

A short piece from the Careers section of a recent issue of Nature ...

RECRUITERS & ACADEMIA

What makes a good PhD student?

Doing a PhD should be fun and rewarding, because you can spend all your working time discovering things and pursuing ideas — and getting paid for it, without any administrative responsibilities. Those who stick with a career in science do so because, despite the relatively poor pay, long hours and lack of security, it is all we want to do.

Unfortunately most new PhD students are ill-prepared, and as a consequence very few will fulfil their aspirations to be independent scientists. The main reasons for this are the 'grade creep' inherent at most universities, making it difficult to identify the really talented first-class graduates from the rest, and the pressure on universities to graduate as many PhD students as possible. The consequence is that we enrol far too many of them without telling them clearly what doing a doctorate should entail. We therefore set ourselves, and the students, on a path of frustration and disappointment.

So what should we be telling prospective PhD students?

- Choose a supervisor whose work you admire and who is well supported by grants and departmental infrastructure.
- Take responsibility for your project.
- Work hard — long days all week and part of most weekends. If research is your passion this should be easy, and if

it isn't, you are probably in the wrong field. Note who goes home with a full briefcase to work on at the end of the day. This is a cause of success, not a consequence.

- Take some weekends off, and decent holidays, so you don't burn out.
 - Read the literature in your immediate area, both current and past, and around it. You can't possibly make an original contribution to the literature unless you know what is already there.
 - Plan your days and weeks carefully to dovetail experiments so that you have a minimum amount of downtime.
 - Keep a good lab book and write it up every day.
 - Be creative. Think about what you are doing and why, and look for better ways to go. Don't see your PhD as just a road map laid out by your supervisor.
 - Develop good writing skills: they will make your scientific career immeasurably easier.
 - To be successful you must be at least four of the following: smart, motivated, creative, hard-working, skilful and lucky. You can't depend on luck, so you had better focus on the others! ■
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 ■ www.qimr.edu.au/research/labs/georgiat/Guideforphds.doc

... and a longer version from the author's web site.

Guide for PhD students (and post-docs) aiming for a successful career in science

roughly in order of importance, and with apologies to those who have worked these things out for themselves!

This is not an official QIMR document and does not represent the views of QIMR or its committees. It does, however, reflect the collective view of some senior QIMR researchers who manage to enjoy very productive and intellectually rewarding careers in medical research, and who wish to pass on some tips to those who are considering a similar career.

Doing a PhD should be fun, rewarding and be seen as a privilege. It's the only time in your life that you can spend 100% of your working time learning to do research, finding out new things, having freedom to pursue new areas and getting paid for it, without any administrative or other responsibilities. Those who stick it out do so because, despite the relatively poor pay, long hours and lack of security, it is all we want to do because of the intellectual satisfaction it brings, the excitement of discovery, the freedom to make your own work schedule, the opportunities for travel, the pleasure of being in an international community of like-minded people and (for some people) the possibility that we might actually help the human condition!

