The following document was written by Dr. Kurt Reinhart, then a graduate student at the University of Montana. It is presented in three parts:

1. Getting into Graduate School
2. Philosophy and Tactics for Graduate Studies in Biology
3. Tips Every Graduate Student Should know from the Start

The first two parts contain information/advice that the Biology Department¹s Curriculum Committee considers valuable for undergraduates who are thinking about pursuing graduate studies in the biological sciences. The Graduate Student Affairs Committee recommends that current graduate students be aware of the information/advice in Part 3. These issues might provide the basis for a beneficial discussion with your major advisor and/or committee.

We thank Dr. Reinhart for his permission to use this document to assist our students.

On Graduate Studies in Biology

To a Student,
From a Student
By Kurt O. Reinhart, Ph.D. Candidate in 2002

Introduction

Many students majoring in Biology contemplate pursuing graduate studies in their respective field at one point or another. A number of resources exist to aid students in getting into graduate school, and once accepted new graduate students are typically provided with some level of guidance to help assure their success. This document is intended to do one thing–fill in the gaps that currently exist for both the prospective and current graduate students in Biology. Most of the information in this document is general enough to be applied across all disciplines of Biology. The content is divided into three sections: 1.) **Getting into Graduate School** (pg 3-8), 2.) **Philosophy & Tactics for Graduate Studies in Biology** (pg 9-11), and 3.) **Tips Every Graduate Student Should Know from the Start** (pg 12-16). This paper represents mostly the perspective of a single graduate student with a background in Ecology and Evolution. I would strongly encourage you to discuss these different topics with as many people as possible for additional perspectives, tools, and innovations.

This endeavor was inspired largely by Dr. Stewart T. A. Pickett. Dr. Pickett was gracious enough to provide me with a document that he wrote entitled, "Philosophy and Tactics of a Graduate Education." He was the only scientist that I met during my quest for graduate studies that attempted to dispel the myths about graduate school with one comprehensive paper. This document made me appreciate his efforts while realizing the need for wider dissemination of this information.

"On Graduate Studies in Biology" is intended for people in different stages of their careers. The following paragraphs include my general reading recommendations for undergraduate and graduate students. Professional biologists may also benefit from some of the sections especially "**Tips Every Graduate Student Should Know from the Start**."

Content highlights

Undergraduate Students

I would strongly encourage undergraduates to read the following sections: "**Getting into Graduate School**" (pg 3-8) and "**Philosophy & Tactics for Graduate Studies in Biology**" (pg 9-11). The 1st section will provide an overview, resources, and checklists. The 2nd section will give you an insider's perspective of the enormous differences between a graduate and undergraduate education in Biology. Parts of the 3rd section ("**Tips Every Graduate Student Should Know from the Start**" [pg 12-16]) are definitely worth reading once you enter graduate school and potentially worth reading now. Regardless of whether you are interested in graduate school or not, I would recommend that you read the section "Additional Information on Jobs" (pg 14) for information on what jobs are available, what skills you will need for certain jobs, where to look for jobs, etc.

Graduate Students

I recommend that new graduate students read the section on the "**Philosophy & Tactics for Graduate Studies in Biology**" (pg 3-8) to help clarify how graduate school will challenge you in unexpected ways. This section is also a testimonial of the general demands/expectations that you will face and will provide suggestions for additional readings. The 3rd section ("**Tips Every Graduate Student Should Know from the Start**" [pg 12-16]) includes topics that you NEED to know from the start of your graduate education. I was not provided with some of this information until after 4 years of graduate school, and I wish that I had known it in the first month.

Getting into Graduate School

Getting into graduate school can be frustrating. I investigated nearly 10 different universities in detail during my quest for entrance into graduate school. I spoke with a number of faculty and graduate students. As I spoke with more and more people a number of unwritten rules began to emerge. This document will hopefully reaffirm the obvious (See Carson (1999) and Agre (2001) for a more thorough review of all aspects of the Application and Acceptance process) and highlight the not so obvious reality of getting into and succeeding in graduate school.

General

Entrance into graduate school requires an application process where the graduate program attempts to identify your general aptitudes and whether you meet the program and university standards (the term "university" is used throughout this paper and is meant to refer to both colleges and universities). This process is intended to identify your overall potential success and suitability within the program. It is important to realize that within the field of biology diverse areas of specialty promote very different sets of professional attributes. Therefore, one set of aptitudes may lead a person to success in one subdiscipline (e.g., plant taxonomy, plant population genetics, ecosystem ecology, etc.) while impeding success in another field. Most scientists realize that a scientist's future success cannot be reduced to a few easily quantifiable attributes that apply to all students and disciplines. For a thorough review of this process and to develop a strategy for success refer to Carson (1999) and Agre (2001). "Graduate Student Resources" (http://www-personal.umich.edu/~danhorn/graduate.html), on the Web is a useful internet hub that contains a number of useful links.

