Biochemistry 3P03

Inquiry into Biomedical Research

Welcome to Biochemistry 3P03!

Introduction and Expectations:

In this course, students will be introduced to the concept of primary research design through the use of inquiry. Students will gain first-hand experience in devising their own research project. Students will be placed in Teams of 5-7, and each Team will be designated a Mentor.

This year the Teams will work closely with their Mentor to develop a research strategy for characterizing wild type and novel mutants of one of the protein targets specified below:

1. sIHF (SCO1480; *Streptomyces* integration host factor)
   reference:

   This novel protein’s function in chromosome organization is currently being discovered by Drs. Guarne and Elliot in our very own department. They both agreed to provide the Biochemistry teaching labs with the pMC155 plasmid (see table 1 of the reference above). Your task is to conduct small scale protein expression studies in the hopes of purifying wild type sIHF as well as novel mutants of this protein which will be created by you. You will need to download the structure of the protein and mutate select positive residues on the surface of the protein with the hopes of creating mutant proteins that can still fold properly but have lost certain aspects of DNA binding. This will help in understanding the mechanism of action of this protein.

2. DdrB (sequence will be provided for you)
   reference:

   This novel protein’s function in single-stranded DNA binding is currently being discovered by Dr. Murray Junop in our very own department. He agreed to provide the Biochemistry teaching labs with the pProEXHTA-ddrB plasmid (see A2L sequence files). Your task is to conduct small scale protein expression studies in the hopes of purifying wild type DdrB as well as novel mutants of this protein which will be created by you. The Junop lab has identified two regions in particular that appear to contribute to DdrB’s activity: a beta hairpin between beta-6 and beta-7 (residues 87-100) and a loop joining beta-7 and beta-8 (residues 105-125). Point mutants in these areas would be very useful for the Junop lab as they will use them to crystalize the mutant protein and assess DNA binding in an effort to fully understand the mechanism of action of DdrB. There is also an interest in having double point mutants in the following regions: R85A/K102A, R64A/W66A, R85A/W66A. The Junop lab would also be interested in the following DdrB point mutant: Y125S.
3. DHFR (Dihydrofolate Reductase, *E. coli* K12)

references:


This project will assist Dr. Felicia Vulcu in developing new DHFR mutants to be utilized by aspiring Biochemistry students in the Biochemistry 2L06 courses. The DHFR mutants created can be tested for drug resistance and used in screens for future drug design. The purified mutant DHFR proteins can also be crystallized in collaboration with Dr. Murray Junop. Furthermore, teams will have the opportunity to describe their research purpose to the current Biochemistry 2L06 cohort. Last year, Biochemistry 3P03 students successfully created 5 DHFR point mutants: I14M, W30R, M20L, M20V, H45R. These mutants are available in the pET28b backbone vector. However, more mutants need to be developed (they can be double or triple mutants) and the already created mutant DHFR genes need to be expressed and purified. Thus purification/crystallization conditions for these mutants are required.

Each team will choose one project and design a:
- Research hypothesis
- Flowchart describing experimental design
- Step-by-step procedural protocol
- List of reagents and equipment (for each protocol)
- Timeline outlining the experiments
- Division of labour to designate work for all team members

Throughout the course, students will gain an understanding of:
- experimental protocol
- experimental design
- analysis of results and troubleshooting
- verbal and written communication

As this is an inquiry course, proper collaboration and communication skills between Team members and Mentors is an imperative skill that should be exercised.

**Instructor:** Dr. Felicia Vulcu

**Email:** vulcuf@mcmaster.ca; office: HSC-4H43 (please enter through the Undergraduate Program Office: HSC 4H45)

Undergraduate Assistant – Meagan (biochemistryadvisor@mcmaster.ca), office: HSC-1H6, extension: 22495.

**Students that have specific questions regarding techniques or the underlying theories used should contact resources in THE FOLLOWING ORDER:**

1. Mentor
2. Meagan
3. Dr. Felicia Vulcu
Office hours: My door is always open for questions but I do prefer setting up an appointment by email. Please note, students are NOT allowed in the teaching labs after 1:00pm UNLESS the time corresponds to their scheduled course.

Labs: Monday and Tuesday 1:30-5:30 pm in HSC 1H1-8

SAFETY TRAINING REQUIREMENTS:

1. Fire Safety (update) – online (http://www.fhs.mcmaster.ca/safetyoffice/whmis_fire_update.html)
2. WHMIS (update) – online (http://www.fhs.mcmaster.ca/safetyoffice/whmis_fire_update.html)
3. BSL2 training (update) – online (http://www.mcmaster.ca/biosafety/biosafety_training_bsl_update.htm)
4. Site-specific training and lab safety walk-through (will be completed in lab by mentors)

ALL safety training MUST be completed PRIOR to the start of labs. This means that students must have completed ALL the training and handed in ALL quizzes to Meagan in HSC 1H6. You will not be allowed to attend your labs if you do not complete this safety training. You must PASS all safety training quizzes in order to continue in this course.

Evaluation Methods: Each team will be evaluated by their Mentor and the instructor throughout the term. The evaluation process will occur in the form of daily participation/ attendance/ preparation sheets to be completed by the Mentor (and sometimes the instructor), quizzes, and weekly reflections (that test preparedness throughout the term), reports (both team and individual) and presentations. The breakdown of marks is shown below:

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>MARK (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Participation and preparedness (individual)</td>
<td>10</td>
</tr>
<tr>
<td>2. Weekly order forms/ MSDS summary sheets (team)</td>
<td>10</td>
</tr>
<tr>
<td>3. Team contract (team)</td>
<td>1</td>
</tr>
<tr>
<td>4. Notebook (individual)</td>
<td>6</td>
</tr>
<tr>
<td>5. Quizzes (individual)</td>
<td>2</td>
</tr>
<tr>
<td>6. Proposal report (team)</td>
<td>10</td>
</tr>
<tr>
<td>7. Proposal review – includes handout (individual) and workshop (teams)</td>
<td>3</td>
</tr>
<tr>
<td>8. Weekly written communications (individual)</td>
<td>8</td>
</tr>
<tr>
<td>9. Short communications report (individual)</td>
<td>20</td>
</tr>
<tr>
<td>10. Proposal presentation (team)</td>
<td>10</td>
</tr>
<tr>
<td>11. Lab meeting (team)</td>
<td>10</td>
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<tr>
<td>12. Progress presentation (team)</td>
<td>10</td>
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### Course Calendar:

