

Thesis Tips

Here are a few useful tips and pieces of advice based on the experiences of past seniors to help you navigate the process of writing your thesis. Advance preparation, planning, and organization will be your best friends as you begin your work, and careful prior thought and consideration will make your life much easier. That said, research in EEB varies depending on the type of work you are interested in doing. Fieldwork, wet lab work, archival work, and computation can all operate on different timescales, and within these areas, projects vary significantly. Your best resource in helping you stay on track with your thesis will always be your Principle Investigator (PI) and/or your graduate/postdoctoral mentor.

Step 1: Start early

Starting early doesn't necessarily mean jumping into a lab and beginning research on your first day on campus as a first-year, but it does mean thinking well in advance of your senior year about what you hope to accomplish with your senior thesis and taking steps to put yourself in a position where you can achieve these goals.

- Find a lab and get comfortable in it. There is definitely a learning curve to working in any lab. It takes time to learn the relevant techniques, read up on the literature, and reach the point where you are able to plan and develop your own experiments. Often you will start out by shadowing a postdoc or PhD student, who will teach you the basic methodology and support you. If you are particularly excited about getting a head start on research early on, take advantage of the research for credit options to get some experience in a lab.
- Students work on a huge variety of projects at different scales and with different focuses. What your time collecting data and doing research looks like will vary a lot among projects. Remember that a thesis in EEB does not necessarily require research with an EEB faculty member, and if you have a project in another department that you are interested in pursuing, it is definitely worth reaching out to the EEB Director of Undergraduate Studies (DUS) to see whether you can adapt it to fulfill the requirements of the EEB thesis. Some places students look for research groups in which to write their thesis include: The Yale E&EB department, YIBS (Yale Institute for Biospheric Studies), Yale School of the Environment (Formerly Yale School of Forestry and Environmental Studies, among other resources available, there are several PIs running projects based out of the Yale-Myers forest in northeastern CT, which often has housing available for summer researchers), the Yale MCDB, MB&B, and Anthropology departments, and the Yale Schools of Medicine and Public Health. One tool that may help your search for a lab is the Yale Undergraduate Research Association's research database; simply reading through the research interests of faculty on their departmental websites is another fairly effective strategy. You can also ask your former professors to point you to their colleagues based on your field of interest. Bear in mind, however, that professors may not be able to take you on, so you may need to reach out to several faculty before you find one who has space for additional students in their lab.
- Because of the learning curve, the earlier you start up in a lab, the more you will be capable of doing by the time your senior thesis comes around. It is totally ok (and quite common) not to start research until you begin your senior thesis, but know that starting late will limit the types of projects that you will be capable of doing on your own.
- Another benefit of starting early in a lab is that you get time to know the community within the lab, the PhD or Postdoc students with whom you will be working, and figure out whether you want to stay there. It is quite common for students to switch between research groups during their time at Yale. Different labs have different styles that may be a better or worse match for you. No PI expects their undergraduate students to be unwaveringly loyal to them, and if you feel that you would fit better into a different group, you should feel comfortable switching.
- That said, communicate with your PI. Among other things, don't spring it on them at the last second that you are planning to write your thesis with them. Don't take it for granted that they

know that you are planning to stay, even if you have been working there for several years. The better and clearer your communication with them is, the less likely you are to run into any unexpected difficulties. (Likewise, if you are not planning to stick around let them know. Give them advance warning so that they can plan around your departure and take on new students if needed)

- Lastly, for some projects, you may need to make plans with the PI well in advance. In particular, for research involving travel or fieldwork during the summer after your junior year, major advance planning and discussion may be involved. Even if you do not know what research group you are planning to work with, the earlier that you can figure out what type of research you hope to do (wet lab, field work, archival, computational, etc.) the easier it will be to put yourself in a good position to work on the projects that you want to! Likewise, if you are planning to do research over the summer, you will want to plan ahead to acquire funding sources for the associated costs such as include travel, equipment, and housing (A few more notes on funding at the end).

