Supplemental Material

CBE—Life Sciences Education

Kowalski *et al.*

Supplemental Table 1. Student Demographic Data for CURE courses.

Course	Biology major	Chemistry major	Psychology major	Male: Female	Under-represented minorities	Total Students
Fall 2012/Spring 2013						
CHEMBIO	0	8	0	3 : 5	2	8
BIOCHEM	0	8	0	3 : 5	1	8
NEURO	12	1	0	4 : 9	0	13
Fall 2013/Spring 2014						
CHEMBIO	0	6	0	5 : 1	1	6
BIOCHEM	0	8	0	6 : 2	1	8
NEURO	4	0	1	2 :3	0	5
Fall 2014/Spring 2015						
CHEMBIO	0	8	0	4 : 4	1	8
BIOCHEM	0	8	0	4 : 4	2	8
NEURO	9	0	6	6 : 9	0	15
Total						**79**

Supplemental Table 2: Qualitative student feedback on three CURE courses. Student feedback collected from end of semester course evaluation free response. Course evaluations were anonymous and voluntary. For these responses, students were not prompted to respond to specific sections or aspects of the course.

POSITIVE RESPONSES

CHEMBIO

"This class helped me learn a lot including both knowledge and skills."
"I really enjoyed this course. It really made me think about what we were doing and why we were doing it."
"Great job with this class! I enjoyed it, and I feel like I learned a lot. I definitely feel much more accomplished. I think the lab was set up well."
"This was a great lab – my favorite I have ever taken! I would recommend this course to everyone."

BIOCHEM

"I really learned a lot in this class. Because it was set up as a research project, you were really invested in coming back and seeing what happened next week."
"The research project was very enjoyable and I learned a lot."
"It's one of the few classes I've taken where I can see substantial growth in myself over just the semester."
"I really liked the actual labs we did in class. I feel like I learned a lot about lab techniques and writing."

NEURO

"Having a semester-long research project was tough and challenging but way more rewarding than any other lab I have had."
"I loved the lab because I understood what we were doing, why we were doing the things that we did and how to solve problems."
"I really, really, liked the lab component. It was a nice change from the other bio courses I've taken.…we learned more by doing actual research."
"I really enjoyed coming to lab and being actively involved with the research as opposed to having a set protocol yielding expected results as in other classes. It was a lot of work, but worth it."
"I liked narrowly focusing on one project. I felt I got a better overall understanding of the project this way and it also allowed for more creativity."
"Great lab. It actually felt like we were doing important work rather than repeating labs that have been done 1,000 times before."

NEGATIVE RESPONSES

CHEMBIO

"With minimal time spent on teaching rather than gathering data, this course felt more like a job than a class"
"This course should be worth way more than 2 credit hours for the amount of work required outside of the scheduled lab time"
"As someone who has never done research independently, I felt as though I was given a vague sentence and told to find my way. More instruction would have made my life so much less frustrating"

BIOCHEM

"More credit hours please – its more work than that, and its more work for you too. That's not fair."
"I feel like the amount of work required was too much for the time frame and the credit hours given."
"More class-room discussion would have helped me to understand each experiment before we actually conducted the experiments."

NEURO

"This lab required lots of outside time, so students should be warned so that they don't quit in the middle of the semester and leave their lab partners at a disadvantage"
"It was very hard to work and coordinate with a group"
"Course is way to 'heavy' (i.e. an overwhelmingly difficult courseload). . .Consider making this a 5-6 hours credit course or have a the lab and lecture (as) two different courses."
"I learned a lot but often felt lost or overwhelmed. It was extremely frustrating to have to rely so heavily on group members."

CH432: Synthesis and Characterization
Course Syllabus
1:00 PM – 4:50 PM Wednesday
GH328 (and GH318)

Instructor: Geoffrey C. Hoops, Ph.D, Professor of Chemistry
Office: Room 335A Gallahue
Phone: 317-940-9147 (x9147 on campus)
Email: ghoops@butler.edu

Office Hours: I will be available for office hours by individual appointments. A sign-up sheet will be posted on my office door (**GH 335A**) for available appointments times during the week. You may sign-up for appointments directly on my office door or by email (but those who sign up directly on the door get higher priority in case of a direct time conflict). The best way to get a hold of me when you cannot find me is by email - I will try to respond promptly to your email questions.

Materials Required: safety glasses (available for sale at $8.00)
laboratory notebook (non spiral bound book where pages cannot be removed)
closed toe shoes
(recommended) – a lab coat

Prerequisites: Organic Chemistry (CH351 and CH352) and Co-requisite of Biochemistry I (CH361)

Evaluation: Attendance is mandatory for this course unless you have a university activity (such as a varsity sports participation) or university-validated medical/grievance excuse. I can sometimes accommodate make-up sessions **with sufficient prior notice.** All students **MUST** attend at least 13 out of 15 laboratory sessions and turn in assignments corresponding to those sessions in order to pass the course.

The distribution of points for the semester total is as follows:

Oral Presentation of Literature	100 points
Laboratory Report – First Draft	50 points
Peer Review	50 points
Laboratory Report – Final Draft	150 points
Poster & Poster Presentation	200 points
Attendance and Class Participation	100 points
Laboratory Notebook Check	100 points – Collected ten times for 10 points each.
TOTAL	750 points

There are no exams associated with this laboratory course (and so there is no final exam during finals week). Late assignments will be penalized by *10 % per day*. ALL GRADED WORK MUST BE TURNED IN BY 5:00 PM ON Monday, DECEMBER 15th in order to receive any credit at all.

Grade Distribution by Percentage of Total Points:

A =	92.00 –100 %
A- =	90 – 91.99 %
B+ =	88 – 89.99 %
B =	82 – 87.99 %
B- =	80 – 81.99 %
C+ =	78 – 79.99%
C =	70 – 77.99 %
C- =	65 – 69.99 %
D+=	60 – 64.99 %
D =	55 – 59.99 %
D- =	50 – 54.99 %

F = < 50.00 %

SLO's (Student Learning Outcomes):

1. **Understand key concepts related to the physical and chemical properties of matter.**
2. **Communicate within and outside the chemical discipline.**
3. **Develop problem-solving skills through experimentation and analysis.**
4. Appreciate the relationship between integrity, science, and society.

This course directly supports three of the four departmental student learning outcomes (1, 2, 3)

Course Objectives:

1. Implement and evaluate a chemical synthesis.
2. Analyze the chemical and/or biochemical properties of the synthetic target(s)
3. Work collaboratively to solve scientific problems.
4. Develop an interdisciplinary view of science that appreciates the contributions of different scientific viewpoints to solve a single scientific problem.
5. Learn to critically evaluate and communicate scientific problems and hypotheses.

Course Schedule – Schedule subject to change depending on the success of different steps in the synthesis. Your schedule may deviate.

Week 1: August 27th	Syllabus discussion, Lab Safety review, choose carboxylic acids; discuss synthetic procedure
Week 2: September 3rd	Synthesis step 1: Formation of latent fluorophore, determine TLC/column conditions, assign/schedule oral presentations of chemical literature;
	Lab Notebook Check
Week 3: September 10th	Synthesis step 2: Column purification
	Oral Presentation: Student #1
	Lab Notebook Check
Week 4: September 17th	Synthesis step 3: Spectroscopic Characterization of final product and starting materials
	Oral Presentation: Student #2
	Lab Notebook Check
Week 5: September 24th	Continued synthesis step 3: Characterization of final product and starting materials
	Oral Presentation: Student #3
	Lab Notebook Check
Week 6: October 1st	Discuss group projects; work on lab report
	Oral Presentation: Student #4
Week 7: October 8th	Work on Research Proposal
	1st draft of lab report due
Week 8: October 15th	Research Proposal due; order supplies/chemical for independent projects
	Peer Review of Lab Report due
Week 9: October 22nd	Group Independent Projects
	Oral Presentation: Student #5

	Lab Notebook Check
Week 10: October 29th	Group Independent Projects
	Final draft of lab report due
	Lab Notebook Check
Week 11: November 5th	Group Independent Projects
	Oral Presentation: Student #6
	Lab Notebook Check
Week 12: November 12th	Group Independent Projects
	Oral Presentation: Student #7
	Lab Notebook Check
Week 13: November 19th	Group Independent Projects
	Oral Presentation: Student #8
	Lab Notebook Check
Week 14: November 26th	Thanksgiving Break – No Class
Week 15: December 3rd	Data work-up; poster preparation
Week 16: December 10th	Poster Presentation to class (must be complete, but not graded)
	Lab Notebook Check

Friday December 12th : Poster Presentation to Department (graded)

Journal Article Presentation. Each student will give an oral (~20-30 minute) presentation about a current chemistry journal article. You may instead choose to find a journal article on your own and then have it pre-approved by Dr. Hoops. Self-chosen articles for presentation must be sent out to the entire class at least 5 days before the classroom presentation (Friday before your presentation).

The classroom presentation will consist of a short introduction to the journal article and its significance to the "bigger picture". You should then proceed through the most important figures/tables from the paper and ask for student participation to help interpret the important findings from each featured figure/table. End with a summary of the important findings and how the findings impact "the big picture".

The setting of the presentation will be fairly informal with significant input and questions expected from the other students in the class. You will need to read the necessary background articles to insure that you can answer other students questions and so that you can carefully and clearly explain the results from the paper. ***A grading rubric for the presentation is provided in the back of the syllabus.***

Laboratory Report. You will write one journal style laboratory report at the end of the synthesis portion of the course. The lab report will be written as a first draft, followed by peer review, and then a final draft. The due date for the laboratory report listed in the course schedule may be subject to change, dependent depending on the completion the synthesis portion of the project. ***The lab reports will need to be emailed directly to the professor or uploaded to Moodle by 11:59 PM on Tuesday night of the due date week.***

Even though you will perform all of the experiments with a partner, the lab report must be completed as an individual. It is recommended that you have other classmates read your lab report before turning it, but they must be written independently. See the section on academic integrity for additional information.

Peer Review is an essential part of the scientific process. All scientific journal articles and grant applications are sent out for peer review, where the reviewer carefully studies the experiments, results, and conclusions

made in a manuscript. The reviewer then offers critiques of the journal article to help clarify experimental findings or suggest further experiments. Rigorous peer review of scientific findings has been directly mandated by the federal government (www.whitehouse.gov/sites/default/files/omb/memoranda/fy2005/m05-03.pdf), which of course is a major source of research funding in the USA. Peer review is also an important writing process, because it challenges you (the reviewer) to consider another person's writing and decide what constitutes a well-written report.

Peer Review evaluation guidelines: 1) the initial version of the manuscript should be submitted electronically on Moodle. 2) Peer review will be a double-blind process. All original drafts should be submitted to Moodle for distribution to student peer reviewers. Once distributed, peer reviewers will have **ONE WEEK from receiving the manuscript** to review the manuscripts and make comments. During this time, the instructor(s) will also review the draft.