<table>
<thead>
<tr>
<th>DATE</th>
<th>DESCRIPTION</th>
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</table>
| **Sept 9 and Sept 10** | **Monday Sept 9**  
- Welcome  
- Lab safety walk-through and introduction to lab reference material (current lab protocols manual, books, etc.)  
- First lecture describing course setup/project  
- Division into TEAMS and introduction to TEAM MENTOR  
**Tuesday Sept 10**  
- Safety update by FHS Safety Representative  
- Work on research project |
| **Sept 16 and Sept 17** | **Monday Sept 16**  
- Work on research project  
*Team contract due*  
**Tuesday Sept 17**  
- Work on research project |
| **Sept 23 and Sept 24** | **Monday Sept 23**  
- Work on research project  
**Tuesday Sept 24**  
- Work on research project |
| **Sept 30 and Oct 1** | **Monday Sept 30**  
- **PROPOSAL PRESENTATION**  
  - Proposal report due  
  - Primer orders due  
**Tuesday Oct 1**  
- **PROPOSAL PRESENTATION**  
- Weekly order form 1 due to your mentor Wednesday Oct 2 |
| **Oct 7 and Oct 8** | **Monday Oct 7**  
- Proposal review workshop (discuss proposals)  
  - Proposal Review Handout due  
**Tuesday Oct 8**  
- Start of lab work (week 1) – prep solutions, media, buffers.  
- Confirm primer calculations and re-suspend primers  
- Weekly order form 2 due to your mentor Wednesday Oct 9 |
| **Oct 15 only (Oct 14 off)** | **Monday Oct 14**  
- THANKSGIVING therefore no labs  
**Tuesday Oct 15**  
- Lab work (week 1)  
- Weekly order form 3 due to your mentor Wednesday Oct 16  
  - Lab notebook carbon copies due |
| **Oct 21 and Oct 22** | **Monday Oct 21**  
- Lab work (week 2)  
  - Lab notebook carbon copies due  
**Tuesday Oct 22**  
- Lab work (week 2)  
- Weekly order form 4 due to your mentor Wednesday Oct 23  
  - Weekly written communications (1) due |
| **Oct 28 and Oct 29** | **Monday Oct 28**  
- Lab work (week 3)  
  - Lab notebook carbon copies due  
**Tuesday Oct 29**  
- Lab work (week 3)  
- Weekly order form 5 due to your mentor Wednesday Oct 30  
  - Weekly written communications (2) due |
| **Nov 4 and Nov 5** | **Monday Nov 4**  
- Lab work (week 4)  
  - Lab notebook carbon copies due  
**Tuesday Nov 5**  
- Lab work (week 4)  
  - Weekly written communications (3) due |
| **Nov 11 and Nov 12** | **Monday Nov 11**  
- **LAB MEETING** (with instructor/mentor only)  
  - Lab notebook carbon copies due  
**Tuesday Nov 12**  
- **LAB MEETING** (with instructor/mentor only)  
- Weekly order form 6 due to your mentor Wednesday Nov 13  
  - Weekly written communications (4) due |
| **Nov 18 and Nov 19** | **Monday Nov 18**  
- Lab work (week5)  
**Tuesday Nov 19**  
- Lab work (week 5)  
- Weekly order form 7 due to your mentor Wednesday Nov 20  
  - Weekly written communications (4) due |
| **Nov 25 and Nov 26** | **Monday Nov 25**  
- Lab work (week 6)  
  - Lab notebook carbon copies due  
**Tuesday Nov 26**  
- Lab work (week 6)  
**Dec 2 and Dec 3** | **Monday Dec 2**  
- **PROGRESS PRESENTATION**  
**Tuesday Dec 3**  
- **PROGRESS PRESENTATION**  
**Dec 5** |

"The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes."
Policy on Attendance, Missed Work, and Late Penalties:

- Attendance to **ALL laboratories is mandatory**. However, if the lab must be missed due to unforeseen circumstances (such as illness) an MSAF or Approval from the Associate Dean’s **must** be provided. Please go to the following website to obtain information on this process (http://www.mcmaster.ca/msaf/). Additionally, the information on the MSAF process is posted on the A2L content page. Once proper documentation is provided we will accommodate the missed lab on a case-by-case basis. Additionally, the student must complete all requirements of the missed lab notebook/report/etc. Please note that in the absence of proper documentation (from the Associate Dean’s office) for a missed lab, the student will receive a zero on the lab course.

- Missed quizzes/reports/presentations/labs or tests (without MSAF/APPROVAL by the Associate Dean’s office) will be graded as ZERO.

- **Late** lab notebook copies/assignments/quizzes/prelabs/drylabs/reports/write-ups/tests will **NOT** be accepted unless proper documentation from the associate dean’s office/MSAF is provided.

- Any report/quiz/notebook/lab report/test/write-up handed in without a name or ID number will receive an automatic ZERO.

- It is the responsibility of the student to back-up all their computer work. **No allowances** will be given to students for turning in late reports **due to computer problems**.

- Students are responsible to ensure the quality of their printed work is acceptable PRIOR to submission of work.

- ALL remarking requests **MUST** follow the remarking policy found on the McMaster Biochemistry website (also available on the course A2L content page).

