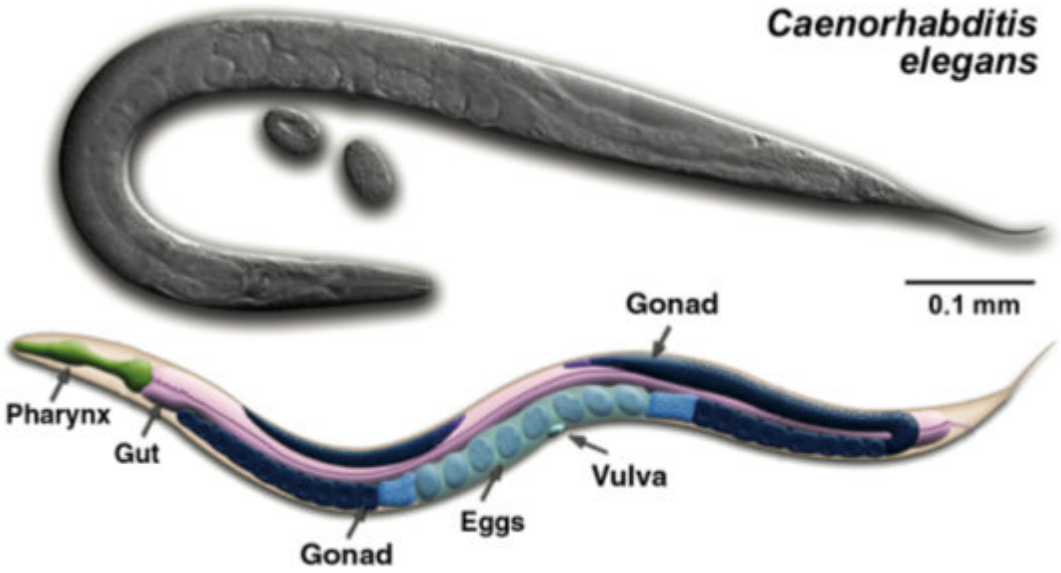
Undergraduate Research in Metabolism and Biochemistry
UAF BIOL 403 (4); CRN XXXXX

Course Syllabus



Studies of the cells and genes of the nematode *Caenorhabditis elegans* have become a cornerstone of current biology. Using this simple and malleable animal model, students will conduct their own biological investigations and, through this research learning, will gain an understanding of intermediary metabolism. Topics include major pathways of carbon, nitrogen, and lipid metabolism, structure and function of proteins, biological regulation and signaling, and longevity and aging.

1. Course Information:

Undergraduate Research in Metabolism and Biochemistry, BIOL 403 (4)
CRN: TBD
Meeting Times: MWF 1:00 – 2:00 pm, Murie Life Sciences Building
Wednesdays 2:15 – 5:15 pm
Prerequisites: BIOL 3XX; CHEM 105X; 106X.

2. Instructing Staff:

Barbara E Taylor, Ph.D., Associate Professor of Biology (Neurophysiology)

Office:	Murie Life Sciences Building Room 113D
Research Lab:	Murie Life Sciences Building Room
Phone:	474-2487 (office)
E-mail:	betaylor@alaska.edu
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Teaching Assistant, graduate student in biology

Office:	Murie Life Sciences Building Room
Phone:	
E-mail:	astudent@alaska.edu
Office hours:	TBA

3. Course Readings/Materials:

ResourceText: ***Lehninger Principles of Biochemistry, Fifth Edition,*** David L. Nelson, Michael M. Cox, W. H. Freeman, 2008, ISBN 978-0-7067-7108-1.
A reserve copy is available in the BioSciences Library.
ResourceText: ***Functional Metabolism: Regulation and Adaptation,*** Kenneth B. Story, Editor, Wiley, 2004, ISBN: 978-0-471-41090-4
A reserve copy is available in the BioSciences Library.
Resource Website: ***WormBook: the online review of Caenorhabditis elegans biology***
http://www.wormbook.org/

Blackboard Page: Students are expected to check the course webpage on **Blackboard** on a regular basis.
Login at http://classes.uaf.edu/webapps/login
Contact us by email if you are unable to access this site.

Email Notifications: On occasion, students will be contacted via email. We will assume that each student will check their university-assigned email address (username@alaska.edu) on a regular basis.