The peer review process: As you begin to review your peer's laboratory report, please keep in mind that the author had the lab report guidelines as a resource. That means everything in the lab report guidelines should be addressed in the report. Furthermore, the author's writing style (their scientific literacy) should reflect the influence that comes from reading the assigned scientific journal articles and laboratory resources. As you review, please:

- Use the lab report-grading guide as a template as you review the report. You may want to additionally review your own lab report for side-by-side comparison.
    - Check to make sure that the lab report has all of the necessary components and that the proper information is included in each section.
    - Look over the formatting of the figures, tables, and citations and offer suggestions for potential improvement.
- Mark minor corrections directly on the report using red ink or enter the corrections directly into the Word® document using track changes. Focus less on grammatical errors and more on sentence structure, writing style, information conveyed, and the overall "story" of the lab report.
- Type a review document for expanded comments. This document should have a separate title page, which can be removed by the instructor so that the reviewer's identity remains unknown to the author.
    - You need to thoroughly and carefully examine the style of the paper. Is the writing style scientific? Is the language used precise or is it too "wordy"? Does it include enough detail? Are citations properly included?
    - You need to consider the logical arguments made in the paper. Does the report discuss the results or does it only report the raw data? Is the student correctly analyzing their results? Are the results presented in a logical and easy to understand fashion?
    - You need to examine the entire "story" of the paper. Does the introduction describe the information necessary to interpret the results and discussion? Do the materials and methods contain enough (but not too much) detail for another scientist to repeat the experiment? Do the results and discussion match with the introduction and overall theme of the lab report? Are the conclusions drawn in the manuscript, the major conclusions from the experiments? Many other potential questions to be addressed here.
- Please phrase all comments in a constructive manner, but be honest in your appraisal of the work you're reviewing.
    - Do not feel bad about providing feedback to the other students. It will only help strengthen their lab report and help you learn about your own scientific writing.
- Provide suggested replacement words or sentences if you have an idea on how a section could be presented more clearly.
    - You are not obligated to rewrite large sections of the paper. Point out the sections that need work and offer some suggestions, but the actual editing is up to the original author.

Evaluation of the peer review

Once the peer review is complete, the comments should be returned to Dr. Hoops for evaluation. You will be assigned a grade based on the quality/depth of your review. In order to receive a high score on the peer review, your review will need to show careful consideration of the manuscript. It will need to include both grammatical and formatting changes and suggestions based on the larger questions above. A scored copy of the peer review will be returned to the reviewer and the original copy will be distributed to the author.

Resubmission of the final draft

The resubmission of the final draft must include a **"Response to Reviewer Comments"** document in the back of the revised manuscript in addition to a corrected manuscript. This response and rebuttal to reviewer comments is an important part of the peer review process. In this document, the author will need to show where they have changed the document to accommodate the reviewers' requests and where the author has chosen to skip the suggested changes with justification for such decisions. If the author feels that a comment is irrelevant, inappropriate, or deals only with a style issue, then the author should explain why a change was not made.

The original author should read the comments given by both the peer reviewer and the faculty reviewer and then address/incorporate these comments and suggestions into the manuscript. The final version of the manuscript should be submitted electronically on Moodle.

Laboratory notebooks: Keeping a careful record of your work is a critical component to laboratory investigation. A hallmark of scientific credibility is reproducibility, and reproducibility is favored by a detailed record of work completed. Your project this semester will be investigative, with the aim of obtaining a publishable outcome, so it will be valuable (to you and to me) to have a clear record of your work. It will take vigilance to make sure you thoroughly record your work. Notebooks will be evaluated ten times in the semester. For the last collection, Dr. Hoops will keep your lab notebook as documentation of your research for the semester.

All laboratory notebook entries must display the date, page numbers, and be legible and detailed enough to repeat. You should still keep this laboratory notebook during class and while you are completing the experiment. Maintaining a clear lab notebook during the experimental procedure is a difficult but worthwhile experience. Each notebook entry must contain the following sections:

1) Purpose Statement: A short sentence or two that lay out the general purpose and direction of that days experiment(s). This can be used to quickly look back through your notebook and determine what experiments were performed that day.
2) Experimental Procedure: You will not be given detailed laboratory procedures so you will be expected to come prepared to laboratory with your experimental procedure for that day written out and you can paste the typed copy from your weekly progress report into your laboratory notebook..
3) Results: If there are results, they should be taped into your lab notebook or placed into the accompanying three ring binder **and properly labeled**. Possible results include TLCs, NMR, MS spectra, and enzymatic rate data.
4) Conclusion: One or two short sentences that relay how that days experiment went. Did it succeed? Were there any difficulties in the measurements or experimental design? Was there anything that seemed unusual or not as you expected? What future experiments does this lead you to perform?

Poster and Poster Presentation: *Your laboratory group will prepare a poster and present and at the Chemistry Department poster session (likely Friday December 12th).* My general rule for preparing a poster is more pictures and fewer words. You will be standing next to your poster and presenting it to the class so you can state orally the long paragraphs of information and not write it out on your poster.

Some resources for presenting and preparing posters are noted below. An assignment page describing the evaluation criteria for posters is given on the back of the syllabus. The general categories that your poster should cover include:

1) Title: A short sentence that accurately outlines the general idea of your poster. It should also include all of the authors and your school affiliation.
2) Introduction: A short description of the background information required to understand your poster. It should contain a figure (drawing or picture) that pertains to the introduction. It should answer the questions: Why is this project interesting? What scientific hypothesis or question are you trying to answer? What similar experiments have been performed previously?
3) Methods: This section is optional depending on whether your methods are novel or interesting, because a poster should not be bogged down in the minute experimental details. A figure describing the methods would also be appropriate.
4) Results and discussion: The major section of the poster, the results and discussion should contain all of the figure (tables and plots) that outline the significant research findings. Figures should be properly labeled and with a descriptive title and legend to accompany each figure. The size of the figures should match the large size of a poster presentation. Numerical data should be presented with reasonable # of significant digits, appropriate units, and estimates of error when possible. Any abbreviations used should be clearly defined and consistent with the other sections of the poster. Short paragraphs highlighting the important results are appropriate but long paragraphs are unnecessary.
5) Conclusions: A short paragraph or a few bullet points that highlight the most important results from your semester of research.
6) Acknowledgements
7) References: You should have references cited in your introduction, methods, and results and discussion section. Approximately 4-10 citations would be appropriate.

You may want to visit the following URLs that offer tips on preparing effective research posters.

1) *Advise for Constructing Scientific Posters* Dr. Colin Purrington, Swarthmore University. http://www.swarthmore.edu/NatSci/cpurrin1/posteradvice.htm
2) *Creating Effective Poster Presentations* George R. Hess (NC State University) and Leon H. Liegel (Oregon State University). Includes several examples incorporating various design features. http://www.ncsu.edu/project/posters
3) *Creating Large Format Posters Using PowerPoint*, Dept. of Biomedical Communications, Wake Forest University School of Medicine. http://www.wakehealth.edu/Creative/Resources/Tip-Sheets/Creating-Large-Format-Posters-Using-PowerPoint.htm

Academic Integrity:

- ***Consulting your lab mates, even to the point of proof reading each other's reports is allowed and even recommended.*** **Peer editing is an important skill to learn in this course.**
- *Backing up your reasoning and explanations with information from primary literature papers or academic sources is necessary for this course and you will need to properly cite the resources used in your lab reports and other writing assignments.* When you cite this information, you need to rewrite the important points in **YOUR OWN WORDS** and without quotations. Regurgitating sentences from other sources even with citations still counts as academic dishonesty.
- Copying lab reports, or even sections thereof (including materials, procedures, etc.) **is not allowed and will constitute academic dishonesty**. Copying graphics (such as ChemDraw schematics) is the same as copying text – not allowed. See the section of the Butler Student Handbook for definitions of academic dishonesty and the overview of policies (http://www.butler.edu/student-conduct/academic-integrity/overview).
- The Butler Student Handbook definitions of plagiarism and fabrication are given below:

- Plagiarism is the fraudulent misrepresentation of any part of another person's work as one's own. Submitting any writing, including take-home exams, that does not properly acknowledge the quoting or paraphrasing of another person's words, or that fails to give proper credit for another person's ideas, opinion, or theory is plagiarism. Any unacknowledged use of sources to which one is indebted including but not limited to, music, video, audio, theatre projects, compositions, Website and computer software constitutes plagiarism.
- Fabrication is the falsification or invention of information or data in reports, lab results, bibliographies or any other academic undertaking.

- The first case of academic honesty, including plagiarism, fabrication, or copying lab reports with another classmate, will result in a 15 % reduction in the score for that assignment. The second offense will result in a 50% reduction in the score for that assignment.
- Additionally, I will document any incidents of academic dishonesty and report them to the university. If you are ever in a situation where you are uncertain about whether a behavior/action is academically dishonest, please come talk to me about it. Such a conversation would be strictly confidential and would not be documented.

Additional Policies:

Health Hazards and the Laboratory - In our courses, laboratory attendance is a fundamental component to the understanding of concepts and techniques of performing chemistry. Additionally, the very nature of laboratory involves using chemical reagents, which can pose potential health risks. If you have concerns about your health, please have a discussion with your professor or *any* chemistry faculty member. Such concerns might include, but are not limited to: any condition that results in an immuno-deficiency; persons considering conception; certain heart conditions; serious allergies; etc. Understand that any information shared will be kept entirely confidential. DO NOT HESITATE TO DISCUSS THIS WITH A CHEMISTRY FACULTY MEMBER (Dr. Hoops) AND/OR MICHELE ATTERSON (JH 136, x9308).

Special Needs: It is the policy and practice of Butler University to make reasonable accommodations for students with properly documented disabilities. Written notification from Student Disability Services is required. If you are eligible to receive an accommodation and would like to request it for this course, please discuss it with me and allow two weeks notice. Otherwise, it is not guaranteed that the accommodation can be received on a timely basis. If you have questions about Student Disability Services, you may wish to contact Michele Atterson, JH 136, ext. 9308.

Biochemistry Lab CH463
Course Syllabus
Spring 2015
1:00 PM – 5:00 PM Thursday GH328

Instructor: R. Jeremy Johnson, Ph.D, Assistant Professor of Chemistry
Office: Room 339 Gallahue
Phone: 317-940-9062 (x9062 on campus)
Email: rjjohns1@butler.edu

Office Hours: I will be available for office hours by individual appointments. A sign-up sheet will be posted on my office door (**GH339**) for available appointments times during the week. You are highly encouraged to sign-up for appointments on my office door rather than by email. The best way to get a hold of me when you cannot find me is by email and I will try to respond promptly to your email questions. Additionally, the lab sections are small so please ask questions during lab and I will try to answer them immediately.

Materials Required: safety glasses (available for sale)
hard-bound laboratory notebook
closed toe shoes

Prerequisites: Biochemistry I (CH361) & Analytical Chemistry (CH321)

Evaluation: Attendance is mandatory for this course. You will receive no credit for any laboratory session missed (without a university-validated medical or grievance excuse). I can SOMETIMES accommodate make-up sessions **with sufficient prior notice.** All students **MUST** attend all laboratory sessions and turn in laboratory reports corresponding to those sessions in order to pass the course.

The distribution of points for the semester total is as follows:

Laboratory Reports:	150 points – 2 Total (300 pts total)
Peer Reviews:	50 points each (100 pts total)
Short Writing Assignments:	20 points each – 3 total (60 pts total)
Poster & Poster Presentation:	100 points
Laboratory Notebook:	25 points – Collected 2x (50 pts total)
TOTAL	610 points

Grade Distribution by Percentage of Total Points:

A =	92.00 –100 %
A- =	90 – 91.99 %
B+ =	88 – 89.99 %
B =	82 – 87.99 %
B- =	80 – 81.99 %
C+ =	78 – 79.99%
C =	70 – 77.99 %
C- =	65 – 69.99 %
D+=	60 – 64.99 %
D =	55 – 59.99 %
D- =	50 – 54.99 %
F =	< 50.00 %

Laboratory Reports will comprise a large percentage of your grade. The due dates for the laboratory reports are indicated on the schedule. Experiments will all run more than 1 week, in which case the laboratory report for the entire experiment will be due ~ 1 week after the completion of the experiment. Lab reports need to be uploaded to Moodle by 5:00 PM on the Due Date Given in the Table Below.

