Preparing for Graduate School in the Biological Sciences

Purpose

This handbook is aimed at providing you with insights into preparing for entry into graduate programs in the Biological Sciences. Although a rigorous undergraduate education in the Biological Sciences is an essential starting point for a career in the life sciences, many of the most challenging and satisfying careers in biology require post-undergraduate training.

Acknowledgments

The Loyola University New Orleans Biological Sciences faculty constructed these pages from decades of experience in higher education and in helping former and current students get placed into graduate programs. Dr. Craig Hood drafted the text and the faculty contributed edits. Illustrations by Jean Cassels

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LOYOLA UNIVERSITY NEW ORLEANS

Knowing yourself – what are your interests and skills ?

Your undergraduate years are part of your life's journey. You are having new experiences and learning new things about yourself and about the world. It should be expected that you will grow and that your interests and views of the world will evolve. At some point you will focus on busying yourself in a specific field, perhaps to a lifetime of engagement in that field, or perhaps for only a short while. Regardless of where you are right now, you need to stay in touch with your interests and skills and how they might align with becoming a biologist.

What interests you ? – Obviously the answer to this at any given moment depends on your experiences. And, underlying it all is the intrinsic "passion" you have – or don't have – about understanding yourself and the natural world. Concerning topics in biology, realize that our Core Biology courses seek to introduce you to all (or rather most) of biology at an introductory level. As you navigate through those courses, learn as much as you can, but also be paying attention to what excites you. The Elective Biology curriculum is where you explore the vast fields of biology at a deeper level. **We encourage you to experience different courses.** You can find your passion somewhere.

What do you know, what are your skills ? – As above, the "what" here is not just knowledge of biological patterns and processes, but of the physical world, of history, of human institutions, actions, and behavior. Skills are not just technical scientific skills, but how to think, act, and communicate as a biological scientist.

The breadth of courses you take as an undergraduate and all of the experiences you have (both academic and outside academics) shape your knowledge and skills. In preparing for graduate studies in the biological sciences, all of these things are important. Having mastery of established knowledge of biological patterns and processes is very important. But so too is having the skills of being a scientist – to be able to ask challenging questions to design creative and rigorous studies to test those questions, and to have the technical skills to carry-out an investigation. Critical reading, writing, and communication skills are especially important. You should challenge yourself to acquire a good knowledge base and to develop your skills.

Fields in Biology

Fields and careers in Biology. – The biological sciences cover a vast landscape of patterns and processes that operate over a fantastic range of time and space. As can be said for any major field of human activity, there are many levels of work one can do that is biological. However, the most engaging – and arguably fulfilling – positions require not only a passion for being a biologist, but significant knowledge and skills. These usually require education beyond the Bachelor's degree -- including especially graduate education that includes research. We encourage you to seek the advice of your faculty and of visiting biologists – these folks can help you understand the opportunities. The following **list of websites** introduce you to fields of study in biology.

Website link	Description
Careers in Science	Website for ***American Assoc. Advancement of Science***, publishers of ***Science*** magazine. You can also visit the ***Science*** website **www.sciencemag.org** and see lots of stories on what's happening at the cutting edge of science.
Careers in Biology	Website for the ***American Institutes of Biological Sciences***, a consortium of nearly 100 biological professional societies. The Careers materials here span all fields in the biological sciences.
Ecology	Website for the ***Ecological Society of America***. This is the largest scientific ecological society in the world.
Botany 1	Website for the ***American Society of Plant Biologists***. This professional society is one of the largest plant biology organizations in the world.
Botany 2	Website for the ***Botanical Society of America***. This professional society is onr of the largest plant biology organizations in the world.
Cell Biology	Website for the ***American Society for Cell Biology***, the nation's largest professional society for study of cells.
Biochemistry & Molecular Biology	Website for the ***American Society for Biochemistry and Molecular Biology*** . This professional society focuses on study of both basic and applied problems in biochemistry and molecular biology.
Microbiology	Website for the ***American Society of Microbiology*** . This is the world's largest professional society focusing on the study of microorganisms.
Physiology	Website for the ***American Physiological Society*** . This professional society focuses on animal physiology from cell/molecular to organismal levels.
Ichthyology	Website for the ***American Society of Ichthyologists & Herpetologists***. This professional society focuses on the study of fishes, reptiles, and amphibians, worldwide.
Herpetology	Website for the ***American Society of Ichthyologists & Herpetologists***. This professional society focuses on the study of fishes, reptiles, and amphibians, worldwide.
Mammalogy	Website for the ***American Society of Mammalogists***. This professional society focuses on the study of mammals, worldwide. In addition to this page, you can visit the following **weblink** to read about mammalogy.
Wildlife Biology	Website for the ***U.S. Fish & Wildlife Service***. This site gives a general overview of the diversity of careers and positions working with wildlife in nature.
Wildlife and Zoos	Website for the ***U.S. National Zoo of the Smithsonian Institution***. This is a good introduction to working in zoos, aquaria, and conducting conservation biology projects.
Furman Biology site	A nice website, created and maintained by ***Furman University*** (South Carolina) -- covers most fields in the Biological Sciences. Lots of very nice resources.
Emporia Biology site	A nice website, created and maintained by ***Emporia State University*** (Kansas) -- covers most fields in the Biological Sciences.