4. Course Description:

Welcome to Undergraduate Research in Metabolism and Biochemistry. The UAF Catalogue describes the topic of this course as follows: Studies of the cells, genomics and proteomics of the nematode *Caenorhabditis elegans* have become a cornerstone of current biology. Using this simple and malleable animal model, students will conduct their own biological investigations and, through this research learning, will gain an understanding of intermediary metabolism. Topics include major pathways of carbon, nitrogen, and lipid metabolism, structure and function of proteins, biological regulation and signaling, and longevity and aging.

The goal of this course is to provide an understanding of metabolism by studying its major pathways, regulation, and molecular components. **This course is designed as a research encounter with metabolism and biochemistry for students that have taken introductory biology and chemistry courses. It will cover the fundamental facts and**

principles of metabolism and biochemistry, and it will give students an opportunity to investigate metabolism in a simple and genetically tractable animal model, the nematode *Caenorhabditis elegans*.

Biochemistry is the chemistry of living things. All living things have in common that they are adapted to survive, grow, and reproduce. To do this they must produce a variety of biomolecules using resources they acquire from their environment. In this course we will strive for an understanding of how living organisms convert resources they acquire from their environment into more of themselves.

Course Organization: The course will lead the student in a consideration of the foundations of metabolism and biochemistry, which integrate with the distinguishing features of living organisms. Living organisms have in common six distinguishing features

1. their chemical complexity and microscopic organization;
2. their systems for extracting and transforming energy;
3. the defined functions of their components and the regulated interactions among their components;
4. their mechanisms for sensing and responding to the environment;
5. their capacity for self-replication and self-assembly;
6. their capacity to change over time.

These common features will be explored through the cellular, physical, chemical, genetic and evolutionary foundations of metabolism and biochemistry as they occur in our model organism, *C elegans*. There are **3 central concepts** each divided into topics (readings will be posted on Blackboard). We will spend up to one class period on each topic. The first three weeks in lectures and laboratories, however, will introduce student to the basic biology and culture techniques for *C elegans* and by the third week of the semester students will have identified a research project and begun culturing worms for that project. Questions and discussion throughout the course lecture and laboratory periods are encouraged and this syllabus should be considered flexible. We will **begin with a general introduction** to the chemistry of biological molecules and then consider the central concepts in more detail. The central concepts associated with this course are:

1. structure and catalysis;
2. bioenergetics and metabolism;
3. information pathways.

Course Activities: Four credits are assigned because each week the students must attend 1600 minutes of lecture and participate in 1600 minutes of laboratory activity and a combined 2400 to 4800 minutes of research practicum and/or supervised research activity. The combined 4800 minutes of research practicum and/or supervised research activity will be scheduled according to the student's and supervisors' availability.

The following standards establish the minimum requirements for an academic unit of credit:

1. 800 minutes of lecture (plus 1600 minutes of study)
2. 1600 or 2400 minutes of laboratory (or studio or other similar activity)
3. 2400 - 4000 minutes of supervised practicum
4. 2400 - 4800 minutes of supervised scholarly activity

Given the above information the formula used for computing credit/contact hours is 800 minutes (13.3 hrs) per credit. This equates to approximately 1 hour of lecture per week for a normal 14 week semester. The number of minutes required for one credit of laboratory (1600 or 2400) depends on the amount of instruction given during the lab. For this biology lab the faculty member will interact with students and provides feedback throughout the laboratory period, thus 1600 minutes (2 hours/week/credit for a 14 week semester) is used. In this biology course, students will also engage in research practica and supervised research activity, which differ from lab instruction in that there is no structured daily educational exercises nor daily instructor evaluation, and a significant portion of the activity is not supervised by the instructor of record.

Practicum activity is embedded in BIOL403 are to be a hands-on supervised research experience done by a student as part of the biology capstone experience, an educational strategy to attain the educational objective of synthesizing biological knowledge acquired from multiple courses. A faculty member, the class instructor or another knowledgeable researcher, will supervise the work. The class instructor will establish the objectives and evaluation metrics, evaluate the

outcome and assigns a final grade. Credit for practicum activity requires a minimum of 2400 minutes of work (3 hours/week for 14 weeks) per credit in addition to the contract hours of the associated class.

Supervised research activity (a type of supervised scholarly activity) is also embedded in BIOL403. In these activities, the student meets with the instructor to discuss research design research methods and progress and data analysis and presentation, but the work itself is basically unsupervised. The class instructor approves the work activities and goals, evaluates the outcomes, and assigns the final grade. The student prepares a final written and oral report on the work performed. Credits for supervised research activities are awarded at a rate of 2400 minutes of work (3 hours/week for 14 weeks) per credit.

