

BIOC 310

Independent research in Biochemistry & Cell Biology for Undergraduates

Student Manual

(Spring 2015)

RICE HHMI *from reading to research*

Table of contents

Forward

This manual was created to help undergraduate researchers find and succeed in research labs in the Department of BioSciences program in Biochemistry & Cell Biology (BCB) at Rice University and elsewhere in the Texas Medical Center. In addition to information for undergraduates, it also features sections for prospective faculty advisors and postdoctoral and graduate student mentors. It is useful for everyone to read all sections to be aware of the expectations of and for all parties. For answers to questions that may not be specifically addressed in the main sections of the manual, please read the Frequently Asked Questions section. Among the questions answered are:

Can my schedule in lab be flexible? How many hours am I expected to work during the semester?
Am I required to…
…work during school vacations and finals?
…make up the hours I miss if I add the class late?
…write a weekly report in the first week when I am just setting up?
…write a research abstract even if I am continuing my project from last semester?
Can I take BIOC 310 if I plan to perform research in a Rice lab outside of the Rice BCB program?
Will my proposed project (in a non-BCB lab) qualify for BIOC 310 research?
Can I take BIOC 310 if I am a Century Scholar?
What is the difference between BIOC 310, BIOC 401/402/412 (BCB Honors), and HONS 470/471 (RUSP)?
Can I take BIOC 310 and RUSP in the same lab at the same time?
When is the best time in my college career to take BIOC 310?
Can I take BIOC 310 during the summer?
What do I do if I have two projects in the lab? Which do I include in my paper/poster?
If I am working in a non-BCB lab at Rice, which research-for-credit course should I take?

Several people will give you input over the course of the semester, and to keep these straight, the following definitions are provided:

- *Professor (a.k.a. faculty research advisor, principal investigator, PI*) – the faculty member who heads the lab in which you conduct research.

- *Mentor* — the postdoc, graduate student or other individual working in the lab who provides the day-to-day advice on experimental details. For some BIOC 310 students, the day-to-day mentor will be their professor.

- *BIOC 310 Instructor* – Dr. Dereth Phillips (derethp@rice.edu; Anderson 340). Dr. Phillips advises prospective BIOC 310 researchers. She acts as a general resource for all current BIOC 310 students and as the on-campus advisor/instructor of record for all non-clinical off-campus research (section 1).

Acknowledgements

The BIOC 310 manual was developed by Dereth Phillips and Bonnie Bartel with support provided by a Howard Hughes Medical Institute Professor grant to Bonnie Bartel. We would like to thank Lucia Strader for the lab notebook protocol, Richard Gomer and Janice Hewitt for documents regarding proper use of citations, Seiichi Matsuda for useful suggestions on the text, Erin Beisner, Brianne Hobbs, Grace Lin, Allie Obermeyer and Alyssa Baevich for examples of student assignments, and numerous other undergraduates and faculty members for input on content.

Course requirements and deadlines

Schedule and Deadlines

All written materials (student agreement form, proposal abstract, weekly reports, paper/poster drafts and final paper/poster) must be submitted to your **research professor** and copied to your **mentor at the bench**. If you are in an off-campus section (sections 1 or 2) you will also submit copies to the **BIOC 310 instructor** listed for that section. *These people receiving copies of your work will be called collectively "**your advisors**" for the purpose of the course deadlines.

Fall semester

Spring or summer – prospective BIOC 310 students begin planning for fall semester; find professor, gain acceptance into a lab; off-campus research students contact BIOC 310 instructor, complete Medical Center paperwork and safety training, and *submit BIOC 310 application at least two-weeks prior to the start of classes*; all students must complete and submit Student Agreement Form to your advisors*.

- **By the end of each week (Saturday, 11:59 pm)** – email weekly report to your advisors.
- **Before the end of the second week (Saturday, 11:59 pm)** – email 1-page proposal (abstract, aims, and references) to your advisors. Also email them a photo your signed agreement form.
- **Date TBA** (Time and location TBA) – informational meeting with the BIOC 310 instructor or writing consultant.
- **Last week in October** – email outline to your advisors and request feedback.
- **Last week of classes (or before)** – draft of research paper due to your advisors for feedback.
- **Due by the BIOC 310 final exam time slot (see registrar's exam listing for BIOC 310)** – final research paper and time sheet due to your advisors and uploaded to your BIOC 310 drop box. For off-campus research students, the final research paper, handed in to the BIOC 310 instructor, should include the signature of the professor. (Alternatively the final copy of the research paper can be emailed to the BIOC 310 instructor by the research professor as a confirmation of its receipt).

Spring semester

- **Fall** – begin planning for spring semester (and summer research); find professor, gain acceptance into a lab; off-campus research students contact BIOC 310 instructor, complete Medical Center paperwork and safety training, and *submit BIOC 310 application at least two-weeks prior to the start of classes*; all students must complete and submit Student Agreement Form to your advisors.
- **By the end of each week (Saturday, 11:59 pm)** – email weekly reports to your advisors.
- **Before the end of the second week (Saturday, 11:59 pm)** – Email 1-page proposal (abstract, aims, and references) to your advisors. Also email them a photo of your signed agreement form.
- **Date TBA** (Time and location TBA) – informational meeting with the BIOC 310 instructor or communication consultant.
- **Late February** – if presenting a poster, submit poster abstract with title and author list to your advisors for review.
- **Early-mid March** – if presenting a poster, submit poster abstract and registration to RURS (check RURS website).
- **Mid-late March** – if presenting a poster, submit poster or paper draft to your advisors for feedback!! If writing a paper, present an outline of your paper to your advisors for review.
- **First week of April or earlier** – if presenting a poster, print completed poster and present at RURS poster session.

- **Last week of classes (or before)** – if writing a paper, present draft of research paper due to your advisors for feedback.
- **Due by the BIOC 310 final exam time slot (see registrar's exam listing for BIOC 310)** –*Final poster* (electronically and printed as a single 8.5x11 inch page) and time sheet due to your advisors and uploaded to your BIOC 310 drop box. For off-campus students, the final poster one-page printout handed in to the BIOC 310 instructor should include the signature of the professor. (Alternatively the final copy of the poster can be emailed to the BIOC 310 instructor by the research professor as a confirmation of its receipt). **–or—**
  —*Final research paper* and time sheet due to your advisors and uploaded to your BIOC 310 drop box. For off-campus research students, the final research paper, handed in to the BIOC 310 instructor, should include the signature of the professor. (Alternatively the final copy of the research paper can be emailed to the BIOC 310 instructor by the research professor as a confirmation of its receipt).
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Student agreement form

The following form is to ensure that you, the student researcher, have read the BIOC 310 manual and understand the expectations of you during your semester in BIOC 310.

Over the course of the semester, we expect that BIOC 310 students will:

1. spend *at least* 3 hours in lab per week per credit hour of BIOC 310 (42 hours/credit/semester)
2. be intellectually engaged in their research
3. be familiar with the relevant research (read articles, confer with researchers)
4. understand the larger context of their work
5. perform experiments carefully and with an attention to detail
6. keep a detailed notebook
7. be responsible with lab reagents and equipment
8. keep a regular lab schedule and inform their professor and bench mentor prior to an absence
9. be on time for meetings and experiments
10. work well with and be respectful of their bench mentor and other lab colleagues
11. complete clear and detailed weekly reports by Saturday night of each week
12. complete a thoughtful proposal abstract by the end of the second week of classes
13. present their research and research findings clearly and effectively in a final research paper or poster presentation
14. properly cite all contributions by others (published and unpublished) in all of their written work for this course, in accordance with course policies regarding plagiarism
15. share drafts with their research professor and mentor, giving them an opportunity to suggest edits and approve documents, prior to submission of any final copy of papers or posters
16. ask for clarification from their professor, mentor, and course instructor if they are unsure of any of their lab protocols or course expectations

I have read the BIOC 310 manual and understand what is expected of me in this course.

______________________________	______________________________	______________
Student name	Signature	Date

Please submit this form to your professor prior beginning work for the semester. If you are performing research off-campus, submit this form to your professor and the BIOC 310 instructor. Keep a copy for your records.

BIOC 310 is an independent program of study for students interested in biological or biomedical research. All students will complete a laboratory-based independent research project under the supervision of a faculty member. There is no formal classroom instruction.

Summary: BIOC 310 students must perform research in the laboratory of a faculty member in the Biochemistry & Cell Biology (BCB) Program in the BioSciences Department at Rice University (sections 3 and above) or in off-campus Texas Medical Center laboratories (sections 1-2). Students are required to spend at least 3 hours per week in the laboratory for each semester hour of credit (42 hours/credit/semester). Additional weekly time should be allotted for reading of the scientific literature and writing reports. If taken for 3 or more hours, BIOC 310 counts as one required lab course but not as 300-level elective in Natural Sciences or Engineering. BIOC 310 requires a research proposal, weekly reports and a final project (research paper in the fall semester / paper or poster presentation in the spring semester pending professor permission and RURS acceptance). The prerequisite is either BIOC 111 or BIOC 211 and instructor permission is required. To receive credit, a student must participate in a laboratory-based biosciences research project. Credit cannot be received for physician shadowing. Students will not receive course credit if they are being paid for their work. It is strongly recommended that all students register for 3 credit hours their first semester of BIOC 310. Fewer hours will leave insufficient time for meaningful research and more might be unsustainable with a busy academic schedule. Students in the off-campus sections (sections 1 and 2) must register for at least 3 credits.

Finding a lab: Prior to enrollment in BIOC 310, you must secure a position in a laboratory. You can identify candidate labs by reading faculty members' scientific publications and website research summaries. You can then email the faculty member to inquire about the possibility of performing research in their lab. If the faculty member agrees, you and the faculty member can meet and discuss the available projects, the number of hours to sign up for, and other details. For additional help with locating research opportunities on or off campus, see the BIOC 310 manual (www.bioc.rice.edu/bioc310/) section on "Finding a research lab". You may also contact Dr. Dereth Phillips (derethp@rice.edu).

Registration: Once you have found an on-campus BioSciences BCB program lab, you must obtain a special registration form (http://registrar.rice.edu/student/special_registration/), obtain the signature of your BioSciences research professor, and register for that professor's section of BIOC 310. If you wish to perform BIOC 310 research off-campus, you must complete a BIOC 310 Off-Campus application form ("application" link on www.bioc.rice.edu/bioc310/) at least two weeks before the start of classes. The BIOC 310 instructor will contact your off-campus professor to confirm that s/he has agreed to host you in their lab. On confirmation, the instructor will then prepare a BIOC 310 registration form for you. Note: For on-campus researchers, the instructor serves as a course resource. For off-campus research students, the BIOC 310 instructor also serves as the on-campus professor and contributes to the assigned grades. All BIOC 310 students should register before the beginning of the semester. Students who begin their research late will be required to make up missed research hours over the course of the semester.

Required writing assignments

Research proposal: Prepare a 1-page research project proposal containing an abstract that summarizes the basis of the planned project, experimental aims for the semester, and references. Develop this proposal in consultation with your professor and submit it to all of your advisors (professor, mentor, and the instructor of your BIOC 310 section) before the end of the second week of classes. To ensure that all students communicate with their research professors and secure viable research projects in a timely manner, there will be a grade penalty for late submission of the research proposal. Late proposals decrease the final semester letter grade for each week late. For example: an "A" student who submits the proposal in the third week of classes would earn an "A-", in the fourth week a "B+", and so on. One purpose of this research proposal is to help you get concrete guidance early. Your deadline to submit this document gives your professor a deadline to provide you with input.

Weekly progress reports: Send weekly email progress reports to your professor and your research mentor; off-campus students will copy their reports to the instructor of their BIOC 310 section as well. This weekly email will include: hours in lab that week, experiments conducted, results obtained, conclusions drawn, and plans for the following week. These reports will be due by the end of each week (Saturday, 11:59 pm). Your professor is welcome to request an earlier deadline. Please consult the weekly report section of the BIOC 310 manual for the suggested format and examples.

