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## Learning Science by Doing Science: An Overview of Independent Work in Molecular Biology

Our goal is to equip students with the knowledge and skills needed to explore the central questions of 21st century biology. We firmly believe that the best way to learn science is by doing science. Foundational material, learned in the formal coursework, is integrated and applied by students in the context of original research, beginning with the junior year independent work and culminating in the senior thesis and the oral thesis exam. Independent work in the Department of Molecular Biology provides the opportunity for students to work with world class scientists, conducting original research at the frontiers of modern science. We expect students to gain proficiency in all aspects of the practice of scientific research. In addition to becoming a scholar in their chosen field, students will become adept at formulating testable hypotheses, planning and executing well controlled experiments, analyzing and interpreting data, and formally presenting their findings both orally and in writing.

### Junior Year

The fall junior tutorial provides a forum for students to learn to read and analyze critically the primary scientific literature in molecular biology. Throughout the semester, students participate in small group tutorials to discuss research papers in current topic areas.

Students are matched with Molecular Biology faculty advisers for their spring junior independent work and senior thesis. In the spring semester, students meet in individual tutorials with their faculty advisers to discuss background literature and formulate a research plan. Students may begin laboratory research during the spring semester.

The goals of the junior independent work are:

- Learn how to do critical analysis of the formal scientific literature (fall)
- Develop a deep understanding of the relevant background literature and context for the research project (spring)
- Learn to formulate hypotheses and design experiments/studies to test the hypotheses critically (spring)
- Integrate the relevant background literature, research aims, and experimental plan/study design in a grant-style research proposal. The writing of the grant proposal provides direct experience in the formal communication of scientific hypotheses.

### Senior Year

The capstone of the Princeton degree is the senior thesis – the opportunity for all students to conduct original research in their chosen field of study. Students will build on the skills learned in the junior year, and apply them in the context of an independent research project under the guidance of their faculty adviser. Most students elect to work in an adviser's laboratory (lab-based thesis). Alternatively, students may choose non-laboratory thesis research.

Students will have opportunities to present their work in the form of poster presentations to peers, graduate students, post-doctoral fellows and members of the faculty. At regular intervals, students will give formal oral presentations to the members of their laboratories or to the group of students doing non-laboratory theses and their advisers. Ultimately, students will formally describe their research in the form of a written thesis that generally takes the form of an extended science paper.

The goals of the senior independent work are:

- Demonstrate a solid knowledge of molecular biology and of the problem under analysis
- Learn to analyze and interpret critically the results of experiments/data studies and use the results to guide subsequent experiments/studies.
- Integrate knowledge from various sources to contextualize results
- Formally describe the research accomplished in a written thesis that generally takes the form of an extended science paper. The written thesis is the culmination of original research conducted by the student with the guidance of a faculty adviser.

#### *Experimental (laboratory) thesis research*

The student works independently but under supervision to plan and conduct experiments to advance scientific knowledge. To maximize their educational experience, students who choose a lab thesis are strongly encouraged (but not required) to participate in the department's Summer Undergraduate Research Program (SURP) after their junior year.

#### *Computational (laboratory) thesis research*

Students who are performing computational analysis using experimental datasets generated by others in the lab rather than their own data can opt for a computational thesis. The primary difference between the computational thesis and the experimental thesis is in the rubric used to evaluate the thesis. The choice to submit a computational thesis is at the discretion of the adviser in consultation with the student.

#### *Non-laboratory thesis research*

In the non-laboratory-based thesis, the student's hypotheses are also examined by original research. Original research does not merely consist of a literature review. Rather, students are expected to analyze new or existing data in order to test their hypotheses. Sources of data could include (but are not limited to): online databases chosen in consultation with the thesis adviser, existing experimental data perhaps from the adviser's lab, or new student-initiated surveys or ethnographic studies.