Lab safety rules: Our lab is a fun working environment, but it is also a science lab full of chemicals/biologicals and equipment. And so, to maintain a fun and exciting work environment we need to ensure that we are all working together as a team and we create a safe work environment. To do this we need to make sure that the following procedures are followed at all times while in the lab:

General lab rules:
1. Be alert at all times while in the lab. The lab is full of people and so you must always stay alert, be prepared and always let the people around you know when you are working with dangerous substances/equipment. Also, be very cautious when moving around in the lab space. Notify your TA/Meagan/Felicia immediately if you observe any unsafe practices.
2. Please conduct yourself in a professional manner at all times while in the lab. There is absolutely no improper behavior/horseplay allowed in the lab as this is a potential safety hazard.
3. No student is allowed to work alone in the laboratory (a TA/Meagan/Felicia must be present at all times).
4. Please do not touch any of the equipment without proper training and supervision by your TA.
5. **No food or drink in the lab.** This means that you may NOT bring food or drink into the lab and you may NOT throw out empty food/drink containers in the lab garbage. You will receive a mark of zero on your participation if we see food/drink containers in the lab area (includes garbage)!
6. **YOU MUST BRING YOUR LAB COAT, SAFETY GOGGLES, LAB NOTEBOOK, COURSEWARE, CALCULATOR, AND PEN TO ALL LABS!!!!** You must wear close-toed shoes (no sandals allowed) and long hair must be tied back! Dangling jewelry are a hazard in the laboratory and should be secured. Please note, if you forget your labcoat or goggles you must purchase them from the bookstore prior to attending the labs. **We do not provide you with lab coats or goggles.**
7. You will have a storage area for your book bags and jackets that is not in the actual wet-lab space. You must leave your pencil case, hats, etc. in this area. **You may NOT eat or drink in this area!!!**
8. You need to carry your lab coat in a separate plastic bag.
9. Please do NOT wear your lab coat outside the lab space. The hallway is NOT an appropriate place for you to put on your lab coat.
10. No laptops/cell phones/etc. are allowed during the lab.
11. Please keep your hands away from your face, eyes, mouth, and body while using chemicals or lab equipment. Wash your hands with soap and water in the designated hand washing sink after performing all experiments and prior to leaving the lab.
12. Please make sure that you do not walk around the lab and distract other students during the lab period. Please focus on your own work and on conducting the lab in a safe manner.
13. Please make sure that you take notes during the lab safety walk through and you know the location of safety features (like fire pull boxes, fire extinguishers, etc.) in the lab. Please make sure that you know the proper procedures in case of emergencies like fire, injury, chemical spills, etc. These will all be discussed both during the labs and as part of your safety training.

14. Never return unused chemicals to their original container.

15. All chemicals/biologicals in the laboratory are to be considered dangerous. Avoid handling chemicals without gloves. Always read the MSDS prior to handling any chemicals/biological and follow the proper safe handling instructions. Do not taste, or smell any chemicals/biologicals.

16. Report any accident (spill, breakage, etc.), injury (cut, burn, etc.) or broken equipment to your TA immediately. Do not panic. If you or your lab partner is hurt, immediately (and loudly) yell out your TA’s name to get the TA’s attention. Do not panic.

17. Dispose of all chemical waste properly. Never mix chemicals in sink drains. Check with your TA for disposal of chemicals and solutions. Never dump any chemicals down the hand washing sink.

18. Please maintain good housekeeping practices. Work areas should be kept clean and tidy at all times. Any area in the lab left untidy will result in a mark of ZERO on the day’s participation sheet for the students (individual, pairs or entire group).

19. Perform only those experiments authorized by your TA. Carefully follow all instructions, both written and oral. Unauthorized experiments are not allowed. If you do not understand a direction or part of a procedure, ASK YOUR TA BEFORE PROCEEDING WITH THE ACTIVITY.

20. You may not eat or drink anything from the lab.

21. You may not take anything home from the lab (test tubes, gels, reagents, Petri dishes, pipettes, etc.)

**Time in the Laboratory:**

A minimum of 8 hours per week are provided from 1:30-5:30 on Monday and Tuesday to be spent in the lab or in meetings. These 8 hours are provided but are not expected to suffice. Additional time will need to be spent outside of the times specified in your timetable to conduct individual research and/or because experiments cannot usually be packaged exactly into a 4 hour time slot. **No student is permitted to be in the lab without a Mentor/Meagan/Felicia present.**

**Avenue2Learn:**

A2L will be an important means of communicating between the course instructor, TAs and students, as well as of submitting documents. It is imperative that students check A2L on a daily basis, or a minimum of every two days for important announcements. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in this course will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

**Academic Integrity:**

I am confident that students attending this course are here to genuinely discover the world of Biochemistry. Any student that would like to ignore my assumption should visit the Academic Integrity Policy at McMaster University for information on academic dishonesty (http://www.mcmaster.ca/academicintegrity/).
ASSESSMENT GUIDELINES:

1. **Participation and preparedness (10%)** ➔ Each lab day students will be assessed by their Mentor (with some input from the instructor) to ensure all students are prepared for the day’s lab. The assessment sheet outline follows:

<table>
<thead>
<tr>
<th>Lab Notebook:</th>
</tr>
</thead>
<tbody>
<tr>
<td>☑ Has the student completed all the sections required for the notebook?</td>
</tr>
</tbody>
</table>

A mark of zero on day’s participation if a section is missing.

<table>
<thead>
<tr>
<th>Preparedness:</th>
</tr>
</thead>
<tbody>
<tr>
<td>☑ Does the student know what they are doing for the day’s lab?</td>
</tr>
<tr>
<td>☑ Is the student relying on their partner/team to complete the experiments?</td>
</tr>
<tr>
<td>☑ Is the student using the equipment properly</td>
</tr>
<tr>
<td>☑ Is the student working in a safe manner?</td>
</tr>
<tr>
<td>☑ Is the student obtaining positive results?</td>
</tr>
<tr>
<td>☑ Is the student utilizing the lab notebook properly</td>
</tr>
<tr>
<td>☑ Can the student troubleshoot their data?</td>
</tr>
<tr>
<td>☑ Can the student explain the progression of steps in the protocol and their importance?</td>
</tr>
<tr>
<td>☑ Is the student following the protocol appropriately?</td>
</tr>
</tbody>
</table>

A mark of zero on the day’s participation if:

- no lab coat
- no goggles
- no notebook
- late
- inappropriate behavior
- lab left untidy
- food/drink (or empty containers) found in lab (includes garbage)

The marking scheme is out of 3, where 0 = not satisfactory, 1= satisfactory, 2 = good, 3=excellent.

2. **Weekly Order Form (10%)** ➔ Each week during the “lab work” portion of the course, each team must complete and submit a “weekly order form” to their mentor **on the WEDNESDAY BEFORE the start of the lab period** (see the course calendar for specific dates).