Each of the two lab reports must be completed as individuals. It is recommended that you have other classmates read your lab report before turning it, but they must be written independently. See the section on academic integrity for additional information.

Late lab reports will be penalized by *20 points per day*. Resubmissions are due 1 week after the graded initial lab report is returned to you. ALL LAB REPORTS, INCLUDING REWRITES, MUST BE TURNED IN BY 5:00 PM ON MONDAY, April 27th in order to receive any credit at all.

For the first lab report, the first draft will be worth 25% of the final grade and the revised lab report 75% of the final grade.

For the second lab report, the first draft will be worth 40% of the final grade and the revised lab report 60% of the final grade.

Each lab report must follow the guidelines set forth in the LAB REPORT WRITING GUIDE (posted on Moodle for this course). Individual lab reports will require specific instructions for completion, which will be posted on Moodle under that particular experiment. Additionally grading rubrics for each lab report will be handed out in class prior to completion.

Experiment Title	Class Dates	Lab Report/Poster Due	Revised Lab Report/Poster Due
Protein Mutagenesis	1/15/15 – Mutagenesis 1/22/15 – Transformation 1/29/15 – Miniprep 2/05/15 – Sequencing	2/13/15	One week after revised lab report returned – Exact date given in lab
Protein Expression, Purification, & Protein Analysis	2/05/15 – Transformation 2/12/15 – Purification 2/19/15 – Western Blot I 2/26/15 – Western Blot II/ Thermal Stability 3/05/15 – Fluorescent Kinetics 3/19/15 – Kinetics Analysis	3/27/15	One week after revised lab report returned – Exact date given in lab
Independent Experiments	3/26/15 – Week1 4/02/15 – Week2 4/09/15 – Week3 4/16/15 – Week4	4/23/15	4/27/15

Peer Review is an essential part of the scientific process. All scientific journal articles and grant applications are sent out for double blind peer review, where the reviewer carefully studies the experiments, results, and conclusions made in a manuscript. The reviewer then offers critiques of the journal article to help clarify experimental findings or suggest further experiments. Peer review is also an important writing process, because it challenges you (the reviewer) to consider another person's writing and decide what constitutes a well-written report.

Peer Review evaluation guidelines: 1) the initial version of the manuscript should be submitted electronically on Moodle. 2) Peer review will be a double-blind process. All original drafts should be submitted to Moodle for distribution to student peer reviewers. Once distributed, peer reviewers will have **ONE WEEK from when you receive the manuscript** to review the manuscripts and make comments. During this time, the instructor(s) will also review your draft.

The peer review process: As you begin to review your peer's laboratory report, please keep in mind that the author had the lab report guidelines as a resource. That means everything in the lab report guidelines should be addressed in the report. Furthermore, the author's writing style (their scientific literacy) should reflect the influence that comes from reading the assigned scientific journal articles and laboratory resources. As you review, please:

- Use the lab report-grading guide as a template as you review the report. You may want to additionally review your own lab report for side-by-side comparison.
    - Check to make sure that the lab report has all of the necessary components and that the proper information is included in each section.
    - Look over the formatting of the figures, tables, and citations and offer suggestions for potential improvement.
- Mark minor corrections directly on the report using red ink or enter the corrections directly into the word document using track changes. Focus less on grammatical errors and more on sentence structure, writing style, information conveyed, and the overall "story" of the lab report.
- Type a review document for expanded comments. This document should have a separate title page, which can be removed by the instructor so that the reviewer's identity remains unknown to the author.
    - You need to thoroughly and carefully examine the style of the paper. Is the writing style scientific? Is the language used precise or is it too "wordy"? Does it include enough detail? Are citations properly included?
    - You need to consider the logical arguments made in the paper. Does the report discuss the results or does it only report the raw data? Is the student correctly analyzing their results? Are the results presented in a logical and easy to understand fashion?
    - You need to examine the entire "story" of the paper. Does the introduction describe the information necessary to interpret the results and discussion? Do the materials and methods contain enough (but not too much) detail for another scientist to repeat the experiment? Do the results and discussion match with the introduction and overall theme of the lab report? Are the conclusions drawn in the manuscript, the major conclusions from the experiments? Many other potential questions to be addressed here.
- Please phrase all comments in a constructive manner, but be honest in your appraisal of the work you're reviewing.
    - Do not feel bad about providing feedback to the other students. It will only help strengthen their lab report and help you learn about your own scientific writing.
- Provide suggested replacement words or sentences if you have an idea on how a section could be presented more clearly.
    - Try your best to reword a section or rearrange a document, but you are not obligated to rewrite whole sections of the paper. Point out the sections that need work and then offer suggestions, but the actual editing is up to the original author.

Evaluation of the peer review

Once the peer review is complete, the comments should be returned to Dr. Johnson for evaluation. You will be assigned a grade based on the quality/depth of your review. To receive a high score on the peer review, your review will need to show careful consideration of the manuscript. It will need to include both grammatical and formatting changes and suggestions based on the larger questions above. A scored copy of the peer review will be returned to the reviewer and the original copy will be distributed to the author.

Resubmission of the final draft

The resubmission of the final draft must include a **"Response to Reviewer Comments"** document in the back of the revised manuscript in addition to a corrected manuscript. This response and rebuttal to reviewer comments is an important part of the peer review process. In this document, the author will need to show where they have changed the document to accommodate the reviewer's request and where the author

has chosen to skip the suggested changes with justification for your decision. If the author feels that a comment is irrelevant, inappropriate, or deals only with a style issue, then the author should explain why a change was not made.

The original author should read the comments given by both the peer reviewer and the faculty review and then address/incorporate these comments and suggestions into the manuscript. You **ONLY** need to include your response to the **PEER REVIEWER COMMENTS** in your "Response to Reviewer Comments" in the back of your final draft. The final version of the manuscript should be submitted electronically on Moodle.

Laboratory notebooks: Keeping a careful record of your work is a critical component to laboratory investigation. A hallmark of scientific credibility is reproducibility, and reproducibility is favored by a detailed record of work completed. Your project this semester will be investigative, with the aim of obtaining a publishable (see poster) outcome, so you need to maintain a clear record of your work. It will take vigilance to make sure you thoroughly record your work. Notebooks will be evaluated twice in the semester. The two collection dates will be February 13th by 5 pm and April 27th by 5 pm. For the first collection, your lab notebook will be returned at the next class meeting and for the second collection, Dr. Johnson will keep your lab notebook as documentation of your research for the semester.

All laboratory notebook entries must display the date, page numbers, and be legible and detailed enough to repeat. Each notebook entry must contain the following sections:

1) Purpose Statement: A short sentence or two that lay out the general purpose and direction of that days experiment. This can be used to quickly look back through your notebook and determine what experiments were performed that day.
2) Experimental Procedure: For the basic details of the methods, you can directly cite the laboratory procedure handouts that were provided for each week of lab. In your laboratory notebook, you need to point out sections where the procedure changed from that given in the handout or where additional detail is needed for you to repeat this experiment. Because this is the first time that you have performed these experiments and because you may use some of the same methods again when designing your independent project, you will want to provide significant detail in the method so that you or an outside reviewer could repeat every step of the procedure, given both your lab notebook and the laboratory procedure. This often means documenting details like which tubes, tips, centrifuges, or other supplies were used for each step of the procedure.
3) Results: If there are results, they should be taped into your lab notebook and properly labeled. Possible results include sequences, growth curves, gel pictures, enzyme measurements, and antibody staining.
4) Conclusion: One or two short sentences that relay how that days experiment went. Did it succeed? Were there any difficulties in the measurements or experimental design? Was there anything that seemed unusual or not as you expected? What future experiments does this lead you to perform?

Independent Project: You and a partner(s) will propose an experiment that you will perform jointly during the last four weeks of class. The experiment proposed will need to be a direct extension of the research performed in class. The project should be one that takes three to four weeks to complete, and one that reflects significant principles in biochemical experimentation. The project should use the hydrolase enzyme that we purified in class and test additional properties of the enzyme, test potential applications for the enzyme, or prepare future experiments based on the enzyme.

To help you decide on an interesting independent project, multiple research papers will be uploaded to Moodle that perform experiments on similar bacterial hydrolases. Additionally, you are encouraged to perform your own independent literature searches for potential projects. You should first read the background material for the class, search for related research articles, and think about interesting biochemical experiments. You will then compile an outline of your project and the literature sources that support your proposed project. Then each group will consult with Dr. Johnson about your ideas regarding the project. Your group needs to

set up a meeting with Dr. Johnson to discuss your proposed project. **Your meeting needs to be completed by March 5th**, so that Dr. Johnson can order the necessary supplies for the independent projects.

I have provided a short list of potential projects below, but I would strongly encourage your group to first consider your own independent ideas. Taking personal ownership of the project will make the experimentation and results more exciting to your group.

1) Test the dependence of the enzyme activity on pH.
2) Test the dependence of the enzyme activity on temperature.
3) Test the dependence of the enzyme activity on concentration of organics
4) Test the dependence of the enzyme activity on concentrations of metals.
5) Test the dependence of the enzyme activity on esterase inhibitors or chelating agents.
6) Test the dependence of the enzyme activity on additional substrates.
7) Determine the quaternary structure of the hydrolase.
8) Examine the folding of the hydrolase using chaotropic reagents.
9) Measure the pI of the hydrolase compared to other hydrolases.
10) Perform sequence analysis of the hydrolase gene to determine its evolutionary relationship to similar hydrolase and hypothesize about the biological role of this hydrolase.
11) Design new amino acid substitutions of the enzyme that would create new activities or test additional areas of the enzyme besides the substrate-binding pocket.
12) Perform saturation mutagenesis on a specific position and determine which amino acids could be substituted at that position.
13) Clone an evolutionarily similar hydrolase and compare its enzymatic activity.
14) Synthesize new fluorogenic hydrolase substrates for the enzyme.
15) Set up new enzyme assays using different hydrolase substrates and compare the activity.

Poster and Poster Presentation: Your laboratory group will prepare an electronic version of your poster and present the outcomes of your independent research project to the entire class on the last day of class - April 23rd. You will then revise your poster, get your poster printed, and present the final version of the poster at the Chemistry Department poster session – April 27th. My general rule for preparing a poster is more pictures and fewer words. You will be standing next to your poster and presenting it to the class so you can state orally the long paragraphs of information and not write it out on your poster.

Some resources for presenting and preparing posters are noted below. An assignment page describing the evaluation criteria for posters will be on Moodle, as the time draws nearer. Since you have all presented posters previously in analytical chemistry, we will not dwell on this significantly in the course. The general categories that your poster should cover include:

1) Title: A short sentence that accurately outlines the general idea of your poster. It should also include all of the authors and your school affiliation.
2) Introduction: A short description of the background information required to understand your poster. It should contain a figure (drawing or picture) that pertains to the introduction. It should answer the questions, 1) why is this project interesting, 2) what scientific hypothesis or question are you trying to answer, and 3) what similar experiments have been performed previously.
3) Methods: This section is optional depending on whether your methods are novel or interesting, because a poster should not be bogged down in the minute experimental details. A figure describing the methods would also be appropriate.
4) Results and discussion: The major section of the poster, the results and discussion should contain all of the figure (tables and plots) that outline the significant research findings. Figures should be properly labeled and with a descriptive title and legend to accompany each figure. The size of the figures should match the large size of a poster presentation. Short paragraphs highlighting the important results are appropriate but long paragraphs are unnecessary.