Brief Overview

Universities will require that you submit an application for entrance into their graduate program. The application typically requires your undergraduate grade point average (GPA [and Master's GPA if you have one]), general and subject Graduate Record Exam (GRE) scores, letters of recommendation (probably three letters-see Carson (1999) for a description of strategies for attaining good letters of recommendation), research experience, publications, entrance essays, cover letter, and processing fee. How each of these parts is weighed varies between universities and even programs within a university. Obviously, it is helpful to excel in all areas in which you will be evaluated. You may also wish to inquire about how the attributes are weighed. It is probably worth mentioning that a wide variety of people gain entrance into graduate school. If you feel that you do not have the most stellar GPA, etc. then you would certainly benefit from reading the optimism of Carson (1999).

Before continuing it is important that you examine your present and future goals to recognize how graduate school will help or hinder you. Graduate school is a huge commitment (2-4 years for Master's of Science degree and 5-8 years for Ph.D.) for low pay and long hours. Moreover, seriously consider your career path (i.e. private sector, management, faculty job [research institution, teaching school, etc.], federal job, etc.) and make sure that your graduate career is helping you achieve your goals. If you are contemplating graduate school because you enjoy undergraduate coursework then you are in for a big surprise. Read the second section, "**Philosophy & Tactics for Graduate Studies in Biology**" (9-11) and also Janovy (1996) which discuss the fundamental differences between undergraduate and graduate studies. Also,

recognize that once you have your degree you will be competing for scarce jobs that will provide you with low pay and long hours. If you have any doubts, reservations, or simply want an insider's view on being a graduate student in Biology continue reading this and also read Janovy (1996) and Carson (1999).

Funding dilemma

Acceptance into many Biology graduate programs is dependent upon meeting their standards, competing for funding, and having faculty support. Competition within many science programs can be stiff. Even the most exceptionally qualified students are not necessarily guaranteed acceptance. Availability of funding appears to be the primary driver of this competition. Many graduate programs (i.e., law, medicine, English, etc. and some disciplines in Biology) accept students, and the students are then expected to pay for their own schooling. Stellar students may be eligible for grants and fellowships. Otherwise, the students will rely upon their own wealth and money derived through loans and second jobs to survive.

Some graduate programs in Biology (with emphasis in Ecology and Evolution) often bar students from entrance if they are not awarded financial support from the department or an outside funding source (e.g. National Science Foundation). Lack of funding may equal no acceptance. Funding comes in one of three forms: Teaching Assistantships (TA), Research Assistantships (RA), or Fellowships. Fellowships and RAs typically pay graduate students more for doing what is already expected (i.e., research). Some level of inequality exists between students with these different funding sources and competition for any of these funding sources can be especially fierce depending upon supply and demand. For more information on how to find out about different RAs and fellowships (jobs, etc.) see the below sections titled, "Join a Listserv" (pg 13-14) and "Searching and Alerts for Funding Opportunities" (pg 16). I should also mention that some RAs and fellowships are internal and are awarded within universities or departments. Other sources of funding are open to nearly any one. I would encourage students to ask departmental representatives about the requisite for financial support and inquire about available funding opportunities.

How high should I raise the bar?

Ultimately, you need to decide if you want a Master's degree (Masters of Science) or Doctoral degree (Ph.D.). Your career goals should correspond with your plans for post-graduate degrees. If you choose a Ph.D. then you need to decide if you want to go directly into a Ph.D. program or attain a Master's degree first. Historically, it was common for programs to require a Master's degree prior to entering a Doctoral program but these days it is very common for Ph.D. students to skip a Master's degree. Acquiring a Master's degree prior to attempting a Ph.D. is a great test of your general motivation and interest in your prospective profession. Refer to Stearns (1987) and Carson (1999) for some information on Master's and Ph.D. and refer to Agre (2001) http://dlis.gseis.ucla.edu/people/pagre/grad-school.pdf for information on Ph.D. studies.

Important Information regarding Master's vs. Ph.D.