This means that if you want to conduct a lab on Monday/Tuesday Oct 21/22 you MUST submit your form to your mentor (via email) by Wednesday Oct 16. Your mentor will look over and mark the form and submit it to Felicia/Meagan no later than Thursday of the same week. If you do not place your order in on time you will lose marks and we cannot guarantee that you will be able to conduct experiments on time. The form templates are found on A2L as a Word file and should contain the following sections:

**Weekly Order Form (date submitted):**

<table>
<thead>
<tr>
<th>Team Letter:</th>
<th>Mentor name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>One paragraph describing the main experiments to be conducted and why. Also, describe:</td>
<td></td>
</tr>
<tr>
<td>➢ number of samples and replicates</td>
<td></td>
</tr>
<tr>
<td>➢ if you need to reproduce data and why</td>
<td></td>
</tr>
<tr>
<td>➢ if you are troubleshooting and how</td>
<td></td>
</tr>
<tr>
<td>➢ controls for reactions must be specified. Also include what you are controlling for and why this control is important (i.e. what information will this control give you).</td>
<td></td>
</tr>
<tr>
<td>➢ feasibility of experiments proposed – are you able to complete the proposed experiments in the allotted time (please make sure you build in time required for prep, setup, wait times, etc. in your answer).</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technique (i.e. SDS-PAGE, Western blotting, etc.)</th>
<th>Number of samples (please be specific and calculate number of gels needed, etc.)</th>
<th>Equipment needed (what type and how many)</th>
<th>Supplies needed (number of tubes, type of tubes, reagents, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orders (please write out any chemicals/primers/kits that require ordering; please include the catalogue number, price and name of company). These must be previously discussed with mentor, Felicia/Meagan:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name of item to be ordered</td>
<td>Catalogue number</td>
<td>Price (Canadian $ please)</td>
<td>Company name</td>
</tr>
<tr>
<td>Comments from Mentor (please comment on above form, feasibility given lab times, any notes on how to best prepare for the labs to increase efficiency):</td>
<td></td>
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</tbody>
</table>
**MSDS summary sheets** – each lab work week, each team must have an MSDS summary sheet containing the names of all chemicals/biologicals to be used that week, main safety considerations within the context of the lab (how are using it, the concentration of the reagent), appropriate handling and personal protective equipment, proper handling of a small spill and appropriate references. **This summary sheet must be submitted to your mentor at the same time as your weekly order form.** Also, each student in the team must have a copy of this sheet in their lab notebook prior to the start of the lab work for that week.

3. **Team Contract (1%)** → This contract must be prepared by each TEAM PRIOR to the start of the project. The contract is a binding agreement between all members in the team to work together towards a common goal. The contract should contain all pertinent information that clearly communicates all aspects of this team process. This should alleviate any confusion regarding expectations towards team work. Please complete the contract and return it to your Mentor by September 16th.

- **Guidelines:** The contract can be as long as you wish and should include (at least) these topics:

  ✓ Names of team members and contact information (you can choose to use email or A2L for daily correspondence). **Please do not include your student ID numbers on any team assignments!**
  ✓ Team Goal/Objective – in a sentence or 2 clearly state the main goal that each member in your team will work towards in this course.
  ✓ Meeting information –
    - When, where, how often?
    - How will you communicate this information?
    - What is your timeline for allowing members to respond to the meeting time?
    - How long will the meetings last?
    - What is the team policy on attendance? SPELL IT OUT CLEARLY
    - What other expectations are there for team meetings (this includes preparedness for each member, professionalism, etc.)?
  ✓ Data sharing – how will the data be posted and by whom? (please use A2L)
  ✓ Workload – you need to determine the following:
    - Person responsible for recording meeting minutes (one person or rotation)
    - Will you have a team leader? If so, what are their responsibilities?
    - How will you communicate changes that occur during the lab to one another (remember, you might be splitting up and working on different protocols throughout a given lab day, but you must ALL communicate your experiments for your lab notebooks)?
    - Person responsible for meeting timeline and deadlines (one person or rotation)?
    - How will you evaluate each other’s work BEFORE it is submitted in the form of: 1. report, 2. presentation?
    - Will you work individually on sections THEN meet OR will you accomplish all work at team meetings?
    - Will all decisions be made at meetings? If not, how will you communicate these decisions to everyone in the team?
    - How will you divide the work to ensure fairness?
  ✓ Team conflicts – how will you manage team conflicts? What are your expectations for each team member?
  ✓ Code of conduct

4. **Lab Notebooks (6%)** → One lab entry should encompass the entire week (Monday and Tuesday). This means that you have 1 purpose, 1 timeline, 1 flowchart, etc. for the entire week. You will hand in your lab carbon copies on the Monday following your lab week so that you can insert your data and discuss the results fully. For figures generated, please paste one copy of a professional figure (with figure caption) in the lab notebook and submit one copy attached to your carbon copies. Please note; you are responsible for all the protocols and all the data generated by your entire team. You may have multiple protocols for the week depending on your research project. You will hand in 6 lab notebook carbon copies. Your Mentor will choose any 2 of the 6 to mark.

**Also, please note that any data generated (gels, blots, etc.) will be scanned and posted on A2L by Felicia/Meagan. You may not take this data home with you. It is the property of the Biochemistry Teaching Labs. A folder will be provided for you to store the original data while in the teaching labs.**
The laboratory notebook is made up of carbon copied and numbered pages so that your supervisor or TA can also keep a
detailed record of your work. The contents of the notebook should be brief and concise, yet descriptive. It should be written
in enough detail that another person with no knowledge of your experiment could reconstruct your study, and reproduce your
results. Maintaining an effective notebook will also facilitate the future writing of a good quality lab report or scientific
research paper, or act as a starting point for future experiments.

For these reasons, it is important that you follow these general instructions when writing your lab notebook:

- Unfold the back cover of the notebook and place it directly under the page that you will be writing on – otherwise the
  pressure of your pen will imprint on the pages beneath it
- Writing must be done in dark ink – black ball point pen is best, blue ink fades more readily
- Pencil should never be used in the lab notebook
- Place your name and date on every page
- Record all data directly in the notebook – never use odd scraps of paper or the edge of your lab book to record data
- Never write over unwanted or incorrect text or numbers – always cross out erroneous material with a single line and re-
  write the correct data
- Never use white-out in a lab notebook!!!
- Reserve two-three pages for a table of contents at the beginning of the notebook
- Never tear out or remove a page from the notebook, unless it is the carbon copy duplicate
- Data typed or obtained from a computer MUST be printed and TAPED into your notebook; you might need 2 copies, one
to hand in to your TA.