5) Conclusions: A short paragraph or a few bullet points that highlight the most important results from your semester of research.
6) Acknowledgements:
7) References: You should have references cited in both your introduction, methods, and results and discussion section. I would say 5-10 citations would be appropriate.

You may want to visit the following URLs that offer tips on preparing effective research posters.

1) *Advise for Constructing Scientific Posters* Dr. Colin Purrington, Swarthmore University. http://www.swarthmore.edu/NatSci/cpurrin1/posteradvice.htm
2) *Creating a Poster Using MS PowerPoint* University of Washington School of Public Health and Community Medicine http://depts.washington.edu/mphpract/ppposter.html
3) *Creating Effective Poster Presentations* George R. Hess (NC State University) and Leon H. Liegel (Oregon State University). Includes several examples incorporating various design features. http://www.ncsu.edu/project/posters/IndexStart.html
4) *Creating Large Format Posters Using PowerPoint*, Dept. of Biomedical Communications, Wake Forest University School of Medicine. http://www.wfubmc.edu/biomed/tipsheets/ppt_poster.html

We will be conducting the experiments this semester individually and with a partner. **I expect each individual member to:**

- Come prepared (do background reading, arrive on time, be properly dressed, and be actively engaged with the experiment)
- Record all procedures and data in their own individual notebooks
- Write their own individual laboratory report.

Academic Integrity:

- Consulting your lab mates, even to the point of proof reading each other's reports is allowed and even recommended. Peer editing is an important skill to learn in this course.
- Backing up your reasoning and explanations with information from primary literature papers or academic sources is necessary for this course and you will need to properly cite the resources used in your lab reports and other writing assignments. When you cite this information, you need to rewrite the important points in **YOUR OWN WORDS** and without quotations. Regurgitating sentences from other sources even with citations still counts as academic dishonesty.
- Copying lab reports, or even sections thereof (including materials, procedures, etc.) **is not allowed and will constitute academic dishonesty**. See the section of the Butler Student Handbook for definitions of academic dishonesty and the overview of policies (http://www.butler.edu/student-conduct/academic-integrity/overview).
- The Butler Student Handbook definitions of plagiarism and fabrication are given below:
    - Plagiarism is the fraudulent misrepresentation of any part of another person's work as one's own. Submitting any writing, including take-home exams, that does not properly acknowledge the quoting or paraphrasing of another person's words, or that fails to give proper credit for another person's ideas, opinion, or theory is plagiarism. Any unacknowledged use of sources to which one is indebted including but not limited to, music, video, audio, theatre projects, compositions, Website and computer software constitutes plagiarism.
    - Fabrication is the falsification or invention of information or data in reports, lab results, bibliographies or any other academic undertaking.

- The first case of academic honesty, including plagiarism, fabrication, or copying lab reports with another classmate, will result in a 25 % reduction in the score for that assignment. The second offense will result in a 75 % reduction in the score for that assignment.
- Additionally, I will document any incidents of academic dishonesty and report them to the university. If you are ever in a situation where you are uncertain about whether a behavior/action is academically dishonest, please come talk to me about it. Such a conversation would be strictly confidential and would not be documented.

Additional Policies:

Health Hazards and the Laboratory - In our courses, laboratory attendance is a fundamental component to the understanding of concepts and techniques of performing chemistry. Additionally, the very nature of laboratory involves using chemical reagents, which can pose potential health risks. If you have concerns about your health, please have a discussion with your professor or *any* chemistry faculty member. Such concerns might include, but are not limited to: any condition that results in an immuno-deficiency; persons considering conception; certain heart conditions; serious allergies; etc. Understand that any information shared will be kept entirely confidential. DO NOT HESITATE TO DISCUSS THIS WITH A CHEMISTRY FACULTY MEMBER AND/OR MICHELE ATTERSON (JH 136, x9308).

Special Needs: It is the policy and practice of Butler University to provide reasonable accommodations for students with properly documented disabilities. Written notification of Student Disabilities Services is required. If you are eligible to receive an accommodation and would like to request it for this course, please contact Student Disability Services. Allow one-week advance notice to ensure enough time for a reasonable accommodation to be made. Otherwise, it is not guaranteed that the accommodation can be provided on a timely basis. Students who have questions about Student Disability Services or who have, or think they may have, a disability (psychiatric, attentional, vision, hearing, physical, medical, etc.) are invited to contact Student Disability Services for a confidential discussion in Jordan Hall 136 or by phone at extension 9308.

BI460: Cell and Molecular Neurobiology

Spring 2015

Instructor:
Jennifer R. Kowalski, Ph.D.
Office: Gallahue Hall 271
Phone: 940-8879: E-mail: jrkowals@butler.edu
Office Hours: 10:00 - 11:00 a.m. Mon., Wed., & Fri.

Class Schedule:
Lecture: GH290, TR, 9:35-10:50AM
Laboratory: GH292, R, 2:25-5:15PM

Course Description:

Neuroscience is a broad, integrative sub-discipline of biology that investigates how the nervous systems of diverse animals are organized and how that organization leads to functions that determine behavior. The study of neuroscience can be done at a systems level (think anatomy and circuit physiology), at the behavioral level, at the cellular/molecular/ genetic level, or even at a psychological level. From nervous system development, to learning and memory, to the causes and symptoms of neurological diseases, the breadth of neurobiology makes it an exciting and dynamic area of research. However, this breadth as well as the complexity of neuroscience, makes it a challenging field that requires a working knowledge of a number of areas in biology (e.g., cell biology, physiology, genetics), chemistry, and even physics. Since covering all facets of neurobiology, even a basic level, is not feasible for a single semester-long course, in this course we will focus our efforts in both lecture and lab on understanding the molecular and cellular principles and processes that underlie nervous system development and function.

While it is expected that you all have a fundamental understanding of cell structure and function and molecular genetics from your introductory coursework, it is likely that none of you have identical biology backgrounds. Thus, each of you has a unique base of knowledge from which to work. Despite the fact that your diverse backgrounds may mean that you will sit through some review of familiar material in the beginning (which is quite new for other students), the major advantage of having different backgrounds is that, as a group, we have a wide range of information, skills and experiences from which to draw. As we move through the semester, I hope you will see this course as an opportunity to share your own knowledge and perspectives, while learning from those of others as we explore together the intricacies and exciting new discoveries in molecular neurobiology.

Overall, my goal for this course is that you learn something about the cellular basis of nervous system function; however, equally important is that you develop an understanding of *how* neuroscientists acquire knowledge through experimentation in these areas, as well as strengthen your own experimental design and analysis skills. Finally, I hope to make this YOUR course as much possible. In the lab, you will clearly have control of the direction of your projects, but even in lecture, while I have suggested a list of topics that to discuss, I am open to your ideas and suggestions. I welcome your input throughout the course and look forward to learning with you!

Course Objectives:

By the end of this course, you should be able to

- Explain and demonstrate the fundamental organization and development of nervous systems across phylogeny and the cellular and molecular principles governing nervous system function. (Departmental Student Learning Objective #1)
- Apply knowledge of normal neuronal function to understand the molecular basis of neurological disorders. (Departmental Student Learning Objectives #1 and 5)
- Explain common experimental approaches used to investigate the cellular and molecular basis of nervous system function and describe their benefits and caveats. (Departmental Student Learning Objective #1)
- Design, execute, trouble-shoot, and analyze data from both open-ended and hypothesis-driven scientific experiments aimed at addressing basic questions in cellular and molecular neurobiology. (Departmental Student Learning Objective #3)
- Read, interpret, and critically evaluate scientific literature. (Departmental Student Learning Objective #2)
- Communicate orally and in writing concerning your own and others' scientific data. (Departmental Student Learning Objective #4)

Course Format: In our Tuesday and Thursday class meetings, we will discuss what is known about the cell biology of neurons and other cells of the nervous system through a combination of lecture and group work, as well as regular discussions of relevant primary scientific literature. We will approach these topics from a comparative viewpoint, drawing on studies done in a variety of organisms. As we do this, it will be important to keep in mind that not all changes at the molecular level impact nervous system function in obvious ways and, due to the complexity of the nervous system, even with clear cellular phenotypes, it is sometimes difficult to predict what will be the ultimate effects on the nervous system as a whole. In addition, the field of molecular and cellular neuroscience has emerged only in recent years with the advancement of imaging and electrophysiological techniques, as well as more sophisticated molecular genetic methodologies. In the laboratory, you will use several of these modern cellular and genetic techniques firsthand in a semester-long independent project investigating the molecular control of nervous system function in the model roundworm, *C. elegans*.

Text:

"Neuroscience", 5th edition, 2012. D. Purves, G.J. Augustine, D. Fitzpatrick, W.C. Hall, A.-S. LaMantia, L. E. White. Sinauer Associates, Inc., Sunderland. ISBN: 978-0-87893-695-3.

Additional readings, lab handouts, and other homework assignments will be posted on Moodle.

Final Grade Determination:

Your final grade will be determined by summing your total points earned divided by the total points possible. The following is a tentative list of the point distribution in the course. Each component is described below.

200pts	Take-home Exams (2 @ 100 pts each)
100pts	Final exam
80pts	In-class quizzes (5 @ 20 pts each, dropping the lowest quiz score)
25pts	Lecture assignments/activities
40pts	Paper discussion leader (partner)
50pts	Class/lab participation
70pts	Lab notebook (30pts)*/assignments (30pt)/peer evaluations (10pt)
80pts	Research project plan (group: draft, mini-presentation, final version)*
80pts	Research manuscript (drafts and final version)
20pts	Research progress reports*
80pts	Poster presentations (group)*
825	**total points**

The grading scale for this course is:

A	92-100%	B	82-87%	C	72-77%	D	62-67%
A-	90-91%	B-	80-81%	C-	70-71%	D-	60-61%
B+	88-89%	C+	78-79%	D+	68-69%	F	< 60%

EXAMS, QUIZZES, & LECTURE ACTIVITIES

Exams: There will be two mid-semester exams and a final exam in the course. Each of the exams will be largely essay question-based and worth **100 points**. The focus will be to test your ability to synthesize, analyze, and apply information that we have discussed in the course. The two mid-semester exams will be administered as take-home exams given over the weekends indicated. The final exam will be taken in class on the date set by the university.

Quizzes: There will be five in-class quizzes administered throughout the semester as noted on the course schedule. Each quiz will be worth 20 pts, and your lowest quiz score in the course will be dropped to give a total of **80 quiz points**. These quizzes will contain more knowledge-based questions along with one or two critical thinking questions and will include a combination of multiple choice, fill in the blank, and short answer formats. The purpose of these quizzes to ensure that you are keeping up with the course material so that you will be prepared for the paper discussions, lab projects, and exam questions that will follow.

Other assignments/activities: In addition to quizzes, exams, and paper discussions (see below), there will be occasional other small homework or in-class activities for which you will receive points. Points for these assignments may vary, but in total, **25 points** in the course will be accounted for by these assignments.