Final project: A research paper will be required in the fall semester and a paper or poster will be required in the spring semester. On-campus students will turn in their final project to their BioSciences BCB program professor and their research mentor; off-campus students will hand in their projects to the Rice instructor of their BIOC 310 section as well as their off-campus professor and research mentor. Submit drafts of papers or posters to these same individuals for comments prior to the final deadline. See the "Schedule and Deadlines" below for the relevant deadlines. For off-campus researchers, the professor's signature on the final project or confirming email will be required to indicate that your documents have been reviewed and approved. Alternatively, the professor may send an electronic copy of the final document as proof of receipt. The research paper is due at 5 pm on the last day of finals; the poster, if students are approved to present one, will be presented at the Rice Undergraduate Research Symposium (RURS) in the spring (http://rurs.rice.edu/). First semester BIOC 310 students will prepare research papers. After their first semester of research, BIOC 310 students, approved by their research professors to do so, may present a poster in the spring session. It is the student's responsibility to register for the poster session. Individual professors may impose additional requirements, such as a research paper in the spring semester, and should inform students of these additional requirements and associated due dates by the end of the second week of classes.

Honor code for BIOC 310

Guidelines for collaboration with colleagues: As research is a collaborative effort, you are expected to communicate with and receive input from others. While the work reported in your written materials should be your own, you may include data and figures produced by other members of your lab as background if they are relevant to your conclusions about your own research and are properly attributed to the individual(s) who produced them. Although many of the projects in a lab originate from a common starting point, your abstract, summary, and introduction should be in your own words and not simply copied (plagiarized) from existing lab documents.

Guidelines for proper citation of written work: Plagiarism is a form of academic fraud and is a violation of the Rice Honor Code. Forms of plagiarism include: copying a source word-for-word, inadequate paraphrasing without proper acknowledgement, and claiming another's ideas as one's own. BIOC 310 students are required to educate themselves in the use of proper citations in all of their written work by reading the following three sources:

- the Rice Honor Code information on Academic Fraud and Acknowledgement of Sources: http://honor.rice.edu/honor-system-handbook/
- the document, "Recognizing and Avoiding Plagiarism" by Dr. Janice L. Hewitt, which is posted in the resources folder on the BIOC 310 Owl-Space site
  the BIOC 310 manual sections, "When should I reference something?" and "How do I reference material from a review article?" written by Dr. Richard Gomer

Disability support

Guidelines for students with disabilities: If you have a documented disability that will impact your work in this class, please inform your research professor to discuss your needs (off-campus students should inform their section instructor as well.) Additionally, you will need to register with the Disability Support Services Office in the Allen Center. For more information visit the Rice Disability Support Services site (www.dss.rice.edu).

How not to plagiarize

Plagiarism is a violation of the Rice Honor Code and is not tolerated. BIOC 310 students are required to educate themselves in the use of proper citations in all of their written work by reading the sources described in Honor Code section above. Below are brief guidelines on proper citation technique.

When should I reference something? Adapted from text by Dr. Richard Gomer.

Give a reference if

- it is someone else's idea
- it is someone else's technique
- it is someone else's observation

> *Disruption of xxx blocks the yyy pathway in Arabidopsis (Smith and Jones, 2003). Because of their similarity to xxx, the abc kinases may be part of the yyy pathway (Doe, 2005). To test this hypothesis, I will use homologous recombination (Jones and Smith, 2001) to disrupt abc1 and determine if this blocks the yyy pathway.*

You can leave the reference off of the second sentence only if this is completely your idea and was not published by someone else or told to you by someone else. So if Doe mentioned this idea to you but never published it, you would write:

> *Because of their similarity to xxx, the abc kinases may be part of the yyy pathway (Doe, personal communication).*

A good rule of thumb is that each sentence in an introduction probably needs a reference; sometimes a sentence clearly continues the description of the work in a previously referenced sentence and then doesn't need a reference.

How do I reference material from a review article? Adapted from text by Dr. Richard Gomer.

Sometimes you get a review article (Epsiloni, 2008) that reads something like

> *The abc kinases were first discovered by Alpher (Alpher, 1982). There are 15 abc kinases (Beta, 2007). There are two types of abc kinases, type I and type II (Gamow, 2006). The type I but not the type II abc kinases are present in plants but not in animals or fungi (Delter, 2008).*

If you paraphrase the above section without reading the four articles, and/or without referencing the review article, you will be in trouble. If you didn't read the four original papers, you should only reference the review article:

> *Two types of abc kinases have been described (see Epsiloni, 2008 for review).*

If you read the 4 original papers, and in your writing you follow the general outline or format of the review paper (or any other document), you need to reference the review paper or document.

In a recent review, Epsiloni (Epsiloni, 2008) describes how Alpher first identified abc kinases (Alpher, 1982), and that there are seven type I and eight type II abc kinases (Gamow, 2006; Beta, 2007)….

Finding and succeeding in a research lab

Finding a BIOC 310 research lab

Start early! Begin your search the semester before you intend to register. It may take multiple contacts before you can find a lab home. If you plan to work in a Texas Medical Center (TMC) lab outside of Rice, you will most likely need to complete various applications, immunization forms, and other paperwork as well as undergo any required training before stepping foot in the lab. (In some TMC institutions, it can take 30 days to process completed paperwork.) The entire process of finding an advisor, meeting with him/her, selecting a project, and completing the required paperwork (if non-Rice) can take from weeks to months.

Where do I start? Look at the various research summaries of the faculty on the web. View the books of faculty research summaries available from the BIOC 310 instructor. Look for a lab that is interesting to you. Talk to juniors and seniors about their lab experiences. Which labs do they recommend? Discuss your research interests and goals with your academic advisor in the BioSciences Department, Biochemistry & Cell Biology program (students with Biochemistry & Cell Biology interests have advisors even before declaring a major; see the listing at http://biosciences.rice.edu/Content.aspx?id=2147483822 for your advisor) and ask which lab might be a good match. If you are serious about joining a particular research group, visit the lab, ask to meet the undergrads already working there, and inquire as to the best method of approaching that particular professor.

Decide what you want out of your research experience. Are you looking for a job for extra money or do you want research experience? Would you prefer to perform mostly laboratory maintenance or do you want to be performing research as part of an ongoing project in the lab? Do you want to work for pay (including work study) or course credit? In some labs, paid positions will be lab maintenance and actual research will only be available for students working for credit during the academic year. However, many labs offer some paid research positions over the summer.

Narrowing your search: Think about what sort of research might interest you or would further your educational goals. Research approaches are often divided into the categories of *basic* and *applied* research. While many labs participate in both approaches and the lines between the two are often blurred, it is helpful to think about these distinctions when directing your search. *Basic research* seeks to increase understanding of nature and not specifically to create something, to cure a disease, etc. In contrast, *applied research* is directed toward solving particular medical or technological problems, and often has obvious commercial applications. Regardless of your long-term interests, basic research labs can offer a broad view of biology and provide the intellectual foundation on which applied research is based. The BioSciences department at Rice is primarily a basic research department, although many of our faculty members have applied research interests as well. Within the broad area of basic research in biology there are a number of fields in which you can participate. For example, the BioSciences BCB program includes scientists performing research in developmental biology, cell biology, microbiology, genetics, biochemistry, protein structure, enzyme kinetics, metabolism, and evolutionary biology. Remember that most applied research is a subset of an area of basic research. For example: cancer results from defects in normal cell and developmental biology, diabetes is a defect of metabolism, antibiotic resistance results from the evolution of pathogenic organisms, mad cow disease results from a defect in protein structure, and biofuels engineering requires an understanding of basic plant or bacterial metabolism.

Do not be overwhelmed by your choices. If you have not developed a preference for any particular area of research, you still can narrow your search by the recommendations of your peers or by viewing the research summaries of the faculty in the BioSciences department BCB program.

How do I contact a professor (a.k.a. principal investigator, head of a lab)? Do your homework. Most positions are not advertised, but are filled from among the students who contact the professor. Read about the professor's work and, if possible, talk with people working in the lab to get a feel for the personality and expectations of this individual and the lab. Write a personal email to the professor. Do not send a mass email to multiple faculty members or your email will be considered spam and ignored.

Your introductory email conveys an important first impression and can influence how easy it will be for you to find a lab home. All heads of research labs will have either a PhD or an MD degree and should be addressed as "Dr." or "Prof." and not "Ms., Mrs., or Mr." In your email, tell the professor who you are (name, year at Rice), why you are looking for a position in a research lab, and why you are interested in his or her lab in particular. Include mention of any relevant course work or prior research experience, even if it was in high school. You also may want to include whether you are looking for a short (1 semester) or longer experience, whether you prefer to work for credit or for money (if you have a preference), and how many hours per week you would like to devote to lab work. Your application will be viewed with greater favor if it appears that your motivation is scientific interest rather than a desire to pad a medical school application. If you are considering graduate school after Rice, include this interest in the letter.

How many labs should I contact? Getting into a lab is partly timing and luck, so do not be discouraged if your first efforts are not successful. You will probably need to contact several labs to find a position. If you know someone in a lab where you want to work, ask that person to put in a good word for you. If you are not successful after several attempts, you may wish to ask for feedback on your contact letter from the BIOC 310 instructor.

How do I know if I have enough time in my schedule to take BIOC 310? Research requires quality time. If you will not have a few free mornings or afternoons in your schedule, you will probably not be able to dedicate quality time to your research. You should design your research schedule in blocks of at least 2-3 hours each. Longer blocks are better, and at least some of these blocks will need to be during daylight hours when your research mentor is more likely to be present. Don't try to find time for research in one-hour chunks between classes. If you are already carrying 15 or more hours, you should think seriously about waiting a semester or eliminating another course from your schedule before enrolling in BIOC 310.

How do I register for BIOC 310? If you have found a lab on campus in the Program in Biochemistry & Cell Biology, simply have your research professor sign a registration form for you. Each BCB professor has his/her own section number so make sure you are registered for the correct section. If you wish to perform BIOC 310 research off-campus you must complete a BIOC 310 off-campus application form at least two weeks before the start of classes and submit it to the BIOC 310 instructor. After reviewing your application, the BIOC 310 instructor will contact your off-campus professor to confirm that that they have agreed to host you in their lab and will then prepare a registration form allowing you to enroll. Note: For off-campus research students, the BIOC 310 instructor of your section also serves as the on-campus professor and contributes to the assigned grades.

If you find a lab in a non-BioSciences Rice department and you are a Biochemistry & Cell Biology major wishing to register for BIOC 310, there are two main requirements for obtaining BIOC 310 credit. First, your project must have a biological or cell-biological component and second, you must secure a BCB faculty sponsor in the BioSciences Department (your BCB sponsor should be willing to read all of your written material and collaborate with your out-of-department professor to determine your grade). Be aware that BCB professors are under no obligation to advise students not working in their own labs.

On-campus versus off-campus research opportunities

Opportunities in the Rice BCB Program: We recommend that Biochemistry & Cell Biology majors begin looking for opportunities on the Rice campus. Because BCB professors rarely advertize openings, it may appear that there are no positions available on campus. Most BCB professors prefer to wait to be approached by an interested student, so it is prudent to contact any BCB faculty member whose research interests you even if they have not posted formal research opportunities. To find out which faculty members are working in areas that you find intriguing, see the "Research" section in BioSciences Department website and select an area of interest (http://biosciences.rice.edu). You also may find it helpful to join the "BioSciences Opportunities" Owl-Space site as numerous opportunities both on and off campus are posted as announcements here.

Opportunities elsewhere in the Texas Medical Center: If you have a particular research interest that is not found among the current BCB faculty, you are free to find a faculty member in the medical center willing to host you. You must complete a BIOC 310 off-campus application (link found on the BIOC 310 website) at least two weeks before classes to have your project and lab situation approved by the BIOC 310 instructor. Note: not all kinds of research will be approved. The research should fall under the umbrella of something that could be considered Biochemistry & Cell Biology laboratory research (working with DNA, protein, cells, tissues, or model organisms to answer biological questions). Additional types of research may be acceptable. If you have an interest in a particular lab or type of research outside the guidelines mentioned above, you should discuss this with the BIOC 310 instructor to see if it would be appropriate for a BIOC 310 project. Some types of clinical research may be accepted for enrollment in the clinical section (section 2) of the course. See the instructor of that section for details. BIOC 310 is not the only research-for-credit independent study course that enables students to perform research off campus. A partial listing of such courses includes: EBIO 306, BIOE 400, BIOE 401, KINE/HEAL 495/496, NEUR 485, CHBE 499, CHEM 491, HONS 470/471 (RUSP), etc.

BIOC 310 research in off-campus Texas Medical Center labs: For those considering working off campus: be advised that the decision perform BIOC 310 research off-campus should not be made lightly. While undertaking research at another Texas Medical Institution can be a very rewarding experience, there are a number of factors that add to the complexity of off-campus research.

1) **Travel time**—You should allow between 30 minutes and an hour for the round trip, which will necessarily reduce the amount of time you have to spend in the lab.