## **What to Expect from Advising of Your Independent Work**

Independent research is an individual process and each student will develop a unique working relationship with their adviser. In some laboratories, professors work closely with undergraduate students and guide their research at all stages. In other laboratories, professors may work closely during the planning phases of the project, but then expect students to work independently in the



October 2

First critical analysis paper due 12:00 p.m. (noon), submit to Katie Pyott (MOL Undergraduate Administrator)

Week of October 30 through week of November 27

Student discussion groups switch to second topic and instructor  
Groups meet times for Part 1 (no meetings week of November 20)

January 5

Second critical analysis paper due 12:00 p.m. (noon), submit to Katie Pyott (MOL Undergraduate Administrator)

### OTHER FALL DATES

September 12

Junior Meeting: Orientation

September 29

Junior Meeting: Thesis adviser selection

October 2 / November 3

Faculty office hours for senior thesis adviser selection

November 6

Senior thesis adviser selection forms due

### SPRING

January 29

Spring term classes begin  
Students begin spring semester independent work with faculty

April 30

*University deadline for Junior Independent work*

Spring Junior Paper due submit by email one PDF to adviser and one to Katie Pyott (kpyott@)

### SUMMER

June 3

Summer Undergraduate Research Program begins

August 1

Summer Poster Session

**August 2**

Summer program ends- tentative

**Senior Year****FALL****November 16**

Senior meeting: Thesis submission process

**SPRING****February 2**

Senior Thesis Progress Report due

**February- April**

Departmental and Writing Center Senior Thesis Writing Workshops TBA

**March 18**

Senior Thesis Reader Selection Form due

**April 17**

Thesis readers assigned

**April 19**

MOL Thesis Deadline

Submit one PDF (and hardbound copy, if requested) of thesis to adviser, email one PDF to each reader, and upload one PDF to Mudd Library via Thesis Central

**May 6-9**

Senior oral exams

**May 27 (Memorial Day Monday)**

MOL Class Day

**May 28**

Commencement

**The Junior Tutorial in the Fall Semester**

Throughout the semester, students participate in 8 small group tutorials to discuss research papers in current topic areas. Tutorials are led by postdoctoral fellows, who receive training in instruction by the McGraw Center for Teaching and Learning, and are supervised by a faculty director. Students practice scientific writing by preparing short, weekly summaries of the readings. They use both critical analysis and writing skills to prepare two longer critiques of a relevant research paper assigned by their instructor, one at mid-term and one at the end of the semester. The critiques are evaluated by the tutorial instructors according to a grading rubric, and students receive additional feedback from their instructors.

## Junior Tutorial Paper Guidelines and Structure

- Each student will be given an article to analyze for the paper.
- Students may not discuss the article or collaborate with other students on the critical analysis paper.
- Students may not refer to previous student papers on the topic.

## Format of the Junior Tutorial Papers and Other Tips

- 5 -7 pages in length (but no longer than 7 pages, excluding references)
- double-spaced (except for references)
- a minimum of 1 inch margins
- Arial 11 or Times New Roman 12 font only
- 12-14 characters per inch maximum
- Each of the two papers shall include the following sections:

### Cover Page

Please include your name, the date, instructor's name, and tutorial group number. A signed honor pledge should be on the cover page as well. We will remove the cover pages and assign your papers numbers so that the papers may be graded in an unbiased fashion. To preserve anonymity, please do not include your name in the text.

### Summary/Abstract - (no more than 200 words, or half a page)

Concisely describe the major findings presented in the article along with a summary of your critical review of the findings.

### Background - (approximately 1 page)

Students are asked to conduct a literature search and summarize the major and most relevant findings in the field. The background should be a succinct review of the topic in the paper being critiqued. You can rely on review articles to point the reader to a more extensive source of information, but do not use a review article as a primary citation for a fact. You are strongly encouraged to research beyond the articles discussed or provided in class. Typically at least 5-10 references should be used for the background section.

### Experimental Approach and Findings - (approximately 2 pages)

For the key experiments in the article, summarize the following:

- (a) The question being addressed
- (b) The experimental approach used
- (c) The results of the experiment

### Critical Review/Original Analysis - (approximately 2 pages)

Discuss each of the following:

- (a) Evaluate the quality of the data (e.g., Do the experiments include the appropriate controls? Could an experiment have been conducted differently to answer the question at hand?)