Paper Discussions: While we will use a textbook for much of the basic material in the course, we will regularly go beyond the textbook to read and discuss current primary scientific literature related to the topic at hand. The purpose is to expose you to a range of research questions, techniques and model systems used in modern neurobiological research and to train you in the critical evaluation of the scientific literature. We will have seven paper discussion days, as noted on the course schedule. I will prepare and lead the first of these discussions. For the remainder, you each will take a turn working with partners to help select a paper, write reading questions, present relevant background information, and lead a journal club style discussion of the paper in which the rest of your classmates will participate. You will earn up to **40 points** for this activity. Details will be provided in class.

Participation: This course is designed to be an upper level seminar in which student participation is paramount. This is seen most obviously in the paper discussions and lab components of the course; however, even on other days, while there will be some lecturing, I will frequently stop to ask questions, solicit your input, or have small group discussions. In addition, I welcome questions from you. Thus, the attendance and active engagement of each of you is essential for the success of the course. For this reason, there are **50 points** in the course designated for participation. To earn full points, you must not only attend class but also actively participate in discussions both in lecture and lab, as well as pulling your weight in your lab group (see below). You will be allowed two unexcused lecture absences without penalty. (NOTE: These absences MAY NOT include Paper Discussion classes, as your attendance and participation on these days is necessary for a productive class discussion. Unexcused absences from paper discussions will result in a reduction of your final course grade by up to 10%.) Beyond that, unexcused absences (that is, absences without legitimate documentation) will lead to a reduction in your final participation score. If you do miss a class, please make arrangements with a classmate to review their notes.

LABORATORY

Laboratory attendance each week is mandatory. Because of the ongoing nature of the projects and the live animals being used, you should plan to attend the entire length of the lab sessions. Any unexcused absence from lab will result in a reduction of your final course grade by up to 10%. In addition, the independent projects you will be performing will involve the maintenance of live worm strains and bacterial cultures; thus, you will be required to spend time outside of the normal lab period caring for your worms and/or setting up your experiments (see below). The lab room will be left open for your convenience.

The lab component of this course is unique for several reasons. First, as you will notice on the course schedule, the lab is completely project-based and involves a semester-long investigation into nervous system function using the model roundworm, *C. elegans*. Second, the work you will be doing is completely novel – that is, you are not doing canned labs that have been pre-tested to ensure your success. Instead, you are doing real research that has not been done before – you are on the forefront of science and have the potential to contribute new knowledge that has not been discovered previously by anyone in the world! In addition, the work we will do in the course this semester will pave the way for even more cutting edge research to be done by students in future semesters who will hopefully be able to link some of the research that you do to some novel research being done in the Biochemistry and Chemical Biology lab courses in the Chemistry department. So, you are doing some pretty important studies that I hope you will find exciting and motivating.

The project itself is focused around identifying and characterizing enzymes that regulate neuronal communication in *C. elegans*. As many worm genes have human homologs, this means that you may very well be learning more about the enzymes that control human nervous system function, as well. To do this, each group will first select and test a panel of candidate enzyme genes for their ability to affect the structure of synapses using fluorescence microscopy. Based upon the results of that initial screen, each group will then choose one or more genes to test in follow-up functional studies of their choosing (additional imaging experiments, behavioral studies, etc). Along the way, you will learn several important cellular, molecular, and genetic techniques that are frequently used in modern neuroscience studies, and even more importantly, you will gain experience in doing authentic scientific research, which involves experimental design and execution, data collection and analysis, oral and written communication of your findings and lots of trouble-shooting! These are the ultimate goals of the lab experience in this course, as *doing* science is how scientific information is generated. As you will see, it is not always a linear path, but it often is more exciting that way!

A special note about independent research and this course: A noted above, the lab is a critical part of this course. Here, you will utilize experimental design and data analysis skills, as well as learn to trouble-shoot experiments in real time. While the techniques you will use are routinely used in the field, the experimental questions you are addressing have not been previously tested - you are doing novel research! The downside is that this type of research doesn't always work the first time, or the second time, or sometimes even the third time. . . , so patience and thoughtful perseverance are essential skills for success here. Because I understand the nature of scientific research, your grade on this project does not necessarily depend on your experimental success. That would be great; however, I am simply looking for your ability to carefully research and design well-controlled experiments, to execute them as precisely as possible, to interpret the results, and to trouble-shoot efficiently. Thus, your care, effort, and ability to explain what you are doing are the goals here. The assignments described below are designed to help you achieve these outcomes.

Lab Notebook/Assignments/Peer Evaluation: An integral component of success and accuracy in the laboratory is the maintenance of a detailed, organized lab notebook. This notebook contains a written, dated record of each experiment you perform, including your experimental questions and hypotheses, the composition of solutions, ages of animals, treatment conditions and timing, and other observations, as well as a detailed log of your results and conclusions. This information is important for ensuring that you (or others) can replicate your experiment, and accuracy is critical for maintaining the integrity of the scientific process. Finally, you will need the experimental information that you keep in your notebook when it comes time to prepare your research manuscript and final poster. Each group will keep one shared notebook of their work. These notebooks will be checked periodically by me, and you will turn in the final notebook at the end of the semester for a total of up to **30 points**. There also will be a few other small assignments/quizzes totaling **30 points** in the early portion of the lab to help get you acclimated. Details and specific assignment guidelines will be provided in class.

Since the nature of the lab projects throughout the semester requires significant cooperation and teamwork among group members, along with submitting your group's notebook and other group assignments (*, see above list), each student will be asked to submit confidential evaluations (**2 points each**) of your group members' (and your own) contributions to the project. These evaluations will be used to determine if each group member is contributing equally to the work. Any group member not doing his/her fair share on the project may lose some or all lab notebook points earned by the group, as well as receive a reduction of up to 50% of the points for class participation and/or specific group assignments, depending on the nature of the issue. Please do your part to be an engaged group member – the project will be more meaningful and your final reports will be much easier if you do!

Research Project Plan: You will work in groups of three or four students throughout the semester on projects investigating genes controlling nervous system function in *C. elegans*. These projects will proceed in two parts: first, the groups will work in parallel to test a panel of genes for their effects on the abundance and distributions of a synaptic vesicle protein; second, each group will select one or more candidate genes on which to perform follow-up studies. The nature of these studies will be decided by the group and will depend on the nature of the candidate genes tested. Once an idea for the experimental plan is established, the group will prepare a written proposal to be submitted on the Friday before spring break. The group also will present and discuss their plan in a lab meeting format at which time they will receive feedback from their peers and from me. That feedback will then be incorporated into a final, revised version of the project plan, which will be resubmitted. The group will earn a total of **80 points** for these components (initial plan, mini-presentation, and final draft) of the project plan.

Research Manuscript: To gain practice in written scientific communication, upon completion of the screening portion of your research projects, each student will write a scientific manuscript describing your work. However, as good writing of any sort requires revision, you will write drafts of each portion of the manuscript during the first half of the semester while the screen is in progress (see course schedule). You will receive feedback on these drafts which you will be able to use to help you in writing the final completed manuscript. More details and writing guidelines will be provided; you will earn up to **80 points** for this assignment.

Research Progress Reports: To monitor progress on your independent projects, twice during the semester you will be asked to submit progress reports on your groups' activities. These reports may involve discussing problems encountered, analyzing results, or just updating on work that still needs to be completed. Reports generally will be done as a group but parts may be individual. **20 total points** are allotted for these reports.

Poster Presentation: For the culminating activity related to your research projects, each group will prepare a scientific poster summarizing both parts of their investigation (screening and follow-up studies). These posters will then be presented in two poster sessions at the end of the semester. The first of these sessions will occur during the final lab period. Students will receive feedback on their posters at this time and will have the opportunity to revise their poster layout prior to presenting it during a cross-departmental Chemistry/Biology poster session during **the afternoon of Monday, April 27th** (the final day of classes for the semester). Additional assignment details and examples will be provided in class. The poster and presentations will be worth **80 points**.

COURSE POLICIES

Attendance in both class and lab is required (see "Participation" and "LABORATORY" sections above). Be advised that assignments given in class may not be announced, and in many cases will require group work or discussions. **In class quizzes and assignments cannot be made up**. Documented legitimate absences will be worked out case by case. If you expect to be absent during the time period of an exam you must contact me in advance, **i.e., BEFORE the exam**. If you fail to notify me, you have one week to apply in writing for a make-up exam. Make-up exams will be granted **only** for a legitimate excuse (such as illness) that can be documented.

Late Policy: All assignments are due at the beginning of the period or by the stated time online. If you do not have them ready to turn in then, they are considered late. For lab assignments and papers, **25% of the point total will be deducted for each day late.** Documented legitimate absences will be worked out case by case.

Academic Honesty: Cheating is forbidden, as is plagiarism. The way this course is designed will necessitate working closely with other students. You will be asked to discuss problems in class and in lab, as well as working together on specific assignments. But, items for which you are receiving an INDIVIDUAL grade must be done as an INDIVIDUAL. Plagiarism is a form of cheating and is defined by the Student Handbook as "the fraudulent misrepresentation of any part of another's work as one's own." Plagiarism thus includes but is not limited to copying from past or present students, failure to cite the sources of ideas or information (especially in written work), and the use of quotes without quotation marks. No form of cheating will be tolerated; the formal procedures outlined in the Student Handbook will be instigated if cheating is discovered.

Use of TurnItIn: By taking this course, you are agreeing that all assignments may be subject to submission for textual similarity review to Turnitin.com for the detection of plagiarism. All papers submitted to Turnitin become source documents in the Turnitin.com reference database, which is used solely for the purpose of detecting plagiarism of such papers. Additional notifications are found on the Moodle site used in this and other Butler courses. Additional information is also available on the Usage Policy posted on the Turnitin.com site.

Requests for Academic Accommodations: t is the policy and practice of Butler University to make reasonable accommodations for students with properly documented disabilities. Written notification from Student Disability Services is required. If you are eligible to receive an accommodation and would like to request it for this course, please discuss it with me and allow one week's notice. Otherwise, it is not guaranteed that the accommodation can be processed in time. If you have questions about Student Disability Services, please contact Michele Atterson, JH 136, ext. 9308.

A FINAL IMPORTANT NOTE ABOUT THIS CLASS

This class will function as a community of learners working in an environment that fosters inquiry and free expression. Such communities work best when all members feel free to express themselves without fear of ridicule or disrespect. Respect for the community also means that individuals do not disrupt the focus of the class with behaviors/actions that may distract others. Examples include **tardiness, ringing/ vibrating cell phones, texting**, **leaving/re-entering class once it begins, or packing up prior to the end of class.** Please be respectful of your classmates and me by refraining from these activities.

Communications: If you do not do so already, please begin checking both your Butler University email account and Moodle on a daily basis. E-mail is my preferred means of communication, and I will send the class communiqués, information, and reminders via e-mail. If you need to contact me, use e-mail for best results.

BI460 Spring 2015 Course Schedule

The following is a TENTATIVE schedule for the activities and topics we will cover this semester. We will do our best to keep close to this schedule, but the topic, timing, and/or nature of the activities may change depending on the needs of group. I will let you know of any changes with as much advance notice as possible, and I appreciate your flexibility in working to make this a productive and engaging experience for each of you!