2) **Hard to drop in for a few minutes**—Sometimes when you have a break between classes you will want to drop into lab for a few minutes to start a gel, inoculate a culture, feed cells, or talk to your professor. These few minutes can often give you a head start or eliminate waiting when you have your next block of time in the lab. Due to the distance problem mentioned above, most students in off-campus labs can't afford the luxury of popping in and out of lab.

3) **Cultural differences between Rice and med-center labs**—Most labs at the medical center are not as accustomed to working with undergraduate researchers and may be less accommodating of undergraduate schedules and instructional needs.

4) **Paperwork and safety training courses**—Additional paperwork and safety training courses are required for most off-campus labs, so you will have to budget extra time to complete these before the start of your research. To ensure that you acquire your approvals and ID badge in time to begin your research, you should contact the BIOC 310 instructor and complete all medical center paperwork at least 30 days prior to the start of classes.

Students who have prepared for these complexities can enjoy access to one of the largest medical centers in the world where hundreds of labs produce ground-breaking research on a daily basis.

Finding a lab in the Texas Medical Center: Finding research opportunities in the Texas Medical Center may seem daunting. After all, it is not trivial to sort through the hundreds of laboratories in the TMC member institutions and find one that interests you and has a position available. There are, however, ways to narrow your search. It may be helpful to join the "Biosciences Opportunities" Owl-Space site. When we receive information about opportunities in the TMC and elsewhere we post them as announcements on this site. In addition, you can visit the websites meant to help graduate students look for research labs. The schools, programs, and departments listed below are linked on the BIOC 310 website (http://www.bioc.rice.edu/bioc310/).

Two of the largest graduate schools in the Texas Medical Center are the *University of Texas Graduate School of Biomedical Science* and the *Baylor College of Medicine Graduate School of Biomedical Science*. Visit the websites of these graduate schools to find the names of programs or departments that hold promise or try going directly to the following department and program pages to see the lists faculty research interests:

UT Biochemistry and Molecular Biology
UT Cell and Regulatory Biology
UT MD Anderson Genes and Development
UT Microbiology and Molecular Genetics
BCM Molecular and Cellular Biology

BCM Molecular and Human Genetics
BCM Molecular Physiology and Biophysics
BCM Virology and Microbiology
BCM Immunology
BCM Neuroscience,
BCM Pharmacology

There are many other departments and programs in the Texas Medical Center, so you should plan to do some web surfing to experience the full range of options. You may notice a particular faculty member's name listed in multiple departments or graduate programs. Many professors have joint appointments to foster collaboration and accommodate the interdisciplinary nature of their research.

Research during the summer (paid, not BIOC 310)

Summer is a great time to delve deeply into a research project without the time and scheduling constraints imposed by other classes. If you have not considered summer research because of financial concerns, you should note that most summer research opportunities are paid positions. If you are interested in working in a research lab in the BioSciences Department at Rice over the summer, you do not need to apply to a particular summer program. Beginning in the spring semester, you should approach faculty members whose work is of interest to you. If you are already in a BCB program lab, the spring semester is also a good time to initiate a conversation with your research professor about your interest in participating in summer research in their lab.

Beyond the hedges, there are a number of formal summer undergraduate research programs hosted by various universities throughout the country. In addition to core research opportunities in faculty labs, most organized summer programs also offer some professional development components, which may include, training on the ethical conduct of research, graduate-school or medical-school application advice, or scientific writing and presentation coaching. Most summer program applications are mini-versions of professional-school applications and require transcripts, essays, and letters of recommendation. Some summer programs are restricted to undergraduates at particular stages of their college careers, so check each listing for requirements.

National Science Foundation's Research Experience for Undergraduates (NSF REU) program: A listing of NSF REU programs at various universities around the country can be found at:
www.nsf.gov/crssprgm/reu/list_result.cfm?unitid=5047

Association of American Medical Colleges Summer Internships:
www.aamc.org/members/great/summerlinks.htm

Houston Programs: Rice hosts a few formal summer programs coordinated through the Institute of Biosciences and Bioengineering. Off-campus programs like the Baylor Medical School SMART program and UT Medical School Summer Research Program connect students with local Texas Medical Center faculty, many of whom will allow you to continue your research in their labs throughout the school year in courses such as BIOC 310 or BIOE 401.

Links to summer programs, such as those offered at Rice, Baylor College of Medicine, University of Texas Health Science Center and MD Anderson Cancer Center can be found in the undergraduate section of the Rice Biosciences website:
http://biosciences.rice.edu

Expectations of and for an undergraduate researcher

What is expected of me in a lab? Your professor and/or your research mentor will probably tell you about specific expectations. If these guidelines are insufficiently clear, be proactive to get more concrete guidance. Whenever you are in doubt, ask. Each lab has its own culture and expectations. Senior undergrads in the lab may be well positioned to give you guidance. They live under constraints similar to yours with coursework and life outside of lab, and made the transition to undergraduate research recently enough that they'll remember the issues.

BIOC 310 is more like an apprenticeship than a regular course. Undergraduate research differs from many of your previous educational experiences in that the people who will teach you are under no obligation to do so. Faculty members do not have unlimited lab space and financial resources and are free to decline to take BIOC 310 students. Graduate students and postdocs can give up on their undergraduate colleagues if they so choose. Like most human relationships, your connection to your lab will only continue if it is mutually beneficial. A substantial investment of time and energy is necessary to get a new student up to speed, so you should be sure that your contributions to each individual in the lab outweigh the time that s/he spends on you. Always look for ways to be an asset.

In many labs, you will not be working directly with the professor, but with a graduate student or postdoctoral research mentor. This person probably is not doing this extra work out of pure altruism, but rather hopes that adding you to the team will further his or her research agenda. This person has a full-time job even without mentoring you, so be respectful of his or her time.

You should keep regular hours, especially at the beginning. It will be difficult for your mentor to help you if you do not work similar hours. You should work closely with your mentor until you are sufficiently independent to complete procedures on your own, which might take months. Even after those first few weeks, you should maximize your overlap with your research mentor. You should plan your schedule in blocks of 2-3 hours or more. Less time is insufficient to set up most types of experiments, especially in the beginning of your training. In addition, you should have the flexibility to spend an occasional extended evening or weekend day in the lab when your experiments require it.

Let your co-workers know if you will not be able to make it to lab or if you will be late so that any ongoing experiments can be monitored in your absence. Clearly communicate the days that you will be gone due to vacations or finals. A paper calendar that lists your anticipated in-lab times, when you are in classes, and your contact information should be posted above your bench. A worksheet for this purpose is included in this manual; be sure to update it with your current schedule as the semester progresses.

You are expected to ask questions any time you are confused. Your co-workers much prefer that you ask them for help rather than having you break equipment or waste time and resources. You are part of a team and should be very aware of the effect that your actions have on others in the lab. Be neat and clean up after yourself, particularly when using common areas or equipment. Return materials to their proper locations after use. Do not use your co-worker's materials unless you have been invited to do so. Complete your lab jobs in a timely fashion.

Be sure to maintain positive working relationships with everyone in the lab. Often expertise is distributed throughout a lab and you may need to consult multiple lab members for help on a single project. Additionally, many of us find that the casual scientific discussions that we have with our colleagues are some of the most intellectually stimulating and productive aspects of our research experience.

Pay attention, pace yourself and keep a detailed notebook. Some mistakes will happen, but repeated avoidable mistakes indicate a pattern of carelessness. You need not judge yourself harshly for misjudgment. Getting an experiment to work correctly can require hundreds of tiny decisions (e.g., whether to pour with your right hand and hold the receptacle with the left, or vice-versa) and your ability to make decisions on the fly will improve with experience. You should, however, avoid careless errors such as mislabeling or having forgotten instructions. When you are told how to do an experiment or use an instrument, write everything down in complete detail, even if the instructions seem perfectly clear and logical at the time. Remember that research is a marathon and not a sprint. Take the time to perform each experiment as carefully as you can and take assiduous notes so that problems can be documented and corrected. When in the course of an experiment you think of a way to improve a future iteration, write it down.

Most experiments that are worth doing do not turn out exactly as expected. If all of your experiments work as planned, you're not making discoveries, but simply confirming the world is as someone might have predicted. Always keep in mind that every concrete result is a good result. If you can prove unambiguously that every conclusion you've made in the last year was wrong, it's a good result — the outcome is that you will be in a much better position to reach a positive solution than the day before when your understanding of the system was flawed. The objective is to find the truth rather than to confirm that you or your professor had a good idea.

While you are in the lab you should be occupied with your research. You will not convey a favorable impression if you are reading novels, websurfing, texting, talking on the phone or participating in other recreational activities while your colleagues are at work. Do not chat on the phone at your bench if others are in the room. If you must take a call, move to the hallway to avoid disturbing your colleagues. If you find that you are in a holding pattern wile waiting for the completion of a gel, PCR, or other assay, think of other work that may enhance your research experience such as reading relevant articles, preparing your weekly reports, updating your notebook, graphing your data, or preparing for future experiments. Ask your mentor for suggestions if you find yourself at a loss for productive work.

Because your weekly hours in the lab are limited, you will want to avoid dead time. When you feel sufficiently comfortable with your techniques, you will find that you can effectively double your productivity by using your waiting time for additional procedures. While running gels, performing PCR, digesting DNA fragments, incubating blots, you can be planning and even starting your next experiments. Focus your efforts on being heroically efficient rather than working heroically long hours.

Occasionally students find that their relationships with their professors or coworkers become strained. One cause of misunderstandings is that senior people do not want to be too demanding or critical, and consequently do not intercede promptly. A very useful approach is to periodically ask your professor or mentor for concrete input on how you could improve. Do this in a formal way; bring a pad of paper, take notes, and try seriously to address any feedback you get. If you find yourself in a misunderstanding with someone in the lab, try to think of how you may have contributed to the problem and apologize for it. People are basically forgiving, and are happy to drop conflict as long as they know that the other party did not have ill intentions.

Additional time and writing requirements: Participation in a lab often requires time and work in addition to your required hours and writing assignments. You may be expected to attend, and occasionally give a presentation, at weekly lab meetings. If you have contributed data or materials to a research project that will result in a publication, you will be expected to assist the other authors in writing the research article.

Communicating with other faculty members about your research: If in the course of your research, you find that you have questions for a faculty member or researcher outside of your lab, first discuss the question with your professor to see if he or she thinks it would be valuable to consult outside of the lab and would not risk releasing sensitive unpublished information. If given the go-ahead to communicate, make sure to copy your professor on all email communication with the outside individual. This courtesy will both serve to keep your professor informed and to let the person you are consulting know that you are not circumventing the head of your lab.

Leaving a lab: You will be judged not only on your performance while you are in the lab, but also on the gracefulness of your exit. First, let everyone you are working with in the lab know that you will be leaving the lab and when. Prior to leaving the lab, make sure that you document everything that you have done and leave precise instructions as to where to find your stocks and other materials. It is crucial that those who will follow you in your research project are able to pick up where you left off. It is also more than a nice gesture to keep in touch with the faculty member of the lab. Even if you left what you believe were explicit notes, your lab mates may still have occasional questions about stocks, protocols, etc. that you made or used.

What should I expect throughout my research experience? You should expect that your questions about protocols, equipment, and your research subject will be welcomed and that you will gain valuable experience in the process. You should expect that your professor will be available to meet with you regularly—at least on a weekly basis—and that he/she will assign you to a mentor, usually a graduate student or postdoctoral researcher who can serve as your daily mentor in the lab. You should expect that hard work, regular hours, enthusiasm, and attention to detail will be rewarded with positive feedback and a positive letter of recommendation by your professor.

Establish and guard your good reputation within the community. You are part of a small close-knit community. Remember that Rice faculty and staff share information about student behavior good and bad, and that communication crosses departmental boundaries and employee rank. An administrator in one school at Rice may play tennis with the dean of another school. Rice professors have spouses and friends working at the Texas Medical Center. It is always in your best interest to treat all employees and students with kindness and respect and to establish a pattern of responsible behavior throughout campus.

Hours: You are expected to work at least three hours in lab per week for every hour of credit. Note that this is a minimum requirement. Those who add the course late are expected to make up the hours they missed over the remaining time in the semester.

After your initial training period, your schedule can be more flexible. You may work more one week and less the next as your research and study needs dictate. Just make sure that you keep your professor and your research mentor informed of your schedule. As you plan your schedule, remember that it is much harder to make up hours when things get busy at the end of the semester. It is prudent to bankroll some hours early in the semester to avoid falling into a deficit. You are not required to work during Rice vacations and finals but you should remind your coworkers if you will be gone and make sure that you don't leave cells or other experimental organisms to die in your absence. Remember that the graduate students and postdocs in the lab are there a minimum of 40 hours a week and don’t follow the Rice academic calendar. They will expect to see you unless you let them know otherwise. Post your schedule and contact information above your bench so that those who are looking for you know when you will be in and can contact you if they have a question (see form for this purpose later in the manual).

