

SYLLABUS- INTRODUCTORY CELL BIOLOGY LABORATORY, LIFE 212-FALL 2022

COURSE INFORMATION

Instructor: Dr. FARIDA SAFADI-CHAMBERLAIN

E-MAIL: FSAFADI@COLOSTATE.EDU

(970) 491-1771

OFFICE: YATES 314

OFFICE HOURS: WED AND FRIDAY 1-2 PM,
IN PERSON, BY EMAIL, ONLINE OR BY APPOINTMENT.

Emails will be answered within 36 hours

WEEKLY RECITATION: Monday, 4:00 pm to 4:50 pm *FACE-TO-FACE* ROOM: BIO136

LAB SECTIONS: SEE CANVAS FOR GTA OFFICE HOURS

Section	GTA's emails	Day and Time	LAB ROOMS
L01 (CRN 69458)	Ryan Coops Ryan.Coops@colostate.edu	Tues 9:00 - 11:50 AM	Yates 309
L02 (CRN 66591)	Bridget Doe Bridget.Doe@colostate.edu	Tues 9:00 - 11:50 AM	Yates 311
L03 (CRN 66593)	Randy Grant Randy.Grant@colostate.edu	Tues 2:00 - 4:50 PM	Yates 309
L04 (CRN 66592)	Melea Barahona Melea.Barahona@colostate.edu	Tues 2:00 - 4:50 PM	Yates 311
L05 (CRN 69179)	Victoria Talbott victoria.talbott@rams.colostate.edu	Tues 2:00 - 4:50 PM	Yates 316

COURSE DESCRIPTION

Why do you need to take this lab? Whether you are a Biochemistry, a biomedical science, or neuroscience major, you will be in labs in almost every course throughout your 4-year schooling. This course will teach you the basic techniques that will make you comfortable and confident going into your labs; from using the pipettes in measuring accurate volumes, to calculating and preparing your solution concentrations accurately, to understanding enzymes and their roles in cells and health, to using a simple, fluorescence or laser guided microscopes to see cell parts, you will be confident in your labs, in your senior research projects, internships and your future careers. You will have the hands-on laboratory skills used in modern cell biology research labs and you will learn the science behind the experiments. You will learn how to design and execute an experiment, collect, record, and interpret the data through critical thinking, and then communicate your results through scientific writing. You will not only appreciate these skills when you go into the real world, but you will understand the science that revolves around medicine, health, medical lab results and vaccines.

The Lab exercises cover the following topics distributed over 12 weeks:

- Calculating concentrations and Preparing solutions
- Enzyme kinetics (3 modules)
- Protein characterization and quantitation
- Types and proper use of microscopes
- Cell fractionation
- Cellular Metabolic pathways: Photosynthesis and respiration
- Immunoassays
- Fluorescence microscopy
- 3-D structures of Proteins

The course materials align with the goals, priorities and missions of the College of Natural Sciences and The Department of Biochemistry and Molecular Biology for excellence in Undergraduate Education.

COURSE GOALS

Upon completion of this course, you will be able to:

- Master basic computational chemistry and units of measurements
- Recognize the importance of accuracy and precision of lab instrumentation.
- Use the UV/visible spectrophotometry in the study of protein and solute concentrations.
- Purify enzymes and study enzyme kinetics.
- Analyze proteins through protein gel electrophoresis
- Conceptualize and practice immunoassays to detect antigens or antibodies in organisms or tissues.
- Acquire hands-on skills in light and fluorescence microscopy to study cell ultrastructure and function.
- Describe the metabolic pathways of respiration and photosynthesis.
- Use vital dyes, cell counting grids and microscopes to assess viability of cells
- Practice technical writing through lab reports and a science-journal-format term paper
- Utilize online tools to understand and analyze the 3-D structures of proteins. Textbook:

LABORATORY MANUAL

The Lab manual is available for purchase at the CSU bookstore or Kendall Hunt Publishing CO. ISBN: 9798765708057. "Safadi-Chamberlain, Farida. (2020). "Cell Biology Laboratory Manual" (Fifth Edition). Kendal Hunt Publishing Company. Dubuque, IA. Your purchase entitles you to the print and digital formats of the manual. Lab Exercises and downloadable Reports are compiled in this manual. For support with the digital version, you can email websupport@greatriverlearning.com to let Kendall Hunt know of any issues you are having.