- (b) Evaluate the conclusions made by the authors. For example, are there alternative explanations or conclusions for the data?
- (c) Evaluate the major implications of the findings in the article as they relate the field of study.
- (d) Propose future experiments not mentioned in the research article.

References - (not included in the page limitation and may be single-spaced)

- You may use any appropriate scientific format for listing references.
- Any fact that is discussed should be referenced.
- The complete references should be detailed in a Reference Section found at the end of the document.
- List all of the articles cited. Only include a reference if it is specifically cited.
- Referencing the internet - Please note that many items found on the internet have not undergone “peer review” scrutiny and may be unreliable. Try to avoid the internet as a reference. Rely on published research articles as much as possible.
- A good site for how to reference an internet source is:

<http://www.apastyle.org/electref.html>

A direct quote from that page suggests the following: “At a minimum, a reference of an Internet source should provide a document title or description, a date (either the date of publication or update or the date of retrieval), and an address (in Internet terms, a uniform resource locator, or URL). Whenever possible, identify the authors of a document as well.”

Currently enrolled students may access additional information about the Junior Tutorial including the fall meeting schedule, list of instructors, student group assignments, and detailed information about the structure and format of the papers on the "MOL Junior Independent Work" Canvas site.

**Grading of the Junior Tutorial Papers**

Students will be evaluated based on class participation in each section, a weekly summary of each paper, and two larger critical analysis papers. As a % of total grade, the breakdown is as follows:

Class participation Part I	10%
Weekly summaries Part I	5%
Paper for Part I	35%
Class participation Part II	10%
Weekly summaries Part II	5%
Paper for Part II	35%

Because papers are “blind” graded, the only place your name should appear is on the cover page. Make sure the cover page is detachable (i.e., don't use double-sided printing for the cover page). Also, make sure that you have signed the honor pledge on the cover page only.

There are multiple components to the Fall Junior tutorial papers, each of which is evaluated separately; the detailed grading rubric of the Junior Tutorial is available on Canvas. In general, the best papers are concise but thorough analyses of the experimental approaches in the primary literature, and in-depth critiques of data and conclusions. Remember that the goal of the assignment is to practice how to assess experimental methods and results and then to shape that assessment into an effective argument. This will help develop important skills for writing the research proposal and the senior thesis.

Students will receive comments on the papers, as well as the breakdown of the rubric scores. Students are encouraged to discuss their paper evaluations with their instructor, as well as Professor Silhavy. There are no regrades on junior tutorial papers.

Please contact Tom Silhavy (tsilhavy@) or Katie Pyott (kpyott@) if you have any questions about the Junior Tutorial.

## The Research Proposal in the Spring Semester

In the spring term, students carry out a second program of independent work with a faculty adviser with whom they will eventually do their Senior Thesis research. Students who plan to do an experimental thesis may begin laboratory research during the spring semester or may wait until the summer/fall semester; this decision should be made in consultation with the adviser. Over the course of the semester, students will meet frequently (6 to 10 meetings) with the adviser to analyze the relevant literature, discuss experimental research if relevant, and formulate a research plan in preparation for writing a formal research proposal, modeled on a typical grant proposal.

### Format of the Research Proposal and Other Tips

The proposal should be 10-12 pages (double-spaced) in length, in Arial 11 or Times New Roman 12-point font, with 1 inch margins. There is no limit on figures and tables. The proposal should be written so that it can be understood by a scientist who is not in your field, avoiding jargon.

