.

We hope to initiate the goals of the new course by providing small groups of four or five students in the class with three or four different sets of experimental recipes and the experimental observations based on those experiments.

EXAMPLE
T4 Virus Life Cycle

Infect live cells, see a large increase in viral numbers
Infect heat killed cells, see a large decrease in viral numbers
Infect heat killed cells then add live cells, see a decrease in viral numbers
Infect chloroform killed cells, see no change in viral numbers
Infect chloroform killed cells then live cells, see a large increase in viral numbers

One observation from these results is that the nature of killing cells affects their ability to interact with viruses and form progeny. There could be several explanations of this observation.

We will then expect students to design new experiments and protocols to test their explanations of the supplied observations rather than simply following the supplied recipe.

In some cases their explanations might only require a modification of the supplied recipes, in other cases the students might need to invent an entirely new experimental protocol.

In either case, once their experiment has been acceptably designed, the students will be expected to prepare the supplies, set up equipment, and carry out the experiment.

They will then analyze the results and prepare a formal journal style report that describes their experimental purpose, the methods, the results and the conclusions. The course instructors will review this report. It will then be returned to the students to correct any significant problems in style, logic or fact before it is "published" to a web file where all the rest of the students in the class can access the report.

In subsequent years the new students in the class will be able to design their own experiments by using the original experiments and observations or the experiments and observations made by the successive classes. They will be allowed to repeat a previous experiment to ensure that the results were correct but will still need to produce and test their own experiment based on the resulting observations and explanations.

We intend to allow the students to apply their pooled knowledge and experience in a Scientific Process. We will have some constraints imposed by time, equipment and costs. However, we hope that the supplied experiments will focus the thinking sufficiently that the ideas will remain within the realm of the available equipment and supplies.

We will provide some assistance in the design by reviewing proposals to ensure that they are practical and safe. We will also provide a resource manual that will provide instructions for available equipment, recipes and sources for common protocols. We will also make suggestions if the students have a great idea but are having difficulty designing the experiment. However, the students will do the actual design and development.

We expect all the students in the groups to participate but the work can be split up such that different students will participate in different parts of the experiment so the total workload is still reasonable. We will also have the course available on WebCT such that students will be able to communicate outside the classroom.

OVERHEAD of **WebCT**

Questions?

If the revised hypothesis-based approach works, we believe that it will provide a more complete and realistic research experience. We also believe that it will be more interesting for the students because each of the student groups will use their skills to solve real scientific questions instead of questions arbitrarily chosen by the instructor. We also believe that it will be more exciting for the TAs because they will be expected to work as mentors and assistants in the scientific process.

LIST ADVANTAGES AND DISADVANTAGES OF THE TRADITIONAL AND EXPERIMENTAL LABORATORY SCIENCE APPROACHES

TRADITIONAL laboratory Courses

- Constrained
- Easy to cover important details in class
- Common exposure to information
- Lacks scientific development
- Difficult for students to apply to the real world

EXPERIMENTAL Laboratory Courses

- Easier to apply to the real world
- More interesting for all participants.
- Increases the potential for self-actualized development
- Less focused so gaps emerge in the training
- Potentially more time consuming

Questions for the audience

1. Within the term, we will expect students to develop detailed understanding of specific areas of microbial growth, physiology and molecular biology in order to design experiments and analyze the results. Will the pooled expertise of four or five students be sufficient to achieve these goals? Should the reports include recommended follow-up ideas to help direct later students to new experiments?

    a. Would this type of assistance decrease creativity?
    b. Would it be more interesting because it allows faster insight into the problems or would it be less interesting because it directs students (if they choose to use the suggestions)?

2. How do we ensure that all students participate in all the different aspects of the science over the term?

3. We are currently thinking of basing 50% of the grade on the lab work, including reports, planning and effort then base the remaining 50% of the grade on common exam concerning the general area of theory encountered in all of the experiments. Is there a better way to assess a grade that is fair for all of the students and foster individual understanding of the background for the experimental methods?

Appendix XII - Scholarship of Teaching and Learning

The following notices are examples of the seminars and forums that I attend at UBC to remain aware of modern knowledge concerning teaching and education.

UBC Curriculum Renewal Forum:

Implications for Student Learning, Faculty Development and Scholarship

Wednesday, January 25th, 2012, 12-2:00 pm, Dodson Room, Room 260

Irving K. Barber Learning Centre, 1961 East Mall,

Lunch will be served

Theme: *Program-level Learning Outcomes Assessment Within and Across Disciplinary Contexts*

Forum Objectives

Participants can expect to:

- Engage with curriculum leaders from across the UBC disciplines to discuss scholarly approaches to *Program-level Learning Outcomes Assessment* in order to meet the needs and circumstances of student learning in diverse curricula contexts.
- Examine the strategic use of on-line technology to enable *Program-level Learning Outcomes Assessment* within the pedagogic design of multi-year undergraduate and graduate level programs
- Discuss scholarship and faculty support initiatives within and across the disciplines to enhance *Program-level Learning Outcomes Assessment.*

Agenda

Poster display set-up 1130am

Start 12:00 noon

- Curriculum scholarship within and across disciplines: Poster displays on *Program-level Learning Outcomes Assessment*
- Lunch

12:45 pm

- Welcome/Opening Remarks
- Introductions / Recap UBC context for curriculum renewal and *Program-level Learning Outcomes Assessment* in diverse program contexts: Key lessons learned and opportunities for collaboration.
- Forum engagement theme/questions/panel discussion (innovation, challenges, scholarship)
- Next steps: UBC curriculum renewal and support initiatives (Adjourn 2pm)

Curriculum Scholarship Facilitators:

Dr. Harry Hubball, Senior Advisor, Teaching and Learning *pro tem*; Academic Director, CTLT *pro tem*
Dr. Joanna Bates, Director, Centre for Health Education Scholarship, Faculty of Medicine
Dr. Anthony Clarke, Director, CTSE, Faculty of Education
Dr. Sarah Gilbert, Acting Director, The Carl Wieman Science Education Initiative (CWSEI)

INSTITUTE FOR THE SCHOLARSHIP OF TEACHING AND LEARNING
CENTRE FOR TEACHING, LEARNING AND TECHNOLOGY
THE UNIVERSITY OF BRITISH COLUMBIA

October 18, 2011

To: Associate Deans

cc: Deans, Principals, College of Health Disciplines; College of Interdisciplinary Studies
Dr. David Farrar, Provost and VP Academic

From: Dr. Anna Kindler, Vice Provost and Associate Vice President
Academic Affairs and Resources
Dr. Harry Hubball, Senior Advisor, Teaching and Learning *pro tem*;
Academic Director, CTLT *pro tem*,

Re: Curriculum Renewal and Student Learning at UBC, January 25th, 2012 Forum.

Building on the successful UBC curriculum forum and retreat throughout 2011, we write to invite you and curriculum representatives from each Faculty/College to attend a lunchtime forum entitled **"*UBC curriculum renewal within and across the disciplines: Implications for student learning, faculty development and scholarship*" on Wednesday, January 25th from 12-2:00pm** in the Dodson Room, 260, Irving K. Barber Learning Centre, 1961 East Mall.

The central theme for this curriculum forum is ***Program-level Learning Outcomes Assessment***. At this forum, there will be a poster display of curriculum scholarship within and across the disciplines, followed by panel discussions to engage participants in broader consideration of UBC's *Place and Promise* commitment to student learning (please see the attached agenda).

The event will be hosted by the Institute for the Scholarship of Teaching and Learning (ISoTL), which is an integral, scholarship-focused part of the UBC Centre for Teaching, Learning and Technology (CTLT).

We very much appreciate your Faculty's engagement with and support for curriculum renewal at UBC. We will be grateful for you sharing this information with and encouraging your colleagues responsible for the design/oversight of undergraduate and graduate curricula within your Faculties/Colleges to attend the January 25th forum.