Finding out about opportunities – what to do, where to go.

Your Loyola professors – Probably the single best source of information and advice about graduate school is your faculty. Each of us have been where you are now (admittedly, many years ago!), went to one or more graduate programs, and ultimately became professional biologists. We also have peers and colleagues in many fields of Biology and – obviously – have mentored hundreds of undergraduates into all sorts of graduate programs. We have a world of experience, so why not take advantage of it?

Visiting speakers from other Universities – One of the reasons why we host the Faculty Research Seminar Series and bring biology researchers and professors to campus is so that you can find out about the wide diversity of programs, careers, and institutions in the world. It is very important to realize that graduate programs do not typically have "admissions directors" who come to campuses like pre-health professions admissions directors do (see also the section below). So, attend every Research Seminar and Guest Lecture you can and don't be shy about asking the speaker about careers in their field and/or about how to apply to their graduate program.

University and Professional Society websites – Given access to the web, it is easy to find out about careers and the mechanics of how to apply to a particular graduate program. With some suggestions and guidance from your faculty or from visiting biologists -- go to the university website of your choice, check to see if they have a biological sciences department or field that interests you, see what kind of degree program they have, and how to apply. Professional Biological Societies also have websites and many of them have "Careers in ..." resources that describe the field and what the career opportunities are.

Difference between "graduate schools" and "professional schools" – Any degree program beyond the Bachelor's (baccalaureate) degree can be referred to as a graduate program. However, many are specialized to provide specific training to enable you (certify you) to enter a profession. Health Professional schools (all forms of medicine, veterinary medicine, dentistry, and allied health fields of nursing, physical therapy, pharmacy, public health, occupational therapy, etc....) are professional schools. Many of the allied health fields award Masters degrees (e.g., Masters of Public Health) and sometimes additional national certification exams are required. These professional school programs usually have a fixed curricular structure, they do not require original research, they are usually of short fixed duration (2 years for most allied health programs and up to 4 years for medical degrees), and they cost you a moderate to large amount of money. The "payoff" to the cost is that most of these professions pay very well and one can retire your educational debts pretty quickly. For more information about professional schools, see the Loyola University Health Professions Board and their materials that are maintained on the webpages of the Counseling & Career Development offices.

Graduate school programs are very different. They have a very flexible curricular structure (you and your graduate faculty advisor design most of your curriculum), they require original research (the main focus of your training!), they usually require 4-6 years of work, and they usually cost you little or nothing. The goal of these Masters and Ph.D. programs is that you are developing into an independent professional biological scientist. Most programs give accepted and continuing students in good standing a full tuition waiver (you don't pay tuition) and actually pay you a stipend (nationally, Masters programs provide about $15,000 and Ph.D. programs $20,000 a year). Because graduate programs are accepting only a few students each year, they are investing a lot in your success. The biggest qualitative difference between graduate and professional schools is that in graduate school programs you develop a deep mentoring relationship with your research advisor and collaborative relationships with your graduate student peers.

In recent years a number of universities have developed non-thesis graduate programs. These are 1-2 year programs that involve taking courses with no research requirement and no financial support (you pay full tuition and get no stipend). These programs are usually designed to help students improve their chances of entry into professional schools or into technical positions (e.g., as a research technician). Local examples include Tulane University's 1-year M.S. program in Cell & Molecular Biology.

What does one need to do to enter a graduate school program ?

The application process. – The process of applying for entry into a graduate school program has some common general features, but varies by institution and by program within an institution. Generally speaking, you apply to two places – to the university (typically, the Graduate School) and to the program within a department. At most universities, the Graduate School has online instructions and forms that are very simple to understand and complete. But, the process at the department level is more involved and important. Departments typically have a website or at least they have contact information (a faculty member who is the Graduate Coordinator) and they include details of the structure of the program and how to apply. You should look at and interact with the Department first, because, it is the department that accepts you as a student. Also, at many universities **it is the department that awards full tuition waivers and stipends –** and the deadlines for consideration of stipends is usually December–February the year prior to starting in the Fall.