The proposal should be structured as follows:

#### Abstract (200 words)

The abstract should accurately summarize the contents of the JP. Abstracts typically do not contain references. The key aspects of an excellent abstract include:

- a brief summary of the problem/question under investigation and its relevance
- a brief summary of your hypothesis, goals and objectives
- a brief statement regarding the approach/methods
- a concise summary of preliminary findings (if relevant)
- the overall implications your findings will have; how answering the question will advance our understanding of the problem

#### Background & Significance (3-5 pages)

The Background & Significance section should establish the context of the work being proposed. This section must answer the questions, "What do I plan to study? Why is it an important problem/question? How does work published by other investigators motivate the proposed research – what has been done, what gaps remain in our understanding? How will my study, if successful, advance our knowledge about the specific problem and the field more generally?" The key elements to an excellent Background & Significance section are:

- a concise summary of the relevant primary literature that frames the proposed question/study
- the purpose of the work in the form of a hypothesis or question
- the rationale for the approach to testing the hypothesis or answering the question
- a brief statement as to how the field would be advanced by successfully testing the hypothesis

An important criterion for evaluating the Background and Significance concerns the Scholarship:

- Reference each fact presented with the primary source, not a review. The citation is typically included at the end of a sentence; however sometimes citations appear within a sentence.
- Rely on recent reviews to point the reader to a more extensive source of information about a field. The style of citation is the same as for a primary literature citation; however, the citation should be preceded by, "reviewed in...", or "... and the references therein".

#### Specific Aims (1/2 to 1 page)

The Specific Aims section is the "master plan" for your proposal. If the Background & Significance section has set up the question well, the Specific Aims section should easily transition into what you will do for your thesis work. You do not need to restate the background information in this section but it should concisely state the problem you are studying, the central hypothesis you are testing, and the "to do" list of objectives – the Aims – for addressing the hypothesis. A senior thesis proposal should have at least two specific aims, but these should be reasonable for the time you have to complete the work. List each aim as a bold header. Under the header state the experimental approaches you will take and, briefly, how the aim will help prove your hypothesis. Each aim can have its own hypothesis if warranted. Readers will also consider whether the Aims are reasonable and designed to test the stated hypothesis.

#### Preliminary Results (1-2 pages)

This section reports unpublished work only and may include your own results or data generated by others in the laboratory. Only unpublished work relevant to your hypothesis and specific aims should be included. You must indicate clearly whether you or another lab member obtained the results you present. Concisely explain the experiments/analysis that was done and why, and how the results inform your hypothesis.

If you are initiating a completely new project, there may be no preliminary results to report. In this case, you will state that there are currently no preliminary results for the project. Unpublished data generated by another lab member that directly supports the proposal may be included, but must be properly cited. Regardless, **any data that are presented are evaluated on how they are presented and their relevance to the proposal**, not on what was accomplished.

### Research Plan (4-5 pages)

This section should provide a detailed work plan for your thesis. This section should be organized by specific aim. Each experiment/approach in this section should include:

- A concise outline or description of the experiment or study, including appropriate controls, and how data will be analyzed. The experimental approach should be understandable to an audience not familiar with the system.
- Potential outcomes and how these would relate to the hypothesis being tested
- Potential problems or pitfalls that may occur and how these would be addressed.

### Bibliography (at least 10 references)

This is a comprehensive list of the sources used in developing your proposal. Include full references, with titles, in your bibliography using the format of a published journal. Format citations with last name of the first author and date, for example (Gavis et al., 2015).

- Only list articles in the Reference list that you cite in the document
- Learn to use RefWorks, Mendeley, or Endnote (the first two are free and the library gives tutorials)

### **Submission and Grading**

Students should turn in their junior papers to their advisers AND email a PDF to Katie Pyott by 5:00 PM of the university deadline for spring junior independent work. The Junior Paper will be read by the adviser and a second, anonymous faculty reader. The faculty will assign a rubric score to the paper and the undergraduate committee will assign a grade based on the rubric score. The current grading rubric is available on Canvas. Students will receive written comments on the junior paper, as well as the average rubric scores for the two readers. Students are encouraged to discuss their papers with their faculty and/or lab members. There are no regrades on Junior Papers.