5. Course Goals:

The overall goal of this course is for the student to gain a fundamental working knowledge of metabolism and to appreciate the impact of this field on other areas of biology. Specific areas of student development include achieving an understanding of:

1. the relationship between the structure and function of biological molecules;
2. the balance of anabolism and catabolism in an organism's overall metabolism;
3. the intermolecular interactions between macromolecules and their ligands;
4. the dynamics and regulation of metabolic pathways.

These specific areas will be addressed with references to and examples from the research project being conducted by students enrolled in the course.

Expectations: Over the semester certain information will need to be understood in order to reach the goals set above. A list of this information includes:

1. general recognition and understanding of biological molecules;
2. basic elements of protein structure;
3. basic understanding of reactions in glycolysis, glycogen metabolism, citric acid cycle, beta-oxidation, and the electron transport chain;
4. methods of metabolic regulation.

These information topics will be addressed with references to and examples from the research project being conducted by students enrolled in the course.

6. Instructional Methods:

1. **Lecture and Discussion.** Lectures and discussions will focus on the basic concepts of metabolism, which will be addressed with references to and examples from the research project being conducted by students enrolled in the course. An important source for this information is written material. ***Lehninger Principles of Biochemistry, Fifth Edition*** (David L. Nelson, Michael M. Cox, W. H. Freeman, NY) and ***Functional Metabolism: Regulation and Adaptation (***Kenneth B. Story, Editor, Wiley) are optional textbooks. Assigned readings from these texts along with material from the online resource WormBook (www.wormbook.org) will be made accessible via the course Blackboard page. Primary research literature and review articles will also be made available on Blackboard to support the topics covered in the lectures as well as the student research projects.
   You are expected to complete the assigned readings, to attend the lectures, and take part in class exercises. The readings and the lectures together define the **material covered in the exams.**

2. **Term Assignment – The Research Project.** Students will work individually or in teams of two on a research project of their own choosing and design. These research projects will meet the biology program requirements for a capstone project; these requirements are listed at the end of this syllabus. Research topics can be inspired by any sub-discipline of biology, but each project must be approved by the course instructors, who will ensure the feasibility of each project. Research topics and experimental designs are due in the third scheduled laboratory period. For the remainder of the semester, students will work on their research projects during the scheduled laboratory periods, where they will learn and perform specific biochemical and metabolic assays on the worms as well as during

practicum and supervised research times they schedule themselves. Students are expected to schedule about 6 hours per week to work on their research project. Students are to record these times and the activities performed in a designated research notebook and have their efforts witnessed by a research supervisor. Students cannot work in the laboratory unsupervised. A list of supervisors (the instructor, TA and perhaps other appropriately trained individuals) and their scheduled presence in the laboratory will be posted at the beginning of the semester and updated weekly. The list will also include contact information for each supervisor so that students can make arrangements for additional time in the laboratory if necessary. During the scheduled laboratory periods for the last 10 weeks of the semester, in addition to performing specific assays on the worms (biochemical and metabolic or other physiological assays as listed in the Table of Laboratory Activities and Course Assignments), and thereby acquiring data for their projects, students will be graded on assignments/activities designed to aid students in conducting and completing their research projects. These assignments are listed in the Table of Laboratory Activities and Course Assignments.

Table of Laboratory Activities and Course Assignments

Week #	Laboratory Activity*	Course Assignment
1 (Sept. 6)	observation and manual manipulation of worms	
2 (Sept 13)	preparation of worm culturing plates	
3 (Sept. 20)	fluorescent imaging of live worms	written summary of worm culture techniques
4 (Sept. 27)	mechanosensory assay	written summary of experimental methods
5 (Oct. 3)	locomotory assay	preliminary of data presentation
6 (Oct. 10)	mitochondrial functional assay and imaging	written description of background and potential significance of the research project
7 (Oct. 17)	protein aggregate assay	peer feedback on background and significance
8 (Oct. 24)	oxidative stress assay	full outline of research report
9 (Oct. 31)	RNA interference assay	data blitz – presentation of data collected to date
10 (Nov. 7)	hypoxic stress assay	draft of results section of research report
11 (Nov. 14)	hypercapnic stress assay	complete draft of research report
12 (Nov. 21)	thermal stress assay	peer feedback on research reports
13 (Nov. 28)	antioxidant assay	final draft of research report
14 (Dec. 5)	Reactive Oxygen species (ROS) assay	

* the order of these laboratory assays will be adjusted to match the order in which students will use them in their projects