You MUST bring your lab notebook and custom courseware to each lab

Each lab needs to contain the following sections in your notebook:

1. A Table of Contents – please reserve a few pages at the beginning of the notebook for a table of contents. This should
   include the lab number, page number and a short (1-2 sentences) description of each lab. Each lab needs to be represented
   in this table of contents.
2. Your name/ TA name/ Date: (required for all lab entries) – on ALL pages used!
3. Title of lab: (required for all lab entries) – To be completed prior to the lab. Please make the lab title descriptive with
   respect to the main point of the lab.
4. Purpose of lab: (required for all lab entries) - To be completed prior to the lab. This section (1-2 paragraphs) should be
   used to describe the main purpose of the day’s lab, the main results to be obtained and how data pertains to the overall
   goal of the project (both short term and long term)

The purpose section should be divided into 3 main components:

- Purpose of immediate experimental procedure with a brief description of the procedure (i.e. today we will be performing
  SDS-PAGE on our samples derived from the Ni-NTA purification of E. coli DHFR-His\(^{6}\). The samples will be run on a
  polyacrylamide gel. The samples will be treated with SDS, a detergent, to denature our proteins and subjected to heat in
  the presence of a reducing agent (beta-mercaptoethanol) in order to further denature and break up any disulfide bonds.
  The samples will be loaded on the gel and, following electrophoresis, visualized after staining with Coomassie, etc.)
- Main expected results (i.e. we hope to see the presence of our band of interest (DHFR-His\(^{6}\)) which runs at ~ 20kDa. We
  also want to see the protein profile in all our samples so we may determine the purity level of our elution fractions, etc.)
- How this data pertains to the overall project goal (i.e. this data will help us determine whether or not we successfully
  purified DHFR-His\(^{6}\). If successful, it will allow us to continue with our project as we will determine the concentration of
  purified DHFR-His\(^{6}\) from our best (most pure and concentrated) elution fraction using the Bradford assay (lab #). Also,
  we can use a sample from this fraction to set up crystal trays as described in lab #, etc. If unsuccessful, describe ways to
  proceed with the research project (i.e. troubleshooting)).

5. Flowchart: (required for all lab entries) -To be completed prior to the lab. This section should be used to highlight the
   MAIN steps of the lab (not too much detail). This should visually depict the main experimental techniques in a cohesive
   flow from one concept to the other. This flowchart should be very practical in nature and show an understanding of the
   main steps in a protocol and the order of events when performing experiments that require multitasking. Also this is a
   great place to highlight any main safety concerns. Here is an example of a flowchart for setting up a Western blot (please
   note, this is just a basic example that can be elaborated on by each student).
6. **Safety:** (required for all lab entries) - To be completed prior to the lab. This section should include ALL main safety precautions pertaining to the lab including safe handling instructions. MSDS sheets should be referenced here (websites are fine). This section should contain the following information:

- A copy of the MSDS safety sheet for the week’s lab.
- Name of all equipment to be used in the lab with main safety precautions highlighted.

7. **Calculations:** (required for all lab entries) - To be completed prior to the lab, whenever possible.

8. **Charts/tables:** (required for all lab entries) - To be completed prior to the lab, whenever possible.

9. **Protocols and procedures:** (required for all lab entries) – Detailed protocols of ALL experiments to be performed in-lab by all team members are required for this section.

10. **Discussion:** (required for all lab entries) - This section should contain your observations and discussion on data generated and what the result mean. This section also includes figures/figure captions, whenever required. For figures generated, please paste one copy of a professional figure (with figure caption) in the lab notebook and submit one copy attached to your carbon copies. Please note; you are responsible for all the protocols and all the data generated by your entire team.

11. **References:** (required for all lab entries) - You must have proper references for all your lab notebooks. Please embed references throughout your notebook (numerically) and include a reference list at the end of EACH lab notebook section.

   You will NEED to go to the following RefWorks site: [http://refworks.scholarsportal.info/Refworks/login.asp?WNCLang=false](http://refworks.scholarsportal.info/Refworks/login.asp?WNCLang=false)

   Start an account and learn how to use RefWorks. Build your reference list. You will export your reference list (bibliography) using the ACS (American Chemical Society) citation style. This is a requirement for this course! Examples for how to use the ACS citation style are posted on the A2L content page (entitled ACS citation guide).

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### Notebook marking scheme

1. **Purpose of lab (/4)** – 1-2 paragraphs describing the main purpose of the week’s lab, the main results to be obtained and how data pertains to the overall goal of the project (both short term and long term)

   The purpose section should be divided into 3 main components:
   - Purpose of immediate experimental procedure
   - Main expected results
   - How this data pertains to the overall project goal

2. **Flowchart (/4)** - highlighting the MAIN steps of the lab (not too much detail). This should visually depict the main experimental techniques in a cohesive flow from one concept to the other. This flowchart should be very practical in nature and show an understanding of the main steps in a protocol and the order
of events when performing experiments that require multitasking. Also this is a great place to highlight any main safety concerns.

3. Safety – (4/4)* This section should include ALL main safety precautions pertaining to the lab including safe handling instructions. MSDS sheets should be referenced here (websites are fine). This section should contain the following information:
   - A copy of the MSDS safety sheet for the week’s lab.
   - Name of all equipment to be used in the lab with main safety precautions highlighted.

4. Protocols and Procedures – (4/4)* Detailed protocols of ALL experiments to be performed in-lab by all team members are required for this section.

5. Discussion/Observations – (10)** This section should contain your observations and discussion on data generated and what the result mean. This section also includes figures/figure captions, whenever required. For figures generated, please paste one copy of a professional figure (with figure caption) in the lab notebook and submit one copy attached to your carbon copies. Please note; you are responsible for all the protocols and all the data generated by your entire team.

6. Overall flow, organization and references (4/4)* - this section applies to each lab and includes clarity of thought throughout the notebook entry, proper grammar and proper usage of technical language and technical terms. The notebook must be legible to receive proper feedback. Must have references throughout, especially when describing a new technique, protocols, etc. At a minimum: each lab must have MSDS references.