Universities will clearly state what degree options are available. On paper, these degree options may appear to be treated equally. In reality, there may be factors that contribute to greater acceptance of one option over the other. For example, a factor that may reduce your ability to receive funding and thus entrance into a program is whether you choose to pursue a Master's or a

Doctoral degree. Many schools will not clearly state that Ph.D. students are given precedence in receiving available TAs. If there are few TAs, then the deck may be stacked against students seeking funding for a Master's degree. In other cases, professors may have their own individual preferences. In some cases professors may actually prefer M.S. over Ph.D.students, because they will have more control over the student's research projects. Programs may also accept few Master's students because administrators may be striving for Ph.D. quotas to secure or retain federal or other types of funding. It is important that you choose a degree program and ask for clarification of M.S. vs. Ph.D. preference prior to starting the application process. I would suggest contacting a faculty member, graduate coordinator/representative, and/or the program director for the answer.

<u>You need an advocate</u>

Some schools will not accept students if they do not have a faculty member willing to sponsor or "take them on." Many schools will accept students and give them approximately one year to find a faculty advisor. Regardless of the process, you should be thinking about faculty members that you would consider interacting with if accepted. Requiring a faculty sponsor may lead to stellar students not gaining acceptance if they did not contact prospective faculty in advance and identify whether the prospective faculty has any interest in taking on a new student. It is critical that you identify a faculty member and develop a relationship so that you have an advocate. Your chances of being accepted into a graduate program will increase if you have a faculty member saying, "I want to accept this student."

Finding an appropriate mentor can be extremely challenging. First, you need to define your own research interests and then attempt to find a scientist that shares your research interests and is capable of serving as a graduate advisor. There are a number of ways to try and find someone with similar interests (i.e., review the current literature, attend seminars, "Join a Listserv" (13-14), talk with your undergraduate advisor and other faculty, etc.). Attending national and international conferences is a great way to meet potential graduate advisors. Once you have found someone with similar research interests then I would encourage you to e-mail and write this prospective advisor. Once you have established some initial communication with this person then phone and visit with them. Meeting with this person will help you (and prospective faculty) to determine your suitability with them and their laboratory. As soon as you become interested in a specific individual contact them and as many of their current and past graduate students as possible to help develop an accurate perception of this person as a scientist and a mentor. Also, if you attempt to contact faculty members via. e-mail or letter, do not be surprised when most of them neglect to reply to your e-mails. If they have not responded to your e-mail or written letters then you may want to call them. You will probably be pleasantly surprised with their open enthusiasm over the phone. Faculty members are extremely busy people and it is reasonable for them to not reply to every e-mail message they receive. See "Checklist for Picking the Right Advisor" (pg 6-7) and "Department and University Checklist" (pg 8) to help you identify a suitable advisor and university/graduate program.

Checklist for Picking the Right Advisor

It is important that you clarify what is important to you (i.e., what do you want to be and do in the future) and what is important to your potential advisor. Both the student and the advisor will be making a huge commitment to one another and it is important that you share a number of key attributes to help guarantee a successful and productive relationship. You should learn as much as possible about your potential advisor. A series of topics are listed below to help guide you.

a. What is your current or planned research emphasis (i.e., what is the theme of your research and are you willing to deviate from that theme [if so by how much])?

i. How is research in this lab funded?

b. What is your research focus and does it emphasize specific research tools, organisms, places, or questions?

i. Will this constrain a student's research directions?

c. Is this scientist renowned and if so then in what field(s) and for what?

d. Will we both benefit from our interactions and collaborative efforts? How?

e. What are your research goals?

f. How do you define your mentoring agenda/philosophy?

g. How do you feel about:

i. M.S. or Ph.D. focus?

ii. Independent or directed projects?

iii. Importance of course work and teaching vs. research?

iv. Anticipated level of interaction (individual or lab/group)?

h. What is your ideal number of current graduate students and what is the current size of your lab?

i. What do graduate students and other people within the department think of this person as a potential advisor and scientist?

j. Does it look like any personality conflicts will develop between you and your prospective advisor?

k. Is this potential advisor a senior scientist near the end of his or her career or a scientist just beginning their career? Both types have typical strengths and weaknesses.

l. Will this person help me develop as a professional _____? Example: If you are seriously interested in research (applied, basic, vs. theoretical), management, advocacy, federal organizations, teaching, etc. then how will this person help or hinder your development?

Choosing the right advisor is much more important than the quality or reputation of either the program or university. However, here are some additional criteria worth considering for the graduate program and the university that you plan to attend.