Day	Topic	Textbook Readings	Assignments (more TBA)	Labs (Thursdays)
Jan 13th Jan 15th	Intro to Course/Neurobiology Neuron & Nervous system structure	Chpt 1, 7	Review assignment; RCR training	Intro to *C. elegans*; project goals; safety & lab notebook training *Read Worm handbook, IBC protocol
Jan 20th Jan 22nd	Membrane Potentials Electrical Signaling (GPs, APs)	Chpt 2-4	Mello & Conte, 2004 (lab)	Select RNAi target genes; ***Worm quiz – Part I***
Jan 27th Jan 29th	**Quiz #1;** AP propagation; Info coding Synaptic Transmission Intro		Kammath, et al., 2002 (lab)	Design RNAi experimental protocol ***Worm quiz – Part II***
Feb 3rd Feb 5th	**Paper Discussion #1 (Dr.K)** Presynaptic Mechanisms	Chpt 5, 6, 8	Sun, et al., 2013 (NMJ imaging); Outline Hmwk	RNAi & slide training; Start cultures *Scientific writing workshop*
Feb 10th Feb 12th	Post-synaptic Mechanisms **Quiz #2;** Synaptic Integration		Screen Summary/Intro Outline (Tues)	RNAi screening
Feb 17th Feb 19th	Synaptic Plasticity **Paper Discussion #2**	Chpt 5, 6, 8; Assigned articles	Screen Intro and M&M (Tues)	RNAi screening *Lab Notebook Check*
Feb 24th Feb 26th	Nervous System Development Neuronal Differentiation & Migration	Chpt 22	**Take-home Exam #1 due**	RNAi screening
Mar 3rd Mar 5th	**Paper Discussion #3** **Paper Discussion #4**	Assigned articles	Screen Results/Disc (Fri 3/6)	Screen analysis; Plan follow-up studies
Mar 9-13th	**No Classes – Spring Break!**			
Mar 17th Mar 19th	**Quiz #3:** Axon Outgrowth and Pathfinding Synapse Formation, Trophic Factors;	Chpt 23	Initial Project Plan (Thurs AM)	**Research Mtg**: Mini-presentations; Discussion of Project Plans
Mar 24th Mar 26th	Synapse Elimination; Synaptic Circuitry Changes **Quiz #4;** Technique Review	Chpt 23, 24	Final Project Plan (Mon 3/23) Final Manuscript (Fri 3/27)	Independent Projects
Mar 31st Apr 2nd	**Paper Discussion #5** **Paper Discussion #6**	Assigned articles	Progress Report I (Fri 4/3)	Independent Projects
Apr 7th Apr 9th Apr 10th	Injury, regeneration and repair Neurodegeneration (Friday) **Butler URC**	Chpt 25	**Take-home Exam #1 due**	Independent Projects *Lab Notebook Check*
Apr 14th Apr 16th	Stem cells and therapeutics **Paper Discussion #7**	Chpt 25; Assigned articles	Progress Report II (Fri 4/17)	Independent Projects Wrap-up/Data Analysis
Apr 21st Apr 23rd **Apr 27th** **Apr 29th**	**Quiz #5;** Hot topics in Neuroscience Course Wrap-up **(Mon) Bio/Chem Poster Session, TBA** **(Wed) FINAL EXAM 1-4pm GH158**	Assigned articles	Final Poster (Sat 4/25, noon)	Class Poster session

***Note:** We will integrate examples of both normal and pathological nervous system function into these topics.

CHEMBIO Weekly Lab Schedule

Week 1

1. Introduction to overall lab and goals (5 minutes)
2. Assessments (30 minutes) – CURE and Experimental Design questions
3. Project Overview and timeline (45 minutes) – with Powerpoint slides
    - general utility of fluoresent probes
    - acyloxymethyl ethers of fluorescein as fluorogenic probes for hydrolase activity
    - combinatorial synthetic scheme for preparing acyloxymethyl ethers of fluorescein
4. Discuss oral literature assignment (30 minutes)
    - Students are assigned (on their own time outside of class) to identify a journal article that focuses on structure-activity relationship (SAR) data of small molecules interacting with protein targets. While the assignment is fairly open-ended, students are pointed toward particular journals that contain a high proportion of such articles (Journal of Medicinal Chemistry, etc.).
    - Scheduling of presentations: Students agree on schedule for presenting a ~20 minute oral presentation summarizing the significance and results of their article, one student per week.
5. Design Fluorogenic probes (90 minutes)
    - Review the laboratory inventory of acyloxymethyl ethers of fluorescein prepared to date
    - Students each choose two carboxylic acid starting materials that will make novel and logical additions to the existing chemical library. Two possible approaches: 1) incremental changes to existing library compounds or 2) theoretical modeling to a known protein structure.
6. The instructor orders the student-chosen chemicals (post-class)

Week 2

1. Student #1 presents SAR article and answers questions (30 minutes)
2. Students set up their two S_N2 reactions (100 minutes)
3. Students identify TLC conditions suitable for monitoring their reactions (60 minutes)

Week 3

1. Student #2 presents SAR article and answers questions (30 minutes)
2. Students confirm the completion of their two reactions by TLC (30 minutes)
    - If a reaction failed, student troubleshoots to identify the problem, and then sets up a replacement reaction (60 minutes)
3. Students purify one of their two products via silica gel chromatography. Removal of last traces of chromatography solvent is accomplished by placing the purified product under vacuum in a pre-weighed vial overnight. (120 minutes)

* Students are asked to come in the next day to remove the vial containing dried purified product from the vacuum system, weigh the vial, and then store in the freezer.

Week 4

1. Student #3 presents SAR article and answers questions (30 minutes)
2. Percent yield of reaction #1 calculated (10 minutes)
3. Students purify the second of their two products via silica gel chromatography. Removal of last traces of chromatography solvent is accomplished by placing the purified product under vacuum in a pre-weighed vial overnight. (120 minutes)

* Students are asked to come in the next day to remove the vial containing dried purified product from the vacuum system, weigh the vial, and then store in the freezer.

Week 5

1. Student #4 presents SAR article and answers questions (30 minutes)
2. Percent yield of reaction #2 calculated (10 minutes)
3. Students receive training on use of NMR spectrophotometer and the preparation of NMR samples (60 minutes)

Week 6

1. Student #5 presents SAR article and answers questions (30 minutes)
2. Students collect ^{1}H-NMR spectra (180 minutes)

Week 7

1. Student #6 presents SAR article and answers questions (30 minutes)
2. Students analyze ^{1}H-NMR spectra data (120 minutes)
3. Students prepare and submit samples for high resolution mass spectrometry analysis (60 minutes)
4. The contents and structure of the laboratory report are discussed (10 minutes)

* Students collect ^{13}C-NMR data in scheduled overnight runs, spread out over the week

Week 8

1. Student #7 presents SAR article and answers questions (30 minutes)
2. Students analyze ^{13}C-NMR spectra data (60 minutes)
3. Students analyze MS data (30 minutes)
4. Students collect and analyze IR data (60 minutes)
5. Groups identify their independent projects, and begin to discuss methods and prepare a project outline

Week 9

1. Student #8 presents SAR article and answers questions (30 minutes)
2. Lab Reports are submitted
3. Personal discussions with each independent project group about their project outline and refinement of their independent project goals and methods (30 minutes x 4)
4. Students begin to gather materials for independent projects and schedule instrumentation & equipment use over the next three weeks

*Depending on the overlapping need for equipment and instrumentation, this week and the next three may easily involve significant time spent outside of the scheduled class

Week 10-13

Phase II independent projects. Groups work autonomously on approved independent projects, coming to seek help from the instructor as needed.

Week 14

Groups submit drafts and give presentations of their scientific posters covering their independent projects. Peer and instructor feedback is given prior to submission of the final poster and presentation at the joint Chemistry-Biology poster session on the last day of classes.

BIOCHEM Weekly Lab Schedule

Week 1

1. Introduction to overall lab and goals (5 minutes)
2. Assessments (30 minutes) – CURE and Experimental Design questions
3. Project Overview and timeline (45 minutes) – with Powerpoint slides and protein structural visualization
4. Discuss introductory reading and writing assignment (5 minutes)
    - Students read the article, "Redesign of substrate specificity and identification of the aminoglycoside binding residues of Eis from *Mycobacterium tuberculosis*" about protein structure-function analysis by site-directed mutagenesis and rewrite the abstract for this article.
5. Introduction to primer design and nucleic acid mutagenesis (10 minutes)
6. Design Quikchange mutagenesis primers (30 minutes)
    - Instructor designed primers are provided to students on the first day, but students also design their own primers, which they compare to those provided by the instructor. Students check the melting structure and secondary structure temperature of their primers via OligoAnalyzer (www.idtdna.com).
    - Mutations chosen by the instructor cover the active site and binding pocket of an interesting mycobacterial serine hydrolase. Each mutation is usually assigned to two different students to provide redundancy and to help insure successful mutation.
7. Set up two Quikchange mutagenesis reactions (30 minutes)

Week 2

1. Introduction to DNA gel electrophoresis and bacterial transformation (20 minutes)
2. Discuss DNA gel electrophoresis writing assignment (5 minutes)
    - Student label their DNA gel electrophoresis picture, including DNA standards and samples and write a short (3-4 sentence) explanation of the success of the mutagenic PCR reaction.
3. PCR reaction digest and transformation (150 minutes)
    - Individual students add DpnI enzyme to their Quikchange reactions to digest the template plasmid and then transform the digested mixture into chemically competent *Escherichia coli*.
4. DNA gel electrophoresis analysis of Quikchange mutagenesis (90 minutes)
    - Students work in small groups (~2) to analyze the success of their mutagenesis reactions by DNA gel electrophoresis. Students pour, run, and analyze their gels by comparing the relative composition of each Quikchange reaction before and after DpnI digestion compared to a template plasmid control.

Week 3

1. Introduction to DNA isolation and the miniprep DNA purification procedure (15 minutes)
2. Discuss miniprep methods writing assignment (5 minutes)
    - Student write a short methods section describing the miniprep DNA purification procedure.
3. Miniprep DNA plasmid purification (90 minutes)
    - A standard miniprep plasmid kit and accompanying procedure are used to isolate plasmid DNA for each Quikchange reaction. Each student analyzes 4-5 colonies per mutagenesis reaction.
4. Measure DNA concentration and purity. (20 minutes)
    - Absorbance readings and purity ratios are collected for each plasmid.
5. Send isolated plasmid DNA for DNA sequencing (20 minutes)

*Students come in briefly on the day before lab to inoculate small cultures for mini-prep.

Week 4

1. Introduction to Sanger DNA sequencing (15 minutes)
2. Discuss lab report 1 writing assignment (15 minutes)
    - Students write a journal style lab report about the molecular biology portion of the BIOCHEM lab, focusing on the success or failure of their Quikchange mutagenesis and connecting their experiments into a coherent story. For each report, students write a first draft and a final draft with peer and instructor feedback on the first draft. A detailed lab report writing guide is provided to assist students.
3. Analyze Sanger DNA sequencing (60 minutes)

- DNA sequences are analyzed for the proper amino acid substitutions using a combination of Expasy translate (http://web.expasy.org/translate/) and protein BLAST (http://blast.ncbi.nlm.nih.gov/).

4. Bacterial transformation. (90 minutes)
    - Transformation of successfully mutagenized plasmids into a protein expression strain of *E. coli*.
5. Discussion about molecular biology results for lab report 1 and independent projects ideas (30 minutes)

*Instructor in combination with an undergraduate TA heterologously express small cultures (250 mL) of each hydrolase variant. Cultures are collected and frozen for purification in week 5.