Step 2: Make a plan

Once you have identified the group in which you intend to write your thesis, the next step is to make a plan for what you will actually be doing. Bear in mind that the timeline may vary significantly based on the type of research you are doing (fieldwork, wet lab, archival, computational, other). Here are a few things to bear in mind as you make that plan:

- Independent research can seem like a daunting phrase. Don't worry. You are not expected to be an expert in the field yet, writing grant proposals and identifying research topics from scratch. Research can still be independent if it is part of a larger ongoing project in the lab. Often labs will already have funding to focus on certain topics prior to your arrival. Your job as an independent researcher is to take on a piece of work and make it your own. You will likely work with a graduate student or post-doc who will supervise and train you, but as long as you are performing your experiments and analyzing your data, your project counts as independent even though you are receiving lots of support and guidance along the way. That said, if you ever have doubts about whether your project qualifies as independent research, do not hesitate to talk to your PI or to the DUS. They can help you make sure that your work meets the standards for a senior thesis.
- A year is a lot shorter than you think. While it seems like a huge amount of time, science can be slow, and the year is broken up by breaks, exams, travel, and other events that make the actual time that you have to work on your thesis much shorter than you might expect.
- Ten hours a week over the course of two semesters is about 300 hours of total work. That may sound like a lot, but it is the equivalent of a little under 8 weeks of full-time lab presence. Be reasonable and realistic about what you expect to accomplish in this time. Communicate with your PI and your supervisor – they have a lot of experience and can help you think about how to design a research project that you can finish within that time.
- Once you figure out what your project is going to be, start doing some preliminary work or readings before the fall semester starts so that you can hit the ground running. Particularly with field work, it is fairly common for much of the thesis research to be done over the summer, but even within a wet lab, having preliminary experiments and methods figured out and optimized before the fall semester begins will help you jump right into it. Often the first few weeks of work can be very slow as you get things up and running, so it may be worth trying to find time during Camp Yale or shopping period to get some of the setup and initialization going in order to maximize productivity during the actual semester. Because these first few weeks are pretty light in terms of class load, being able to get a head-start on data collection during this time is a nice way to make up for future delays that will undoubtedly occur once your schedule gets busier.
- For field work, you may need to discuss your project plan with your PI farther in advance than for other types of research. It is fairly common to go into the field during the summer before senior year, and data collection may follow a rigorous and pre-defined schedule, which can require

much of the experimental design and literature review to be completed well in advance. For other types of summer research, the experimental design may not need to be completed in advance, but it will help if you can get comfortable with your background readings before you start.

- Discuss your goals and expectations with your PI as early as possible. If you are hoping to contribute to a publication or to attend a conference, these are important things to make clear from the start. While these goals may or may not be achievable, clear and early communication will help avoid potentially frustrating misunderstandings and give both of you an opportunity to change your mind if you seem to have different goals. These conversations may seem awkward, but if you approach them with respect and courtesy they will go smoothly, for part of the function of an advisor is to look out for your academic and career interests as well.
- Lastly, as you are making plans for your project, don't forget to budget time for writing and data analysis at the end of the year. You will put in a lot of time and effort to collect all this cool data and research your story, but if you don't give yourself enough time to write and analyze, you won't be able to showcase your work as nicely as it deserves.

Step 3: Research!

This is the fun part! Again the magic words are advanced planning. This section has the least advice, because so much of the research itself is project-dependent. Your advisor and colleagues will be your best resources for helping you manage the research itself, so take advantage of their wisdom and experience.

- Have a plan with your experiments/analysis for the week and be conscious of things coming up in the future. For fieldwork or multi-day wet lab experiments, you may not have much flexibility to adjust your schedule after the project begins, and so the bulk of this planning will occur before the data collection process begins.
- Be proactive about making sure that the prep for future experiments is done in advance and think about how to organize your experiments chronologically to maximize time efficiency and minimize moments when you are stuck waiting for days on end. For example, sequencing DNA, ordering reagents, and various other components of your research may take a lot of time. By planning for those well ahead of time you can make sure that all of your time in the lab can count. Having some flex projects/experiments that you can work on in lulls and moments when you don't have much else going on is a nice way to keep yourself productive.

Step 4: Analyze

Evan more than the writing, strong analysis is what makes the final product. The words on the page should be guiding your reader through the logic of what you have done, but the analysis and results are the core of the excitement and novelty of what you have found.