These are the typical requirements to enter graduate programs in the Biological Sciences:

a). you have taken the GRE general exam and subject area exam.

b). you have or will graduate with a bachelor's degree in the field

c). you have completed specific courses in the field.

d). you have letters of recommendation from professors in the field.

e). you satisfy other specific requirements of the program.

f). you have contacted and been accepted by a research advisor in the program.

Concerning undergraduate courses and degrees. – Most graduate programs in the Biological Sciences expect that you have completed a B.S. in Biology (or some related biological field) by the time you would enter their program, that you have taken typical core biology and physical science courses, calculus, statistics, and 5-6 upperlevel elective biology courses that are relevant to the specific graduate program you wish to enter. Of course, they expect that you have done well in these courses – typical science GPAs of entering students are 3.2 or higher, although lower GPAs can be acceptable if your junior/senior years are outstanding and you have had significant relevant experiences (especially undergraduate research). Most graduate programs do an assessment of a student's background, sometimes including an oral or written test. Based on a student's previous coursework and skills, specific graduate courses might be required as part of your curriculum.

Relevant experience, including especially Undergraduate Research. – Because graduate programs involve research, the single most important experience you can have is participation in Undergraduate Research. Whether you did a summer research project at another institution during your undergraduate career, or did a 2-year project with a faculty member in our department is immaterial. The important thing is that you participated and that you have learned how to do a research project. Having communication skills (e.g., being able to create and present a powerpoint presentation in front of an audience) is extremely valuable. Completing an honors thesis and being able to show that thesis (assuming it is of good quality) to a prospective research advisor is extremely valuable. Participation in professional meetings, especially if you make a presentation is extremely valuable – it shows you have experience working and interacting with professional biologists. Having a publication in a scientific journal (or one that is in the process of being reviewed) is the most valuable experience you can have.

In addition to undergraduate research, attending our Faculty Research Seminars and Guest Lectures and understanding how these things work are extremely valuable. Being comfortable and professionally conversant (being able to ask questions of speakers) is extremely valuable. Other relevant experiences can include volunteering or internships at institutions or in programs that are appropriate for the field you are trying to enter. For example, having an internship at a zoo that involves care of animals could be very appropriate for someone trying to enter a wildlife program.

GRE general and subject area exams. – All graduate programs require the general exam of the GRE. This is generally similar to the ACT/SAT exams that you took to enter undergraduate school. Most universities and departments – remember that the department accepts/rejects your application first – have minimum acceptable scores for the general exam. Many departments weigh the general GRE score heavily in their decision to accept a student and most of them will use it as a major factor for awarding stipends so they are very important. Like the ACT/SAT exams, you can study for the exam, there are classes you can take, and the ETS (they run the exam) has excellent materials to help you prepare (see below). Because departments award their stipends sometime in Dec - Jan - Feb (you need to find their deadline), it is imperative that you have taken the general GRE in time for the scores to be available then. Generally speaking, you should take the general GRE exam in the Spring or Summer the year prior to the year you want to begin graduate school (this is similar to the situation for the MCAT and medical school).

GRE General Test

GRE Subject Test

Concerning the subject area GRE exams, some graduate programs require them and others do not. You need to check with potential programs to see their requirements. There are two relevant subject area exams for the Biological Sciences **–** a) **Biochemistry, Cell & Molecular Biology**, and b) **Biology**.

See also many GRE tutorial website, such as – **www.mygretutor.com**

Finding a research advisor and being accepted by the department – If you visit websites of various graduate programs in the Biological Sciences and talk to Loyola faculty and visiting biologists, you will realize that there are many variations on how prospective students find and secure a research advisor.

In most biology graduate programs, a prospective graduate student must contact potential research advisors before they apply and, often, you correspond with them extensively and even visit them at professional meetings or at their institution. If they "accept" you as a potential student, their commitment to you is an important part of the acceptance process -- especially with regards to the awarding of stipends. Contacts with research advisors are often facilitated by good letters of recommendation and by personal contacts of your Loyola professors with them. Often, we will be able to point you towards a professor or program that we believe are of high quality, but also we know them and they know us.

In contrast, in some laboratory biosciences, especially those housed within health sciences centers and medical schools, students do not contact and join a research advisor prior to or during the application process, but are accepted by a committee of faculty in the department. When an accepted student enters the program, they go through a series of rotations, spending a few months in each of several faculty members' research labs and then selecting (or be accepted by) an advisor with whom they will spend the next 4-5 years working (esp. for the Ph.D.).