Week 5

1. Introduction to protein expression using the T7 expression system, to protein purification, and to immobilized metal affinity chromatography (20 minutes)
2. Affinity purification (120 minutes)
    - Students lyse their bacterial pellets using a combination of lysozyme and bugbuster and isolate their protein variants using nickel metal affinity chromatography spin columns. Samples are collected throughout the purification for analysis by SDS-PAGE and Western Blot in Week 6.
3. Dialyze protein variants (15 minutes)
    - Eluted proteins are dialyzed into new phosphate buffered saline over the week in dialysis cassettes.

Week 6

1. Introduction to Western Blotting, as SDS-PAGE was already covered in the lecture portion of the pre-requisite course (20 minutes)
2. SDS-PAGE (90 minutes)
    - Samples from the Week 5 purification are analyzed by SDS-PAGE pre-poured SDS-PAGE gels.
3. Western Blot (180 minutes)
    - Jointly with SDS-PAGE analysis, Western blot analysis is performed with students performing SDS-PAGE separation, membrane transfer, and membrane blocking in Week 6.
4. Protein concentration measurement (30 minutes)
    - Using Expasy Protparam (http://web.expasy.org/protparam/), extinction coefficients for protein variants are calculated and used to analyze protein concentrations by 280 nm absorbance values.
5. Continued discussion of ideas for independent projects, as the protein gels run (30 minutes)

Week 7

1. Introduction to protein thermal stability measurement (10 minutes)
2. Western Blot (120 minutes)
    - Continuation of Western Blot from Week 6 with washing of the primary antibody, addition of the secondary antibody conjugated to HRP, and visualization using NBT/BCIP reaction.
3. Thermal stability measurement by differential scanning fluorimetry (45 minutes)
    - Entire class sets up one 96-well thermal stability measurement, inserting triplicate replicates of each protein variant and a wild-type protein control.
4. Continued discussion of ideas for independent projects (30 minutes)

*Students came in briefly in the middle of the week to remove the original blocking buffer from the Western Blot and to replace with blocking buffer containing the primary antibody (anti-his antibody).

Week 8

1. Refresher on Michaelis-Menten kinetics and introduction to fluorogenic hydrolase substrates and microplate assay for kinetic measurements (30 minutes)
2. Microplate kinetic analysis (150 minutes)
    - Analysis of kinetic activity of their two protein variants in comparison to the wild-type protein.
3. Groups turn in 2 page outlines of their independent projects with sections for main hypothesis, significance, methods, and necessary reagents (30 minutes)

Week 9

1. Introduction to analysis of Week 8 kinetic results and Week 7 thermal stability measurements (30 minutes).
    - Students analyze their protein biochemistry results from Weeks 5-9 and work as a class to understand effects of their amino acid substitutions on structure and function of the serine hydrolase.
2. Analysis of kinetic results (60 minutes)
    - Construction of standard curve, calculating initial velocities, fitting to Michaelis-Menten equation, and extracting kinetic constants.
3. Personal discussions with each independent project group about their project outline and refinement of their final project goals and methods (30 minutes)
4. Discussion about protein biochemistry results from Weeks 5-9 for lab report 2 (30 minutes)

Week 10-13
Phase II projects. Groups work autonomously on approved independent projects, coming to seek help from the instructor as needed.

Week 14
Groups submit drafts and give presentations of their scientific posters covering their independent projects. Peer and instructor feedback is given prior to submission of the final poster and presentation at the joint Chemistry-Biology poster session on the last day of classes.

NEURO Weekly Lab Schedule

Week 1

1. Introduction to lab and goals (10 minutes)
2. Assessments (25 minutes) – CURE and Experimental Design questions
3. Project Overview and timeline (60 minutes) – with Powerpoint slides
4. Lab safety (10 minutes) - Quiz at end of presentation
5. Worm Introduction; Viewing wild type and mutants (20 minutes) – Worm information quiz in 1 week
6. Practice picking worms (45 minutes) – Picking quiz in 2 weeks

Week 2

1. Worm Biology Quiz – Part I (10 minutes)
2. Discussion of RNAi review paper (Conte and Mello 2004) and project recap (20 minutes)
3. Intro to gene/protein databases (30 minutes)
    - WormBase & WormBook (These are two most accessible databases for the students to gather information on their genes' functions, potential homologies, etc.), NCBI/BLAST, PubMed, Allen Brain Atlas (mammalian homolog expression in brain), Mouse Expression Database, Human Protein Atlas.
    - Students also download Excel Files with the Ahringer and Vidal lab feeding RNAi library clones from Source Bioscience and Open Biosystems to look for availability of their clones.
4. Group assignments (5 minutes)
    - Instructor assigned groups to ensure spread of students with different background and expertise among different groups (Students filled out questionnaire at start of semester)
5. Selection of candidate ubiquitin ligase genes – Group work (60 minutes)
    - Each group received a list of 25 ubiquitin ligase genes that they had to narrow to 10 genes (plus two alternates). Student groups used databases to narrow list of candidate genes based on homology to human genes, nervous system expression, disease relevance or other criteria of interest to them.
6. Lab notebook training (10 minutes)
    - Each group has lab notebook to keep. Verbal and written instructions and samples provided.
7. Worm picking/practice for next week's quiz (40 minutes)
    - *nuIs152; nre-1lin15* RNAi sensitized worms expression *Punc-129::SNB-1::GFP* transgene to label synaptic vesicles in a subset of cholinergic motor neurons

Week 3

1. Hand back worm quizzes and ubiquitin ligase gene lists with final clone list. (10 minutes)
    - Clones obtained from the *C. elegans* RNAi feeding libraries (Open Biosystems, Source Bioscience) in collaboration with Dr. Richard Nass (Indiana University School of Medicine).
2. Kamath et al 2000 RNAi feeding protocol paper discussion (30 minutes)
    - Reading questions completed in advance by students
3. RNAi protocol introduction (90 minutes – done simultaneously with the Worm picking quiz below)
    - General overview protocol provided by instructor along with the information from the Kamath paper.
    - Groups devise timeline and quantities of materials needed, including positive and negative controls that are discussed with the instructor.
4. Worm picking quiz (90 minutes – done simultaneously with the Worm picking quiz below)
    - Students taken in pairs to identify and correctly transfer worms of different stages
5. Worm picking for next week (30 minutes)

Week 4

1. Writing workshop (30 minutes)
    - Sun et al (2013) paper is discussed in journal club style in lecture portion of course.
    - Students submit outlines of the Introduction section; these are discussed in conjunction with other scientific writing tips
2. Sterile technique/ RNAi plate and culture prep demonstration (20 minutes)
3. RNAi plate and culture preparation (two groups) (60 minutes); then switch groups

4. Slide preparation and fluorescent microscopy training (two groups) (60 minutes); then switch groups

*Students come in briefly outside of lab time to spot bacteria onto RNAi plates (day after scheduled lab meeting), to pick worms onto RNAi plates (2-3 days after lab), and to maintain worm strains.

Weeks 5-7

Group RNAi screening – round 1 (each group screens ~1/3 of their 10 genes)

- Two groups begin with RNAi screening on fluorescent microscopes (1.5 hours), while two groups pick worms for maintenance and prepare RNAi cultures and plates for next week.
- Groups switch roles (1.5 hours)

Week 5: Students individually submit a Project Overview, which is a summary of the research questions, model system, and project approach in their own words, as well as an outline of the Introduction section for a scientific manuscript they will write on the phase I screening project. Students receive feedback on both documents prior to submitting the first drafts of their manuscript sections.

Week 6: Students submit drafts of Introduction and Materials & Methods sections of their screen manuscript, on which they receive instructor feedback.

*Students come in briefly outside of lab time to spot bacteria onto RNAi plates (day after scheduled lab meeting), to pick worms onto RNAi plates (2-3 days after lab), and to maintain worm strains.

Week 8

Group RNAi screening – round 2 (each group rescreens candidates with interesting round 1 phenotypes)

- Two groups begin with RNAi screening on fluorescent microscopes (1.5 hours), while other two groups discuss results and consider ideas for phase II. Groups switch roles (1.5 hours)

Students submit drafts of the Results and Discussion sections of their manuscript and receive instructor feedback.

Week 9

1. Research Meeting Mini-presentations (2 hours)
   - Each group submits a draft of a Project Plan for phase II in grant-style format.
   - Each group gives an informal Powerpoint presentation (10-15 minutes) describing the background, rationale, hypothesis, methodologies, expected results and potential problems for their proposed project on which they receive feedback.
2. Worm picking to begin projects (20 minutes)

Week 10

1. Final research project plans are submitted and final modifications to protocols made. (30 minutes)
2. RNAi cultures and plates prepared and worms picked (90 minutes)
3. Groups practice with new assays (behaviors, new imaging approaches, etc) (30-60 minutes)

*Students come in briefly outside of lab time to spot bacteria onto RNAi plates (day after scheduled lab meeting), to pick worms onto RNAi plates (2-3 days after lab), and to maintain worm strains.

Week 11-13

Phase II group experiments. Each week, groups must perform experiments and prepare RNAi plates and cultures and pick worms for the following week.

Week 11: Students submit final full draft of their phase I screen manuscript.

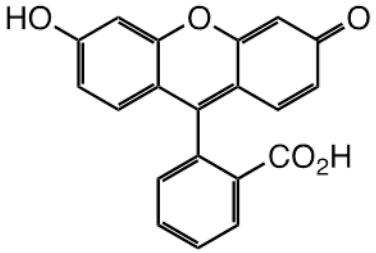
*Students come in briefly outside of lab time to spot bacteria onto RNAi plates (day after scheduled lab meeting), to pick worms onto RNAi plates (2-3 days after lab), and to maintain worm strains.

Week 14

Groups submit drafts and give presentations of their scientific posters covering both phase I and II of project. Peer and instructor feedback is given prior to submission of the final poster and presentation at the joint Chemistry-Biology poster session on the last day of classes.

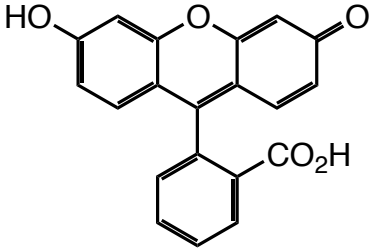
*Lab notebooks were assessed and group member peer evaluations were solicited at two points in the semester. Feedback was provided on notebook content; peer evaluations were used to ensure appropriate group dynamics.

Pre- and Post-Course Scientific Reasoning Questions. Each student response was graded on a 4-point scale. Detailed evaluation rubrics for these scales are available upon request.

CHEMBIO Q1	How would you go about modifying the compound shown below so that it would bind more tightly to a hydrophobic binding pocket, be cell permeable, yet still remain water soluble? 
CHEMBIO Q2	In synthesizing latent fluorophores, two acyloxymethyl ether bonds are attached to the two phenolic oxygens on fluorescein. However, the reaction also yields significant side products, including the formation of ester bonds at the two phenolic oxygens. Explain a experiment that you could use to differentiate the correct di(acyloxymethyl ether) fluorescein product from ester by-products.
BIOCHEM Q1	How would you go about evaluating the role of a particular amino acid residue in the catalysis of a chemical reaction by an enzyme?
BIOCHEM Q2	After site-directed mutagenesis, you transform a small aliquot of the reaction into chemically competent *Escherichia coli*, but you get zero bacterial colonies back after overnight growth on the plate. Propose two simple control experiments that you could have run alongside your experiment to determine why you did not get any bacterial colonies.
NEURO Q1	You identify an ubiquitin ligase enzyme that regulates the distribution of a particular fluorescently-tagged synaptic vesicle-associated protein in *C. elegans*. In worms lacking your ubiquitin ligase gene, there is a small, but reproducible decrease in the abundance of the fluorescent protein at synaptic sites compared to that seen in wild type animals. How could you experimentally determine whether the changes caused by loss of your enzyme impact nervous system function in these animals?
NEURO Q2	You perform a visual screen using RNA interference (RNAi) to examine the requirement for each member of a panel of ubiquitin ligase enzyme genes in controlling the distribution and abundance of a fluorescently labeled synaptic protein in *C. elegans* motor neurons. For a handful of the genes tested, inhibition with RNAi treatment causes a clear difference in the fluorescent protein as compared to wild type animals. However, for most of the genes there is no difference between RNAi-treated and untreated worms. Discuss two control experiments that you would need to perform to determine whether the effects (or the lack of effects) you observed are specifically due to knockdown of the individual genes you tested.