- Have a plan for what you are going to do with all of the data that you have collected. If you are going to run statistical tests, it is good practice to choose what tests you are going to run before you look at your data.
- Consider learning R or, depending on your subfield, another programming language. This is not required, but in addition to being helpful on your thesis, it is a nice tool to have mastered as you move forward into graduate or professional work. I highly recommend several statistics classes such as S&DS 230 and 360 which will give you a strong introduction to working in R, and then using your thesis as an opportunity to practice with and apply these tools to your own datasets. This is a very effective way to develop your skills! While R is the most commonly used programming language in E&EB, it is not the only one. For example, Python is commonly used in genetics research, and SPSS is a slightly more user-friendly tool for data analysis that can handle many common statistical tests.
- Get started on the analysis early. Working on data analysis is a great way to make sure you are keeping up with your lab work on weeks when you can't easily run experiments or collect data,

and the timing can offer you a lot of flexibility. Performing some preliminary data analysis as you go along is also a helpful way to catch any technical problems at an early stage, before they become any larger. For observational projects, preliminary analysis can also help guide your literature review in helpful directions and narrow your focus.

- Organize your computer files. Take some time early in the process to make a plan for how you are going to name/store/order the data files you generate and then stay consistent throughout the process. Avoid having 8 graphs or R files all saved on your computer as ThesisResultsPart1.jpg. Having a plan from the beginning is important, because it is much more challenging to retrospectively organize files than it is to follow an initial plan.

Step 5: Write

Go slow, be clear, and have good notes.

- The most important piece of actually *writing* a good thesis is, you guessed it, starting early. If at all possible, have your data collection and preliminary analysis done early in the spring. Spring break is a common target to shoot for, but even aiming for earlier in the spring may be wise as there are inevitably delays that will push you behind schedule. Coincidentally, spring break is also a nice chunk of time to focus your energies on getting a draft of your final paper put together. You may also want to consider working on a preliminary summary of your literature review at an early stage – it can form the core of your introduction later on.
- Use your research/lab notebook. This is part of good scientific practice and a good habit to form, one that will make your life much easier as you begin to write up your work. There are many ways to organize a research notebook, so find what works best for you, but in general, the more clearly and precisely you record your work as you do it, the more pleasant it will be for you as you go back through everything to review it and write it up. Furthermore, carefully keeping track of your work in your notebook will reduce the likelihood that information gets lost (which might require you to re-do work that you have already done). Using your notebook will reduce memory errors and ensure scientific accuracy when you write up your final results. It will also facilitate any follow up work that needs to be done after you are gone. This last reason is one that is particularly important if you are hoping to publish your work, as often there will be a few experiments which remain to be done after you graduate. Having a journal that provides a clear roadmap through your thinking process will make it easier for your colleagues and collaborators as they see the final stages of your work through to the end after you have left New Haven!
- Finally, start writing methods early in the process. It is much easier to write methods as you do them, rather than looking back six months later and trying to remember them. Your lab notebook is a tool that will help you, but it is often easier to describe things while they are fresh in your head. You can always update these methods later on if things change.

Step 6: Edit

Congratulations! You followed all of the prior advice and finished your thesis work with plenty of time. Now you get to edit it!

- Give yourself time to clear your head. Let the text of your thesis sit while you focus on other things. This is a good time to read back through papers that you are planning to reference, and to think about and discuss future steps with your mentor. For example, figure out what – if anything – you will need to do to help them wrap up your project after you move out of the lab. Take enough of a break from your writing to allow you to look at it with fresh eyes. This will help you to see your work through the lens of a future reader rather than as its author.
- Present your work! Lab meetings are one of the best opportunities you will get for feedback from experts in your field. Your colleagues in your lab are familiar with the methods and the literature relevant to your project and will be able to provide helpful points and suggestions that you can

incorporate into your thesis. Choosing the best time to present to them can be a bit tricky, but ideally you would like to find a balance between presenting too early when you don't yet have your final data and results and presenting too late when you no longer have time to incorporate their thoughts into your final paper. If you have the opportunity to present at a conference, that is another wonderful chance to receive feedback as well! In addition to receiving comments from others, preparing your work for a presentation forces you to think critically about how to compose it into a coherent narrative and to ensure that you fully understand how the different components of your work connect together. A good thesis does not just present a series of facts – it presents an arc of data and reasoning that answers the question you are studying.