LABORATORY NOTEBOOK

A physical lab notebook is packaged with the lab manual. Use the notebook for your lab writeups as specified in the addendum. The notebook writeups are checked weekly by the TAs and graded thoroughly twice a semester by the GTAs. More details in the Course Organization, Teaching Methods/Assignments section.

TENTATIVE SCHEDULE-FALL 2022

Week of	LECTURE AND LABORATORY	Learning Objective	Resources
Aug 22 1	RECITATION: Introduction to Concentrations of Solutions, Units of measurement, Accuracy and Precision of lab instruments Exercise: Concentrations of Solutions, Accuracy and Precision	Mastering Basic Lab techniques	Lab Manual, Report download, Videos, Lecture
Aug 29 2	Recitation: Introduction to Immunoassays Exercise: <u>E</u> nzyme <u>L</u> inked <u>I</u> mmunosorbent <u>A</u> ssay; ELISA	Immunology, testing for antibodies and antigens	Lab Manual, Lab session 10, Report dnload Videos, Lecture
Sept 5 3	Cancelled, Labor Day Holiday: RECITATION: Introduction to Spectrophotometry and Enzyme Kinetics Exercise: ENZYMES I: Partial Purification of Tyrosinase Enzyme from Potato Tubers, Enzyme Reaction	Enzyme Kinetics	Lab Manual, Report download, Videos, Lecture
Sept 12 4	Enzymes II: Effect of the Environment on Enzyme Kinetics Exercise: Effects of Enzyme Concentration, pH and Temperature on Tyrosinase Activity	Enzyme Kinetics	Lab Manual, Report download, Videos, Lecture
Sept 19 5	RECITATION: Enzymes III: Parameters of Enzyme Kinetics Exercise: ENZYMES III: Kinetic analysis of the Tyrosinase Enzyme: K_M and V_{MAX} , Enzyme inhibitor analysis	Enzyme Kinetics	Lab manual, Report download,
Sept 26 6	RECITATION: Characterization of Proteins: Determination of Protein Concentration; Protein Gel Electrophoresis Exercise: Gel Electrophoresis: Examining Tyrosinase by SDS PAGE Exercise: Determination of Protein Concentration: Bradford Assay	Protein detections and Quantitation methods	Lab manual,
Oct 3 7	Review/ assessment MIDTERM EXAM Notebooks DUE First term-paper Staged assignment due		Study Guides Library resources
Oct 10 8	RECITATION: The Microscope: Part 1: Types and Proper Use. Exercise: Compound Light Microscope: Types and Proper Use.	Cell structure and Function/the microscope	Lab manual, videos, and purple folders
Oct 17 9	TOPIC: Microscopy part 2: Cells of Living Organisms, Mini-test: covers lab 6 Exercise: Scale of Cellular and subcellular features; Imaging methods	Cell structure and Function/the microscope	Lab Manual, Report download.
Oct 24 10	RECITATION: Cell fractionation/cell metabolism. Mitochondria Isolation and Respiration Exercise: Qualitative Assay of Mitochondrial Respiration	Cell structure and Function/respiration	Lab manual, videos, Report download.
Oct 31 11	RECITATION: Photosynthesis: Light/Hill Reactions Exercise: Chloroplast Isolation and Quantitative Assay of Hill reaction	Cell structure and Function/photosynthesis	Lab manual, Report dnwld.
Nov 7 12	RECITATION: Introduction to Fluorescence Microscopy. Exercise: Immunofluorescence staining of Cells	Cell structure and Function/Fluorescence microscopy/immunology	Term Paper assignments
Nov 14 13	Viewing The Fluorescent cells Hemocytometer and Cell Viability Assay?	Cell structure and Function/cell viability	Term Paper assignments
Nov 21-27	Fall Recess: Fall Recess		
Nov 28 14	RECITATION: 3-D Protein Structure: PDB of tyrosinase or choose-your-enzyme Exercise: PDB of tyrosinase and exercise with questions to answer.	Protein Biochemistry	Posted lab exercise, videos, Staged assgnt ?
Dec 5 15	review week Lab notebook due (Review session TBD), Check out and evaluations		
Dec 12 16	Exam II , in Bio 136 Mon 11:50a-1:50p	Covers Labs 1 – 13	