Safety: Safety training is required for research both on and off the Rice campus. Basic lab safety is taught as part of BIOC 111 and BIOC 211 and also in the introductory lab courses in the Chemistry Department. For additional safety information, please consult the Biochemistry & Cell Biology Safety manual located in the BIOC 310 Resources folder on OWL-Space. Additional safety modules and even immunizations may be required if you will be working with radioactive isotopes, animals, blood products, or special pieces of equipment. For this reason, it is strongly suggested that you inquire about the safety requirements of your particular research project well in advance of your start date.

Proper lab attire: For safety reasons, you should always wear long pants and closed-toe shoes when working in the lab lest any of your solutions be spilled on you from the bench. Gloves, eye protection, and lab coats are also to be worn when working with hazardous materials. Among common lab reagents are strong acids and bases as well as various carcinogens, neurotoxins, and other poisons. Proceed with care and always be aware of the safety requirements of your reagents. When in doubt, wear gloves.

Radios and music players: While you may enjoy listening to music when you work, understand the impact that it may have on your lab-mates. Audible radios or other music players may disturb those around you. Ask your lab-mates permission to play music and also make sure to let them know that they are welcome to turn your player off at any point. Personal listening devices with headphones are less likely to distract your colleagues but can reduce communication and collegiality between you and your lab-mates and can become a distraction to as you become removed from the immediacy of your research environment.

Required written materials and forms

Maintaining a proper laboratory notebook

One of your most important tools in the lab is your lab notebook. If you keep accurate records, your notes will help you to repeat your successes and identify your mistakes. Poorly documented experiments can render your results meaningless and lead to repeated mistakes. A detailed, accurate, and well-indexed notebook is a required part of your research and your grade for BIOC 310. Your laboratory notebook should be left in your lab and will remain the property of the lab. Information on how to prepare a proper lab notebook can be found in the following section.

Keeping a laboratory notebook
(Modified from text by Lucia Strader)

I. Format

A. Each experiment should have a title and the entry dated.

B. The purpose or objective of the experiment should be clearly stated (can be the same as the title).
- May be appropriate to state references of methods used.

C. The methods should be present in a very easy-to-follow format.
- Details of the protocol should be included
- Complex experiments should have a flow chart / numerical guide to steps
- Simple experiments can be referenced or outlined

D. The notebook should always form the basis of an "experimental log" where notes are kept during the execution of an experiment.
- What do the pellets look like?
- Lot #s of chemicals (especially if an unusual compound)
- Keep track of changes in stock solutions
- Make drawings of what things look like
- Always note if something is strange or different than usual
- Calculations should be present for buffers, dilutions for gels, etc. These should be complete as they are especially critical. Do not use paper towels or post-its!

E. Data should be included in an accessible form.
- Experiments should be "completed" in the sense that the data is graphed, labeled, or listed in a format that allows you to remember what the numbers mean
- Publication-quality data should be stored in a way that you can retrieve it later
- Negatives / gel photos should be logged and placed with the matching experiment immediately.
- Data that will be photographed should be stored in an envelope or sleeve for later removal (autorads)
- Data that is logged in directly into a computer should be printed and included in the notebook

F. Each experiment should have a conclusion.
- Even simple preps (DNA, protein, whatever) should have yields and concentrations listed as a final entry
- Make an entry of any experiment that fails or is aborted and clearly state the reason (this is critical if this experiment "goes against the trend" in deciding whether if should be included in the final publication or whatever). ALL data should be entered, not just the data that fits with your dogma or you think your professor would like to see. Quite simply, this is what scientific integrity is all about.
- Whenever possible, the data should be interpreted in words.

II. Other Uses of the Notebook

A. As a scientific journal
- Record of your ideas, plans for experiments, phone calls related to

- the work, conversations with colleagues, etc.
- "I wonder what would happen if…"
- A primary source of information and progress

B. As a detailed record of protocols
- Finalize your own adaptations of standard methods and put these in as sections, include buffer recipes, and other hints
- Refer to these sections and update them as you learn

C. As a place to tape ads for products worth trying at some time, or to jot down ideas the other people give you.

III. Managing Notebooks

A. Each notebook should have a "table of contents" that is updated every week or two.

B. Another person should be able to read about your experiment and do it from your notebook without further explanation
- I.e., it ain't no good if we can't read it

C. Experiments / topics should be together on sequential pages
- Learn to leave room for the amount of data coming in

D. The notebook should stay in the lab at all times. Special permission may be granted to remove a notebook from the lab for a brief period of time.

Remember:

- Notebooks stay in the lab when you leave.
- Notebooks are the primary source of information concerning what you've accomplished.

- Idea priority is established here.

For more information on managing your laboratory notebook consult David Caprette's BIOC 211 "Guidelines For Keeping a Laboratory Record."
http://www.ruf.rice.edu/~bioslabs/tools/notebook/notebook.html

Preparing your weekly reports

Carefully prepared weekly reports are an effective way to communicate what you are doing with your professor. Because your professor may be advising many different projects in the lab, it is important to begin your reports with a few context sentences to remind him or her of the scope your project. Weekly reports must be emailed to your professor every week by Saturday at 11:59 pm and copied to your research mentor, and, if you are in an off-campus lab, you should also copy the BIOC 310 instructor of your section as well.

Reports should include:

Your name:
Lab of: Professor's first and last name
Week being reported (Sunday's date):
Lab hours this week:
Project title:
Project Summary: Brief (2-3 sentence) summary of project context
Where I left off last week: A summary your previous week emphasizing the experiments that you will be continuing this week.
This week: Detail your experiments conducted and results obtained. Include graphs, charts, experimental failures and mishaps.
Conclusions: Tell what you can conclude from your experiments this week. Often the conclusion will be not be groundbreaking but confirmatory, such as that a reagent is good, or that a result is consistent with a previous one. If you extract every bit of information from your experiments, your research will progress much faster.
Next week: Plans for the upcoming week

Unless your project title and research summary change, you can just cut and paste them into your weekly reports from one week to the next. If you have more than one project with different aims, include separate "last week", "this week", "conclusions", and "next week" entries for each project.

Detail: It is good to have perspective in your weekly reports, while still giving sufficient detail so your advisors can help you trouble shoot any problems you may be having. If something isn't working, don't say "I performed a [digestion, southern blot, PCR, etc.] but it didn't work." Make sure to tell your readers what samples, primers, enzymes, etc. you used and a description of the procedure or kit you used. Often, in the process of explaining the problem, you will figure out what went wrong. While giving us some detail, make sure that you don't get *lost* in the details. Keep focused on the important elements of every procedure. What is this procedure supposed to accomplish? What was your starting material? Which are your experimental samples and which are your controls? How can you tell if the procedure or experiment worked properly? What is the read-out? What was unexpected or unsuccessful?

Use clear and readable prose: Simply providing us with your task list for the week will not help us to understand the flow of your thoughts or experiments. Using complete sentences in your reports will ensure that you can wrap both your brain and your words around a problem and will help you to hone your communication skills when it comes time for your paper or poster presentation. By using the active voice and first person ("I gel-purified the 1-kb fragment" vs. "The 1-kb fragment was gel purified"), you will make your prose more readable and will help professor to differentiate what you did and what your mentor did for you.

Cite your sources: While you are not necessarily required to produce formal bibliographies in your weekly reports, it is important to make some references to any sources you may have had for your ideas or protocols (e.g., "Mary Chen [a graduate student in the lab] suggested that ..." or "One possibility, suggested by Smith and Park (2009), might be that ..." or "I followed the Jones, et al (1998) protein expression protocol as modified by Mary Chen.").

File format: Please consult with you professor to identify the preferred format for your weekly reports. Your professor may prefer to receive your weekly report in the body of an email rather than as an attachment or in the form of the PowerPoint presentation you use in lab meeting each week. If you are including reports or other data as attachments, make sure to use a file format that all of your advisors can open. After sending your first report, ask if they can all open and read your document. In addition to emailing your reports to your professor(s), print them out and put them in a section of your notebook for your own reference.

Email etiquette: Put your research professor's email address first in the "to" field followed by your bench mentor(s). If you are working in an off-campus lab, include your BIOC 310 instructor in the "cc" field. By listing your professor and mentor in the "to" field, and by putting their names in your greeting, you will welcome and encourage them to make comments or ask questions about your reports. Label each report by week so that your research professor will be reminded of how many weeks are left in the semester (e.g. "Weekly report: week 9 of 14". Remember that weekly reports are not just an assignment for BIOC 310 but an important line of communication with your professor and mentor. If you ever have a concern about your research or research environment that you don't wish to share with your professor or mentor in your weekly report, you can send your concerns to the BIOC 310 instructor in a separate email with "help" in the subject line.

Remember, the point of weekly reports is for you ...

- to think about and communicate the context for your research,
- to be reflective about what you have done and what the results mean,
- to plan, thoughtfully, for the next week, and
- to communicate regularly and effectively with your professor and mentor.

A good weekly report should not be a lab notebook dump of every milliliter you pipetted that week, but should answer the questions, "Why am I doing THIS particular procedure? Why am I using this sample? What do I hope to see? What results did I see and what do they mean? etc." For instance, you can start a section with a justification:

"To determine which of my purification steps yielded the highest concentration of protein, I ran a 10% SDS PAGE gel containing the purified ADK samples 1-4 on along with a protein standard xxx and an ADK sample of known concentration from my mentor."

"To control for normal cell growth and to quantify the amount of growth suppression in the context of each cell line, I grew wild-type xxxx cells in parallel with my kidney tumor cell lines with and without the tumor-suppressor transgene [xxx]."

"By adding [ligand x] we expected, given the expression profiles from last week, to see growth differences between wild type and receptor mutant embryos."

"Because I saw no bands in the lane supposedly containing my GFP promoter fragment, I must have lost my DNA in one of the earlier gel purification steps. Next week I will go back and repeat the procedure with a beta-agarase gel purification method instead."

If you are stuck on a procedure and would like your professor and mentor to help you to diagnose the problem, you can add additional detail (amounts, concentrations, recipes, etc), but you never want to lose focus on what you hope to accomplish by performing that particular procedure.

There may be many projects ongoing in your lab. To remind your professor of your project topic, it is good to start your weekly reports with a project title and a sentence or two about the big question you wish to answer over the course of the semester. A nice example of an actual weekly report may be found in the appendix of this manual.

Below is an example of a fictional weekly report. See appendix for real student sample.

Name: *Julie Doe*
Lab: *Bonnie Bartel lab*
Week of: September 7, 2008
Hours this week: *9*
Project title: *Characterization of putative peroxisomal mutants in Arabidopsis thaliana*
Project summary: *Our goal is to find genes required for plant peroxisome formation. Peroxisomes house reactions that convert the fats in oil seeds to energy for germinating seedlings. Screening for seedlings that fail to germinate without supplemental sugar yielded ten mutants defective in fatty acid beta-oxidation and presumably peroxisomal function. I am investigating one of these mutants to clone the defective gene.*
Where I left off: *Last week I sowed wild-type and the X3556 mutant on the hormones IAA, IBA, and 2-4D, with and without sucrose and put the plates in either 24-hour light or foil-wrapped them to keep them dark.*
This week: *Using the plates of plants sown last week, I measured root and hypocotyl length of the seedlings on each of the plates. (See attached charts and graphs.)*
Conclusions: *From these data, it appears that X3556 is sucrose dependent in the dark but not in the light. Unfortunately, I had a mold-infestation on my control (no hormone + sucrose + 24-hour light) plate that may have affected my results.*
Next week: *I will repeat the experiment in a limited form to confirm the sucrose sensitivity of X3556 in the dark and to rule out experimental artifacts created by the mold contamination.*

One of the most common criticisms of students by research professors is that the students do not have sufficient intellectual engagement and do not regularly read the scientific literature. To counter this, it is good practice to try to read (and discuss) at least one relevant research article a week. This will enrich your knowledge of the field in which you are working and give you something to discuss with your professor and mentor.

Preparing your research proposal (abstract)

The preparation of a one-page research proposal in the beginning of the semester will aid you in focusing your research goals while at the same time help you to understand how your research fits in the larger field. This proposal is due to your professor by the end of the second week of classes to avoid a final grade penalty. Off-campus research students should also submit their reports to the BIOC 310 instructor of their section.