In keeping with its writing-intensive designator, Undergraduate Research in Metabolism and Biochemistry requires students to engage in numerous writing activities throughout the semesters. Writing-intensive elements are indicated by their corresponding letter: A) a majority of the final grade is derived from writing activities; B) a research paper/project; C) a personal conference with the student; D) drafts/revisions/feedback. The instructors (professor and TA) will regularly evaluate students' writing and inform students of their progress (writing-intensive element D). The major written project (research project; writing intensive element B) that is part of the course is supervised in stages over the last ten weeks of the semester as seen in the schedule above. In addition, each student will have at least one personal conference (writing-intensive element C) with the instructors writing intensive element , which will be devoted to the student's writing, and draft components of the research report will receive evaluation from the instructors and other students in the course (writing-intensive element D). Also, note that written materials comprise a majority (> 60%) of the graded work in the course (writing-intensive element A). This "written material" consists of exams with short answers, draft written components of the research report that are submitted during the semester (in weeks 3,4,6,10 and 11; 5 written assignments each worth 3% or together worth 15% of the final grade), and the complete research report submitted at the end of the semester and worth 45% of the final grade. Note that the week 3 writing assignment “written summary of worm culture techniques” will serve as a diagnostic assignment to assess the students’ writing competency and determine what if any additional

resources might be made available to the students' to ensure success in scientific writing. The rubric that the instructors will use to grade the term assignment (= research or capstone project) is included as the last page of this syllabus.

Blackboard Page. Several learning resources will be available on the course Blackboard Page:

- **a.** A copy of the lecture slides will be posted just prior to class.
- **b.** A manual for *C elegans* culture in the UAF laboratory will be posted.
- **c.** Answers to the exam questions will be posted on Blackboard after the exams have been completed and graded.
- d. The course Blackboard Page will contain links to other instructional and informative pages on biochemistry. Some of these will include practice quizzes and short movie clips, which are especially good learning aids.
- **e.** A copy of this syllabus and the course calendar will be posted separately on Blackboard.

3. **Exams.** There will one midterm exam during the semester. It will test your knowledge of the lecture subjects to the depth covered in the readings. You must complete the readings to be fully prepared for the midterm exam. The midterm exam will consist of multiple choice and short answer questions and will count toward 10% of the final grade. Do not miss the scheduled exam time! If you miss the exam, your ONLY opportunity for a make-up exam will be the first lecture period following the exam.

4. **Final Exam.** The final exam will be held **Saturday, December 15 from 10:00 AM – noon.** The final exam will be a cumulative test of your knowledge of metabolism to the depth covered in the readings. The exam will consist of multiple choice and short answer questions. It will count toward 15% of the final grade.

7. Course Policies

As a UAF student, you are subject to the Student Code of Conduct. In accordance with Board of Regents' Policy 09.02.01, UAF will maintain an academic environment in which the freedom to teach, conduct research, learn, and administer the university is protected. Students will enjoy maximum benefit from this environment by accepting responsibilities commensurate with their role in the academic community. The principles of the Code are designed to facilitate communication, foster academic integrity, and defend freedoms of inquiry, discussion, and expression among members of the university community. You should become familiar with campus policies and regulations as published in the student handbook.

UAF requires students to conduct themselves honestly and responsibly, and to respect the rights of others. Conduct that unreasonably interferes with the learning environment or that violates the rights of others is prohibited. Students and student organizations will be responsible for ensuring that they and their guests comply with the Code while on property owned or controlled by the university or at activities authorized by the university.

Disciplinary action may be initiated by the university and disciplinary sanctions imposed against any student or student organization found responsible for committing, attempting to commit, or intentionally assisting in the commission of any of the following prohibited forms of conduct:

A. cheating, plagiarism, or other forms of academic dishonesty;
B. forgery, falsification, alteration, or misuse of documents, funds, or property;
C. damage or destruction of property;
D. theft of property or services;
E. harassment;
F. endangerment, assault, or infliction of physical harm;
G. disruptive or obstructive actions;
H. misuse of firearms, explosives, weapons, dangerous devices, or dangerous chemicals;
I. failure to comply with university directives;
J. misuse of alcohol or other intoxicants or drugs;

K. violation of published university policies, regulations, rules, or procedures; or
L. any other actions that result in unreasonable interference with the learning environment or the rights of others.

This list is not intended to define prohibited conduct in exhaustive terms, but rather to set forth examples to serve as guidelines for acceptable and unacceptable behavior.