## **The Senior Thesis**

### **An Introduction**

Molecular Biology graduates cite the Senior Thesis as one of their most rewarding experiences at Princeton. In Molecular Biology, there are two basic formats: a laboratory-based and a non-laboratory-based thesis. Both types of thesis are the culmination of original research conducted by the student with the guidance of a faculty member in the Molecular Biology or an Associated faculty member. The thesis will describe all aspects of the research, from the context and hypothesis, through the materials and methods, to the results, conclusions, and discussion. The thesis will be read and evaluated by three faculty readers, including the faculty adviser, who will evaluate all aspects of the thesis research. Finally, students will defend the thesis orally before

the two non-adviser readers. The 30-minute oral defense will provide an opportunity to assess the student's ability to discuss their research, test their knowledge of the discipline, and their ability to extend the research by proposing new hypotheses and experiments/studies to test them.

The very best theses are those that clearly describe a gap in our scientific understanding, that set out a cogent series of experiments or method of analysis, and that then proceed to use the scientific method to advance our understanding. With the help of their advisers and scientific mentors many students are able to make significant contributions. Indeed, a large number of students generate original findings that are eventually incorporated into peer-reviewed scientific articles. Although not all projects prove to be so fruitful, all students will help advance the field, even if that is only by demonstrating that a particular approach will not be successful. A complete description of the qualities of successful theses can be found in the thesis grading rubric (available on the "MOL Senior Independent Work" Canvas site).

### **Thesis Progress Report**

A Progress Report in the form of an outline of your thesis content is due in mid-January. The report is intended to help you and your faculty adviser plan the end game for your thesis. The report should be succinct and should not exceed 6 double spaced pages. A pass/fail grade will be assigned by your thesis advisor and will be reported to the Undergraduate Committee. You and your faculty adviser will meet in-person to discuss the report and agree on a plan for completing the thesis.

Each report should contain:

- The title of your project and the name of your faculty adviser
- A background paragraph that puts the study in perspective and states the objectives of your work.
- A summary of the work you have accomplished and data/results obtained to date, accompanied by drafts of the corresponding figures and legends you will include in your thesis.
- A list of the remaining work/figures needed to complete the thesis. Depending on whether you are doing a lab, non-lab, or computational thesis, this could include anticipated experiments, data that need to be collected, and/or computations/programming to be completed.

### **Thesis Format and Submission Guidelines**

The thesis should be typed in at least 12-point font, double-spaced, with adequate margins (at least 1 in. top, bottom, and right; 1.5 in. on the left for binding) on standard size paper. The written format of the thesis should be decided in consultation with your adviser, but in general the style should be the same as that used for the Ph.D. thesis.

Laboratory thesis:

- Not to exceed 25,000 words, excluding figure legends, bibliography, and appendices

- No limit on figures

Computational thesis:

- Not to exceed 25,000 words, excluding figure legends, bibliography, and appendices (code should be included as appendices)
- No limit on figures

Non-laboratory thesis:

- Not to exceed 50,000 words, excluding figure legends, bibliography, and appendices
- No limit on figures

Copies of past Molecular Biology theses can be examined either from your adviser or in Mudd Library. Theses for the class of 1991 through 2000 are housed in the Biology Library. Theses written in 2014 and later are available via [DataSpace](#).

**Thesis Deadline:** April 19, 2024 by 5PM.

Submission process:

- One PDF copy sent to your adviser by email
- One PDF copy sent to each reader by email
- One PDF copy uploaded via Thesis Central to Mudd Library
- One hard bound copy of the thesis submitted directly to your adviser by April 22 **if requested**

Extensions up until Dean's date can only be granted by the Director of Undergraduate Studies, with approval of the adviser. Extensions will only be granted for documented illness (requires note from McCosh) or exceptional circumstances. Extensions beyond Dean's date can only be granted by your college Dean with the approval of the Director of Undergraduate Studies and will only be considered under extreme circumstances. Any thesis submitted after the deadline set by the department (or by the Dean in extraordinary circumstances) will be penalized one-third of a letter grade per day. In addition, University regulations preclude a student who submits a late thesis without prior approval from receiving departmental honors. Extension requests should be submitted via email to the Director of Undergraduate Studies (gavis@) and should contain a full explanation of why the request is being made.