Appendix XIII - Career Prep Mentoring

On these pages I have included two examples of the response from the secondary students to show the value of the Career Prep Experience for their students.

KILLARNEY SECONDARY SCHOOL
6454 Killarney Street
Vancouver, B.C. V5S 2X7
Telephone: (604) 435-8121 • Fax: (604) 435-8066

August 1, 1998

Dr. Bill Ramey
Wesbrook Building # 1219
6174 University Boulevard
Vancouver, B. C.
V6T - 1Z3

Dear Dr. Ramey;

I would like to thank you for providing such an excellent work experience placement for Rita Shah this past summer.

Rita was very enthusiastic about her experience and really enjoyed the opportunity to work on such an interesting project. She said that she found the experiment fascinating and learned an incredible amount. I am very grateful that you were willing to take on another student this summer when you had no technicial help. I appreciate the fact that you had to spend even more time than usual in explaining the project and teaching the necessary techniques.

Thank you once again for providing such a stimulating and worthwhile experience. Thank you again and I hope that I can count on your co-operation in the future.

Sincerely,

Joanne Melville

Joanne Melville

SIR CHARLES TUPPER SECONDARY SCHOOL

419 East 24th Avenue, Vancouver, B.C. V5V 2A2
Telephone: (604) 874-9131 • Fax: (604) 875-6900

1993 August 17

Dr. Bill Ramey
Senior Instructor
Microbiology and Immunology Department, UBC
#300 - 6174 University Boulevard
Vancouver, B. C. V6T 1Z3

Dear Bill,

I would like to thank you for providing our student, **Cliff Saito**, with the opportunity to learn about Microbiology during his three week work experience from 1993 July 26 till August 13.

I was very impressed with the assignment that he was given and the assistance that he received. As a teacher, you always want the best learning opportunities for your students. The opportunity to learn some microbiology techniques in a university atmosphere may have a significant impact on Cliff's career objectives. He told me that he found some E. coli but he was unsure if he found salmonella. Cliff enjoyed the entire process of streaking the plates, watching the growth, and identifying the bacteria. The opportunity to try Thin-Layer Chromatography was appreciated. Man Hong and Tai provided quality, well-explained information every step of the way. Please thank them for me.

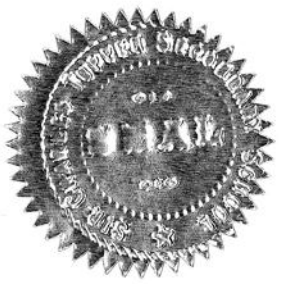
I would also like to thank you for your support while I was getting the program approved by the ministry. Thanks also for your suggestions regarding placements of my other students.

Cliff's work experience in your lab will fulfil several of the goals of our program, Career Preparation in Science/Technology. He has had the opportunity to observe and participate in scientific research as a member of your lab. This has enabled him to see how scientific work is conducted and how the academic, technical, and interpersonal skills of scientists can be important to their careers. In addition to all of this, it appears that Cliff has made some friends.

I appreciate the time and resources that you provided for Cliff's training. Once again, thank you for your assistance in providing a "hands on" experience.

Yours sincerely,

John Worobec, Science Department Head
Pager: 293-9321



Appendix XIV - Shad Valley

Shad Valley is a summer program for academically gifted students in grades 10, 11 and 12 from across Canada. I have included a document that demonstrates the strong interest in the lectures that I arranged as part of the enrichment activities for these students. The second document is a description of the two of the four lectures that attracted the students to show the nature of the interactions.

UBC Shad Valley Program
c/o Geophysics and Astronomy Department
143-2219 Main Mall, Vancouver
Canada V6T-1W2

David Vogt
Program Director

(604)-228-2802
UBC MTS: David_Vogt@UBC.MAILNET
Calgary Multics: DVogt.Shad

and Astronomy Department
sity of British Columbia
ain Mall, Vancouver, B.C.
6T-1W2, (604)-228-2267

On: August 11, 1986
Monday at 12:31:46

To: Dr. Doug Kilburn
Head, Microbiology
Wesbrook Bldg.
UBC Campus

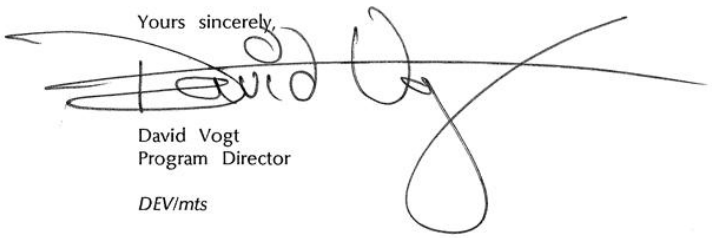
Re: **Thanks so much . . .**

This letter is to formally thank you for your participation in the 1986 UBC Shad Valley program, which was an enormous success in its first year due to good planning, great students and the very generous efforts of you and many other supporters. I'm very grateful.

I attach copies of evaluation forms completed by the students who took the Biotechnology seminar, just to show how well it was received. We could only accommodate about 1/4 of the students who wanted to take that seminar, and I was almost lynched when I couldn't offer it again! This one and the Medical Genetics seminar and the PET/NMR Imaging seminar were all among the most sought-after and successful four or five seminars in the whole program. I'm afraid I had to send some students home quite disappointed when they weren't able to take any of these, let alone all three. I understand just how much work it took to put on, but it was worth it: a real highlight for the students involved. I really want to do more of the same next year!

I think we really surprised everyone, especially the other Shad Valley campuses, with pulling off a real winner on such short notice. Thanks again for helping it happen.

Yours sincerely,



David Vogt
Program Director

DEV/mts

THE UNIVERSITY OF BRITISH COLUMBIA INTERDEPARTMENTAL MEMORANDUM

TO: Dr. David Vogt..... FROM: Dr. Bill Ramey.....
Department of Geophysics/.. Department of Microbiology.....
Astronomy..... DATE: June 12, 1987.... TEL. NO. 3300..

RE: SHAD VALLEY

I have not been able to confirm times that are suitable for all of the Department members that want to participate in the Shad Valley program but I think that we will be able to present a combined series of labs and lectures on the days of July 6, 7, 8 and 9. All of these presentations are designed to show the general nature of microbiology and the relevance of microbiology to molecular biology and biotechnology.

Details:

1) Place for lectures is room 127 of the Wesbrook building.

2) Lectures will be about 1 hour, labs will be about 2 hours.

3) Allow up to 8 participants.

4) Day 1 - July 6

-Presented by Barry McBride, Heather Merilees and Andre Wong.

-Lecture and lab will be concerned with the general nature and diversity of microorganisms. Practical work includes looking at ways that microscopic bacteria can be isolated, grown and characterized. Samples of actual bacteria will be examined with phase contrast microscopes coupled to video cameras, as well as scanning and transmission electron microscopes.

5) Day 2 - July 7

-Presented by Bill Ramey and Susan Leung

-Lecture is concerned with the features of bacteria which make them useful for doing biochemical and molecular genetics. This talk will include some aspects of the structure of genes and the ways that access to the genetic information is controlled.

-Practical work includes selectively isolating large and small DNA molecules and separating the isolated plasmids by electrophoresis.

6) Day 3 – July 8

–Presented by Bob Miller

–Entire presentation will be concerned with the nature and properties of viruses that attack bacteria.

–The lab will show how these viruses are manipulated and characterized. Some time will also be used to look at results from the Lab work on Day 1.

7) Day 4 – July 9

–Presented by Bob Hancock

–This lecture and lab is concerned with the basis for the design of new antibiotics to treat bacterial infections. It will cover the medical problems caused by antibiotic resistant bacteria, the mechanisms of antibiotic resistance, the types of approaches used to isolate new antibiotics and the basis for the greater effectiveness of these new antibiotics.