Department and University Checklist

a. How interactive is the graduate program?

i. Are there interactive discussion groups &/or a cohort of like minded graduate students and faculty?

ii. Is there departmental infighting?

iii. Does this department have close ties with other departments who have additional resources (e.g. intellectual, chemical analyzers, growth chambers, field sites, Electron Microscopes, etc.) that you may need to use?

b. Does the department have any unusual coursework, foreign languages, teaching, etc. expectations?

c. Are exceptional resources available (i.e., access to field stations [e.g. LTER's], long term experiments [e.g., FACE sites], super computers, greenhouses, growth chambers, aviaries, etc.) through your potential advisor, department, or university?

d. Are there departmental/university resource problems (i.e., few TAs, equipment, facilities, or a general lack of administrative support)?

e. How competitive is entrance into the program (i.e., average GRE scores, etc.)?

f. What is the expected salary for TA and/or RA positions for M.S. and/or Ph.D. students before and after paying for school, and you should identify whether this is enough to avoid taking out loans? [Note: schools will vary in how much they pay you and regions will vary markedly in the "cost of living"]

g. What are the expectations/commitments for these different funding sources?

i. Can you still develop your own research niche that will help distinguish you as a scientist?

h. Is the department well respected within your area of expertise (you need to have some idea of your own research interests)?

i. Is the university well respected?

Philosophy & Tactics for Graduate Studies in Biology

"Graduate school is the mechanism by which a consumer of science, an undergraduate, is trained to become a producer of scientific understanding." Pickett mid-1990s

Transition from Consumer to Producer

There are a number of dramatic differences between most undergraduate and graduate education experiences. As an undergraduate, students are typically expected to consume knowledge provided by teachers and books and express what they have learned through written examinations, projects, and papers. Undergraduates typically take nearly twice as many courses and may work a part time job. As a graduate student your primary duty will be to conduct research. As a researcher you will read and access extensive literature, and produce insights and new information through informal discussion, formal presentations, and publications. Graduate students typically take few classes and having a second job is often discouraged. Graduate students will be expected to form a committee, take classes, take comprehensive examinations, attend seminars, defend their ideas and research, teach (possibly), write grant and research proposals, conduct research, analyze data, learn how to use different software programs, attend international conferences, organize and present their research in front of their department and at international conferences, publish, etc. Together these tasks will lead to your own evolution but will require a deep personal commitment, intellectual maturity, creativity, and flexibility. Time management will be one of your biggest challenges. The culmination of these activities will lead toward making a valuable contribution to science and becoming an authority in your field of study.

"Four golden lessons" for young scientists (Weinberg 2003):

1) don't spend too long getting to know the literature – do research!
2) choose a research area that is new and 'messy' - that's where the action is!
3) forgive yourself for wasting time
4) learn something about the history of science, or at a minimum the history of your own branch of science.

Development

A large part of balancing all of this work is developing the skills that you will need to be successful. You will develop a number of visible attributes (field/laboratory research, convincing public speaking and writing style, etc.) and a number of less visible or even invisible attributes (ability for synthesis and deep reflection). Invisible attributes include developing the ability to be critical, skeptical, and interactive, while processing and synthesizing vast amounts of literature, and generating your own scientific questions, etc. You will need to learn to balance both being skeptical and open, independent and collegial, synthetic and analytical. Most importantly, you will need to learn how to think. As a graduate student, you will need to learn, sort through information, and develop your own ideas and questions that will dictate your development as a scientist.

Reputation

All graduate students will work towards developing a number of skills (i.e., public speaking, writing proposals and peer-reviewed papers, analyzing data, etc.); however, it is also important

that you develop an identity that distinguishes you from others. Students that acquire a lot of funding should do a lot with their funding. Your reputation will immerge as faculty and peers compare you on a sliding scale to your peers (i.e. acquiring lots of funding will initially help you acquire a good reputation but doing little in terms of publishing will change opinions). See Dixon (1986) for a humorous list of ways to stand out at an international conference.

Choices and Planning

As your career develops you will constantly find yourself at a crossroads. You will be presented with opportunities to take an extra class or two in "Ohhh Wow!", attend a special training in gadgets or computer program "Only1", undergo taxonomy training in widgets and thingys, travel to "Once In a Lifetime," learn a new language, collaborate with Drs. Fame and Fortune, work in Dr. Prestige's lab, etc. Some of these opportunities will dramatically alter the course of your personal and professional life but others will mostly consume time. The choices that you make now, especially those consuming vast amounts of time and lead to a narrow specialty may have important long-term consequences on your career. Your choices help to define you as a professional scientist. If you spend years learning an expertise that becomes obsolete 5 years later then you may have a serious problem. It is fine to speculate but make sure that you consider how your training will allow you to respond in the future as the window of opportunity opens and closes. Be careful how you commit yourself and constantly revisit your career path.