**Department of Molecular Biology Policy on Re-use of JP material in Senior Thesis**

Molecular Biology concentrators are permitted to re-use portions of their own Spring Junior Paper in their Senior Thesis, provided that such re-use is properly attributed. Within each section of the Thesis (e.g., the Introduction, the Discussion), either of the following two options may be used.

Option 1: Attribution can be made in the standard way (as with any other source) by referencing the student's own Junior Paper directly [<Author>, <Title>, Junior Independent Work Paper, <Semester and Year>].

Option 2: This option is best employed in the case that the re-use of materials within a Thesis section is so extensive (e.g., large sections of the Introduction or the Discussion) that Option 1 would render it difficult to read. In this case, it is sufficient to include the following statement at the beginning of the relevant section:

"This < section name; e.g., "Introduction"> contains text that is based closely on, or identical to, text and Year>]."

In the case of data figures, attribution can be made in the figure legend.

### Grading

Each thesis is read and graded by the student's adviser and two other faculty members. Two of the three readers must be affiliated with the Molecular Biology Department. In early spring, Molecular Biology seniors will be asked to submit a list of potential readers along with a tentative thesis title. The Undergraduate Committee assigns readers and aims to accommodate the wishes of the students while taking into consideration the topic area and the availability of the reader.

The final thesis grade is the weighted average of the three grades—50% from the adviser, 25% from the 1st reader and 25% from the 2nd reader. The graders use a rubric to score the thesis and grades are assigned by the Undergraduate Committee with the approval of the faculty (available on the "MOL Senior Independent Work" Canvas site). The Molecular Biology grading strictly adheres to Princeton University's grading practices. There are no regrades on senior theses.

### Oral Exam

Students are required to present their work to the two (non-adviser) thesis readers during an oral exam, at which the adviser is not present. PowerPoint presentations are not allowed. The exam usually takes about 30 minutes and students should be prepared to describe the background of the thesis, defend its contents, and propose future directions. The oral defense grade is the average of the two from the (non-adviser) faculty members. A grading rubric (available on Canvas) will be used by the examination committee. Grades are assigned by the Undergraduate Committee with the approval of the faculty.

### Honors, Department Prizes, and Awards

The Department of Molecular Biology awards honors based on a combination of the grades awarded for departmental courses and for the various forms of independent work. The Department also awards several departmental prizes and awards. The George Khoury award is given to the senior with the highest departmental GPA. The Sigma Xi Book Award is given to the student presenting the best experimental thesis. Several additional Molecular Biology Thesis awards are given for outstanding theses. Thesis awards are determined from nominations by

the three readers, and selected by the Faculty Undergraduate Committee. Honors and Awards are announced at Class Day.

### Thesis Funding

The Department of Molecular Biology provides funds to faculty help cover expenses directly related to on-campus experimental senior thesis research. These expenses are reimbursed through departmental accounts, and students need not worry about funding.

Students are also eligible to apply to the [Office of Undergraduate Research Senior Thesis Funding Program](#) for funding for activities or materials that are not normally supported by laboratories in the department. For example, proposals for funding to conduct non-laboratory research projects, to travel to an outside laboratory to learn a method, or to travel to a professional meeting may be eligible, whereas requests for laboratory supplies used at Princeton would not. Awards are typically made in the amount of \$250 but may total several thousand dollars, depending on the project. Students seeking such supplemental support for senior thesis research may apply through the [Student Activities Funding Engine \(SAFE\)](#). The online application process requires a full account of your research proposal, a detailed itemized budget, planned itinerary if relevant, and name of your thesis adviser. We encourage you to start working on your application materials early so that you have ample time to meet the strict deadlines set by the various funding sources.

### Senior Thesis Writing Group and the Writing Center

Several senior thesis writing workshops for Molecular Biology seniors held over the course of the academic year will provide guidance on various aspects of thesis writing and preparation. The workshops, taught by Molecular Biology graduate students, cover an assortment of topics, including organizing the document, writing in the scientific style, and developing computer skills necessary for the preparation of a professional document.