–The lab will use old and modern varieties of penicillin to demonstrate the major points of antibiotic design and the specific targeting of antibiotic action.

WR/ch/0083R

Appendix XV - Mentoring Science Fair Projects

Many schools participate in the Regional Science fair hosted by the University of British Columbia. I have assisted students to develop their projects. The assistance consists of listening to their ideas, providing advice and providing supplies. I have included a series of e-mails as an example showing part of the development for one of these projects in order to demonstrate one aspect of my involvement and the progressive maturation of the student's thoughts. This particular project concerned the effect of heating on the survival of bacteria in cooked hamburgers.

----- Original Message -----
From: William Ramey
To: Nicole
Sent: Tuesday, October 26, 2004 4:20 PM
Subject: Re: high school science project

I will get some surplus plates of media from the left over teaching supplies. There would likely be 20 to 30 plates. At this time most of the medium tends to be poured already but it might be in tubes.

At 01:05 PM 10/26/04 Tuesday, you wrote:
Hi Bill,

Naturally the hamburger meat is going to have more bacteria, that we know. And, we realize that this is due to the fact that it has more surface area as you mentioned. With all the talk of EColi and bacteria in ground meat over the last few years, we thought it might be an interesting and more simple experiment for Sandra to see just how much more bacteria ground meat has than a solid chunk. Anything you can loan us is greatly appreciated. Dilution tubes and measuring syringes/pipettes would be great. I suppose the chances of a lab happening on your end using agar prepared petri dishes in the next few days are next to nil. If this is the case, we can order them over the internet unless you know of some place here where we could get them.

Thanks again,

Nicole

----- Original Message -----
From: William Ramey
To: Nicole
Sent: Tuesday, October 26, 2004 10:59 AM
Subject: Re: high school science project

Hello Nicole

If you are working with two samples with different structure then you need to be aware that the structure affect the available surface area where growth can occur. A gram of steak is a single "solid" lump of material so it has much less surface area than a gram of hamburger that is made up of many small pieces of material. This means that an observation of a certain number of bacteria per gram is biased against the hamburger. It would reflect actual bacteria load but you should also try to estimate surface area to express the amount per square centimeter of surface. This latter comparison allows you to decide whether higher numbers in the hamburger are just because of the larger surface area. If there are more in the steak then the surface area analysis is not as important.

Once the plates are made the bacteria are on them. This means that you could count them on several days to see if the number increases. Rather than two days, I would suggest days 1,2 , 4 and 8 or days 1,2 and 7.

We can loan you dilution tubes and measuring syringes/pipettes when you get the medium and plates. How will you maintain the melted agar at 49 degree centigrade? If you do not have a means to control the temperature for the hour or so that it takes to make the plates then you can borrow a thermostated water bath for a few days. The alternative would be to get pre-poured plates and spread the 0.1 ml of sample on the surface rather using the "molten" medium.

Bill Ramey

At 10:39 PM 10/25/04 Monday, you wrote:

Hi Bill,
Glad the bleach idea will work. As the experiment would seem to require an enormous amount of dishes (10 for each meat totaling 40), we have tried to simplify. Sandra has decided to simply compare the bacteria in ground beef to that in a steak. She will prepare the samples as you suggested making the various dilutions. She will then put the prepared petri dishes in an incubator which she has made and they will incubate at 37C. She will count the bacteria each day for 2 days and record the results. So, I suppose she will need - 15 petri dishes (allowing extra for screwups), nutrient or tryptic soy liquid agar (for 15 petri dishes), tubes for measuring the dilutions (15?), sterile syringes (15?) to prepare dilutions and put samples in the petri dishes.
Please let me know if you would be able to provide these items and when I could come and pick them up. Sandra is supposed to start her experiment on November 4th (or thereabouts). You have been a tremendous help and we have learned a great deal.
Thanks so much,
Nicole

----- Original Message -----
From: William Ramey
To: Nicole
Sent: Monday, October 25, 2004 3:43 PM
Subject: Re: high school science project

Hello Nicole

The bleach would be enough to sterilize the blender (and blades and cap) without the bactericidal soap. However, it would need to be rinsed thoroughly with sterile water to eliminate the residual bleach. Residual bleach would kill bacteria in the samples. It would need to be sterilized between the processing of each sample. I have never measured this type of food sample so I do not know what to actually expect. The actual dilution would depend on the degree of contamination. In student exercises the descriptions place 10 grams of ground meat into 90 ml of sterile water (at room temperature) then blend for 1 minute. After blending the material is serially diluted through four successive tubes. Each tube uses 9 ml of sterile water and 1 ml of the preceding dilution so there are 1/10, 1/100, 1/1000 and 1/10000 dilutions. After completing five plates are prepared by placing 0.1 of the original material and 0.1 ml of the successive dilutions into separate Petri dishes. After the material is added approximately 15-to-20 ml of melted 49 or 50 degree Centigrade medium is added to the plates, mixed to fully disperse the samples throughout the medium then allowed to solidify by sitting at room temperature for 20 or 30 minutes. After the plates are solidified they need to be incubated at room temperature or in the cold. Some plates will develop a useable number of colonies, some will be too crowded to use and some will lack colonies. If the liquid medium is too hot it will kill some of the bacteria, if it is too cold it will solidify before it is poured out of the tubes. The volumes in the dilution tubes could be measured with a sterile syringe.
If you do the samples in duplicate to get one plate for each temperature you will need 10 plates for each sample plus an extra plate to ensure that the water is sterile.

Ideally, the water should be distilled or de-ionized water but the boiled water will be suitable in this case because all the samples are done with the same water.

Bill Ramey

At 12:25 PM 10/23/04 Saturday, you wrote:
Hi Bill
We were thinking of using boiled water for the diluent and keeping it in the covered pot it was boiled in and allowing it to come to room temperature. It could then be poured into a sterilized glass measuring cup to measure. The blender will be used to prepare the sample and we were thinking of sterilizing it by washing it with antibacterial soap, then rinsing it with a bleach solution to kill any remaining bacteria and finally, rinsing it with boiling water to further sterilize it and rinse out any remaining bleach which would kill the bacteria we are trying to measure. The actual dilutions would be done in the blender by putting a weighed amount of meat in the blender and the appropriate amount of sterilized water (to make the predetermined dilution concentration) and then blend them together. Do you have any suggestions for the dilution concentration - 1 gr meat/ ? ml water?
The experiment is to be conducted starting November 4 and must be finished by December 1.
I think to make things simple (remember it is a 13 year old doing this) just counting the colonies is enough. So, I guess we would need the nutrient agar (or tryptic soy, whichever you think would work best) that we would warm up to liquefy and pour into the sterilized petri dishes where the appropriate amount of diluted sample solution has been placed (do you have a suggestion of how much sample solution to put in each dish and how much agar).
Let me know if we have any holes in our procedure (I'm sure we do) and if you have any suggestions.
Thanks a billion,
Nicole

----- Original Message -----
From: William Ramey
To: Nicole
Sent: Friday, October 22, 2004 9:50 AM
Subject: Re: high school science project
Hello Nicole

What will you use for the diluent for the samples? How will the diluent be contained? How will you sterilize the homogenizer? What will you do the dilutions in? When were the tests intended to be done?
If you just want counts then the samples could be done in Petri dishes where the nutrient agar is mixed with the sample so the sample grows throughout the agar. If you want to observe sizes and "types" of colonies it is better to use prepared plates where the bacteria are spread on the surface and all growth is on the surface.