CHEMBIO Pre- and Post-Course Scientific Reasoning Questions ASSESSMENT RUBRIC

1. How would you go about modifying the compound shown below so that it would bind more tightly to a hydrophobic binding pocket, be cell permeable, yet still remain water soluble?



Scale: 0-4

1.5pts – The proposed structural change makes the molecule more hydrophobic.

Potential answers include:

- All groups should be primarily carbon chains, but would ideally contain some polar, even H-bonding, functional groups in order to retain water solubility
- Small cyclic rings and aromatic groups would also be reasonable
- Add acyl groups to the obviously phenolic OH
- Add an acyl group to the less obvious phenolic O (drawn as carbonyl above)
- Add an alkyl group to the phenolic oxygens
- Add an alkyl group to the carboxylic acid
- Cyclization of the carboxylic acid to a lactone

0.5pts – Proposed synthetic addition is likely to increase protein binding.

Potential answers include:

- Adds molecular weight to the structure
- Adds alkyl chains
- Adds acyl chains
- (Cyclization of the carboxylic acid to a lactone DOES NOT qualify)

1pt – The proposed structural change is chemically reasonable as a synthetic route.

Potential answers include:

- Acylation of the phenolic oxygens
- Add an alkyl group to the carboxylic acid
- Cyclization of the carboxylic acid to a lactone
- Friedel-Craft acylation or alkylation

- All groups should be primarily carbon chains, but would ideally contain some polar, even H-bonding, functional groups in order to retain water solubility

1pt – The proposed structural change is not too hydrophobic (limited to addition of 8 carbons OR contains a hydrophilic functional group to offset excess hydrophobicity) to maintain necessary water solubility

2. In synthesizing latent fluorophores, two acyloxymethyl ether bonds are attached to the two phenolic oxygens on fluorescein. However, the reaction also yields significant side products, including the formation of ester bonds at the two phenolic oxygens. Explain a experiment that you could use to differentiate the correct di(acyloxymethyl ether) fluorescein product from ester by-products.

Scale: 0-4pts

1pt – separation of products (chromatography)
Potential answer include
- Liquid (or "silica gel") chromatography
- Fraction collection
- Something about the solvents used for the separation

3pts – Characterization by NMR and IR spectroscopy, mass spectrometry, Thin layer chromatography (TLC)
- Classical organic chemistry approach:
  - Listing of techniques (up to one point each method, up to 3 pts total)
    - Potential answers include:
      - NMR
      - IR
      - Mass spectrometry
      - Thin layer chromatography
      - Chromatography with explanation of separation differences between products based on solvent conditions
  - Explaining what data from the technique would support the conclusion (up to 2 points)
    - Potential answers include:
      - Talking about comparing key peaks by NMR or IR
      - Discussing the different in mass by mass spectrometry
      - Comparing Rf values or relative mobility on the TLC

(thus all three points can be earned either by listing multiple techniques or by choosing one technique and explaining in detail how the expected data would support the structural identity)

OR

- Analytical biochemistry approach:
  - Characterize the chemical properties of the compounds
    - Potential answers include:
      - Study the difference in enzymatic or hydrolytic catalysis

- Characterize difference in spectroscopic properties
- Observe differences in stability by spectroscopy or heating

BIOCHEM Pre- and Post-Course Scientific Reasoning Questions ASSESSMENT RUBRIC

1. How would you go about evaluating the role of a particular amino acid residue in the catalysis of a chemical reaction by an enzyme?

Scale: 0-4

1.5pts – Mutation of amino acids

Potential details:

- Use site-directed mutagenesis to change the plasmid DNA coding for the residue of interest

0.5pt – overexpression, purification, confirmation of identity and purity

Potential details:

- Overexpress the variant enzyme in *E. coli*, purify from cell extract, and confirm identity/purity by SDS-PAGE. Confirm folding stability by differential scanning fluorimetry (or some similar experiment).

1pt – Analyze catalytic activity of the variant enzyme

Potential details:

- Use steady state kinetics to analyze the catalytic efficiency of the variant enzyme

0.5pt – COMPARE catalytic activity of the variant enzyme to that of the wild type

0.5 pt – Identify kinetic constants (k_{cat} & K_M) to allow for quantitative comparison to the wild-type enzyme

Potential details:

- If the amino acid residue in question was important to catalysis, then the catalytic efficiency of the variant enzyme (k_{cat}/K_M) should be significantly lower than that of the wild type enzyme

2. After site-directed mutagenesis, you transform a small aliquot of the reaction into chemically competent *Escherichia coli,* but you get zero bacterial colonies back after overnight growth on the plate. Propose two simple control experiments that you could have run alongside your experiment to determine why you did not get any bacterial colonies.

Scale: 0-4

2pts for EACH of the two answers:

1pt – valid experiment proposed

0.5pt – description of expected results

0.5pt – explanation of the scientific relevance of results (i.e. what the results indicate)

Valid Experiments Include:

- Plate the "transformed" bacteria on media containing no antibiotics:
  - There should be lots of bacterial growth. If no growth, the cells were likely not viable. If abundant growth, the cells were viable but either 1) transformation was unsuccessful or 2) the cells were not competent.
- Plate non-transformed bacteria on media containing no antibiotics:
  - There should be lots of bacterial growth. If no growth, the cells were not viable. If abundant growth, the cells were viable, indicating that transformation was unsuccessful in the original experiment
- Transform the competent *E. coli* with the parent plasmid, rather than the mutated clone (plating onto media containing antibiotic)
  - There should be observable, but limited, bacterial growth.
- Repeat entire site-directed mutagenesis procedure, using control primers and plasmid from the commercial Quikchange kit
  - There should be observable, but limited, bacterial growth.
- Transform a different strain of competent *E. coli*
- There should be observable, but limited, bacterial growth.

NEURO Pre- and Post-Course Scientific Reasoning Questions ASSESSMENT RUBRIC

1. You identify an ubiquitin ligase enzyme that regulates the distribution of a particular fluorescently-tagged synaptic vesicle-associated protein in *C. elegans*. In worms lacking your ubiquitin ligase gene, there is a small, but reproducible decrease in the abundance of the fluorescent protein at synaptic sites compared to that seen in wild type animals. How could you experimentally determine whether the changes caused by loss of your enzyme impact nervous system function in these animals?

Scale: 0-4

Experiment: Test mutant vs. wild type for effects on behavior associated with a particular synapse being investigated **OR** do electrophysiology (intracellular current recordings) to directly record transmission.

1pt – mutant vs. wild type (**0.5pt** for mutant only)
1pt – behavior or electrophysiology
1pt – to assess specific synapse function **OR** example/description of specific behavior assay
1pt – explanation of expected results based on comparison of test groups in behavior or recordings

2. You perform a visual screen using RNA interference (RNAi) to examine the requirement for each member of a panel of ubiquitin ligase enzyme genes in controlling the distribution and abundance of a fluorescently labeled synaptic protein in *C. elegans* motor neurons. For a handful of the genes tested, inhibition with RNAi treatment causes a clear difference in the fluorescent protein as compared to wild type animals. However, for most of the genes there is no difference between RNAi-treated and untreated worms. Discuss two control experiments that you would need to perform to determine whether the effects (or the lack of effects) you observed are specifically due to knockdown of the individual genes you tested.

Scale: 0-4
For positive results::
1pt - Need a negative control to be sure that the result is not just a non-specific effect of the knockdown procedure (correct explanation of this control is worth 1pt even without using "control" terminology)
(0.5pt) - If ONLY state the term negative control with no explanation of why a negative control is needed .

1pt - Compare animals with RNAi knocking down your gene of interest to animals treated with RNAi targeting an empty RNAi vector or a gene whose knock down you know will have no effect on the phenotype you are measuring **OR** do rescue experiment in which you express an RNAi-resistant version of the gene of interest in the knockdown animals and see if you can restore the phenotype to normal.

For negative results::
1pt - Need a positive control to be sure lack of effect isn't just because the RNAi did not work efficiently.
(0.5pt) - If ONLY state the term positive control with no explanation of why the control experiment is needed

1pt - Do RNAi targeting gene with known knockdown phenotype **OR** Do RT-PCR or Western blot to quantify amount of knockdown in wild type vs. knockdown animals for your gene of interest.

Poster Evaluation Rubric. 21-point scale.

Criteria	**3= Present and fully meets expectations**	**2 = Partially meets expectations**	**1 = Minimally addresses expectations**	**0 = Not present**
Poster contains the necessary sections (minimum of introduction, results, discussion/ conclusion, references)	All sections are included and labeled correctly	Most sections are included and labeled correctly	Some sections are present and labeled correctly	Majority of sections absent or unlabeled
The broad significance of the project to the field and its connection to the experiments is clearly stated	Significance of project to field and connection to experiments is stated clearly and completely	Broad significance to field is stated but connection to experiments somewhat unclear or incomplete	Broad significance to field is stated but connection to experiments is very unclear, mostly incomplete, or inaccurate	No statement of project significance
Poster contains a clearly defined statement of the problem, goal, and/or hypothesis	Hypothesis/goal/ problem is stated clearly and completely	Hypothesis/goal/ problem statement present, but is somewhat unclear or incomplete	Hypothesis/goal/ problem statement present but is very unclear, mostly incomplete, or inaccurate	No hypothesis/goal/ problem statement
Experiments are well-designed with appropriate controls and sample sizes/replicates.	Experiments contain all appropriate controls; appropriate sample sizes/replicates present or intended.	Experiments contain most controls and appropriate samples/replicates OR experiments contain all controls but too few samples/replicates	Experiments contain few/no controls and appropriate samples/replicates OR experiments contain some controls and inappropriate samples/replicates	No controls present and inappropriate sample sizes/ replication.
Data are presented in clear, well-labeled graphs, tables, or figures.	Data clearly presented in appropriate, well-labeled tables/figures.	Data are presented in tables/figures that are somewhat inaccurate or incomplete.	Data are presented in tables/figures that are largely inaccurate or incomplete.	No data presented in any format.
Conclusion concisely addresses the statement of the problem and/or hypothesis in light of the observed data/results.	Conclusion clearly addresses the problem/hypothesis in relation to results.	Conclusion mostly addresses problem/hypothesis in relation to results but is somewhat unclear, incomplete, or inaccurate.	Conclusions are stated but relation to problem/ hypothesis is very unclear, incomplete, or inaccurate.	Conclusion statement is not present or has no relation to problem/ hypothesis.
Future directions are described and represent appropriate modifications and/or logical extensions of the work.	Future directions include appropriate modifications and/or extensions of the work.	Future directions include modifications and/or extensions of the work but are somewhat unclear, incomplete, or inaccurate.	Future directions are present but are very unclear, incomplete, or inaccurate.	Future directions are not stated.