As mentioned, you will need to plan numerous things (e.g. class schedule, research schedule, committee meetings, department requirements, etc.). If you are a Ph.D. student and plan to eventually acquire a job in academy then you may also need to do *post-doctoral research* following the completion of your degree program. The post-doctoral research or post-doc as the name implies is something that you will want to do after you graduate, but you may need to plan for it ca. 1.5 year before graduating. Post-docs come in primarily two forms. People/Research Groups that have substantial research funding will often hire a post-doc or you will have to submit a research proposal for a post-doc through an appropriate funding agency (i.e., NSF, USDA, EPA, Fullbright, etc.). Post-doc positions are routinely advertised on listserves (see "Join a Listserv" [pg 13-14]). The quality and expectations for advertised post-docs may vary dramatically from position to position. Some positions are really exaggerated tech (technician) positions and others are diverse experiences that will really help you define yourself as a scientist. Instead of relying on sporadic post-doc opportunites, you may want to find a funding source and write a post-doc proposal to fund your own research project. This is more work, but acquiring your own funding will help pad your CV and will give you more intellectual independence. If you want funding for a post-doc immediately after you graduate then you will probably need to submit your proposal the previous autumn. My best advice is plan ahead (ca. 1.5 year).

Comprehensive Examination

Overall, comprehensive examinations (comps, qualifying exams, etc.) can be one of the greatest experiences in your career. Studying for these exams is a unique opportunity to explore the literature and develop an appreciation for what others have done while also identifying what has been left undone. Passing your comps is often a right of passage that will help elevate your professional confidence. There is; however, a dark side to these examinations and the stress often associated with them. Because program/committee standards and individual experiences

vary widely it is important that you discuss comps with faculty and senior graduate students to clarify the expectations, process, etc. Also, I recommend that you develop a "Life List" of scientists. Create a list of influential authors and their contributions to science. This list should be both broad (e.g., influential contributions to ecology) and specific (e.g., know all of the important players in your field of specialty). This list is by no means the solution to comps mastery but one small step towards your own development.

How Does Anyone Survive?

Are you overwhelmed yet? Well, remember you are not alone. You will likely have a cohort of other graduate students, primary advisor, and graduate committee who will help support you. It is not uncommon for major advisors to "tear up" during your hooding ceremony at graduation. However, it is important to realize that ultimately this is your show. Your successes and failures are mostly yours and will have a much greater impact on you than your advisor or anyone else. See the next section for "**Tips Every Graduate Student Should Know from the Start**" (pg 12-16) to help you succeed.

For an entertaining "Good cop, Bad cop" perspective of the graduate school experience read **Stearns (1987)** and **Huey (1987)** http://rav.sio.rssi.ru/~lena/Grad.html.

A Word on Skepticism

Being skeptical and critical is exceptionally important because of the high standards that society has placed on scientific information (see Committee on Science, Engineering, and Public Policy 1995 http://books.nap.edu/books/0309051967/html/index.html for a discussion of scientific standards and ethics). Scientific information undergoes a rigorous process; therefore, it is held in high regard by society. Unfortunately, some scientists have promoted untruths. For example, scientists have made false claims about the development of cold fusion (Fleischmann and Pons, Press Conference in 1989), governments have invented overestimates of their annual fisheries harvest (Watson and Pauly 2001), etc. Scientists have in some cases helped perpetuate hoaxes but have also helped uncover them. It is important that we remain both critical and skeptical to help identify hoaxes and their influence on scientific understanding, public opinion and policies, etc.

Tips Every Graduate Student Should Know from the Start

The obvious
Know what things need to be done (i.e., proposals, committee formation and meetings, seminars, examinations, etc.) and when. Your department will probably provide you with the department regulations. Be sure to review whatever material they provide.

The not so obvious
Learn how to read
You will have so much to read and so little time that you need to read efficiently. Here is a simple suggestion. Start with the title, abstract, and results. If you have more time or fewer papers then read the discussion, introduction, and methods. Obviously, there will be times when you only want to read one section (i.e., methods). My suggestions are intended to improve your reading efficiency and not intend to discourage you from reading. Reading is one of the most valuable ways to spend your time but **spend your time wisely**.