Bill Ramey

At 08:08 PM 10/21/04 Thursday, you wrote:
Hi Bill,
Thanks so much for all the info. We understand it now and you have simplified the project procedure enormously. Let me know when you might have the agar prepared petri dishes available. Would you also have one of those wire innoculation loops available for us to use as well? I think that's all we would need. If you think of anything else, let me know.
Thanks again,
Nicole

----- Original Message -----
From: William Ramey
To: Nicole
Sent: Thursday, October 21, 2004 11:58 AM
Subject: Re: high school science project
Hello Nicole

That is approximately correct but is a bit more complex. Any assay for bacteria will not measure all of the bacterial types that could be present. Some of the bacteria that grow at room temperature might grow at fridge temperatures and vice versa so summing the values would exceed the initial number. However, there should be a preference for growth at different temperatures so the ratio should be an indication of whether there are more bacteria that will induce spoilage at the respective temperatures. The absolute number at either temperature gives an idea of how many you start with but the numbers will probably not be the same.

Both the ratio and the absolute number are useful for the analysis. For example, if Sample A has a ratio of 6/1 but Sample B has a ratio of 2/1 where the ratio is mesophiles (warm temperature organisms)/psychrophiles (cold temperature organisms) then Sample B will have more of a preference for spoiling at either temperature compared to Sample A if the starting numbers of mesophilies are similar. However if there are a thousand times more organisms in sample A then it will have more psychrophiles than sample B even though the ratio is higher. It will have the potential to spoil faster than Sample B at both temperatures but will spoil faster at room temperature than in the fridge.

Bill Ramey

At 09:44 AM 10/21/04 Thursday, you wrote:
Hi Bill,
I woke up in the middle of the night thinking about your suggestion. I think I understand now how you would get the initial contamination level. Tell me if I'm right. Because different bacteria grow at different temperatures, by adding the number of bacteria that grow in the refrigerator sample to the number of bacteria that grow in the room temperature sample you will have a good idea of how many you started with. The ratio of how many grow at each temperature will tell you in what temperature environment the meat is more likely to spoil. Do I get it?
Thanks,
Nicole

Appendix XVI - Mentoring Aventis Biotech Students

I have included copy of the mentor guidelines for the Aventis Biotech Challenge and part of a student project proposal to demonstrate the commitments to mentor these activities and the quality of the students taking part in these activities.

Guidelines

Aventis Biotech Challenge Mentorship Guidelines

Introduction

The Aventis Biotech Challenge (ABC, formerly the Connaught Student Biotechnology Exhibition) is now entering its eighth year in Toronto, fifth year in Montreal and London, fourth year in Ottawa and St. John's, third year for Vancouver, Saskatoon, and Halifax, second year in Winnipeg and first year in Edmonton.

The objective of Aventis Biotech Challenge is to promote and encourage interest in the biological sciences among high school students in Canada. The term biotechnology is used to emphasize the application of research ideas in various disciplines of biological sciences. To participate, students are asked to come up with research ideas in biotechnology and submit a written research proposal that is evaluated by a committee of research scientists from the academic, industrial and government sectors. For Toronto's ABC, Dr. Lap-Chee Tsui from the Hospital for Sick Children has served as the Chair of the Evaluation Committee in the past years. His committee members represent several areas of the biosciences, such as biochemistry, biomaterials, genetics, microbiology, molecular biology, plant biotechnology, etc.

The Evaluation Committee approves the proposals based on the feasibility (do-ability) and merit of the students' research ideas. The Committee must also keep in mind that the proposals come from students at the high school level.

Some students have already made arrangements to work with a particular mentor in the course of developing their research proposal. In most cases, however, it is the Evaluation Committee that identifies scientists and researchers whose expertise and facilities would be most helpful to a particular student team. The potential mentors are contacted by the chair or coordinator of the Evaluation Committee to see if they are interested in working with high school students. If the mentor agrees, his or her name and telephone number are given to the students with the instruction that they are responsible for contacting the mentor and persuading him or her to assist them.

At the final competition in the spring, the student teams will present their work and results to a panel of judges comprised of scientists, managers, presidents of companies, government representatives, and education representatives (high school teachers or principals). The panel represents people from all walks of life and the challenge for the student teams is to explain science (in this case, the science and application in biotechnology) to the general public, and to present their experimental work in a convincing manner.

The level of competition is very high because the students are competing for cash prizes ranging from $500 to $2,500, as well as other awards such as university entrance scholarships, and/or summer jobs.

By participating in ABC, students will have gained experience in conceiving research ideas and describing them in writing, in carrying out experimental work, in learning data collection and analysis, in discussing and networking with scientists and professors, and in preparing and

presenting scientific findings to an audience. Feedback received from students who have participated in the past Toronto Exhibitions include "great experience", "very valuable", "more confident now", and "great opportunity to work with real scientists". The mentorship opportunity that is provided to each student team with an approved project is really the essence of this educational outreach program.

We believe that if students carry out a research project of their own design, they will better understand the practice of science. They learn how to master laboratory techniques, how to think critically, and how to acquire strategies for problem solving. They would also learn the importance of patience and perseverance in dealing with the unpredictable context of research. In offering mentorship support to a student team, the mentor plays a vital role in the integration of a research experience into the students' total education.

Guidelines for Mentors*

1. When the students call, offer an appropriate time at your convenience for an initial meeting with the student team** to discuss their proposal.
2. Listen to the students' presentation on their proposal that has been conditionally approved by the Evaluation Committee. (A note to that effect would be forwarded to the mentor's attention.)
3. Evaluate the proposed research project, and also the student team in terms of their experience, preparedness, desire and commitment to perform research work under your supervision.
4. Provide comments, criticism, advice and guidance to the student team on their proposed project.
5. Provide help to the student team to modify and improve the proposed project, if deemed necessary, as long as the changes fall within the main theme of the proposal as approved.
6. Assist the student team in planning of their research work so that it can be completed within a defined period of time.
7. Work with the student team to set up a clear time-line for completion of research work. Set high but realistic goals.
8. Define and clarify with the student team the data collection, analysis and interpretation process in a research project.
9. Offer the opportunity to the student team to carry out defined experimental work in your laboratory under the supervision of qualified personnel who have been assigned and authorized by you to take on these responsibilities. (Qualified personnel in your laboratory include graduate students, post-doctoral fellows, technicians and other scientists.)
10. Define the responsibilities of the person(s) you have assigned to supervise the student team in terms of training of general and specific techniques, lab safety, and routine lab management.
11. Define the responsibilities of the person(s) you have assigned to supervise the student team in terms of the extent of assistance provided. The student team should carry out the experimental work by themselves, except procedures that they are not qualified to do in a safe and professional manner.
12. Define your own responsibilities, including lab meeting, advice, regular feedback and evaluation of progress.

13. Define the student team's responsibilities, including punctuality, lab cleanliness and safety, the type and amount of research work they have to carry out, and the communications required among the person(s) involved in their project.

14. Remind the student team to make connections between research work and the literature.

15. Provide explanation, reasoning and critical analyses on the experimental results, whether positive or negative, as generated by the work of the student team.

16. Provide guidance, comments, and assistance to the student team to prepare progress report as required, and to prepare and present their work on the proposed project at the final competition.

William Mak, Ph.D.
ABC National Scientific Coordinator
December, 2000.

* Developed with consultation on a published document for mentoring undergraduate and graduate students, "Advisor, Teacher, Role Model, Friend", by National Academy Press, Washington, D.C., 1997 (website: www.nap.edu/readingroom/books/mentor/).
** A student team in ABC is composed of up to 4 high school students.

Example of Part of a Student Proposal for an Aventis Biotech Research Project

RESEARCH PROPOSAL

Proposal ID: CRYSTAL LEE / R.A. MCMATH SECONDARY SCHOOL
Proposal Title: Gone Without Trace
Proposal Keywords: Biodegradable, Styrofoam, Biopolymer

ABSTRACT:

Biodegradable materials will be used to attempt to create a substitute for Styrofoam in food containers. This material will have properties similar to Styrofoam, and can decompose. Recently, cardboard is used to create food containers, however, cardboard is not very water proof, and tends to break easily when it is wet. Also, cardboard with food on it can not be recycled, so our problem of creating too much garbage will not be solved. Therefore, it is not the best alternative. If a biodegradable substitute for Styrofoam can be created, it will eliminate the hazardous gas produced when Styrofoam is burnt, and reduce the amount of garbage produced.