The Princeton University Writing Center offers free one-on-one conferences with experienced fellow writers trained to consult on assignments in any discipline. Special 80-minute conferences are available for JP and senior thesis writers, who may sign up to work with a graduate student fellow from the department of their choice. Relevant workshops sponsored by the Writing Center can be found on Princeton's Undergraduate Research Calendar <http://undergraduateresearch.princeton.edu/calendar>.

### Library Support

To learn how to effectively navigate the library system for your independent work in Molecular Biology, you may want to consult with Kelee Pacion, Biology and Environmental Sciences Librarian in the Lewis Library (kpacion@) or browse through the [Molecular Biology Research Guide](#).



## A Student's Perspective: Top 10 things I wish I knew before I started

1. Make a commitment. Research takes time. You need to be sure that you can set aside several hours on a regular basis for lab work. A good test to see if you'll be overcommitted – see how busy you are at the beginning of the semester, when course workload has not begun to pick up yet. If you're sitting around feeling like you could comfortably take another class or two, you probably have enough time to dedicate to lab work. Otherwise, you might want to cut back while you still can.
2. Stay motivated. Research is the study of the unknown, and as such, the path to success is not always clear. You'll make many, many false starts before getting anywhere. Hopefully, it will be tempered by some successes, too. However, after the umpteenth time an experiment fails, you'll need to remember those successes and stay confident that you'll succeed – at some point.
3. Make friends with the people in your lab. Since you will likely be spending many hours in the lab, a good way to make those hours more enjoyable is if you are friends with the people around you. Usually, they are friendly and interesting to talk to. They can also provide loads of help for a starting undergraduate – see below.
4. Ask for help. Don't know how to use that expensive-looking, delicate piece of equipment? Ask. Your fellow lab members hold a wealth of information and experience you should take advantage of. An advantage to being an undergraduate is that you can ask basic questions and not feel dumb, as you're the least trained in the lab in terms of formal education. You may feel like a leech at times – that's okay. More often than not, your lab mates are more than happy to help.
5. Respect those around you. Remember that people are taking time and energy away from their own work to help you out. Feel free to ask questions about things that you don't know and have not been told. However, don't ask the same question multiple times of the same person. If someone explains a procedure to you, write it down or make a copy. Also, make sure a person has time to help you out before asking. At the same time though, better to annoy someone by asking the same question again than to annoy him or her by breaking that \$8000 piece of equipment.
6. Don't sweat the small stuff. Unless you're freakishly careful and very lucky, chances are you'll make a stupid mistake in lab at some point. Hopefully, you'll realize it in time and won't have wasted too much effort on it or affected anyone else's work by it. Even if that isn't the case, accept it, minimize the damage as best you can, and move on. Everyone makes mistakes from time to time. Sometimes these things can't be helped.
7. Label EVERYTHING. Picture this. You're back from break, ready to begin work again, and upon opening your box you're confronted by tubes labeled "A9" or "B+B120 L". Having no clue what that means, you sigh and throw it away, not knowing that you have just thrown away the product of weeks' of work. Don't fall into this trap – label your materials well with full names and a date.
8. Keep backups and a record of what you do. There may come a point when you realize that something's gone wrong and you need to retrace your steps back to a midway point. If possible, it is very useful to keep materials in storage along the way that you can fall back on

so you don't have to restart from the beginning. Keeping up your lab notebook here helps too—you may be able to tell by looking over your notes what might have gone wrong and where you would want to tweak the procedure a bit.

9. Budget more time than you think you'll need. Almost always, lab procedures will take longer than you think they will. Something will go wrong and you'll need to start over, or a buffer you thought you had has run out and you need to make some more—you get the idea. If you don't want to be constantly scrambling to race the clock, take the time you think the procedure will take, multiply by 2.5, and you should have a safer and likely more accurate estimate.
10. Have fun. Don't get too caught up in experiments that don't work or the time you spend in lab. Relax, remember the broader view, and enjoy the ride.