TERM PAPER: FLUORESCENCE MICROSCOPY

STAGED ASSIGNMENT SCHEDULE

Introduction: The Fluorescence Microscopy experiment will be the subject of a Term Paper written in the format of a publishable scientific journal article. To help you with writing the paper, I broke the assignment down into stages as outlined in the table below. You will submit parts of the paper at various due dates starting in the second half of the semester. We will grade the submitted portions of the paper and give you feedback that you will incorporate into your final product. We hope that staging the paper will eliminate some of the stress of writing and help you learn from the feedback. Since the paper is assigned to a lab experiment that is conducted later in the semester, I will give you earlier reading assignments. I will also give you instructions and guidelines for writing a scientific paper. We will also go to the library during midterm week for instructions on searching the data base for articles on our topic. The CSU librarian and I will post resources on writing and database search on the LIFE 212 Library research Guide <http://libguides.colostate.edu/LIFE212/Safadi-Chamberlain>. The Rubric for the term paper will be on Canvas.

The table below outlines the scheduled paper assignments and their due dates.

Timelines for the assignments (40 points):

Date	week	Assignments/Due	Notes
August 22nd	First week of classes	Brief description of the staged paper assignment and deadlines	Assignment will be described briefly as an Addendum to the syllabus
October 3 rd	Midterm Week	Asst #1: Reading: FM and the paper guidelines. Take home quiz (10 pts) Library Instructions Literature search: One review and 3 research articles + Synopsis (8 pts)	Take home quiz: FM and the cytoskeleton
October 10 th	Week 8	Asst #2: Title and Author (3 pts) Due Asst #1: Take home quiz Due Asst #3: Lit search: One review and 3 research articles + Synopsis	Instructors will grade and give feedback
October 17 th	Week 9	Due: Asst #2: Title and Author Asst #4: Introduction (8 pts)	will grade and give feedback
October 24 th	Week10	Due Asst # 4: Introduction Asst #5: Materials and Methods (6 pts) Asst #6: Abstract without results (5pts)	will grade and give feedback
Oct 31st	Week 11	Due Asst # 5: Materials and Methods s Due Asst # 6: Abstract without results	will grade and give feedback
November 7 th	Week 12	Fluorescence Microscopy Lab practicum: Immunostaining	will grade and give feedback
November 14 th	Week 13	Fluorescence Microscopy Lab practical: Fluorescence image viewing, Questions on feedback	will return all graded assignments to students with feedback
November 28th	Week 15: after Thanksgiving	Paper due-online submission: Results and Discussion, Conclusion, and whole paper	will grade and give final feedback

ADDITIONAL RESOURCES

- **CANVAS online:** Additional exercises, instructions and supporting material will be posted online at <http://info.canvas.colostate.edu/login.aspx>. This will be the online educational platform that LIFE 212 instructor and TAs will use to communicate with students.
- **Graduate Teaching assistants (GTAs) and the instructor** hold **office hours** throughout the week, GTAs are an excellent resource for help; and I am always there for you, visit the office hours or schedule an appointment. We will be happy to assist you with any questions you may have.
- **PEER Educators:** Undergraduate TAs (UTAs, your peers who took the course last year) are available to facilitate experiments in the lab. UTAs are a valuable resource for you; they have been there not too long ago and will guide you through the lab. However, please realize that UTAs are still learning the subjects and are not the ultimate experts, for more complicated questions please ask the GTAs or the instructor.
- **CSU MORGAN LIBRARY:** You will need the library to find resources that will help you answer questions in the lab reports and for your term paper assignment. The library has dedicated a webpage for LIFE 212 at <http://libguides.colostate.edu/LIFE212/Safadi-Chamberlain>, a library staff member is available to help you with the assignments. Instructions on navigating the library databases will be presented.

COURSE ORGANIZATION, TEACHING METHODS AND ASSIGNMENTS

The exercises in this Laboratory course contain hands-on experiments supported by their background material. We emphasize the science behind the experiments and the technical reasons for using the steps and the reagents of the protocols. The curriculum is heavily supported by assignments to help all types of learners. To SUCCEED in this course, keep up with the assignments and be sure to understand the flow of the experiments and the reasons behind every step you do. Below are details of the course assignments.

RECITATION MONDAY: 4:00-4:50 PM (VARIABLE PARTICIPATION POINTS)

Every Monday at 4 pm we meet to discuss the week's experiment, questions from previous week, and potential changes to the week's plans. We introduce the topic's scientific background and the experiment's technical basis. We provide learning activities to help you understand the material and we engage you with Iclicker questions that count towards your participation grade. Come to the Recitation prepared, it will help you engage in the recitation discussion, you will do better on the quiz the next day, and finish lab earlier.