Honesty is a primary responsibility of you and every other UAF student. The following are common guidelines regarding academic integrity:

1. Students will not collaborate on any quizzes or exams that will contribute to their grade in a course, unless permission is granted by the instructor of the course. Only those materials permitted by the instructor may be used to assist in quizzes and exams.
2. Students will not represent the work of others as their own. A student will attribute the source of information not original with himself or herself (direct quotes or paraphrases) in compositions, theses and other reports.
3. No work submitted for one course may be submitted for credit in another course without the explicit approval of both instructors.

Alleged violations of the Code of Conduct will be reviewed in accordance with procedures specified in regent's policy, university regulations and UAF rules and procedures. For additional information and details about the Student Code of Conduct, contact the Dean of Student Services or web www.alaska.edu/bor/ or refer to the student handbook that is printed in the back of the class schedule for each semester. Students are encouraged to review the entire code.

A Few Words on Plagiarism: In general, DO NOT present someone else's ideas or data as your own: you are expected and required to give credit where credit is due. Plagiarism is a violation of the law and may lead to serious repercussions! Please follow the following guidelines: for any written assignments, if you use someone else's ideas, data, or other information, write it in <u>your own</u> words and include the reference in parentheses directly following that information. <u>Avoid</u> copying someone else's text. If, however, you feel you have to include an exact copy of that text, put it in quotation marks followed by the reference in parentheses. Of course, include all cited references in the Literature Cited section. During oral presentations, please acknowledge the sources by mentioning their name(s) and year of publication or by printing them on overheads, slides, or handouts. Also be aware that you need to cite earlier work by yourself. Any substantial use of any written or other materials that was used for another course or that was generated in any other circumstances will not be accepted for credit in this course. Only minor contributions from earlier work with appropriate citation(s) will be accepted.

8. Evaluation

The final grade will be based on the average of all assignment marks according to the following fixed scale:

	Required Component	% value of final grade
1.	Lecture Exam (1)	**10%**
2.	Laboratory Research (weekly assignments and activities)	**30%** (3% each assignment/activity; assignments/activities are done one per week for the last 10 weeks of the course; half these assignments require a written product and contribute 15% of the final grade))
3.	Term Assignment	**45%**
4.	Final Exam	**15%**
Total		**100%**

The class will be graded on a straight percentage basis: 90-100% is an A, 80-89.9% is a B, 70-79.9% is a C, 60-69.9% is a D, and < 60% is an F. We will not grade on a curve. This means that, in principle, it will be possible for everyone to get an A in this course.

Missed exams and presentations:
Times for exams and presentations are designated well in advance. Completion of these tasks at the designated time will be the responsibility of the student. Accommodations will only be made for legitimate and documented contingencies.

9. Disabilities Services

At UAF, the Office of Disability Services implements the Americans with Disabilities Act (ADA), and insures that UAF students have equal access to the campus and course materials. We will work with the Office of Disabilities Services (fydso@uaf.edu, 474-5655) to provide reasonable accommodation to students with disabilities.

10. Course Calendar (subject to change)

Undergraduate Research in Metabolism and Biochemistry **Biology 403 Fall 2013**

Section I. *C elegans* a model for biological research

1.	Sept. 5	Class introduction	
2.	Sept. 12	*C elegans* biology	Ecology of *Caenorhabditis* species, Kiontke et al 14pp Intermediary metabolism, Braeckman et al 24pp
3.	Sept. 19	Trends in *C elegans* research	Three recent reviews will be selected and pdfs posted on Blackboard

Section II. Molecular properties of biomolecules

4.	Sept. 26	Amino acids, protein structure	*Lehninger Principles of Biochemistry* p71-147
5.	Oct. 3	Carbohydrates and lipids	*Lehninger Principles of Biochemistry* p235-263; 343-362
6.	Oct. 10	Biosignaling	Signal transduction - Iva Greenwald, ed. WormBook pdf Introduction to signal transduction - Iva Greenwald WormBook pdf Genomic overview of protein kinases - Gerard Manning WormBook pdf RTKRas/MAP kinase signaling - Meera V. Sundaram WormBook pdf Heterotrimeric G proteins in C. elegans - Carol Bastiani and Jane Mendel WormBook pdf
7.	Oct. 17	Bioregulation	