At the point that you begin to write your proposal you should have already had one or more conversations with your professor about your project and have read at least a few articles written by members of the lab or related articles from elsewhere. Ask your professor or co-workers to recommend research articles that are particularly relevant to your research. As you read these articles, make sure to ask questions about anything that you do not understand. It may be particularly helpful to read the proposal for the grant that is funding your research. This document will give you the background that you need to understand the significance the lab's research, perspective on your place in this research, and copious references for future reading. Ask your professor if you may peruse a copy of the grant that covers your project. Your proposal should address the following topics:

1. *What is your research area? What is the importance or relevance of your research area? Why should we care?* In the first few sentences, you should aim to interest your readers in your subject and convince them that it is worth their while.
2. *What has yet to be answered in this part of your field and why is filling this gap important for your field in general?* This is where you make a case for the work you plan to do by establishing a need for such research.
3. *How do you plan to go about answering or at least addressing this pressing question?* Scientific research is incremental, so you will want to clearly define the increment by which you wish to move the field. List your experimental aims and explain how each will allow you to

address part of your scientific question. Include sufficient detail to show your advisors that you understand what you are setting out to accomplish. For example, include the proteins, genes, organism, etc. that you will be manipulating, the key methods or techniques that you will be using to do so and the questions that each of these manipulations will answer or contribute to answering.

Use the first person narrative style to indicate the experiments that you will be performing and to differentiate these parts from experiments that have been completed by other members of your lab or collaborators.

Put the time and effort required into developing a good proposal. Later in the semester, as your research progresses, you will modify this document and it will eventually reappear as the abstract in your final project.

Even students who have taken BIOC 310 previously are required to submit 1-page proposals. The exercise of writing a proposal is a bit different from that of a paper or poster. In addition to introducing your area of research and justifying the need to answer your particular questions, you must also convince your reader of the wisdom of your experimental approach and that it can be completed within the limited time frame of the course. Each semester your proposal will change as you answer some questions and create others. In the beginning of each semester you will have completed the previous semester's experiments and will propose to do the next set of experiments.

Remember that copying text, ideas, or images without attribution is plagiarism and a violation of the Rice honor code. See the manual sections “Honor Code for BIOC 310” and “How not to plagiarize” for examples of proper citation technique.

For an example of a proposal abstract, see the Student Examples section of the manual.

Preparing your poster

Students enrolled in BIOC 310 in the spring semester are required to complete a poster and present it at the Rice Undergraduate Research Symposium (RURS). Your professor is expected to cover or reimburse the cost of printing your poster as it is a research cost associated with the dissemination of science. Your poster should then stay in the lab after the end of the course. If you wish to keep a hard copy of your poster, you should cover the printing costs yourself. The MUDD lab printing costs are very reasonable compared with other facilities. As of 8/26/2014, MUDD lab poster printing costs $3 (matte) or $7 (glossy) per linear foot ($12/$28/poster). http://it.rice.edu/printing.aspx

A poster session is the scientific equivalent of a bustling open-air market. We have a project that we wish to “sell” and must present it visually and verbally in such a way that we can convince our colleagues to “buy” or get excited about it. Keep in mind that poster sessions are usually noisy affairs that take place in large rooms containing long aisles of posters. You want your poster title to be concise and clear and in a large enough font to be read from a few posters down the aisle. The text of the remainder of your poster should still be large enough that it can be read from across an aisle (6 ft). A useful rule of thumb is to make sure that your poster will be legible when printed on a single sheet of 8.5 x 11 paper. If not, your font will be too small to be easily read by those walking by. For the times that you will not be present to verbally guide people through your poster, your poster should speak for itself, using a logical and visual flow that allows a reader to follow your research.

Your poster should answer the following questions: What was the goal? What were the experiments? What are the results? What is the author or lab planning to do next? Visitors to a poster session with hundreds of presenters often do not have the patience to read a lot of text. Where possible, try to substitute schematics and diagrams for long verbal explanations.

The required elements of a poster are:

1. Title
2. Author list – your name goes first, followed by those who worked with you or advised you on your project. The head of the lab gets listed last. (Make sure to consult with your professor on the composition of the author list!!)
3. University and department affiliation
4. An abstract of your research/background*
5. Visual or textual summaries of your experimental design
6. Results/data – tables, graphs, etc.
7. Conclusions/future work
8. References and acknowledgements

* Occasionally presenters, on the recommendation of their advisors, will alter the format such that the

content of the abstract is broken up and distributed throughout the poster.

Please be aware that a poster is a form of publication and, for that reason, you need to show a draft of your poster not only to your professor, but also to all other authors for feedback and approval prior to printing. Remember that copying text, images or ideas without attribution is plagiarism and a violation of the Rice honor code. See the manual sections, "Honor Code for BIOC 310" and "How not to plagiarize" for examples of proper citation technique.

The recommended method for preparing a poster is by using Microsoft Powerpoint and printing your poster on one of the large plotter printers on campus. Be aware that undergraduate researchers from all parts of the university will be preparing their posters within the same time frame. It will be to your advantage to complete and print your poster ahead of the rush on the plotter printers.

BIOC 310 students are responsible for joining the RURS Owl-Space site. This site enables them to register for the poster session, submit abstracts, receive announcements, and view samples and guidelines. Please take advantage of Rice's resources. Staff from the Rice Center for Written, Oral, and Visual Communication offer workshops and one-on-one writing and presentation assistance. Occasionally we will arrange for a specialized CWOVC workshop for BIOC 310 students. http://cwovc.rice.edu

Sample posters are included in the appendix of this manual and are usually available on the RURS Website.

Preparing your research paper

A research paper is required of all students in the fall semester. Some professors may request that you write a paper in the spring semester as well. Please consult the BIOC 310 deadlines page for due dates.

Most researchers begin a research paper by thinking of the figures and tables that they will include. This data forms the framework around which the paper is built. Start early in the semester by making an outline of the background material you wish to cover in your introduction and the key experiments you hope to complete. Read lots of research articles. This will help with both your introduction section and in the planning of your experiments.

To get an idea of acceptable formats, language and reference styles, we suggest that you model your research paper after the research articles in one of the following journals: *Genetics*, *Biochemistry*, or *Cell*. Because these articles contain the work of many individuals over multiple years they will be larger in scope than your work, but they will help you to think about how to organize your information. You don't need to mirror the page layout of published research articles. Your paper may be in a single-column format and the tables and figures may be appended rather than integrated into the text.

After you have had a chance to look at some research articles in the journals listed above, please read David Caprette's BIOC 211 "Writing Research Papers" (http://www.ruf.rice.edu/~bioslabs/tools/report/reportform.html). The information on this site will walk you through the process of writing a research paper and help you to avoid many common mistakes.

All BIOC 310 research papers must contain the following sections:

1. title followed by your name*
2. abstract
3. introduction — background information
4. methods and materials used in your experiments
5. results — text of your findings, containing graphs, tables and other data
6. discussion – interpretation of your findings; may contain schematics and models
7. conclusions/future work
8. references
9. acknowledgements — thank your professor, research mentor, and all those who helped you on the bench, aided you in formulating your ideas, and read and gave critical input on your drafts.

* Unlike the BIOC 310 poster, the BIOC 310 research paper will be a single-author document. We expect that the work represented in your paper will be yours and not data collected for you by another member of the lab or text written for you by others. If any data or figures come from colleagues or outside sources, you must reference them. While we want your advisors to review your document, they are to supply critical comments and suggestions and not rewrite or heavily edit your document for you. Given that many researchers are used to aggressively editing co-authored manuscripts, it is best to give them a

paper copy to help them resist the urge to rewrite various passages.

Remember that copying text, images, or ideas without attribution is plagiarism and a violation of the Rice honor code. See the manual sections, "Honor Code for BIOC 310" and "How not to plagiarize" for proper citation technique.

There are a few programs to help you to manage your citations and bibliography. These programs can be used to generate a library of citations -- downloaded from various indices and journals -- and can interface with your word processing software to allow you to add references to your text as you write your research paper. The computers in your research labs may have a copy of the citation manager, Endnote. A freeware program Zotero is available online (http://www.zotero.org/). Both programs will interface with Microsoft Word. Fondren library offers Zotero and Endnote tutorials and other information on electronically managing your bibliographies. Your mentor in the lab may have already created an Endnote or Zotero library containing many of the references that you are likely to use in your paper. Talk to your mentor about citation management as you discuss your plans for your paper.

Please take advantage of Rice's resources. Staff from the Rice Center for Written, Oral, and Visual Communication offer workshops and one-on-one writing and presentation assistance. Occasionally we will arrange for a specialized CWOVC workshop for BIOC 310 students. http://cwovc.rice.edu

Remember that you must submit outlines and drafts of your paper for review to professor, bench mentor, and BIOC 310 instructor (if researching off-campus). These drafts should be submitted well in advance of the final paper deadline to give your readers ample time to review them. Many professors leave town at the end of the semester and may wish to receive the final version before the course deadline.

A sample of a BIOC 310 research paper is included in the Resources folder of the BIOC 310 owl-space site.

Frequently Asked Questions

Can my schedule in lab be flexible? Yes, your schedule can be flexible after your initial training period. You may work more one week and less the next as your research and study needs dictate. Just make sure that you inform your professor and day-to-day mentor of your schedule well in advance. As you plan your schedule, remember that it is much harder to make up hours when things get busy at the end of the semester. It is prudent to bankroll some hours early in the semester to avoid falling into a deficit. The course ends at the end of classes so you cannot put off your research with the expectation of "cramming" your research hours during reading period and finals. (It is also bad form to do so.) It is also bad form to pack all of your hours for the week in a single day and then not show up for the rest of the week.

How many hours am I expected to work during the semester? You are expected to spend at least 3 times the your registered number of credit hours in lab per week for each of the 14 weeks of the semester (e.g. 3 credits = 9 hours/week or 42 hours per credit per semester = 126). Official Rice vacations, breaks, and recesses are not included in this calculation although you are welcome to work then. Summer BIOC 310 students, working fewer than 14 weeks (8-10 is typical) will spread their total hours (42 hours x # of credits) across the weeks that they will be researching. Most students work more than the minimum hours and you make a better impression if you do.

Am I required to work in the lab during school vacations and finals? You are not required to work during Rice vacations and during finals, but you should remind your coworkers if you will be gone, mark these dates on the calendar that you post above your bench, and make sure that you don't leave cells or other experimental organisms to die in your absence.

Am I required to make up the hours I miss if I add the class late? Like any other class, you need to make up what you missed at the beginning of the semester. If you add BIOC 310 after the beginning of the semester, you will be required to make up all hours missed. Consider your makeup hours when you are deciding how many hours of credit that you sign up for.

What do you mean by professor, instructor, and mentor? Your *professor* is the faculty member who in the head of the lab in which you conduct your research. A research professor is also known as a faculty research advisor or principal investigator (PI). Often, students have a second, day-to-day advisor (research *mentor*) who is a graduate student, postdoc, or other individual working in the lab. This person provides advice on experimental detail and protocols. The BIOC 310 *instructor* functions as an on-campus faculty advisor for off-campus researchers and as a general resource and administrator for on-campus students. Dr. Dereth Phillips is central administrator and the instructor for off-campus section 1 (laboratory research). You will send your weekly reports and other materials to your professor and research mentor (copied to your BIOC 310 instructor if working off campus).

Do I have to write a weekly report in the first week when I am just setting up? All students are required to complete a weekly report for the first week, however, that first report can be something like, "I came into the lab, read the safety manual, and organized my bench. Next week I plan to..."

Do I have to write a research abstract even if I am continuing my project from last semester? All students, including those continuing from the summer or previous semester, are required to submit 1-page proposals summarizing their plans for the upcoming semester. Each semester your proposal will change as you answer some questions and create others. The beginning of each semester is a good time to take stock of where you are and where your research is going during the upcoming semester.

How do I contact the BIOC 310 instructor? BIOC 310 is coordinated by Dr. Dereth Philips. For help, questions, or concerns, students are encouraged to set up meetings with the instructor. As Dr. Phillips works part-time and may not be in her office (Anderson 340) when students drop by, the preferred means of communication is email (derethp@rice.edu).

Can I take BIOC 310 if I plan to perform research in a Rice lab outside of the BioSciences Department (e.g., BioE, CHBE, CHEM department labs)? Normally no, however, an exception may be made if you meet all of the following qualifications: 1) you are a BCB major, 2) you have secured a project that fits the scope of Biochemistry & Cell Biology research, 3) you have not yet taken BIOC 310 for 3 credits or more, 4) you wish to have your research count toward an advanced lab in the major, and 5) you have secured a faculty co-sponsor within the BCB program in the BioSciences department.