PRE-LAB PREPARATION/PRELAB WRITEUP (PLWG: 5 POINTS PER LAB):

Planning your experiments before you attend the lab helps you understand the experiment, finish labs on time and do well on the quizzes. For best preparation, complete the Pre-lab writeup in your notebook on Monday before recitation and as described in the addendum: "Lab Notebook Writeup specifics." Five points per lab will be assessed by the TAs for your weekly notebook Pre-Lab Writeup Grade (PLWG. **Use the following resources for your prelab-writeup:**

- 1) The current lab reading assignments from the manual; rephrase in your own wording, the introduction and the materials and methods in your notebook as described in the addendum.
- 2) Take advantage of some of the additional resources available on CANVAS in each lab Module such as:
 - Lecture slides
 - Pre-recorded past Lecture **Videos**
 - **Suggested Educational/you tube** videos that are relevant to the labs/assignments
 - Suggested references

QUIZZES (20 POINTS)

Weekly open notebook quizzes will be administered at the beginning of your lab session to assess your preparation for the Lab. Quizzes will cover the current week's pre-lab preparation and more comprehensive material from the previous lab. Quizzes will be cumulative; questions will be repeated from earlier labs to foster retention of the information. To do well on the quizzes, do your pre-lab writeups and weekly conclusions, read the background material, review the lecture slides, take good lecture notes, be sure to understand the protocol steps and ingredients, take good experimental observations and evaluate your results.

LABS: A three-hour lab time is reserved for you to run the experiments. Graduate Teaching Assistants (GTAs), aided by Undergraduate Teaching Assistants (UTAs), lead the instruction and supervision of lab experiments in the labs. You will conduct experiments using instrumentation and equipment found in a typical cell biology laboratory. The laboratory exercises do not necessarily follow closely the lecture material in LIFE 210. You are expected to fill the three-hour period by the experiments, plotting your data and answering the report questions.

EXAMS (3 EXAMS FOR A TOTAL OF 250 POINTS):

There will be Three exams: a midterm, a mini-test and a final exam. The midterm and the mini-test exams will be a combination of multiple choice and essay questions, the final exam will be comprehensive and composed of Multiple-Choice questions only.

LABORATORY REPORTS (50 TO 100 POINTS EACH)

You will fill a weekly lab report by recording your data, plotting graphs, and answering critical thinking questions. **We strongly encourage you to complete the report during the lab period.** You are encouraged to discuss the lab results and report questions with your peers and TAs, but you must write lab **reports independently**. Copied reports will be treated as cheating and will get a ZERO grade. Unless otherwise specified, Laboratory reports from the previous week will be due before recitation at 4 pm on Monday of the following week. **NO LATE REPORTS. 10 pts deduction per day for late reports.**

Lab Notebooks (200 points):

Use the physical notebooks for your weekly Lab writeups. Carefully follow the document on the specifics for writing in the lab notebooks in the addendum. A Lab notebook is a legal document in which authenticity of the research and research results are preserved, writing must be in ink to avoid erasing or result falsification, empty spots must be crossed out (Read the Instructions at the preface of the notebook).

LABORATORY COMPLETION GRADE (5 POINTS PER LAB):

Laboratory completion grade (LCG) applies 5 points per lab to assess students' participation in the lab experiment, accuracy in following experimental protocols and obtaining data, careful use of lab supplies and materials and tidiness of the bench at the end of the lab. Completing a good portion of the report in the lab is highly recommended and considered in grading. These points will be assessed at lab check out time.

CONCLUSION (3 POINTS PER LAB)

Follow the instructions in the addendum to write a conclusion for each lab in your notebook. TAs will check that you have completed your last lab's conclusion every week for 3 points.

RUBRICS: Rubrics for reports and other assignments are posted online to guide your homework. The reports will be graded online, and the feedback will be given as comments within the rubric.