Section III. Intermediary Metabolism

8.	Oct. 24	**Exam**	**Exam includes all topics previously covered**
9.	Oct. 31	Glycolysis and gluconeogenesis	*Lehninger Principles of Biochemistry* p527-558
10.	Nov. 7	Citric acid cycle	*Lehninger Principles of Biochemistry* p615-637
11.	Nov. 14	Fatty acid oxidation and synthesis	*Lehninger Principles of Biochemistry* p647-668; 805-845
12.	Nov. 21	Amino acid oxidation and synthesis	*Lehninger Principles of Biochemistry* p673-700; 851-894
13.	Nov. 28	Oxidative phosphorylation	*Lehninger Principles of Biochemistry* p707-762

Section III. Metabolic Integration

14.	Dec. 5	Energy metabolism in health and disease	*Functional Metabolism* p243-262; Disease models and drug discovery - Andres V. Maricq and Steven McIntire, eds. WormBook pdf *C elegans* and volatile anesthetics - P.G. Morgan, E.-B. Kayser and M.M. Sedensky WormBook pdf Anthelmintic drugs - Lindy Holden-Dye and Robert J. Walker WormBook pdf Obesity and the Regulation of Fat Metabolism - Kaveh Ashrafi WormBook pdf
15.	Dec. 12	Oxygen in biology and metabolism	*Functional Metabolism* p319-369
	Dec. 15	**8:00AM - 10:00AM**	**COMPREHENSIVE FINAL EXAM**

Capstone Project in Biological Sciences

The intent of the Biological Sciences capstone project is to integrate a range of knowledge and skills learned in previous courses, including scientific knowledge, quantitative literacy, and communication skills, and to apply these products of the university education to a creative activity. For a biologist, a fundamental expression of applied knowledge, creativity, and critical reasoning is to engage in scientific inquiry.

The capstone project in Biological Sciences consists of mentored research project on a biological topic that is completed in the junior or senior year. The capstone project must be designed or chosen by the student in consultation with a faculty mentor. The faculty mentor must approve the project before work begins. The project must include both evaluation of data and communication of the study intent, methods, results, interpretation, and conclusion in the form of a written paper. The capstone project requirement may be met in two ways, detailed below.

First, the student may pass, with C grade or better, a designated capstone course in Biological Sciences or Wildlife Biology and Conservation. Capstone courses are offered across a range of sub-disciplines within biology. A list of capstone courses in Biological Sciences can be found in the UAF catalog. All capstone courses include the expectation that the student will complete a biological research project. Typically, the capstone course instructor will introduce one or several model study systems and methodologies that will form the basis for the student's project. The course instructor will assist the student to design a study and analyze the results. The student will communicate the results of the project in a in a written report. Some capstone courses may require that students communicate their research findings in additional ways, such as in an oral report or poster presentation

Second, the student may satisfy the capstone requirement by conducting a research project with a faculty mentor, typically a member of the UAF Biology & Wildlife faculty. A student may receive course credits for the research project by enrolling in independent study (BIOL 397 or 497) or undergraduate biology research (BIOL 488 or URSA 488); however, course credits are not necessary for completion of the capstone project requirements. A more informal arrangement, in which the student performs and communicates a project under the supervision of a member of the Biology & Wildlife faculty may satisfy the capstone requirements as well. In either case, to satisfy the capstone requirement using a research project conducted outside a designated capstone course, the student must file a petition with the Biology & Wildlife department chair . The petition must include a memo by the student's faculty mentor confirming that the work was completed and a copy of the mentor's written assessment of the final paper, showing that the work was of satisfactory quality.

All capstone projects will be assessed using a common set of expectations. The rubric used by mentors to grade capstone projects may be viewed here <link>.

Rubric for Undergraduate Research in Metabolism and Biochemistry Capstone Project

Final Evaluation of Capstone Project by Course Instructors (=Research Supervisor)

To be completed by student

Student's name _____ Date _____

Capstone Project Title _____

_____

Research Supervisor _____

To be completed by Research Supervisor

	Yes (excellent)	Somewhat (adequate)	No (inadequate)
1. Does the capstone paper represent the student's own scientific research?			
2. Does the capstone paper make a compelling argument for the significance of the student's research within the context of the current literature?			
3. Does the capstone paper clearly articulate the student's research goals?			
4. Are the methods appropriate given the student's research agenda?			
5. Is the data analysis appropriate and accurate?			
6. Does the thesis skillfully interpret the results?			
7. Are the tables and figures clear, effective and informative?			
8. Is there a compelling discussion of the implications of findings?			
9. Is the literature review appropriate and complete?			
10. Are the citations presented consistently and professionally throughout the text and in the list of works cited?			
11. Is the writing appropriate for the target audience?			
12. Is the paper clearly communicated and free of language errors?			