- Format things nicely. In addition to making it read smoothly, part of making your thesis into a neat and polished final product is making it look good. You have a lot of flexibility in the details of formatting, but it is always good to consult with your PI or mentor, for they may have specific ways in which they would like you to arrange your paper. Make nice clean figures and think carefully about whether they provide the best way to present the results that you have gathered. The figures are the centerpiece of your work, and you want them to be as unambiguous and interpretable as possible. Avoid repeating information across figures and use supplemental figures where necessary. Often you can present a representative image to provide the reader with the final iteration of your analysis rather than all of the intermediate stages. You want your analysis to be reproducible and understandable, but that does not mean that you have to show your work through every step of it. Likewise, be reasonable with your text. More words are not necessarily better, and putting your advisor through a 90-page ordeal is not in your best interest. Be concise, and be clear, and know that all of your hard work will shine through in the quality of your writing and figures, even if you do not showcase every single piece of data that you generated over the year. Remember again that you want to tell a coherent story, and follow a single arc, and that some of the side-questions that you may have examined, while interesting, do not necessarily add to that story.
- Have someone else read your thesis. While you may have presented your work to your colleagues and received feedback on the ideas, it is valuable to get comments on the writing itself. The graduate or postdoctoral student that you are working with is a great person to help you with this, but a peer or friend in E&EB or a related field may also be able to help. The writing center is a particularly helpful resource. In all these cases, it helps to have a draft completed early so that you can wait for feedback. Asking for comments within 24 hours as you scramble to complete your paper before the deadline will not leave room for very helpful comments.

Other Miscellaneous Thoughts and Advice:

Read papers. This is possibly the single most valuable thing that you can do to prepare for your thesis. Obviously, jumping straight into the deep end and trying to tackle cutting edge literature can be intimidating, but take it slow, and remember that your studies over the last few years have helped prepare you for this. Don't worry that you don't understand every word of every paper: very few people do. The more you read, the more comfortable you will find yourself becoming with papers, and the easier it will become. If you haven't had a chance already, take classes that force you to think critically about papers. Such classes will help you to break them down and discuss them, and to learn to tell the difference between a good paper and a bad paper (hint, it isn't just the journal that it is published in). I cannot recommend taking biology seminars enough. The selection of these courses being taught varies from semester to semester due to faculty availability and logistic constraints, but there are always a few available. As with finding a research group, you may also look to the MCDB, MB&B, Anthropology, and Environmental Studies departments as well as graduate courses offered in related fields to find similar offerings focused on building an understanding of the research literature. While intro courses often require a lot of memorization and regurgitation of facts, smaller, discussion-based seminars will remind you that science is actually about critical thinking, questioning everything, and careful analysis of data.

These seminars are wonderful chances to connect with professors on a more personal level, providing great opportunities for mentorship and counsel which will be invaluable as you make your plans to move beyond Yale. Furthermore, while these seminars often give some priority to upperclassmen, in some cases there are few hard prerequisites and openings still available for younger students, so do not wait until senior year to take them. Overall, the more papers you read, and the more comfortable you get with the literature, the better sense you will have of what a good research project should look like.

Have a life! It is easy to let your research slowly erode your time and energy until it takes over everything you do. Be sure to set boundaries and make sure that you are taking time to have a fun and happy college experience in addition to completing your work as a student researcher. You will have many more years to spend doing research if you want to, so don't forget to take advantage of all of the other unique opportunities available to you at Yale!

The student part of student-researcher is important too! Performing research is only one of many responsibilities you have this year. You will enjoy your work a lot more if you are able to plan in advance around other academic commitments that you have. Try to avoid scheduling big experimental weeks when you have major exams or other large projects that will consume your time and provide extra stress. Often research can be fairly flexible in its schedule as long as you plan in advance. Similarly, you may want to think about how to plan your class schedule around your research work. For example, you may need extended blocks of time during the day in which to complete lab work. You don't want to have to skip classes to run experiments, so as you are shopping for classes, consider how and when your time in the lab will fit in. Similarly, communicate with your mentor or supervisor about your schedule as they may have constraints too!