Letters of Recommendation – The writing of letters of recommendation is an important faculty responsibility. As noted above, not only are letters required for application to graduate / professional schools, they are often one of the most important factors in any application process. Your faculty take this responsibility very seriously. To write a strong, positive, and effective letter requires that the letter-writer truly know the person they are writing for and about. Make sure you cultivate your relationships with faculty over your entire career. Request recommendation letter from only those faculty who truly know you well as a student.

What is graduate school life like?

What's it like in graduate school programs in the Biological Sciences? – In one of the previous sections above, we described the differences between graduate and professional schools. Here we focus on graduate schools -- and only those that award research-based Masters or Ph.D. degrees. Traditionally, students entered a research-based Masters program, completing a thesis in 2-4 years, followed by entering a Ph.D. program and completing a dissertation in another 4 years. Increasingly, graduate programs in the Biological Sciences are phasing-out Masters programs. Many programs now will accept students into Ph.D. programs who have just completed their B.S. degrees. Clearly, such students need to be very mature and – most importantly – they need to have the research skills that usually require them to have participated in undergraduate research. Whether you apply to a Masters program first or directly to the Ph.D., it is clear that these graduate programs are all about research. That is, they are all about your development as a biological scientist. It means that the courses you take as a graduate student are not only providing you content, but are designed to have you develop your scientific skills of question-asking, critical thinking, and presentation.

The relationship between a graduate student and their research advisor is crucial and it can be both a highly supportive mentoring relationship that lasts a lifetime, as well as the most challenging relationship of your life. Good communication is critical. Relationships with other faculty, the staff, and your graduate student peers are also vital. At the least, you learn how to work with people and those personal skills will be important when you graduate and your professional life moves on.

The timing and pace of graduate studies is totally unlike that of undergraduate school. Although there are semesters and courses begin and end, most of your time and energy will be devoted to designing and conducting research projects that do not follow a typical academic schedule. Your study organisms are available to study when they want to be (which is often not 9 to 5 on weekdays) and when you have large blocks of time (weekends, summers, and holidays are the best times). There are times when you have to work as late into the night as needed, or for days or weeks on end. This is why you need to be passionate about what you are doing.

Concerning financial support – We have described in some detail the nature of tuition waivers and stipends. Any

graduate program worth its salt should provide you with a full tuition waiver (usually there are some fees of ~ $500 a year that are not waived). You have to maintain your grades and usually there is a maximum time limit of 5 years of support. The stipends that graduate programs award usually require that you serve as a teaching assistant in one or more courses (usually about 8 hours a week) – but that's not too bad for $15-20,000 a year. You have to maintain your grades and there is a maximum time limit of 3 - 5 years of support. Additionally, many faculty have research grants that include a research stipend that can be awarded to a graduate student. These require that you work for your advisor on their project, although often you can do your own research at the same time.

Beyond your degree – As you approach graduation with your graduate degree, you will be looking for a job or for other professional positions. All the skills you have acquired and experience you have had will position you for getting that good job or position. The relationships you have built with your research advisor, other faculty, and student peers will be vital to your getting those jobs or positions. **Letters of recommendation never end.**

Helpful Web Addresses

GRE exams. The ETS (Educational Testing Center), which also coordinates the ACT / SAT and many other exams, administers the GRE. Their website has a tremendous amount of helpful information on the GRE, including practice exams. **– www.gre.org**

Biology Careers – www.aibs.org/careers/

Ecology Careers – www.esa.org/education_diversity/explore.php

Botany Careers – www.botany.org/bsa/careers/ **and** www.aspb.org/education/

Cell Biology Careers – http://www.ascb.org/index.php?option=com_content&view=article&id=29&Itemid=36

Biochem/ Mole Bio Careers – www.asbmb.org/uploadedFiles/ProfessionalDevelopment/Resources/CareerBro04_web.pdf

Microbiology Careers – www.microbiologycareers.org/

Physiology Careers – www.the-aps.org/careers/careers1/ugrad.htm

Ichthyology Careers– www.asih.org/ichjobs

Herpetology Careers – www.asih.org/herpjobs

Mammalogy Careers – www.mammalsociety.org/committees/commeducation/careersinmammalogy.pdf

Wildlife Biology Careers – www.fws.gov/jobs/

Wildlife Zoo Careers – nationalzoo.si.edu/Education/WildlifeCareers/