GRADING

You are learning important skills for your professions; assessments tell me if I am achieving my goal in teaching you. The grade is a good motivating goal, but do not work solely for the grade, it is my hope that you value learning and have fun discovering something new. Letter grade scheme is as follows:

A+ $\geq 95.1\%$	A $90\% \geq \leq 95.1\%$	A- $89 \geq \leq 90$
B+ $85.1 \geq \leq 89$	B $80 \geq \leq 85.1$	B- $79 \geq \leq 80$
C $70 \geq \leq 79$	D $55 \geq \leq 70$	F = less than 55

POINT ALLOCATION:

Quizzes:	20 pts ea	total of 11 quizzes	220
Laboratory Reports	50-100 pts ea	total of 13 reports	710
Term paper	100 pts	one	100
Laboratory Notebook	100 pts ea	graded @ mid-term & final	200
Prelab Writeup Grade (PLWG)	5 pts per lab period	Total of 13	65
Lab Completion grade (LCG)	5 pts per lab period	Total of 13	65
Conclusion	3 points per lab	Total of 13	39
EXAMS	50-100 pts ea	Total of 3 Exams	250
Assignments	60 pts		60
Total			1,709

LAB POLICIES

CLASSROOM CLIMATE: My teaching method is based upon creating an engaging learning environment that is consistent with CSU's mission and vision of access, research, teaching, and service. A collaborative and vibrant community is a foundation for learning, critical inquiry, and discovery. In LIFE 212, I make every effort to create an inclusive community consisting of the instructor, students, and teaching assistants. Together we uphold [CSU Principles of Community](#) of **inclusion, integrity, respect, service, and social justice**.

UNIVERSAL DESIGN FOR LEARNING/ACCOMMODATION OF NEEDS

I am committed to the principle of universal learning. This means that our classroom, our virtual spaces, our practices, and our interactions will be as inclusive as possible. Mutual respect, civility, and the ability to listen and observe others carefully are crucial to universal learning.

Consistent with the university policy, the Student Disability Center (SDC) and the College of Natural Sciences (CNS), my teaching method is committed to provide ALL students with environments that support their learning. If you will need accommodations in this class, please contact me as soon as possible early in the semester to discuss your individual needs. Please note that the week-long Lab Report assignments allow ample time for completion, use all the resources available to you to complete the reports intime.

MISSING OR COMING LATE TO LABORATORY SESSIONS:

DO NOT MISS A LAB! Preparing a lab is a tremendous task for the instructor and the TAs. Labs take at least 3 hours to run and GTA schedules are too tight to make up a lab for one student. Therefore, missing lab activities **CANNOT BE MADE UP**; if you miss a lab your lab report grade will be **ZERO** and you are NOT allowed to use your partner results to submit a report. If you have a justifiable reason to miss a lab, arrange with your instructor (not the TA) **before** the lab session so you can attend another laboratory section. Come to lab on time, LATE arrival to the lab past 10 minutes will affect your Lab Completion Grade.

POST-LABORATORY CLEAN-UP

You are required to clean your bench area at the end of each lab session; dispose of experimental waste, dump ice, wash used glassware with hot water and detergent, and put away all assigned equipment. Before you leave, clean your bench with a disinfectant; sloppy clean-ups, or failure to comply with these instructions will affect your Lab Completion Grade (LCG).

STUDENT ACADEMIC MISCONDUCT

This course upholds [CSU policy of academic Integrity and student misconduct](#) as a part of the university mission in cultivating a community of responsible citizens. Course assignments therefore must be your individual work and cannot be copied from your partner in the lab. Acts of student misconduct are defined as: cheating, plagiarism, unauthorized possession or disposition of academic materials, falsification, or facilitation of acts of misconduct. We have zero tolerance for cheating, acts of academic misconduct are subject to disciplinary action by the instructor and the CSU Office of Conflict Resolution and Student Conduct Services. **A pledge of Honor** is required for to participate in this course

GROUP WORK

Group work is an opportunity for you to learn from one another. We encourage student-to-student engagement to promote deeper thinking and sharing of information, ideas and experiences among you and your classmates. Please respect each other's time, intellect, participation, and contribution to your discussion/assignment. Your learning experience lies within your participation in the critical thinking that goes in the assignment. We reserve the right to change any group individuals or partnership in which discrepancy in participation of the partners is observed and along with it changing the grade that is dependent on participation. **A Team's Pledge** is required for you to participate in this course

DISPUTING AN ASSIGNMENT GRADING

If you feel that the grading of an assignment is unfair, you may submit a written request to revise the grading. Submit your request to the main instructor: Dr. Safadi-Chamberlain: Include in your request your assignment, a clear explanation of your dispute reasons and include the following:

- 1) The question(s) in dispute clearly marked.
- 2) The reason of your dispute supported by lecture, manual (copied and attached), or video material (referenced clearly) that are related to the question. TA explanation must be documented in writing and signed by the TA in question.
- 3) If your dispute is based upon a comparison with your peer's assignment, include both assignments. Be aware that this will result in revising both assignments and possible deduction of points if the question was favorably graded to either one of the assignments

The instructor will discuss the question with you and reach an agreement that revolves around the proper understanding of the material.