Applications: As a senior, you will almost inevitably be applying for something. These applications may be for jobs, fellowships, graduate studies, or other post-graduate opportunities, and depending on the state of the world, they may also involve traveling for interviews. These applications will take time and cause some existential angst as you think about the future. Bear them in mind as you think about pacing your research, make sure to allow yourself some extra time during whichever portion of the year these applications fall into for you, and be kind to yourself and your peers as you go through this process. People in your lab are great resources to talk to as you plan for your career. Even if you do not plan to go into research or academia, your labmates have all been in similar positions and will have valuable thoughts and perspectives to consider as you embark on this journey.

Funding: Depending on the work you are planning to do, acquiring funding may be a necessary step. The most accurate and up-to-date list of Yale directed fellowships is available in the Fellowships database through the Yale OCS website, and external fellowships may also be available outside of Yale. For summer funding, a few Yale fellowships that may be worth considering include: The Yale College Dean's Summer Research Fellowships, The Tetelman Fellowship, The Summer Environmental Fellowship, the Peabody-Smithsonian Fellowship, and your Residential College's Richter Fellowship. Funding opportunities during the semester are more limited, but Residential College Mellon funds are one place worth looking. It is also a good idea to meet with an advisor from the Fellowships office, who may be able to help you find other sources of funding more specific to your project of interest.

Working remotely: This is primarily a pandemic-specific component of advice: think about how to plan around closures of space and loss of access to in-person work. This is particularly important in the early stages of designing your project, but consider selecting something that can be done remotely, or at least having a backup plan in case it is necessary.

Science is hard, it is ok to struggle! As anyone who has worked in a lab can tell you, one of the realities of science is that it doesn't always work. Sometimes your hypothesis turns out not to be right, or your exploration of a certain phenomenon does not yield anything exciting, and that is ok. Set realistic goals and expectations for yourself and keep trying even when things don't feel like they are working. While you can do a lot to set yourself up and put yourself in a position to succeed, part of having a good thesis is getting a bit lucky. Particularly as an undergraduate who only gets to work on one or two projects, it is important to remember that your skill and value as a researcher are not only measured by your results, or whether you get your name on a publication. While those are admirable goals, sometimes as an undergraduate researcher you will just get unlucky, and that is an important part of science to get to see too.

On a related note, research is not for everyone! As much as I personally love and enjoy doing research, it is unrealistic to assume that everyone will feel called to it in the same way. Students go on to work in a wide range of fields after graduating with a degree in Ecology and Evolutionary Biology, and it is ok if part of what you learn from working on your senior thesis is that you would prefer to apply the skills and knowledge you have gained over the last four years in a different context.

That said, research is fun! In few other fields, can you work with cutting edge techniques and methods to discover new information that has the power to change the world. For all of its slow and frustrating moments, research is also exhilarating and deeply rewarding. Writing your senior thesis is a wonderful opportunity to get comfortable in a research setting and to enjoy all of the excitement that comes along with that!

Build community! You'll be spending a lot of time in lab, so get to know your lab mates. It will make it easier when (not if) you need to turn to them for help, and it will make your time in lab much more fun! Likewise, don't forget that you are part of a wonderful community of other EEB students. The Senior Symposium at the end of the year is a great opportunity to see all the projects that your peers have been working on, but don't wait until then to ask them about their work! Like you, other students are putting in many hours on their research and will be delighted to tell you about it. Go to YEEBUG events, EEB Seminars, and get involved with the EEB community. Chat with the peer mentors – they love getting questions – and they have lots of helpful advice and experience to share with you!

You'll do great! This can be easy to forget at times. Imposter syndrome is real, and throughout the process of writing your thesis you will undoubtedly make mistakes, large or small, that may elicit doubt. That is ok. There are lots of resources available to help and support you through these moments. Peer mentors, lab mates, friends, advisors, recent graduates, the DUS, and other EEB faculty are all wonderful people to turn to for help and guidance. Similarly, if as you read this document, you are feeling overwhelmed by the barrage of advice to start early and plan ahead and worrying that you may be too late, don't worry, there are lots of resources available to you, and to help you succeed. You are going to do great!

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