Learning how to write more effectively
a. **Writing**
Many professors think that disciplined writing is the most difficult trait for graduate students to acquire. The tremendous effort entailed in writing papers and theses comes as shock to many graduate students, and writing will probably be the greatest effort you make. However, "science not published is not science." Writing is often a matter of willpower, and nothing will improve it as much as practice. If you are like most people you probably do not write as well as you can or should. Here are some suggested readings that will improve your technical writing: Williams (1990) and Strunk and White (2000). Writing science can be a bit difficult so consider reading Gubanich (1977), Lertzman's 21 tips (1995) (http://aerg.canberra.edu.au/pub/aerg/edulertz.htm), and Magnusson (1996). Writing and reviewing with fellow graduate students can also be a great way to learn about scientific writing. And if you cannot decide who deserves authorship on a paper then you may want to review Galindo-Leal (1996).

b. **Writing Grant Proposals**
When attempting to gain employment as a Biologist it is often helpful if not necessary to prove that you can write successful research proposals to fund your many endeavors. Your general productivity as a scientist; however, is more a product of the quantity and quality of your publishing record than your ability to secure funding. Thus, it is important for you to learn how to write successful grant proposals but not to the extent that it interferes with publishing. Individuals will have to decide for themselves how much time to allocate toward writing proposals. For additional help on writing research proposals see Friedland and Folt (2000). You can also visit http://www.umt.edu/research for some useful internet links on writing proposals.

c. **Reviewing the Work of Others**
You may eventually be privileged to receive a letter from a journal editor requesting that you review a paper submitted to them for review and publication. Regardless of why you were chosen by the editor, this is a great opportunity and probably one that caught you completely by

surprise. Talk to experienced scientists (i.e., advisor, etc.) and see Kuyper (1991) for some general tips on how to review a manuscript.

d. **Impressive presentations**
Other than writing, public speaking may be the most difficult skill you will learn in graduate school. Some advisors and departments require tremendous effort directed at seminar presentation, others pretty much ignore it. You will probably be uncomfortable and/or terrified when you give a public presentation, but I cannot emphasize the importance of doing so, and learning to do so. Through experience you will not only feel more confident but you will radiate confidence and command for your research to the audience. If your choice of a graduate program does not emphasize training in public speaking you may want to consider other options. A number of resources are available that will help improve your presentations (Janzen 1980, Dixon 1986, Pickett et al. 1994) and help you become more comfortable giving public lectures. If you are interested in reading about 10 generic questions that can be asked in presentations read Hedrick (2000).

Taking Advantage of Technological Advances

This section is dedicated exclusively to computer-based applications that can make your life easier. This list is intended to inform you of resources that exist; however, this is by no means an exhaustive list of all Internet services, utilities, or computer programs available. Because the technology industry is undergoing constant change, it is more important that students and faculty recognize the potential that exists and then attempt to see what resources are currently available that are analogs for the specific services mentioned below.

Have a question? Need a job or funding?
Join a Listserv
A listserv is simply a free computer-based bulletin board. To become a member you will need to subscribe. Once you have joined a listserv you will begin receiving messages and also be allowed to post messages. Two professional listservs for Ecologists and Evolutionary Biologists are Ecolog-L associated with the Ecological Society of America and Evoldir, respectively. To join Ecolog-L or Evoldir visit http://www.esa.org/links.htm or http://life.biology.mcmaster.ca/~brian/evoldir_instr.html, respectively.

Here are three reasons why you should join a professional listserv.
1. Funding opportunities (i.e., grants, RAs and Fellowships) are frequently posted on listservs (If you want more information on finding funding read the section below titled, "Searching and Alerts for Funding Opportunities" [pg 16]).

2. Numerous people post job opportunities ranging from: seasonal internships, post-doctoral positions, faculty, private sector, and state/federal positions. A word on jobs—eventually you will need one. Also, you will probably want to know a variety of things about employment opportunities prior to actually needing a job that include: availability, requirements, pay, etc. All of these questions can be answered by occasionally looking at a listservs' e-mails relating to employment opportunities. Some listservs (Ecolog-L, etc.) also archive job listings so that you can receive all of the position announcements for a week or month without seeing all of the other messages. Listservs may also allow you to receive only messages relating to employment or

other topics of interest. For additional information on strategies for gaining employment see Everham (1994) or Tobias et al. (1995). For **Additional Information on Jobs** please refer to the following resources all of which are located on the Ecological Society of America's web page: **Career Resources** http://www.esa.org/ed_resources.htm#careerinfo, **Careers in Ecology** http://www.esa.org/undergraduate.htm#second, **What Do Ecologists Do? Focus on Ecologists** http://www.esa.org/ed_resources.htm, **What Does Ecology Have to do with Me?** http://www.esa.org/ed_resources.htm, and **Careers in Ecology: More and varied demands create opportunities for those with broad interests** http://www.esa.org/ed_resources.htm#careerinfo.