Total (/30)

*(1= unsatisfactory, 2=satisfactory, 3=good, 4=excellent)
** (1-2 = unsatisfactory, 3-4=marginal, 5-6=satisfactory, 7-8=good, 9-10=excellent)

5. Quizzes (2%) → The quizzes will be distributed at random times during the term and will encompass a number of areas from general concepts, to calculations, to flowcharts that test the students’ ability to understand their research project.

6. Proposal Report (10%) → Each team will submit two copies of their project proposal which is due Monday September 30th, 2013 at 1:30pm prior to the start of Monday’s Proposal Presentations. Late penalties: 10%/ hour with a mark of zero after 4 hours.

Maximum page count: 15, double-spaced pages (Times New Roman font size 12, 1-inch margins all around). The proposal should be broken down into the following five subsections:

i. Abstract – 300 word maximum

ii. Introduction and Hypothesis/objective – introduction to the field as a whole with particular emphasis on your hypothesis/objective (state it CLEARLY) and how it fits in the current research field. REFERENCES!!! (Should have lots of references)

iii. Proposed Techniques – introduction to the main techniques you have proposed. These can include overall techniques like: CLONING (site directed mutagenesis, overlap PCR, etc.), protein small-scale expression, purification, Western blotting, functional analysis, x-ray crystallography, etc. Each proposed main techniques should have a description of each planned experiment with detailed protocols and references.

iv. Timeline of experiments and division of labour - detailed timeline of each experiment that follows the course calendar depicted above to be conducted during the lab periods. Please specify any additional time required outside of the lab time (simply state why you require extra time). Also, please specify which team member(s) will conduct each outlined experiment.

v. Budget Analysis - For each series of experiments, each team will be required to submit a ‘Budget Analysis’ in table format, detailing the chemicals/biologicals required (this includes primers, plasmids, etc.), their cost, and from which company they can be purchased. Standard laboratory equipment such as an electrophoresis apparatus, Pipetmans, gloves, Eppendorf tubes, etc. need not be considered in your budget. Your entire project will need to conform to a $1000 budget/team. Please consult with Felicia/Meagan to see which reagents are in stock and which ones need to be ordered so you can properly fill the “In House” column.
Budget Analysis: $1000 (only the BULK cost should be used to calculate the budget!)

<table>
<thead>
<tr>
<th>Item #</th>
<th>Exp’t</th>
<th>Substance</th>
<th>Bulk cost</th>
<th>Source</th>
<th>Catalogue # (only if NOT in house)</th>
<th>In House (Y/N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Amount</td>
<td>Price</td>
<td>Amount Needed</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1, 2, 3</td>
<td>LB media: Tryptone</td>
<td>N/A 500g</td>
<td>$76.50</td>
<td>1L 10g</td>
<td>Teaching labs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yeast extract</td>
<td>500g</td>
<td></td>
<td>5g 10g</td>
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<tr>
<td></td>
<td></td>
<td>NaCl</td>
<td>500g</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>2, 3</td>
<td>SDS</td>
<td>500g</td>
<td>$50.40</td>
<td>10g</td>
<td>Teaching labs</td>
</tr>
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<td>200 µL</td>
<td>$100</td>
<td>2 µL</td>
<td>QIAGEN A0003</td>
</tr>
</tbody>
</table>

Cost of items actually needed to buy (NOT IN HOUSE!): please note, for kits you can split the cost with other teams

Proposal report marking scheme

Abstract (300 words maximum) Is the abstract concise and clear to understand? Does it follow a logical progression of the project? (/4)*

Introduction and Hypothesis – Does the introduction clearly represent the present state of the field as a whole? Is the hypothesis/objective clearly stated? Is the hypothesis/objective clearly integrated into the field as a whole? (/10)**

Proposed Techniques – introduction to the main techniques proposed (such as cloning, expression, etc.) Did the team organize the proposed main techniques in the proper order with respect to experimental and project design? Are the protocols easy to follow, complete and designed specifically for the teaching labs? (/10)**

Timeline of experiments and division of labour – Is the timeline of experiments feasible? Is the labour divided evenly throughout the team members? (/4)*

Budget Analysis – is the budget complete, easy to follow, accurate and feasible? (/10)**

Overall Content and References – demonstrated an overall understanding of the project, great flow of organization, appropriate use of scientific (technical) writing, information flows logically and smoothly throughout, sentence structure is concise and clear with transitions between paragraphs, excessive detail/brevity is avoided. Demonstrated proper use of references throughout: number of references were appropriate and sufficient, referenced the papers that relate to the topic, the information used from the reference is clear and adds value, consistent formatting of references, all references in the reference list are cited in the paper and vice versa, format of in-text references is done correctly as per the ACS guidelines. (/10)**

TOTAL (/48)

*(1= unsatisfactory, 2=satisfactory, 3=good, 4=excellent)

**(1-2 = unsatisfactory, 3-4=marginal, 5-6=satisfactory, 7-8=good, 9-10=excellent)

7. Proposal Review (3%)→ this component requires that each individual submit a 1-page (can be single-spaced and point form) review/critique of another Team’s research proposal (based on their proposal presentation). This component is due by Monday October 7th (at the beginning of the lab: no late submissions).

You MUST comment on the sections highlighted below:

a. Significance of work.

b. Overall design of study (rationale for time utilization and rationale for main technique(s). Please include your input/suggestions)

c. Feasibility of experiments (include possible problem areas, possible alternatives, possible future work).

d. Would you fund this research project? (please be constructive and positive in your response)
Proposal review marking scheme

a. Significance of work.
b. Overall design of study (rationale for time utilization and rationale for main technique(s). Please include your input/suggestions)
c. Feasibility of experiments (include possible problem areas, possible alternatives, possible future work).
d. Would you fund this research project? (please be constructive and positive in your response)

Should depict a clear understanding of each section (a-d). (/16), /4 for each section.

Your mentors will comment on the following:

- Significance of work: did the student capture the other team’s significance in a concise format?
- Overall study design: did the student include feasible comments/suggestions in this area?
- Feasibility of experiments: did the student display a clear understanding of the experiments proposed and how the data obtained from these experiments fits into the research project?
- Would you fund this project: did the student make a strong/convincing argument for their answer?

Participation during workshop (/4): did the student provide insightful feedback during the review process? Was the student engaged in the feedback process (includes receiving feedback from other students)?

TOTAL (/20)

(1= unsatisfactory, 2=satisfactory, 3=good, 4=excellent)

Proposal Review Workshop: this component requires that the Teams that reviewed each-other meet and discuss the proposed research projects.