OBJECTIVE:

Knowing that Styrofoam creates a lot of harm to our environment, is there a way of using biodegradable materials to create a substitute for it? Will that material be as efficient as Styrofoam in terms of being water, oil, and heat resistant, cost effective, and its ability to hold weight? Also, will this material be entirely degradable within a short period of time? Some possible materials to be used are all examples of biopolymers, such as: collagen, casein, soybean oil, polyesters, starch, and polycaprolactone.

INTRODUCTION:

Styrofoam has many problems associated with it. Styrofoam can be easily carried to different areas by wind and water. Marine animals can not distinguish the difference between a piece of Styrofoam and floating plankton or fish eggs, so they eat up the scraps. This can cause digestive tract diseases and intestinal blockages.

Styrofoam has also been known to cause health problems for people. Polystyrene contains a neuro-toxin which can cause fatigue and also chromosomal disorders. It has only been recently discovered that polystyrene can sometimes stick to food you eat. In 1991, the Louisana Agricultural Experiment Station reported that volatile styrene monomers were detected in egg shells stored in polystyrene containers at supermarkets. Egg dishes cooked with these contaminated eggs contained seven times more methylbenzene and styrene than those prepared from fresh farm eggs that had not been packaged in Styrofoam. Researchers suspect that the volatile compounds can migrate through the porous shells into the whites and yolk of the egg.

Even though the polystyrene monomers' presence is minute, it has been found to cause cancer. Many different types of food can break down the polystyrene, which you can ingest.

Environmentally, Styrofoam also creates a lot of harms. Since Styrofoam is non-degradable, it takes up a lot of room, and the only way to get rid of it is by burning it. However, burning Styrofoam creates hazardous toxic gases, that are released to the environment, causing a lot of harm, and contributing greatly to global warming.

Recently, scientists developed a biodegradable plastic based on starch. First, starch is harvested from corn, wheat, or potatoes. Then, microorganisms transform it into lactic acid, a monomer. Next, acid is added, and plastic called ploylactide (PLC) is formed. However, those starch-based biodegradable plastic are not entirely degradable, because starch is mixed in with the hydrophilic synthetic polymers, and only the starch part is degradable.

• • •

Appendix XVII - Trout Lake Coliform Research

In 1993 and 1994, I actively studied coliform populations contaminating Trout Lake in East Vancouver. This research led to specific recommendations on how to control the seasonal contamination of the water. The following list of reports and the two memos demonstrate the value of that study to the Vancouver Board of Parks and Recreation and the swimmers in East Vancouver.

- **Ramey, W.D.** and T.A. Kion (October 24, 1994) "Recommendations for Reducing Coliform Levels at Trout Lake", for Vancouver Board of Parks and Recreation.

- **Ramey, W.D.** and T.A. Kion (September 14, 1994) "Results of the Bird Embargo Study in Identifying the Probable Source of Fecal Coliform Pollution at Trout Lake", for Vancouver Board of Parks and Recreation.

- **Ramey, W.D**. and T.A. Kion (July 7, 1994) "Measurements of Fecal Coliform Pollution at Trout Lake", for Vancouver Board of Parks and Recreation.

- Shukaliak, J. and **W.D. Ramey** (1994) "Investigations into Coliform Contamination of a Freshwater Lake: Sources and Survival", for Vancouver Board of Parks and Recreation.

BOARD of PARKS
and RECREATION
CITY OF VANCOUVER

2099 BEACH AVENUE
VANCOUVER, B.C.
CANADA V6G 1Z4
PHONE (604) 257-8400
FAX (604) 257-8427

August 30, 1994

Dr. Bill Ramey
UBC
Microbiology

Dear Bill;

The Trout Lake experiment on August 17 and 18, 1994 was a success. We now know the reasons behind the "mysterious" pollution that comes about in the middle of every bathing season.

This investigation was a major collective effort, by many people. Your help is greatly appreciated and you should be proud that you were part of a special team that made the success of this project possible.

I personally would like to extend my many thanks to you. Your helpfulness and cooperation made my life easier. It was a privilege working with you. Thanks again.

Best regards,

Denes Devenyi
Doing It Better Coordinator

DD:aeb
:denes\004-4137.cov

SEP-11-1995 07:57 FROM BRD OF PRK & REC (OPER) TO 98226041 P.01

TO DR WILLIAM RAMEY
DEPT. MICROBIOLOGY. FROM Dennis

TROUT LAKE 1995

This year was the first year "gull-control" was in effect in the swimming season. Discouraging people from feeding the birds, cleaning the raft by taking away the deposits (instead of dumping it into the water, etc.) was exercised. It was of very low level of control - yet effective.

The net result was that we gained 5 weeks of extra swimming. If we compare the 1994 and 1995 e-coli readings (raw data, not the geometric means) we can see that 1995 was always substantially lower than 1994 in the months of June, July, and August. This speaks volumes about the influence of gulls on the e-coli population in the lake.

The only time that this year's e-coli counts were higher was in the last week of August. But this is the time when the gull embargo was in effect in 1994. This only proves the point that the birds are the primary source. The vigorous effort of the embargo has been effective.

Last year we have collected rigorously something like 6,000 observations per month. This year that was not done. But from casual observation two things are very clear:

1. We had much fewer birds than ever before (i.e. even low level controls are effective.)

2. The behaviour of the few birds present was substantially different. They were much less aggressive than before (i.e. in previous years the birds expected and received food regularly thus they started to demand it. This year this behaviour was not reinforced thus it did not develop.)

CONCLUSIONS:

Changing (controlling) <u>bird behaviour</u> is the only way Trout Lake can be kept open for swimming after (approximately) July 15. This could be done on many levels but the intensity of control might have to be varied during the season.

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:attach.

Appendix XVIII - Ammonium Inhibition of Nitrification Research

The research leading to a reassessment of the role of ammonia inhibition of nitrification was developed with my graduate student Robert Simm and co-supervisor Dr. Don Mavinic in Civil Engineering. The studies have been published in peer reviewed journals and publicized in major conferences.

- Simm, R., **W. Ramey** and D. Mavinic, "Mechanisms responsible for apparent free ammonia inhibition in a sequencing batch reactor", IWA/WEF Nutrient Removal Conference, March 4-7, 2007, Baltimore, Maryland.

- Simm, R.A., D.S. Mavinic and **W.D. Ramey**, "Development of a conceptual model to explain apparent free ammonia inhibition", Water Environment Federation 79th Annual Technical Exhibition and Conference, October 21-25, 2006, Dallas, Texas.

- Simm, R.A., **W.D. Ramey**, and D.S.Mavinic, 2006 "A targeted study on possible free ammonia inhibition of Nitrospira", J. Envir. Eng. Sci. 5: 365-376.

- Simm, R.A., **W.D. Ramey**, and D.S. Mavinic, 2005 "Nitrifier population dynamics in a bench scale activated sludge reactor following an induced perturbation", J. Envir. Eng. Sci. 4: 385-397.

- Simm,R.A., D.S.Mavinic and **W.D.Ramey**, 2004 "Preliminary evaluation of the use of fatty acid ratios for tracking the nitrite accumulation in nitrifying reactors", J. Envir. Eng. Sci. 3: 31-40.

Appendix XIX - Sudbury Neutrino Detector Research

Neutrino detectors are massive boxes of heavy water. This heavy water emits characteristic light when a neutrino collides with a molecule of heavy water. The light is observed with extremely sensitive light detectors. When bacteria grow in the detectors the water becomes turbid and the sensitivity of the detectors drops too low to be useful. In collaboration with Dr. John Smit in the Department of Microbiology and Immunology and Dr. Chris Waltham in the Department of Physics and Astronomy, I undertook a series of funded research studies that examined the potential growth of bacteria in neutrino detectors. We discovered that the cables leading to the detectors leached sufficient nutrient to cause massive visible growth of bacteria in the samples. This discovery necessitated a change in the chemical composition of the electronic cables used in the Sudbury Neutrino Project. The research culminating in this discovery was developed in the following series of reports.