Will my proposed project (in a lab outside of the BioSciences department) qualify for BIOC 310 research? You can get an idea of the scope of the sort of research that might qualify by viewing summaries of current research in the BioSciences department, but to confirm you should contact the BIOC 310 instructor. Even before you have secured your research position you can inquire about potential labs/projects.

Can I take BIOC 310 if I'm a Century Scholar? Yes, but you must make prior arrangements with the coordinator of the Century Scholars program to ensure that you are not receiving credit twice fore the same work.

What is the difference between BIOC 310, BIOC 401, and HONS 470/471 (RUSP)? BIOC 310, BIOC 401, and HONS 470 are all research-for-credit courses but they differ in required number of credits, application and experience requirements, and expectations of student independence. BIOC 310 can be taken any year during your undergraduate career, can be taken for 1 to 4 credits (3 is recommended), and can be repeated for credit. You are eligible for BIOC 310 regardless of your current GPA. BIOC 401/402/412 (BCB Honors research) is intended for seniors and extremely advanced juniors who meet the GPA requirements, and requires project and student independence. BCB Honors Research must be taken for two consecutive semesters for 5 credits of research each semester and requires the accompanying BIOC 412 seminar course in the spring. RUSP is intended for students of all majors considering graduate school, requires that students develop independent projects, has a seminar component, and is open to students 2nd year and above (recommended for Juniors). RUSP has a limited and competitive enrollment. BIOC 310, if working on-campus, does not require an application but BIOC 310 off-campus, BCB honors, and RUSP all require a completed application.

Can I take BIOC 310 and RUSP in the same lab at the same time? Yes, but you may not get double credit for the same work. Students are encouraged to enroll in BIOC 310 and HONS 470/471 in successive years. The ideal way to schedule your research courses would be as follows: Sophomore – BIOC 310, Junior – HONS 470/471, Senior – BIOC 401/402/412.

When is the best time in my college career to take BIOC 310? You can take BIOC 310 at any time during your undergraduate career, and it is repeatable for credit. If you wish to be involved in a long-term research project or hope to enroll in BIOC 401/402/412 (BCB honors research) or HONS 470/471 (RUSP), it is best to start enrolling in BIOC 310 in your first or second year.

Can I take BIOC 310 during the summer? Yes, but only at Rice or other institutions within

Houston and you may not receive financial compensation for your research during the term in which you are receiving BIOC 310 credit.

What do I do if I have two projects in the lab? Which do I include in my paper/poster? If the projects are closely related, it may be possible to work them both into your paper or poster. If they are in different areas of research, you should use the most complete project for your paper/poster and write a summary document on the other. This summary document should be written in such a way that it will aid anyone who follows you in answering the following questions: 1) What was he/she working on in the lab? 2) How far did he/she get? 3) Did he/she check to see if his/her reagent was made correctly? 4) Where can I find their stuff? To these ends, your summary document should contain any data you have collected in graphical form, a list of all of the constructs, cell-lines, or other materials that you have created, the results of any diagnostics on these reagents, and an indication of where in the lab one could find them.

If I am working in a non-BCB lab at Rice, which research-for-credit course should I take?

- Ecology and Evolutionary Biology – EBIO 306
- Bioengineering – BIOE 400, BIOE 401
- Chemical and Biomedical Engineering – CHBE 499
- Chemistry – CHEM 491
- Neuroscience program – NEUR 485
- Kinesiology—HEAL/KINE 495/496
- Etc. (Check your professor's departmental listing independent course offerings.)

Information for BIOC 310 professors and research mentors

Information for BIOC 310 professors and research mentors

Thank you for your interest in working with Rice undergraduate researchers. The following information is to help current and prospective BIOC 310 professors understand the expectations of and for our students.

Finding a Rice undergraduate researcher: Rice students may approach you, unsolicited, asking to work in your lab. If you have not been approached but are interested in hosting Rice undergraduate researchers, please email the BIOC 310 instructor (Dereth Phillips, derethp@rice.edu) to receive a suggested posting template. Your opportunity will be posted on an internal Rice list whose members have expressed an interest in biological or biomedical research. Ads will be left on the list until we are notified that your positions are filled. We ask that opportunities be submitted by the PI/head of the lab to avoid confusion in cases where a graduate student or postdoctoral fellow has not received their supervisor's permission to host an undergraduate researcher.

For credit or for pay? Rice students may perform research for course credit as long as they are not being paid for their work and have a project that falls under the broad description of biochemistry or cell biology laboratory research (not simply lab maintenance such as making media or washing glassware). The students must work in a research laboratory and will not receive credit for physician shadowing or other clinical or hospital activities. When prospective researchers contact one of our faculty members they usually discuss their expectations of the experience (hours in lab, type of work, credit or pay, etc.). Some faculty only take for-credit students, while some, if they want a part-time lab technician, prefer to pay them hourly. Students usually work for course credit (unpaid) during the school year and for pay during the summer.

BIOC 310 requirements in brief: In addition to their research, BIOC 310 students are required to prepare a research proposal abstract early in the semester, weekly reports throughout the semester, and a final project, either a paper (fall semester) or poster (spring semester) for their professor. Students performing research off-campus copy the BIOC 310 instructor, who functions as their on-campus advisor, on all assignments including weekly reports. For students working in off-campus labs, the off-campus professor provides grade input to the BIOC 310 instructor, who submits the final grade for the student.

Each semester is around 14 weeks long (not counting vacations). Students performing research off-campus must spend at least 3 hours working in lab per week for each credit they receive and can take the course for 3 to 4 credits (9-12 research hours/week). There is no limit on the number of semesters that BIOC 310 can be repeated for credit and we hope that students will continue their research for multiple semesters.

Hosting a student: To have a productive experience, it is best if students have regular access to their research professor/PI (at least once a week) to discuss their project and plans. The student also should be assigned a research mentor who is willing and able to teach them techniques at the bench. This person might be the professor if he or she spends a lot of time in the lab, or a patient graduate student, post doc, or other experienced individual who is interested in educating undergraduate researchers. We encourage labs to include their undergraduates in lab meetings and other lab activities as such participation typically leads to a deeper intellectual engagement and investment in their research. In their first semester, most undergraduates require more time of their professor and research mentor than they give back. In subsequent semesters, however, they often become more independent and some function at the level of part-time graduate students.

BIOC 310 students are entitled to all Rice University vacations and holidays, but we ask that they prepare for their leave by informing their lab and not leaving unfinished work for others to juggle.

Advice for new postdoctoral and graduate student research mentors

Before adopting an undergraduate student mentee, consider which is more important to you, a mentoring experience or help with your project. If you are interested in a mentoring experience and can invest the time to educate and inspire an undergraduate researcher, you should consider mentoring a BIOC 310 student. Students participating in research for credit are interested in learning about your field, your biological questions, and the techniques that you use to answer those questions. They should be able to gain hands-on experience with some of those techniques and should employ those techniques toward experiments that address a biological question. If, however, you seek an extra pair of hands to perform repetitive tasks and have little time to train and advise a novice researcher, it may be best to speak to your professor (advisor, PI) about hiring a student technician for pay. Instead of course credit.

If you are interested in mentoring a BIOC 310 student, determine which portions of your project might be most accessible to an undergraduate researcher. Is the proposed project self-contained? Are the techniques standard for the lab and reliable in your hands? Are the materials needed for the project already available? Can a novice working 9 hours/week in the lab make meaningful progress in this portion of your project?

It may be prudent to start a new person on something that is not terribly critical, such as making starting material through a procedure that you have established. It is reasonably likely that some of the initial experiments will have a problem and you do not want this to derail your most critical work.

Tips for a successful laboratory mentoring relationship

- Be very clear at the outset about your roles and expectations of each other.
- Make sure that the two of you meet to review your calendars to account for any vacations or commitments either of you have that might require that the other cover for the research.
- Give the student current, complete, and accurate written protocols even if you perform the same procedures by memory. Ask for feedback on those protocols after the student has completed the procedure to see if the student has ideas to make your written protocol more clear.
- Make sure that the student is keeping a detailed notebook and has a place to store and organize the protocols they are given.
- At least once a week, review the student's plans for the following week to ensure that they have planned ahead, that you will be available to help them if needed, and that their time will be used wisely.
- Make sure that you are present to answer questions during the hours the student has arranged with you to be in the lab, and that there is a designated back-up person who can answer questions when you are unavailable.
- Make sure that the student has access to research materials he or she will need. Show them where everything is located and try to avoid making them beg for supplies from other labs.
- Remember that in their first few weeks in the lab, the students will probably require nearly constant mentorship but that strong guidance at the beginning will yield a well-trained researcher in the future.
- It is recommended that you copy your professor/PI on all emails to your mentee. This will keep your professor informed if there are issues with the student's experiments or performance, prevent you and your professor from giving the student conflicting information or directives, and will allow your professor to give input on your mentorship.
- It may be particularly helpful for the student to read the proposal for the grant that is funding their research. This document will give them the background that they need to understand the significance the lab's research, perspective on their place in this research, and copious references for future reading. Ask your professor if your student may peruse a copy of the grant that covers the project on which they will be working.
- Read the sections of this manual intended for the students so that you are familiar with our course requirements and expectations of BIOC 310 students.
- Ask to be copied on the student's weekly email reports to your professor, which will give you a good idea of how well the student understands their results and where the research is going.

Interacting with undergraduates: Treat the students like junior colleagues. If they see you as a colleague they will be more likely to ask you interesting questions and perhaps even to see themselves in your shoes someday. You are their introduction to research biology. Much of what you take for granted—both the methods and sociology of scientific research—will be new for your students. Try to look at your field through the eyes of an outsider to help them to engage with what they see and hear.

The students should feel welcome and comfortable around you. This means that you may need to exhibit more patience than perhaps you would normally show. Your students will have many things going on in their lives such as classes, activities, and personal crises, and some younger undergraduates may not handle their lives in the most efficient and mature way. This does not mean that you should lower your expectations of these students, just that extra reminders and gentle nudges are usually welcomed by even the most reliable students.

Your ability to appropriately address the student's questions will be your most valuable asset. Students arrive in the lab with a great diversity of experience and even those with previous research experience will require a thorough orientation. If you dismiss what you feel is a trivial question, you may find that you have discouraged the student from asking valid questions in the future. Some timid students will flounder for days rather than risk future embarrassment. It is important to foster independence but to emphasize that they should ask questions any time they are confused. Even if a student appears to be asking very advanced or jargon-laden questions, don't let the questions pressure you into responding on too high a level. The student's vocabulary may be masking an incomplete knowledge of the subject. Answer the seemingly advanced student in a way that clarifies that they understand the basic information behind what they are asking. Keep in mind that the goal is to convey what you know without being patronizing.

If you have problems in your mentoring relationship, discuss them with your research advisor. Also feel free to contact the BIOC 310 Instructor (derethp@rice.edu) for input or if you have ideas for additional material to be included in this manual.

Instructor grading worksheet for off-campus research students

A note about evaluating BIOC 310 students: Due to the variability of projects and circumstances in the various labs, an "A" does not require a complete publishable unit but is instead awarded for substantial effort, progress, and intellectual engagement given the time and resources available. Please feel free to include input from the student's day-to-day mentor at the bench. The following is not a firm grading rubric but instead serves as a worksheet for thinking about the student's performance in your lab. Please feel free to call the instructor if you prefer to discuss the student's performance by phone.

Dereth Phillips (derethp@rice.edu), office #713-348-2343.

Evaluation of the student's work environment:

- Was the student given access to a daily mentor at the bench?
- Was this person willing and able to mentor the student?
- Were you able to meet with the student to discuss his/her research on a weekly basis?
- Was the student supplied with the reagents and equipment necessary to complete his/her research?
- Was the student supplied with written protocols for his/her procedures?
- Were the procedures needed for the student's research commonly used in the lab (as opposed to being new to- or rarely used in the lab)?
- Was the lab free of personality issues or social conflicts that may have affected the student's performance?

Evaluation of the student as a lab citizen

- Did the student complete at least the minimum required hours of research in the lab this semester? (3 hours average minimum in lab per week per credit, ~126 research hours required for 3 credit hours [hours change slightly per semester])
- Did the student show up regularly to the lab and keep you and their bench mentor informed prior to an absence from the lab?
- Was the student on time for planned meetings and experiments? Does the student respond to email in a timely fashion?
- Did the student work well with his/her bench mentor and other members of your lab? (Did s/he show respect to colleagues? Did s/he

appreciate the communal nature of a research lab?)