8. **Weekly written communications (8%)** → Please try to make these brief: 1-2 pages MAXIMUM. Submit your written communications to your mentor at the start of labs (please follow the course calendar for due dates).

   Weekly written communication 1 → Briefly outline your cloning strategy, including your primers, where they anneal on your sequence, etc. Please try to make it visual/pictorial and easy to understand.

   Weekly written communication 2 → One materials and methods section of a main technique

   Weekly written communication 3 → One MAIN data figure (complete with figure captions) with a brief discussion (should include troubleshooting and possible next steps).

   Weekly written communication 4 → Future work (immediate and down-the-road experiments to continue the project).

Marking scheme for weekly written communications: /4 (whereby 1=unsatisfactory, 2=satisfactory, 3=good, 4=excellent)

9. **Short Communications Report (20%)** → This report has to be written by each individual and handed in on December 5th, 2013 by 4:00pm in the Biochemistry 3P03 dropbox on the 1st floor of the hospital across from HSC-1J11 (FHS safety office). Late penalty: 10% per day, will receive a mark of ZERO after 6 days.

   The length of the submitted report should not exceed 5000 words. As a reference: there are approximately 500 words/page double-spaced with 11-point font (Times New Roman) and 1-inch margins all around. This implies approximately 10-double spaced text pages in length OR 5-single spaced text pages in length. I would prefer if the report was written manuscript-style with 2 columns and embedded figures/captions. Title, references, figure captions, graphical abstract, abbreviations and highlights do not count towards the maximum word count.

   The manuscript should follow this order:

1. Title (on separate title page together with your name, TA name, Team number, date)
2. Graphical Abstract
3. Highlights
4. Introduction
5. Materials and Methods
Examples of this manuscript style are taken from the Journal FEBS Letters. You will notice that the Materials and Methods section is very short and only pertains directly to the main figures shown. You can expand on the materials and methods section by adding a Supplemental Materials and Methods section (please don’t make it too long, 1-2 pages max) if you should so wish.

- **Title:** should be short and straight to the point (no more than 2 printed lines), but should fully describe the main goal of your research project.

- **Graphical Abstract:** A Graphical Abstract is a single, concise, pictorial and visual summary of the main findings of the article. The figure should be specially designed for the purpose of capturing the content of the article for readers at a single glance (this information was adapted from: [http://www.elsevier.com/wps/find/authorsview_authors/graphicalabstracts](http://www.elsevier.com/wps/find/authorsview_authors/graphicalabstracts)). Please make sure you include a descriptive figure caption. Examples of graphical abstracts can be found at this site: [http://www.elsevier.com/wps/find/authorsview_authors/graphicalabstracts#examples](http://www.elsevier.com/wps/find/authorsview_authors/graphicalabstracts#examples)

- **Highlights:** “Highlights are a short collection of bullet points that convey the core findings and provide readers with a quick textual overview of the article. These three to five bullet points describe the essence of the research (e.g. results or conclusions) and highlight what is distinctive about it”. Quote obtained directly from: [http://www.elsevier.com/highlights](http://www.elsevier.com/highlights)

- **Introduction:** should clearly place your findings in the context of the field as a whole. This section should not be used as a long summary of the field. The introduction should contain your hypothesis, the general view of the field to date, your part in the research field and a final paragraph highlighting the techniques used and the results obtained. This is very similar to many journal articles so do some reading before you tackle the introduction. Make sure you have ample references for this section.

- **Materials and Methods:** should be concise and easy to follow so that your experiments can be repeated by another researcher. Methods already published should be indicated by references.

- **Results and Discussion:** This section should combine both a description of the trends in your data and a discussion of the data itself. This section should contain ample data interpretation and troubleshooting. You can include future experiments that need to be done, other controls that should be performed and your opinion on what the data might mean to the field as a whole. Care should be taken not to over-analyze your data. You should present your ideas in a clear, thought-out manner. References must be included here.

- **References:** should be cited throughout the text by number, example (1). Please embed references throughout your report (numerical) and include a reference list as well. Please follow the ACS guide posted on A2L.

- **Figures/Tables with Captions:** should have titles and figure captions describing the experiment in sufficient detail to allow readers to understand the figure in the absence of additional text.

- **Abbreviations:** All abbreviations used in the text should be written out in long form the first time they are introduced, example polymerase chain reaction (PCR). This section should contain all abbreviations used along with their long form.
# Short Communications Report Marking Scheme

## Overall Content
- demonstrated:
  1. an overall understanding of the project
  2. great flow of organization
  3. related the different sections together throughout the report

(/12; /4* for each point)

## Overall Style and Clarity
- concise summary of findings
- appropriate use of scientific (technical) writing and references
- appropriate grammar, sentence structure and abbreviations (in text abbreviations should be written out in long form the first time they are introduced)

(/12; /4* for each point)

### Title, Highlights and Graphical Abstract
- Title – should be short and straight to the point (no more than 2 printed lines), but should fully describe the main goal of your research project.
- Highlights - should be clear, concise and encompass the point(s) of the research project.
- Graphical Abstract - The figure should be specially designed for the purpose of capturing the content of the article for readers at a single glance. The figure should be clear and easy to follow with a descriptive figure caption (/10** for entire section)

## Introduction and Hypothesis
- should clearly place your findings in the context of the field as a whole. This section should not be used as a long summary of the field. The introduction should contain:
  1. your hypothesis
  2. the general view of the field to date
  3. your part in the research field
  4. final paragraph highlighting the techniques used and the results obtained
  5. overall cohesive flow from one concept to another with proper emphasis on the current field and appropriate references

(/10** for entire section)

## Materials and Methods
- should be concise and easy to follow so that experiments could be repeated by another student.
- The experiments must be clearly laid out and must spell out all buffers used (including concentrations), all equipment used, centrifuge rotors used, speeds of centrifuges, method of lysing cells, etc. However, care must be taken not to over describe this section and include information not relevant to the technique (i.e. too much information is not allowed in this section).