3. There may be a time when you actually need information on something and no one at your university has any idea how to help. You can post your question on the listserv, and answers to your inquiry will either be posted for everyone to see or sent directly to you.

A word of caution—listservs frequently have long philosophical dialogs regarding different controversial topics. The temptation to waste your time and not work on matters of fundamental importance will be intense. Make sure that you do not sideline your primary responsibilities because you are reading or writing endless e-mails. Other people may be doing research emphasizing political lobbying, environmental policy, etc. and will benefit immensely from following these discussions. Some people do not bother to use listservs because they get tired of getting too many e-mail messages. Personally, I rapidly delete e-mail messages based on sender and subject information. You can decide what is best for you.

Keeping up with the literature

It may be impossible for you to keep up with the literature depending on how broad your interests and how fast you can read. **Searchable Electronic Databases**, **Online Alert Services**, **Reference Managers**, and **Searching and Alerts for Funding Opportunities** can drastically improve your efficiency. In the future, as more and more literature continues to be produced new technologies will be developed to help review and consolidate literature (see Kareiva 2001 for a discussion of a new online resource where scientists write reviews for individual papers that are made available to the public).

a. **Searchable Electronic Databases**

Searchable databases are fairly common and most graduate students learn to use them very early in their careers. A vast number of databases exist. For a comprehensive list of databases and how to use them visit with a research librarian at your university. I frequently use the Cambridge Scientific Abstracts (CSA) Internet Database Service and WebSPRIS from SilverPlatter, which searches the Biological Abstracts. Most of these programs allow you to search by keywords, boolean operators (i.e. and, or, not), truncation (burn* instead of burn, burns, burned, and burning), wildcards (e.g., wildcar?s), author, and title. Here is an example of a search using keywords, boolean operators, and truncation.

Search for papers on <fire ecology in coniferous forests in the Northwestern United States>.

> (fire* or burn* or forest fire*) and (pine* or conife* or Pinus*) and (Northwest or Oregon or Montana or Washington or Oregon)

Your search results will typically include all of the standard information included in most citations and will often include an abstract if one is available. The results can be either printed, saved to disk, or e-mailed. Information that remains in a digital format (i.e., e-mail or saved on diskette) can be "cut" and "pasted" into a standard word processor file (i.e., Word, WordPerfect, etc.) and saved. The saved file can then be easily imported into a number of reference manager programs (see section "Reference Managers" (pg 15-16) below for a discussion of reference manager programs and their application) with an appropriate filter.

The biggest limitation to these search engines is their historical coverage. Most of these programs only allow you to search back into the 1980s and thus an enormous amount of information is inaccessible from these programs. Therefore, these programs are great tools but are no substitute for the resources that predate ca. 1980 sitting in your university library.

b. **Online Alert Services**

Alert services are one excellent way to make sure that you do not miss any new papers in key journals or on key topics. I use the service Ingenta Uncover that is provided to students and faculty by the University of Montana (individual or institution membership is necessary for access). Other services are likely to exist or will exist in the future. Check your university library to see what services are available.

Alert services allow you to setup an account and to customize your account by either selecting individual journals or creating a list of keywords. Once you have selected one or more journals (e.g. Nature, Science, Ecology, Evolution, etc.) the service will then begin sending e-mails that include the table of contents (TOC) for the new issues of each journal in your list. This service is referred to as a "TOC Alert." TOC Alerts are sent at an interval consistent with the journal publishing frequency (i.e., monthly, bimonthly, etc.). This service will allow you to peruse the latest contents of a number of journals all from the comfort of your computer monitor. Typically, you will receive TOC Alerts before the journals are actually received by your university library. You can also use keywords (e.g. invasive species, phenotypic plasticity, *Homo sapiens*, etc.) to scan all recent TOC's within the service's entire database. The TOC and Keyword Alerts make it nearly impossible for you to miss a recent article of interest. As mentioned in the previous section, the content of your e-mails can be "cut" and "pasted" into a word processor document and later imported into your personal reference manager (see following section for information on "Reference Managers" (pg 15-16) with an appropriate filter.