- **Ramey, W**., J. Smit and C. Waltham (1993) "Incubation of Reformulated Cable Sheath" for the Sudbury Neutrino Observatory project (SNO).

- **Ramey, W.D.,** C. Waltham and J. Smit (1993) "Growth of Bacteria on Cable Sheathing and Urylon" for the Sudbury Neutrino Observatory project (SNO).

- **Ramey, W.D**., C. Waltham and J. Smit (1992) "The Role of Plastic for Potential Enhancement of Bacterial Populations in Water Supplies" for the Sudbury Neutrino Observatory project (SNO).

- **Ramey, W.,** J. Smit and C. Waltham (1991) "Effects of Anaerobiosis on the Growth of Aerobic Bacteria using Nutrients from Plastic" for the Sudbury Neutrino Observatory project (SNO).

- **Ramey, W.D**., C.E. Waltham, W. Luther and J.Smit (1991) Plastics as a substrate for biofilm growth", Canadian Society of Microbiologists 22nd Annual Western Branch Meeting, November 14-16.

Appendix XX - Faculty of Science Achievement Award for Service

The following notices of the service award is included to show that the award recognized my work on curriculum and program development.

THE UNIVERSITY OF BRITISH COLUMBIA

Faculty of Science
6270 University Boulevard
Vancouver, BC Canada V6T 1Z4
Tel: 604-822-3336
Fax: 604-822-5558
Office of the Dean

April 4, 2008

Dr. William Ramey
Department of Microbiology and Immunology
University of British Columbia

Dear Dr. Ramey:

I am very pleased to inform you that you have been awarded a Faculty of Science Achievement Award for Service. This award brings with it a $2,000 prize.

Your prize will be presented to you at the Faculty of Science meeting on May 13, 2008, 2:30pm, in the Social Lounge of St. John's College, 1112 Lower Mall. There will be a reception immediately following for you and a guest. For catering purposes please RSVP to Svetlana Minchenko at minchenko@science.ubc.ca by Monday, April 28, 2008.

On behalf of the Faculty, I want to extend my congratulations on this recognition of your significant contributions to the Faculty of Science. All your efforts in the leadership roles in Faculty of Science curriculum development and the UBC/BCIT Biotechnology program are very much appreciated.

Sincerely,

Simon M. Peacock
Dean

cc. Dr. Charles Thompson, Head

THE UNIVERSITY OF BRITISH COLUMBIA
6328 MEMORIAL ROAD, VANCOUVER, CANADA V6T 1Z2

Board of Governors

July 8, 2008

Dr. William Ramey, Senior Instructor
Microbiology & Immunology
University of British Columbia
136 Wesbrook Building
Campus Mail Zone 3

Dear Dr. Ramey:

On behalf of the Board of Governors, please accept our congratulations on receiving the **Faculty of Science Achievement Award** in recognition of your exceptional, outstanding contribution.

It is always a pleasure to see the efforts of others recognized in this way. We are very fortunate to have someone of your calibre as part of the UBC community, and we would like to share with you our sense of pride.

We wish you the very best for continued success.

Yours sincerely,

Brad Bennett
Board Chair

Appendix XXI – Mentoring of Integrated Sciences Students

I have included the following compilation of the students that I have personally mentored for the Integrated Sciences specialization in order to demonstrate the range of academic background that is needed to help these students develop the individual customized, programs that match their academic goals. Part of this mentoring includes guiding each of these students as they develop a Vision Statement to explain their academic goals and a Curriculum Rationale to explain how their courses address the needs expressed in the Vision Statement. Each student has a unique program with a unique Vision Statement and Curriculum Rationale. I have included an example of a Vision Statement and a Curriculum Rationale from one of these specializations to demonstrate the amount of thought and direction that leads to these essays.

Student	Integrated Disciplines	Status	Finish Date	Start Date
Arreaga, Bernardo	Physiology, Human Health	Graduated	2004	
Hakami, Rana	Physiology, Human Nutrition	Graduated	2004	
Kohli, Kapil	Physiology, Immunology	Graduated	2004	
Ingham, Matt	Immunology, Bioinformatics, Virology	Graduated	2005	
Rahkola, Tuomo	Genetics, Immunology, Parasitology	Graduated	2005	
Yip, Joyce	Physical Chemistry, Virology, Earth and Ocean Science	Graduated	2005	
Chuang, Rita	Medical genetics, Microbiology and Immunology	Graduated	2006	
Clermont, Valerie	Physiology, Microbiology & Immunology	Graduated	2006	
Ibbitson, Deanna	Nutrition, Genetics	Graduated	2007	
Luk, Edmond	Microbiology, Food and Nutrition	Graduated	2006	
Tabanfar, Leyla	Immunology, Biochemistry, Genetics	Graduated	2006	
Wenkeler, Christine	Molecular Development, Microbiology	Graduated	2006	
Chan, Grace	Virology, Chemical Biology	Graduated	2006	
Hicks, Carla	Plant Biology, Ecology	Graduated	2008	
Ho, Alex	Microbiological Pathogens and Immunology, Human Biology and Physiology	Graduated	2007	
Mach, Eileen	Human Biochemistry, Psychology	Graduated	2008	
Myers, Brooke	Genetics, Psychology, Minor in Linguistics	Graduated	2007	
Oberholzer, Monika	Pharmaceutical Issues, Physiology, Pathogenesis	Graduated	2007	
Subrt, Peter	Genetics, Biochemistry	Graduated	2007	
To, Suvina	Biopsychology, Functional Biology, Health Care	Graduated	2008	
Chang, Andersen	Biopsychology, Immunology	Graduated	2007	
Chyn, Eric	Psychobiology, Physiobiology	Graduated	2008	
Hao, Ingrid	Virology, Pharmacology	Graduated	2008	
Kott, Katharine	Molecular Biology, Physiology	Graduated	2008	
Lam, Frank	Physiology, Microbiology	Graduated	2009	
Mandar, Inder	Human Biology, Microbiology	Graduated	2009	

Mikhail, David	Medical Genetics, Medical microbiology	Graduated	2009	
Parhar, Navjit	Microbiology, Genetics	Graduated	2009	
Zhu, Katie	Microbiology, Developmental Biology	Graduated	2009	
Dharamsi, Alia	Metabolic Biochemistry, Microbiology	Graduated	2010	
Hanschen, Erik	Statistics, Evolutionary Biology, Minor in Arts	Graduated	2011	
Lim, Alecia	Parasite Biology and Health, Population Biology	Graduated	2011	
Lu, Ann	Molecular Biology, Microbiology, Physiology	Graduated	2010	
Mai, Cari	Biopsychology, Neurobiology	Graduated	2010	
Sehra, Aman	Pathogenicity, Host Biology	Graduated	2010	
Soros, Kelly	Microbiology, Physiopharmacology	Graduated	2010	
Wilson, Andrew	Molecular Development, Microbiology	Graduated	2010	
Ailon, Evan	Microbiology, Human Biology	Graduated	2011	
Sangsari, Sassan	Microbiology, Human Biology	Graduated	2011	
Wong, Amanda	Microbiology, Medical Genetics	Graduated	2011	
Yassin, Yasmin	Microbiology, Neuroscience, Developmental Genetics	Graduated	2011	
Thorne, Oliver	Microbiology, Physiology, Human kinetics	Approved	2010	
Volikhovska, Nataliya	Microbiology, Earth Sciences	Approved	2010	
Al-Mashhrawi, Deena	Physiology, Nutritional Science, Pathogenic Diseases	Approved	2011	
Alcheikh, Yara	Human Biology, Behavioural Neuroscience	Approved	2011	
Farzam-kia, Negar	Microbiology and Immunology, Biopsychology	Approved	2011	
Ho, Joe	Virology, Molecular Biology	Approved	2011	
Kim, Sungyoon	Pathogenic Disease, Computational Biology	Approved	2011	
Lang, Rebecca	Pathogenesis, Genetics	Approved	2011	
Leon, Griselle	Physiology, Nutritional Biology	Approved	2011	
Liaghat, Soroush	Neurobiology, Genetics	Approved	2011	
Mamdani, Zahra	Microbiology, Physiology, Health Genetics	Approved	2011	
Rasool, Alysha	Microbiology and Immunology, Physiology, Developmental Biology	Approved	2011	
Sharma, Sumedha	Human Biology, Pathogenesis	Approved	2011	
Shivji, Farhan	Physiology, Microbiology and Immunology	Approved	2011	
Assadipour, Paria		Prospective		2011
Chaiton, Jessica		Prospective		2011
Chan, Brennan	Human Health, Human Biology and Physiology	Prospective		
Chen, Chien-Hao	Microbiology, Genetics	Prospective		
Qiu, Xingyu (Ca	Biochemistry, Medical Genetics, Physiology	Prospective		