(/10**)

## Results and Discussion
- This section should combine both a description of the trends in your data and a discussion of the data itself. This section should contain ample data interpretation and troubleshooting. You can include future experiments that need to be done, other controls that should be performed and your opinion on what the data might mean to the field as a whole. Care should be taken not to over-analyze your data. You should present your ideas in a clear, thought-out manner. References must be included here. (/10**)

## Figures/Tables/Figure Captions
- Should be:
  1. numbered and referred to in the text appropriately,
  2. the data should be large enough to see
  3. data should be clearly presented and labeled properly
  4. figure captions should include a heading describing the overall point of the figure, some experimental procedure (if applicable) and descriptive text to clearly identify the purpose of the figure.

(/10** for entire section)

**TOTAL (/74)**

*(1= unsatisfactory, 2=satisfactory, 3=good, 4=excellent)*

***(1-2 = unsatisfactory, 3-4=marginal, 5-6=satisfactory, 7-8=good, 9-10=excellent)**
10. **Proposal Presentation (10%)** → The main goal of the first presentation is to convey your full understanding of the project objective(s) and how it fits in with the field as a whole. This should not be a recapitulation of your proposal. The presentation should be used to highlight 3 main areas of your proposed research:

1. **PROBLEM** – what is it and why should we care?
2. **PROPOSED SOLUTION(s)** – how will you solve this problem?
3. **PREDICTED RESULTS** – what are they and how will they help the problem?

The presentation will be marked entirely on your ability to communicate these 3 areas to your audience and fully help us to understand your research. The presentation CANNOT exceed 20 minutes and will be followed by 20 minutes of questions. Please do not complicate your presentation, make sure you make good use of flowcharts and diagrams and that you are enthusiastic in your presentation style.

<table>
<thead>
<tr>
<th>Proposal presentation marking scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did the presentation serve to address the:</td>
</tr>
<tr>
<td>1. <strong>PROBLEM</strong> – what is it and why should we care?</td>
</tr>
<tr>
<td>2. <strong>PROPOSED SOLUTION(s)</strong> – how will you solve this problem?</td>
</tr>
<tr>
<td>3. <strong>PREDICTED RESULTS</strong> – what are they and how will they help the problem?</td>
</tr>
</tbody>
</table>

(/30), /10 for each of the 3 areas

<table>
<thead>
<tr>
<th>Questions – Did the team answer questions well? Were they knowledgeable or do they have major gaps in their understanding?</th>
</tr>
</thead>
<tbody>
<tr>
<td>There needs to be an even distribution in individual involvement in this process. (/10)</td>
</tr>
</tbody>
</table>

**TOTAL (/40)**

(1-2 = unsatisfactory, 3-4=marginal, 5-6=satisfactory, 7-8=good, 9-10=excellent)

Please note: often times presentations do not always go as planned. It is expected that each student fully understands the team presentation and can overcome any technical difficulties (or other adversities) that might arise.

11. **Lab Meeting (10%)** → this is a meeting between team members, mentor, Felicia and Meagan. Each team will have 50 minutes to discuss their research project and progress (this includes the entire meeting time). PowerPoint slides of all data generated to-date should be prepared as we will use the time to go over data analysis and discuss where to go from here. This is an open-forum lab meeting so please do not prepare a formal presentation as it will not be used. Each team member should be prepared to answer questions on their specific project proposal, data analysis, troubleshooting, future work, etc. I would like to see equal individual involvement in this meeting.

<table>
<thead>
<tr>
<th>Lab meeting marking scheme (individual assessment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did the student:</td>
</tr>
<tr>
<td>1. Understand the problem and was familiar with relevant literature?</td>
</tr>
<tr>
<td>2. Have knowledge of experimental approach?</td>
</tr>
<tr>
<td>3. Interpret/analyze results appropriately?</td>
</tr>
<tr>
<td>4. Engage in the discussion and in answering questions?</td>
</tr>
</tbody>
</table>

(/16), /4 for each section

**TOTAL (/16)**

(1= unsatisfactory, 2=satisfactory, 3=good, 4=excellent)
12. **Progress Presentation (10%)** Students will emphasize the progress of their experiments/research project. Your focus should be in presenting the data generated and describing how your results fit in with your research plan and the field as a whole. This presentation should also include future work and troubleshooting. Please take care how you present the data itself. You must create professional figures, easy to see, well labeled, you must first present how the data was generated, go through the figure (what are we looking at, what do the controls mean, what does each lane/axis represent), then and only then you can tell us what the results are (and point to the exact place on the data figure that supports your presented results).

The presentation CANNOT exceed 20 minutes, followed by 20 minutes of questions.

<table>
<thead>
<tr>
<th>Progress presentation marking scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data analysis: (/10)</strong></td>
</tr>
<tr>
<td>Students should demonstrate appropriate:</td>
</tr>
<tr>
<td>1. interpretation and experimental judgement</td>
</tr>
<tr>
<td>2. progress (sufficient, efficient, significant)</td>
</tr>
<tr>
<td>3. troubleshooting, limitations of technique(s)</td>
</tr>
<tr>
<td><strong>Future work: (/4)</strong></td>
</tr>
<tr>
<td>Students should address:</td>
</tr>
<tr>
<td>1. immediate future work</td>
</tr>
<tr>
<td>2. long term future work</td>
</tr>
<tr>
<td><strong>Overall impression : (/10)</strong></td>
</tr>
<tr>
<td>1. Was the presentation well understood, well delivered, well referenced?</td>
</tr>
<tr>
<td>2. Were the slides clear, consistent, well delivered, in a logical order?</td>
</tr>
<tr>
<td>3. Were technical language and proper grammar used?</td>
</tr>
<tr>
<td>4. Were data figures well labeled and well explained?</td>
</tr>
<tr>
<td><strong>Questions: (/10)</strong></td>
</tr>
<tr>
<td>1. Did the team answer questions well?</td>
</tr>
<tr>
<td>2. Were they knowledgeable or do they have major gaps in their understanding?</td>
</tr>
<tr>
<td>There needs to be an even distribution in individual involvement in this process.</td>
</tr>
</tbody>
</table>

**TOTAL (/34)
*(1= unsatisfactory, 2=satisfactory, 3=good, 4=excellent)
** (1-2 = unsatisfactory, 3-4=marginal, 5-6=satisfactory, 7-8=good, 9-10=excellent)

Please note: often times presentations do not always go as planned. It is expected that each student fully understands the team presentation and can overcome any technical difficulties (or other adversities) that might arise.