Evaluation of student performance in and preparation for the laboratory

- Did the student perform the experiments carefully and with an attention to detail?
- Was the student careful and responsible with lab reagents and equipment?
- Was the student responsive to your suggestions?
- Did the student appear to understand the larger context of his/her work?
- Did the student appear intellectually engaged in the research that s/he was performing?
- Did the student read relevant scientific literature?
- Did the student keep a detailed lab notebook?
- How would you rate the student's overall performance in your lab?
- How would you rate the student's progress in his/her research given the constraints of their project (5=great deal of progress, 1=no progress)
- Please provide detail about the student's performance in lab and the quality of the work performed.

Evaluation of written communication

- How would you rate the student's proposal?
- Did you receive regular weekly reports?
- On average, how would you rate the student's weekly reports?
- **Research paper (fall): not included here**
- **Research poster (spring)- rate the following**
- Title, Background, and Goals: Author identifies and articulates the context, significance, and goals of the work through one or more of the following: title, abstract, introduction, schematic figures, oral presentation, etc.
- Methods: Author understands and describes methods accurately.
- Data: Author considers all data and reports those that are significant (if author has not obtained data, author forecasts predicted results). Data figures are labeled and captioned to promote understanding.
- Conclusions: Author provides distinct and accurate conclusions from the data shown (if author has not obtained data, author draws conclusions about procedures accomplished or attempted so far).
- Organization and Design: Poster is well-organized and captures the scope of the investigation. Poster distills information in short text segments; excessive detail is not provided in text. Poster is visually appealing and easy to read; color, size, and contrast of text and images promote legibility.
- Author list/references/acknowledgements: Author lists all co-authors and PI (at top), references information, data, and figures obtained from others (published/unpublished), and acknowledges support of funding agencies and individuals (if applicable). Note: cases of plagiarism should be referred to the student honor council.
- Oral presentation: Student's oral presentation highlighted key concepts and accurately explained the research project goals and findings. (If the student did not present the poster to you, please evaluate your impression of the student's understanding through your discussions with the student.)

Additional details regarding grade penalties for sub-par work, rewards for exceptional work, and other grading guidelines, will be sent to off-campus faculty at the end of each semester to aid you in preparing a suggested grade for your student.

Additional forms, templates, and surveys

BIOC 310 timesheet

Name:_______________________________________ Number of BIOC 310 credit hours:______

Student researchers are expected to complete at least three research hours for every credit hour. For example, if you are registered for 4 credit hours you must work at least 12 hours in the lab per week. This form is to assist you, your professor, and the course instructor in keeping track of your hours. This form must be signed weekly by your professor. At the end of the semester, those enrolled in BIOC 310 section 1 must submit a copy of the completed and signed timesheet to the course instructor. Students in other sections should also track hours on the form and include the timesheet in their lab notebook.

Week of:	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Total	Professor's signature
Semester total should exceed 42 hours x # of credits						Semester total:			

Planning and sharing your lab schedule

Print calendar pages for the months of the semester (many websites offer free calendar templates, e.g., http://www.printablecalendar.ca), On your calendar, mark your planned work schedule as well as school holidays and any other days that you may be away from Rice or unable to work in the lab. Keep this copy in the front of your lab notebook so that your mentor can reference it as well. Alternatively or in addition, if you and your host lab use Google Calendars, you can make a calendar of your planned work schedule and share the calendar with those who are mentoring you. As you go throughout the semester, discuss your schedule and work plans with your mentor, updating your calendar as necessary. Being transparent about your schedule will allow your mentor to plan for and be available during the hours you will be in and to prepare for the days you will be away.

Posting your schedule and contact information

Below is a template of the information that should be posted above your lab bench.

Contact information for:

email:

home phone (when at Rice):

cell:

Planned weekly work schedule:

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday

I have classes at the following days and times:

I will be away the following days:
(list Rice vacations and lab days you will have to miss due to exams or special functions)

My last day in the lab for the semester will be:

Student post-course survey

Please complete this survey electronically and return it to the BIOC 310 instructor at the end of the semester.

Name:

Major:

Semester/year:

Professor name:

School/Department:

Day-to-day mentor (if different from professor):

Course credits taken:

Average hours in lab/week:

———-

1. How frequently did you meet with your professor? Did your professor help you on the bench? Was the amount of interaction you had with the professor sufficient or would you have preferred more contact?
2. Was your day-to-day mentor available to you on a daily basis?
3. Do you feel that you were given sufficient training to perform the experiments necessary for your research?
4. Do you feel that you had sufficient intellectual support for your research?
5. Were protocols given to you or did you have to locate them or construct them yourself? Were protocols well explained, correct and complete? (if not, please explain)
6. Did you have access to all of the supplies and equipment you needed for your research? (if not, explain)
7. By the end of the semester were you able to perform your research independently without the help of your day-to-day mentor?
8. Do you feel that you had a sufficient understanding of your project?
9. Was the environment in your lab amicable and supportive or were there personality issues that made working there difficult? (please explain)
10. Do you feel that you were treated as a member of the lab?
11. Would you recommend this professor and lab to other Rice undergraduates? (explain)
12. Would you recommend your day-to-day mentor to other students? (explain)
13. What grade do you expect to receive in this course?
14. Was the BIOC 310 manual sufficient to prepare you for your research experience or was there something that you wish you would have known prior to finding and working in your lab?

Appendices

Appendix A: Proposal abstract example

Below is a nicely detailed example of a proposal abstract. This student had already been working in the lab for one semester, so she refers to work in her previous semester and how it ties into her plans for the upcoming semester.

Characterization and Mapping of *Arabidopsis* Peroxisome Mutants

Peroxisomes are the location of many important metabolic functions in plants. Among these are metabolism of the auxin precursor indole-3-butyric acid (IBA) into bioactive indole-3-acetic acid (IAA), a hormone that inhibits primary root elongation and causes lateral root proliferation (Woodward and Bartel, 2005); in addition, peroxisomes are the location of fatty acid catabolism (Graham and Eastmond, 2002). In oilseed plants such as *Arabidopsis thaliana*, fatty acid breakdown is necessary to provide the energy needed during germination and seedling establishment before photosynthesis begins (Hayashi et al., 1998). Therefore, plants with faulty peroxisomes are unable to respond normally to IBA, and unable to germinate properly without an exogenous energy source, such as sucrose (Zolman et al., 2000).

Andrew Woodward conducted a screen for mutants deficient in peroxisome function by incubating seeds for five days on Plant Nutrient medium (PN) in the dark. After discarding healthy seedlings, he added sucrose and incubated in the light for seven more days. All seedlings that arrested in the dark without sucrose, but now developed after the addition of sucrose, were tested for IBA response by transfer to a PN with Sucrose (PNS) plate supplemented with 5 μM IBA and grown under yellow light to minimize UV-light-induced IBA degradation. After a five-day incubation, he moved those plants without many lateral roots to soil.

I am examining the progeny of these putative peroxisome mutants through two screens analogous to two stages of the original screen. I will measure hypocotyl length from these seeds grown on PN and PNS in the dark to measure how well they develop with and without added sucrose. Peroxisome-defective mutants have short hypocotyls or arrest, but are healthier with added sucrose. I will also grow seeds on PNS for five days under yellow light, after which I will move half to a plate with IBA and half to a control plate and incubate for three days more under yellow light. I will then compare the numbers of lateral roots. Peroxisome-defective mutants are less responsive than wild type to lateral root induction by IBA. Thus far I have screened 14 of these putative mutants and found one that is significantly different than wild-type.

I will further characterize the line that I found to have heritable peroxisome-defective phenotypes, *sucrose dependent and IBA resistant39* (*sdi39*), and any others of interest that I find in these assays. I will test for other peroxisome-related phenotypes, such as resistance to 2,4-dichlorophenoxybutyric acid (2,4-DB), a protohormone that inhibits root elongation and is metabolized to an active form, 2,4-dichlorophenoxyacetic acid (2,4-D) in peroxisomes (Hayashi et al., 1998), a process analogous to IBA conversion to IAA. I will also test responses to IAA and 2,4-D to ensure that the plants are unable to metabolize the protohormones, and not simply resistant to the active forms. Simultaneously, I will back-cross the mutant to try to eliminate non-peroxisomal mutations that may contribute to the phenotype. Finally, we will cross mutant lines to another *Arabidopsis* accession and map the mutation that causes the phenotypes using recombination mapping. Completion of this project will allow identification of genes necessary for plant peroxisomes and better understanding of the biogenesis of this critical eukaryotic cell compartment.

Graham, I. A., and Eastmond, P. J. (2002). Pathways of straight and branched chain fatty acid catabolism in higher plants. Prog Lipid Res *41*, 156-181.

Hayashi, M., Toriyama, K., Kondo, M., and Nishimura, M. (1998). 2,4-dichlorophenoxybutyric acid-resistant mutants of Arabidopsis have defects in glyoxysomal fatty acid β-oxidation. Plant Cell *10*, 183-195.

Woodward, A. W., and Bartel, B. (2005). Auxin: regulation, action, and interaction. Ann Bot *95*, 707-735.

Zolman, B. K., Yoder, A., and Bartel, B. (2000). Genetic analysis of indole-3-butyric acid responses in *Arabidopsis thaliana* reveals four mutant classes. Genetics *156*, 1323-1337.

Appendix B: Weekly report example

Below is a nicely detailed example of a useful weekly report. You may not have this much detail every week, but you should aim to replicate the structure. Each project is separately mentioned, titled with the overall goal, and divided into "progress" and "future plans" sections.

Weekly Report -June 19-24

Project One: pBARNbHLH115(Q169STOP)

Progress: We conducted a Top 10 E. coli transformation(1817) and an agrobacteria (GV3101) transformation (1818) of pBARNbHLH115(Q169STOP). We dipped 12 Columbia plants in agrobacteria to infiltrate them. They incubated overnight in dark, humid conditions and were taken to Anderson the next afternoon.

Future Plans: Our part of this project is pretty much complete since all we can do now is wait to harvest the plants which may or may not be ready before we leave.

Project Two: ILR3-GUS---expression profile of ILR3

Progress: This week I continued sterilizing seeds and plating them on their respective days. On Wednesday we stained seedlings and found that all lines showed staining primarily in the root section after a 2 h incubation. We also subjected 4 d seedlings (we used one light staining line and one dark staining line for each treatment) to a manganese treatment and an IAA-Leu treatment. After a rather intensive survey, we determined that the consensus was that ILR3 gene expression is possibly up-regulated in the metal treatment and down-regulated in the conjugate treatment. For all treatments we used a 2 h incubation period and a concentration of 1 ml stock in 10 ml water. Five treatments were used in all: 100 uM IAA-L, 10 uM IAA, Mock (10 ul EtOH), 200 mM $MnCl_2$, and water. Following the staining analysis, the seedlings were destained and preserved in 50% glycerol.

Future Plans: We plan to use a 6 h and 24 h incubation with the metal and the conjugate treatments to confirm the results of the initial staining.

Project Three: Metal transporters-double and triple mutant isolation of mtpc1 and mtpc(and iar3-1)

Progress: I performed PCR (SSLP) on mtpc 2-1 RT with mtpc2-4 product with Col RT with mtpc2-4 as a control. I used mtpc2-3+4 primers which had been used previously with success. My first PCR with 5x diluted DNA yielded no product so we decided to try Ex-Taq with 2 uL of DNA instead of one. The second PCR did produce a product; however, the product was much smaller than the anticipated cDNA band of 180 bp. A third PCR was conducted with the undiluted RT product. Unfortunately this attempt also yielded the small, abnormal product. A final attempt to conquer this PCR was made using a genomic Col leaf prep. Once again the small product was produced. At this point we came to the conclusion that the primers were to blame and we decided to order new ones. A recent revelation by RR has cleared up all confusion-- correct primers are mtpc2-RT-3+4----case closed.

Project Four: bHLH115 Y2H screen

Progress: I transformed AH109 yeast with pBI770-At5g51720 + pBI771 and made 10% and 90% concentration plates on –L-W for Robin to test to be sure At5g51720 did not activate HIS3 transcription on its own. I also made plates with bHLH115+771, bHLH 115+115, and 770+771 to use later in the activation tests.