Examples of a Vision Statement and a Curriculum Rationale developed by a student that I mentored for a program integrating the fields of Genetics, Psychology and Linguistics

Vision Statement

Autism is a disorder which has intrigued me for most of my life. At the age of four my cousin and best friend was diagnosed with this incomprehensible condition. From that day forth, solving a piece of the autism puzzle has been a passion I wish to pursue. My interests concern integrating the two disciplines of Psychology and Genetics with regards to autism. The rationale for this blend of disciplines is that autism is viewed as a behavioural communication disorder in the psychological aspect and a multigenic disease from a geneticist's point of view. I feel that by being given the opportunity to design my own curriculum, with the help of a mentor, I will be able to get the most from my educational experience at UBC because I will have the freedom to study something I am passionate about and wish to continue studying in a postgraduate program. I think that these areas of science are uniquely connected and would therefore provide me with a greater understanding of how the human body works by exploring how our genetic makeup directly affects the biological processes in our body, ultimately affecting us psychologically.

In the future, I would like to research autism and design individualized therapy programs which will benefit these remarkably unique people both psychologically and biologically. As for my postgraduate education, I would like to keep my opportunities practicable and I believe that the Integrated Sciences Program allows me the flexibility to select from a variety of post graduate options. I am very interested in the Genetics Graduate Program at UBC which offers a Master of Science and Doctor of Philosophy in Genetics. I have spoken with Dr. Elizabeth Simpson, who is the Senior Scientist of the Medical Genetics Department at UBC, concerning her research of autism using mice models. Her work of trying to solve the autism puzzle fascinated me immensely, and ultimately contributed to my interest of researching the genetics of autism as a future profession. A strong background in genetics will allow me this opportunity. I have also worked as an Applied Behavioural Analysis (ABA) Therapist over the past two years with several children with autism. This work, along with having an affected family member with autism has provoked me to pursue a career as an Autism Consultant. In order to fulfill this dream, I must obtain a Master's in Applied Behavioural Analysis which would prepare me to become a Board Certified Behaviour Analyst where I would have the ability to open my own practice and ultimately design individualized therapy programs for children with autism. There are several Universities in the States which offer this program, such as Florida State University, University of North Texas (via correspondence), Caldwell College, Penn State and Northeastern University. University of Manitoba is the only University in Canada which offers this program. An undergraduate education with respect to Psychology, provides me with the prerequisite required for admission into this Master's Degree Program. I feel that the Integrated Sciences Program will guide me in a more precise manner towards my undergraduate and postgraduate educational goals by means of learning about the two disciplines of science that interest me most. By forging a creative and unique path in my undergraduate education this will lead to a more open minded future which I believe to be the key ingredient in successfully achieving both my educational and life goals
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Curriculum Rationale

The curriculum I wish to pursue focuses on many different aspects of genetics offered at the undergraduate level at UBC as well as a wide assortment of psychology courses. I believe that courses such as Basic Genetics (BIOL 334), and the Introductory Genetics Lab (BIOL 337) will provide me with the necessary fundamentals of genetics and will be beneficial for admission into a postgraduate degree program. While studying abroad at the University of New South Wales in Sydney, Australia, I was enrolled in a course titled Human Genetics and Variation. My professor, Peter Little raised an interesting point about the multigenic disease, diabetes. He claimed that perhaps "diabetic" genes may have been under positive selection in the past because it would have been beneficial to hunters and their families, who had to persevere feast/ famine cycles, to inherently possess high blood sugar levels. However, in the present day with our fast food lifestyles, these genes that were beneficial to the survival of our species are now predisposing us to diabetes. Perhaps autism works in a similar manner. Could it be that there is some evolutionary importance to these genes that cause autism? Many people who have influenced the human race profoundly are thought to have suffered from autism, for instance, Bill Gates' Microsoft Software, Ludwig van Beethoven's musical masterpieces, Thomas Edison's light bulb, Henry Ford's affordable car, Albert Einstein's theory of relativity and Sir Isaac Newton's understanding of light and gravity. Where would we be today without these

influential people? Perhaps it is the case that common disorders are the result of common genetic variations. There has been a 556% increase in the prevalence of autism between 1991 and 1997 in North America alone, so perchance the genes for autism are under positive selection now and one day the entire human population will have autism! These are some of the reasons that I believe courses such as Evolutionary Genetics (BIOL 336), Genome Evolution (BIOL 430) and Darwinian Medicine (ISCI 350) would contribute a great deal towards my research of autism genetics.

I feel that I will be able to gain a better understanding of all aspects of human development, including psychological development, and the genetics/ biology involved in these processes via this curriculum I have chosen. Cognitive Neuroscience (PSYC 365) will enlighten me about the cognitive development and the processes underlying perception, memory and attention, all of which pertain indirectly to autism. Autistic people tend to have an incredible memory, deficits with respect to attention and some have sensory integration problems which has a lot to do with their perceptions. Information acquired from PSYC 461, Neuroplasticity and Behaviour, could also contribute towards my understanding of how genes directly influence changes within our cells ultimately affecting how we learn. A course concerning Developmental Neurobiology (BIOL458) would also be extremely informative with respect to the development of the human nervous system and specific neurological disorders. Biopsychology (PSYC 360) focuses on the interaction between the nervous system and behaviour and ultimately the biological processes which govern psychological outcomes such as behaviour. All of this knowledge can be applied to my postgraduate educational goals. I also believe that in order to assess someone with autism and design therapy programs which are specific for each individuals needs, there must be a good understanding of both abnormal and normal psychological development. I feel that these criterion can be met by taking courses concerning Child and Adolescent Developmental Psychology (PSYC 315) and Abnormal Psychology (PSYC 300), which I completed during 2004w. Knowledge obtained through Models in Science (ISCI 422) could be directly applied to either researching the genetics of autism or to developing therapy treatments for these individuals. A course that deals with statistical computation, such as BIOL 300, Biometrics, is fundamental to my ISP curriculum. As both genetic and psychological research requires some statistical analysis I feel that this course can be integrated into my Genetics discipline considering that genetics is a statistics oriented science, for instance LOD scores and H-W Equations.