Please note that Ingenta Uncover can also be used to order copies of individual articles. However, you may only be able to place an order at "no charge" if the journal is NOT found within your university library. The selected articles will be faxed to you within 24 to 48 hours.

c. **Reference Managers**

Reference managers are computer programs that help you organize your references or any other information that can be cataloged (i.e., slides, quotes, notes, samples, etc.) and can be used to automate the process of constructing a bibliography. Some of the more commonly used reference manager programs include: Reference Manager, EndNote, ProCite, etc. (see <http://www.risinc.com/>). Individual programs have slight differences but most allow you to create one or more databases containing your cataloged information. You construct a database

by entering information for each paper, book, magazine article, etc. that you wish to include in the database (see the last paragraph in the "Reference Managers" section for entering data the easy way). You can also enter and link important notes, keywords, etc. to specific sources (i.e., individual articles, personal communications, etc.). I find that including notes is very handy down the road when I cannot remember the details of a paper. Simply query the database, find the appropriate citation information, and review the abstract and any potential notes that have been entered for that specific document. The information in your database may be enough to prevent you from having to locate the individual article, book, etc. and spend time rereading it.

The other good reason to invest the time and money (ca. $100 for students) into buying a reference manager and developing a database is because of automated bibliography construction capabilities. Reference codes (i.e., "{349, 1239}" instead of (John 2002, Doe 2002)) can be entered and used later to construct a bibliography. Once you are ready to produce a bibliography the reference manager can scan the document and locate all of your reference codes. The reference manager will convert your reference codes into "in text citations" (i.e., (John & Doe 2002)) and also generate a bibliography to your specifications. This will be a huge help when you begin submitting your manuscripts for review and eventually have to resubmit a paper. A reference manager will allow you to rapidly rescan the document and produce a new bibliography and "in text citations" meeting the new specifications of each new journal. Bibliography formats for different journals will either come with the program, can be downloaded from the companies' web page, or you can customize your own formats.

One obvious problem with a reference manager is that it takes considerable time to enter all of the citation information, notes, abstracts, etc. Luckily, you do not necessarily have to type a thing and can instead import the information into your reference manager. Any reference information that you already have in electronic format (i.e., from either a "Searchable Electronic Database" [pg 14-15] or an "Online Alert Service" [pg 15]) can be imported into your reference manager with the appropriate filter. A filter is required by your reference manager to determine what the jumble of information (e.g. author, title, etc.) is and how to categorize it properly. In many cases you can download individual filters for specific Searchable Databases or Online Services directly from the manufacturer's web site. If a specific filter is not readily available then you can construct your own. It will take some time to learn how to make your own filter but just think about how much information you will be able to rapidly important into your reference manager in seconds.

d. **Searching and Alerts for Funding Opportunities**

One of the best services available for searching for funding on the internet is the Community of Science (COS) web page (<http://www.cos.com/>) or http://fedgrants.gov/. Hopefully, your university has access to this service or a service like COS. COS allows you to search their database and to receive Funding Alerts. You can customize a search by keywords, funding type, location, etc. This can be useful but since new funding opportunities are constantly becoming available, searching becomes a rather inefficient way of trying to keep up with new funding opportunities. COS also allows you to set up a search profile that it uses periodically. Any new funding opportunities that meet your search specifications are then e-mailed to you as a Funding Alert similar to the TOC Alerts described above ("Online Alert Services" [pg 15]). The Search and Alert features should make you confident that you are keeping up with the most recent

funding opportunities. One word of caution—COS is very comprehensive but funding opportunities may still slip through the COS cracks. The Federal Register is the most complete source of information but is unfortunately not very user friendly (see <http:www.access.gpo.gov/su_docs/aces/aaces002.html>).

Conclusion

In conclusion, the philosophies, strategies, and tools mentioned in this document are all suggestions and not necessarily requisites for success. As I mentioned earlier, fields within Biology are incredibly diverse and there is room for people with all sorts of aptitudes. As you begin your graduate career you will hopefully have plenty of time for each of the expectations and developments that I discussed previously, and you can be assured that you will not be required to make all of these changes in your first semester of graduate school. I realize that at times I have painted a rather grim picture of the graduate experience. There will be plenty of light moments and successes but probably more failures than even most pessimists could have predicted. I hope that everyone that reads this document will benefit from these hard-learned lessons and insights. I would strongly encourage you to discuss these different topics with as many people as possible for additional perspectives. Some useful citations are listed below, and many of them can be viewed over the internet. If the source for a citation is difficult to find then search for it on the internet. Many of these papers are continually being republished on the internet.

Acknowledgements

This document benefited from comments by: Ragan Callaway, Adam Collins, Matthias Rillig, Don Christian, and Julie Reinhart. Also, I must thank my wife, Julie Reinhart for her generous love and support for me, and my endeavors. Lastly, I must thank "Kendra" who happily provides continuous mental therapy while asking for very little in return.

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