To test if bHLH115 could activate expression of HIS3, I made streak plates with the two previously mentioned sections for controls using a single colony and for AH109 transformed with pBI770-bHLH115 + pBI771. I performed two replicates on –L-W (growth confirms the presence of both plasmids) and on –L-W-H+ 3AT (selecting for activation).

We conducted a Top 10 transformation with pB1770-At5g51720 #2 (DNA brought from Harding) to be able to amplify DNA for later Y2H screen. We made 1%, 10% and 89% concentration plates and all showed lots of small colonies.

We performed the protocol for a large bacterial prep to purify a large amount of pB1770-bHLH 115 DNA which can be used for a Y2H screen and also be made into stock. I digested this DNA with XhoI for quantitation purposes using 1:10, 1:100, 1:1000 dilutions of the DNA.

Future Plans: Y2H screen!

Appendix C: Poster examples

Included below are two successful poster examples.

In the first example, the author uses a central element – the *Arabidopsis* flower – to serve as a focal point to draw the reader into her poster. The author then lays out her experimental methods and results using large fonts and simple, informative figures. As an added touch, the author's color choices resonate those in the central flower figure.

In the second example from the same lab, the author describes her experimental protocols with pictures rather than words.

Use of chimeric oxidosqualene cyclases to illuminate the mechanism of triterpene biosynthesis

Allie C. Obermeyer, Mariya D. Kolesnikova, Chris R. Zhou, William K. Wilson, Seiichi P.T. Matsuda

RICE

Abstract

Oxidosqualene cyclases in plants create a vast diversity of triterpenes. Cyclases that function in sterol biosynthesis have been extensively studied and important catalytic residues in the enzyme active site have been identified. Nonsteroidal cyclases, however, generate a larger variety of triterpene structures but have been studied to a lesser extent. To gain insight into their mechanisms of cyclization and methods for quenching carbocations, we undertook chimeric studies of several nonsteroidal oxidosqualene cyclases from the model plant system *Arabidopsis thaliana*. These experiments provide insight into the evolution of cyclases and into the mechanisms of cyclization and cation neutralization in terpene biosynthesis.

Amino acid similarity of ORF5 to known OSCs

OSC name	Main product	% Identity
AthORF5	arabidiol 	100
AthORF6	baruol 	83.7
AthORF9	thalianol 	78.6

Introduction

Arabidopsis thaliana encodes 13 oxidosqualene cyclases, all of which have been recently characterized.[1] The most closely related of these enzymes are ORF5 (arabidol synthase) and ORF6 (baruol synthase), which share over 80% of their nucleotides but generate different product profiles. The triterpene products of ORF5 and ORF6, arabidiol and baruol, reveal differences in the two enzymes methods for neutralization of the cation; ORF5 quenches the carbocation with water while ORF6 eliminates to an olefin. While crystal structure has revealed important residues in steroidal type cyclases, no non-sterodial type cyclase has been crystallized.[2] Our goal was to create chimeric enzymes to illuminate the residue(s) responsible for cation hydroxylation.

The Genome Mining Approach

Subcloning
↓
Expression in Yeast
↓
Extraction and Purification
↓
^{1}H NMR and GC-MS Analysis

Subcloning

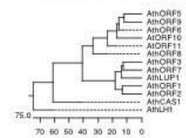
Digestion

Ligation

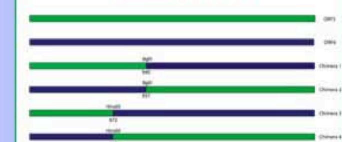
The chimeric genes were cloned into the vector pRS426Gal to be expressed in yeast.

Arabidopsis thaliana

Phylogenetic Tree



Chimeric Genes



Expression in Yeast

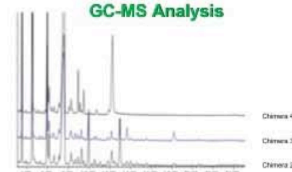
In vivo incubation in synthetic complete media and induced with galactose followed by saponification.

In vitro incubation of galactose-induced, lysated yeast with synthetic (racemic) oxidosqualene.

Amino Acid Comparison

		558	561	735	742
AthORF5	tricyclic diol	V	T	N	Y
AthORF6	tetracycle	I	A	K	F
AthORF8	bicycle	V	T	-	Y
AthORF9	tricycle	L	T	M	F
AthORF10	tetracycle	I	T	K	F
AthORF11	pentacycle	M	T	K	Y

GC-MS Analysis



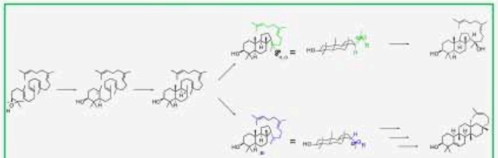
Product Profile

	baruol	arabidiol
ORF5	—	✓
ORF6	✓	—
Chimera 2	—	✓
Chimera 3	✓	—
Chimera 4	—	✓

Future Work

Future work will include the characterization of the chimeric enzymes in vitro. The in vitro reactions will allow for the quantitation of the ratios of the major triterpene products. Any new triterpene structures will be characterized by GC-MS and ^{1}H NMR. More chimeric enzymes will be constructed to help reveal aspects of the mechanism of non-sterodial type enzymatic cyclization. These future chimeras will be characterized and used to illuminate catalytically important amino acid residues. Specific catalytic residues will be identified through mutagenesis studies of ORF5 and ORF6.

Mechanistic Differences



Conclusion

The chimeric enzymes derived from ORF5 and ORF6 all maintain the ability to cyclize oxidosqualene into triterpene compounds produced by the parent enzymes. Chimera 2 and Chimera 4 both produce arabidiol, indicating that the important catalytic residue(s) for cation hydroxylation in ORF5 must reside in the last 450 amino acid residues. These results also indicate that chimeric enzymes can be used to eliminate or narrow down potential catalytic amino acid candidates. Future chimeras will be studied to ultimately identify the amino acid(s) necessary for cation hydroxylation.

Acknowledgements & References

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1. (a) Segura, M.J.R. et al. Org.Lett. 2000, 2, 2257-2259. (b) Kolesnikova, M.K. et al. Org. Lett. 2007, 9, 2183-2186. (c) Fazio, G. C. et al. J. Am. Chem. Soc. 2004, 126, 5678-5679. (d) Shibuya, M. et al. J. Am. Chem. Soc. 2007, 129, 1450-1455. (e) Kushiro, T. et al. Tet. Lett. 2000, 41, 7705-7710. (f) Corey, E.J. et al. Proc. Nat. Acad. Sci. 1993, 90, 11628. (g) Xiong, Q. et al. Angew. Chem. Int. Ed. 2006, 45, 1285-1288.
2. Thoma, R.; Schulz-Gasch, T.; D'Arcy, B.; Benz, J.; Aebi, J.; Dehmlow, H.; Hennig, M.; Stihle, M.; Ruf, A. Nature 2004, 234, 118-122.

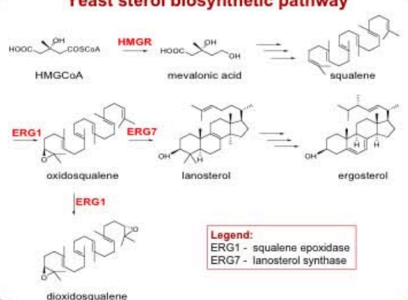
Triterpene production in metabolically engineered yeast

Alyssa M. Baevich, Caroline V. McNeil, Gia C. Fazio and Seiichi P. T. Matsuda
Department of Bioengineering, Department of Chemistry, Department of Biochemistry and Cell Biology
Rice University, 6100 Main Street, Houston, TX 77005 abaevich@rice.edu

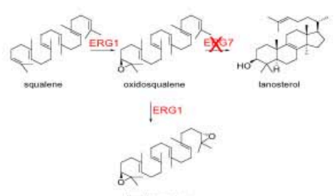
Abstract

The terpenoids are a large family of natural products derived from the five-carbon precursors isopentenyl diphosphate and dimethylallyl diphosphate. From these two precursors, *Saccharomyces cerevisiae* biosynthesizes substantial amounts of sterol intermediates that can act as terpene synthase substrates. Among the terpene synthases are oxidosqualene cyclases, which catalyze the cyclization of the 30-carbon precursor oxidosqualene to over 100 triterpene skeletons. We describe here the development and utility of metabolically engineered yeast strains that accumulate both oxidosqualene and dioxidosqualene. Subsequent expression of oxidosqualene cyclases in these strains can assist with characterization of cyclization products derived from both oxidosqualene and dioxidosqualene.

Yeast sterol biosynthetic pathway



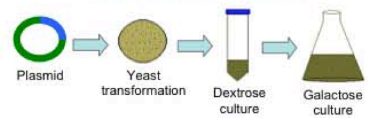
Engineered yeast strain to produce triterpenes



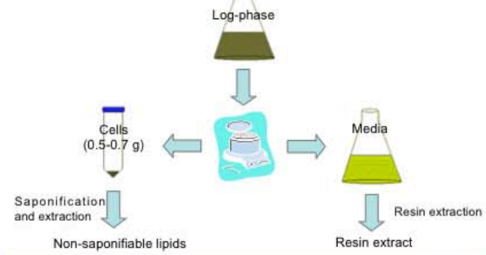
Strain	*Modification*
SMY8[pRS305Gal]	ERG7 deletion
ABY2	ERG7 deletion, ERG1 overexpressed

Control strain is SMY8[1] with empty vector. SMY8 was transformed with plasmid pRS305Gal containing ERG1, the galactose-inducible GAL1 promoter, and a leucine marker to give ABY2.

Triplicate culture growth

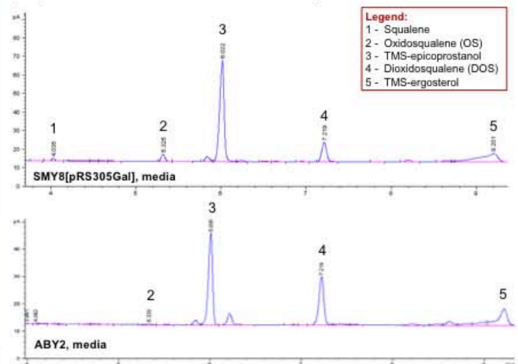


Product isolation



Analysis

Non-saponifiable lipids and resin extracts were analyzed by GC-MS and GC-FID. TMS-epicoprostanol was used as an internal standard for quantitation.



Strain quantitation of log-phase cultures

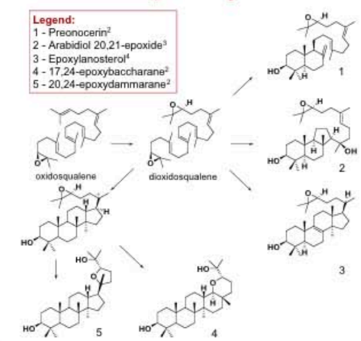
Cells

Strain	OS (mg/L)	DOS (mg/L)	DOS/OS
SMY8[pRS305Gal]	0.135 ± 0.0350	0.653 ± 0.1553	4.87
ABY2	0.046 ± 0.0065	0.298 ± 0.0156	6.64

Media

Strain	OS (mg/L)	DOS (mg/L)	DOS/OS
SMY8[pRS305Gal]	0.198 ± 0.0309	1.68 ± 0.380	8.69
ABY2	0.033 ± 0.0056	2.62 ± 0.450	81.3

Dioxidosqualene cyclization



Conclusions

This work demonstrates the utility of *S. cerevisiae* for triterpene production. With an overexpressed squalene epoxidase (ERG1) in a single yeast strain with a lanosterol synthase (ERG7) deletion, the yeast shows a drastically increased ratio of dioxidosqualene to oxidosqualene production. Subsequent addition of terpene synthases into a strain favoring dioxidosqualene production can lead to a larger library of terpenoid products with potential commercial and pharmaceutical uses.

References

1. Corey, E. J.; Matsuda, S. P. T.; Baker, C. H.; Ting, A. Y.; Cheng, H. *Biochem. Biophys. Res. Commun.* **1996,** *219*, 327-331.
2. Shan, H.; Segura, M. J. R.; Wilson, W. K.; Lodeiro, S.; Matsuda, S. P. T. *J. Am. Chem. Soc.* **2005**, *127*, 18008-18009.
3. Xiang, T.; Shibuya, M.; Katsube, Y.; Tsutsumi, T.; Otsuka, M.; Zhang, H.; Masuda, K.; Ebizuka, Y. *Org. Lett.* **2006**, *13*, 2835-2838.
4. Boutaud, O.; Dolis, D.; Schuber, F. *Biochem. Biophys. Res. Commun.* **1992**, *188*, 898-904.

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