Autism is a multigenic disorder which severely affects individuals' brain function and more specifically results in behavioural and communication impairments. I have decided to minor in Linguistics in order to gain a better understanding of how language development is acquired in humans. People with autism have extreme difficulty with the pragmatics of speech, therefore I feel a minor in Linguistics would be very beneficial to my future where I hope to design therapy programs that focus on both the behavioural and language deficits of autism. During my studies at UNSW I completed a course titled Psychology of Language which taught me the fundamentals of normal and abnormal language development and I learned specifically about different speech disorders including that of autism. PSYC 363, Principles of Animal Learning will contribute to my knowledge of operant and classical conditioning. ABA therapy itself is just a modified version of operant conditioning. Educational Psychology courses such as Education of Students with Autism (EPSE 449) and Augmentative and Alternative Communication for Individuals with Severe Speech and/or Physical Impairments (EPSE 411) are relevant to my future career and would both contribute as credit towards my Board Certified Behavioural Analyst Certificate.

I feel that each course I have selected either pertains to autism directly or the knowledge acquired in the course can be applied to the study of autism. I feel that although this is a heavy course load, I strongly believe it will be extremely interesting and contribute significantly to my future goals of researching autism and designing individualized therapy programs for children with autism.

Appendix XXII – An Explanation of Bloom's Taxonomy

In my CV and the Teaching Dossier, I mentioned that the courses that I have created address the more complex, creative considerations in Bloom's Taxonomy. To clarify the expectations that need to be developed in these courses, I have included a brief review of Bloom's taxonomy.

Bloom's Taxonomy is a framework for aligning learning objectives and learning activities. The original classification was developed by Benjamin Bloom approximately 60 years ago. Approximately 20 years ago that framework was modified by Lorin Anderson to consider current educational thought. Some educational theorists put the final levels of the taxonomy in a different order but still support the general idea that learning exists at different degrees of complexity and abstraction. The following explanation was adapted from the description by Lorin Anderson at the website:

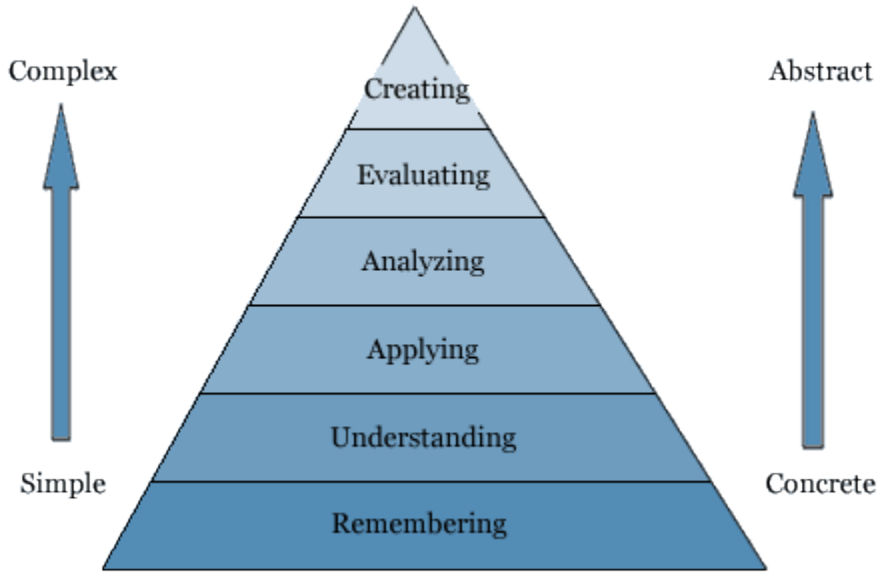
- http://www.ucdenver.edu/faculty_staff/faculty/center-for-faculty-development/Documents/Tutorials/Assessment/module2/index.htm

A wide range of other depictions of the taxonomy are available at the website

- http://www.google.ca/search?q=bloom's+revised+taxonomy&hl=en&prmd=imvns&tbm=isch&tbo=u&source=univ&sa=X&ei=q131TvqNCIv9iQL1ydTDDg&sqi=2&ved=0CCoQsAQ&biw=895&bih=832

Bloom's Taxonomy

Bloom's Taxonomy is a classification system of thinking and learning.



The cognitive domains in Bloom's pyramid illustrate that thinking occurs at different levels of complexity. The basic level is remembering. Advanced levels involve a synthesis that lead to the creation of new ideas or new ways of understanding old ideas and facts.

Appendix XXIII – An Explanation of Authentic Assignments

In my CV and the Teaching Dossier, I stressed that the courses that I have created have authentic assignments. To clarify the expectations that need to be developed in courses using authentic assignments and establish the benefits of the inclusion of authentic assignments for promoting student learning, I have provided the recent published article that was written by Maryellen Weimer, Ph.D. for The Teaching Professor, December 1, 2011. The article defines and explains the essential elements of authentic assignments.

Authentic Assignments: What Are They?

Written by: Maryellen Weimer, Ph.D.

"I've heard several faculty mention the need for authentic assignments ... what are they?" I received that question recently in an email, and it is true that the combination of the two words has come to mean something more than what might be assumed by their association.

One of the best answers to the what-are-they question appears in a classic text—*Understanding by Design.* This is the text that lays out the principles of backward design—meaning you start with where you want to end and design assignments, activities, courses, and curricula working back from this final destination. Authors Grant Wiggins and Jay McTighe propose that a learning task (be it an assignment or activity) is authentic when it has the following six characteristics:

- It is **realistically contextualized.** This means whatever it is you are asking students to do is set in a scenario that replicates or simulates the ways in which students will be asked for their knowledge or skill in real-world situations.
- It **requires judgment and innovation.** The assignment has students using their knowledge and skills to solve problems that are unstructured. Rather than testing a discrete piece of knowledge, an authentic activity challenges learners to figure out the nature of the problem as well as a possible solution to it.
- It **asks the student to "do" the subject.** In an authentic assignment students are not reciting, restating, or replicating what has been learned but are using their knowledge as a professional in the field would use it. They are doing science, literary criticism, teamwork, or whatever else—probably not as well as an experienced professional, but as a novice would.
- It **replicates key challenging situations in which adults are truly "tested" in the workplace, in civic life, and in personal life.** Most professionals face situations that are "messy." The problems are not like those often seen in classrooms, where the lack of "noise" makes the way to the "right" answer easier to figure out. "Students need to experience what it is like to perform tasks like those in the workplace and other real-life contexts, which tend to be complex and messy." (p. 154)
- It **assesses the student's ability to efficiently and effectively use a repertoire of knowledge and skills to negotiate a complex and multistage task.** Most test questions ask for isolated pieces of information. But when professionals use knowledge and skills, they don't use bits of information or one skill; they summon a collection of both, which they must integrate and use as a coherent whole. An authentic assignment is not like a drill used in practice but is more like playing the game.
- It **allows appropriate opportunities to rehearse, practice, consult resources, and get feedback on and refine performances and products.** The idea here is that of the apprenticeship model in which learning is based on a perform-feedback-revise-perform cycle. An authentic assignment is one students complete in stages. They get feedback along the way and are expected to make changes as their work continues.

As this description makes clear, authentic assignments and activities aren't those quick and easy things we might dream up on the way to class or that appear in the instructor's manual that comes with the text. They must be carefully designed, they take time for students to complete, and they

require effort to assess. What makes them worthwhile is the kinds of learning experiences they promote. Students quickly figure out that these assignments are difficult, can't be completed without lots of hard work, and require them to use what they are learning in situations like those they will encounter after college. Usually that motivates their wholehearted participation in these tasks.

Wiggins and McTighe say that the success of authentic assignments and activities rests on the understanding of two important facts. First, you can't design authentic assignments unless you know how adults use (or don't use) the knowledge and skills that are being taught in school. And second, you must help students understand how various assignments and activities contribute to the learning process. Not every assignment can be an authentic one, but even those that aren't promote learning. It's the same for the athlete or musician who must do some practice routines that aren't fun and may seem pointless. They, too, are part of the preparation for performance.

Reference: Wiggins, G. and McTighe, G. *Understanding by Design*. Expanded 2nd Ed. Alexandria, VA: Association for Supervision and Curriculum Development, 2006.