Addendum:

Lab Notebook Writeup specifics

LABORATORY NOTEBOOKS¹

This will be your lab notebook to fill with the lab writeups as specified below and any additional details you need including lecture note if you wish to.

There are three Lab notebook assignments:

- 1) **WEEKLY PRE-LAB WRITE UP ASSIGNMENT (PLWG-5 PTS):** These are written according to the specific instructions below and by filling the corresponding headings in the lab notebook. You may make additional headings if you need to, but do not spend too much time copying details of the protocol, be concise but accurate, making flow charts to plan your experiment will gain you points. Notebooks will be checked weekly for pre-lab writeups by TAs.
- 2) **WEEKLY CONCLUSION (3 PTS):** write weekly conclusion for the previous lab according to the specific instructions below, these will be checked weekly by the TAs
- 3) **TOTAL LAB NOTEBOOK ASSIGNMENT (100 PTS EACH):** Lab notebooks will be collected and graded for all the labs twice in the semester, once with midterm and another before the final exam. Complete lab notebook with all the sections as outlined in the specific instructions below is required at this time.

SPECIFIC LAB NOTEBOOK INSTRUCTIONS: Follow these instructions for writing in your lab notebooks.

a) TABLE OF CONTENTS

Dedicate few pages at the start of your notebook for a table of contents. This includes the title and page of each experiment. Keep it up to date as you write in your notebook.

b) TITLE AND DATE

The title of each experiment needs to be descriptive yet concise. Record the date (and possibly what time, if applicable) the experiment was carried out.

c) PRE-LABORATORY WRITE-UP

Fill in BEFORE recitation on Monday and in your **own wording, NO COPYING directly from the manual. Include the following:**

- Introduction
- Materials and Methods.

Introduction: In your own wording write the following 4 points about each lab

1. the theory or background behind the experiment (not more than 2 to 3 sentences)
2. the question to be investigated based upon the background (one sentence)

¹ Note that in research labs, a notebook is a legal document to protect the authenticity of the lab research discoveries, and patents; nothing should be erased or obliterated. Mistakes are crossed out with a single line, so the original work is still visible, empty spaces in the notebook are crossed out. Online research notebooks that follow these rules are available in research labs.

3. hypothesis which includes the predicted results (one to two sentences maximum)
4. the objectives of the experiment (one to two sentences).

Materials and Methods: This section should be written **BEFORE** the lab period and then modified as needed during the conduction of the experiment. This should contain

- the materials and reagents,
- the equipment used
- the methods (protocol) that you will follow during lab

Methods are best charted as **flow Charts** of the protocol that you and others can easily follow.

d) LAB REPORTS/ RESULTS AND DISCUSSION:

This section is submitted online as a “**Report assignment**” for the purpose of grading in this course only. The results section contains lab observations, sketches of biological specimens, raw data, calculations, tables, and graphs that are generated from the data, and any other notes. In research labs the results/discussion section is usually a part of the notebook where raw data should go **directly** into the notebook for legal reasons such as patents.

Download the report form in a digital format, fill the report with your experimental data and answers to predesigned questions. Submit the report separately from the lab notebooks. **Reports are due at 4 pm before recitation on Mondays** unless stated otherwise by the instructor. Graded reports will be returned to you in the following week.

Graphs: You must use Excel (or a comparable software) to generate graphs. Hand drawn graphs on regular paper will not be gradable. Keep e-copies of your graphs.

e) CONCLUSION:

Conclusion form the previously completed lab will be checked by TAs during student check out from the Lab.

This section is written right after the experiment is completed or after you write your report and before you submit it for grading. The conclusion should include these 6 points:

1. Brief summary of the results of the experiment
2. Brief interpretation of the results
3. Significance of the findings
4. What you learned from this experiment
5. What would you or other scientists do **next**? Future directions based upon your results.
6. Answer the question: “did I achieve my objective/s?”

f) SIGNATURES

Instructor’s (or TA’s) signatures for signing in and out of the lab.