1. **Choose a supervisor whose work you admire** (find out first what work they have done and are doing, and search PubMed to see how productive they are!), located in a department or institute with good infrastructure (equipment, patient samples, seminar series etc), and who has enough grant funding not to limit your project too much.
2. **Get involved and take responsibility for your project.** This is probably the most important transition from the Honours year. To be successful in research you need to develop strong skills in independent and effective thinking, critical analysis, problem-solving, and time management. The *only* way to develop these skills is to take responsibility for your project. You need to immerse yourself in your research and exercise your mind with every experimental plan and every experimental outcome, including failures. Embrace failures as challenges and training exercises for future successes, rather than looking around for people to blame. If you simply follow directions and close the door behind you at the end of the day you will never progress in research. Tenacity is essential!
3. **Work hard.** Don't think you can get away with a 38-hour week. You will need to work long days all week, and for part of most weekends. That gets you to closer to a 50-60 hour week, which is what you need if you want a successful career in academia (or indeed in any professional career). If research is your passion, this is actually easy to do, and if it isn't your passion, then you are probably in the wrong field. You should be going to work because you want to, not because you have to. Of course, ultimately, the number of hours doesn't matter - the only thing that matters is productivity, but unless you are a genius, *and* very organized, *and* very lucky, you will need to work this hard to get out enough good papers to make a good start in a scientific career. A three year stipend might seem like a long time at the start of a PhD but three years goes very, very fast and it might be difficult or impossible (depending on its source) to get an extension into a 4th year. The people who go home with a full briefcase of work to do at home are the ones most likely to succeed. Note who around you does this – aren't they the ones who have 'made' it? The extra hours are the *cause*, not *consequence* of success!
4. **Play hard.** Take some weekends off, and reasonable holidays, so you don't burn out. But if your work is very dependent on people around you, don't plan to work over Christmas and New Year and then take your holidays when your colleagues are all hard at work. On the other hand, if you are totally autonomous and not using equipment that is liable to break down, the holiday season is a great time to work in peace, and without competition for equipment. If you're stuck with a problem in late afternoon or early evening it might be more productive to go home and tackle it fresh the next day.
5. **Read the literature**, both in your immediate area, and around it; both the current and the past. You can't possibly make original contributions to the literature unless you know what is already in there. See it as a challenge to put an interesting paper on your supervisor's desk before they put it on yours! The best time to read papers is between experiments, or in the evenings or weekends. Reading papers at your desk *instead* of doing experiments is a poor use of time. Most people find it challenging to understand some papers when they start out. Don't let this put you off. Instead, go back to the earlier literature or text books, ask questions and discuss the papers with your supervisor or other colleagues. Use this as an opportunity to spark thought-provoking scientific discussions. Your supervisor will be busy, but should always make time for these discussions (if not, find another one!).
6. **Plan your days and weeks very carefully.** If you are in the lab, begin the week, and each day, by carefully dovetailing experiments so that you have the minimum of down time. Make lists of what you have to do tomorrow at the end of each day while today's work is in your mind. This also allows your mind to think about the next day's work while you sleep. Unless you have domestic constraints, be flexible about what time you go home to cope

with unexpected changes to this schedule (and remember, this is probably the most flexible part of your life – once you have children, this goes out the window, so make the most of it).

7. **Keep a good lab book, and write it up every day.** It will make thesis writing much easier, and will also help to protect any intellectual property that might one day make you rich. In particular, write up the details of your methods as you go along. They will easily convert to chapters in your thesis, and also to laboratory protocols which is useful for everyone.
8. **Be creative.** Think, think, and think some more about what you are doing, and why, and whether there are better ways to go. Don't just see your PhD as a road map laid out by your supervisor. Talk to your supervisor, and others around you, about alternatives and watch the literature for new discoveries and ideas that are pertinent to your project. Probably the toughest challenge for a successful scientist is to be creative, while keeping a sharp eye on feasibility. It is never too soon to start working on this aspect of your PhD, and at the end of the day probably the single thing that most distinguishes a great scientist from work horse. Ask Big Questions, and be sceptical about 'conventional wisdom', even if it comes from your supervisor. Don't be afraid to argue with your supervisor on scientific grounds – they are not always right and should appreciate the debate.
9. **Be active, not passive, in your approach to research.** Seek information and advice, and don't assume that it will just diffuse into your head. Your supervisor won't know everything (and may be technically less than competent anyway!), so find the right people for advice and don't be afraid to ask for it. Don't go for weeks without talking about your research with your supervisor and other members of the lab. If your supervisor doesn't seek you out regularly, go and talk to him/her. When you are inexperienced it is *very* easy to get off track and waste valuable time and resources. Those students and post-docs who sit back and wait for the magic to happen, or work in a vacuum, never get anywhere.
10. **Try to keep a three-part portfolio of sub-projects that are 'safe', moderately safe, and challenging** (could this be a *Nature* paper if it works out?). That way you are pretty certain to get a PhD, but might hit the jackpot, and have the thrill of a really exciting discovery.
11. **Go to as many seminars as you can and all of them in your general area.** But don't just sit at the back like a sponge, or fall asleep; sit up the front and ask questions of the speaker in question time, or afterwards, and of your supervisor and others in the lab. Students who speak up in this way gain a much better understanding of their field and are the ones who are really noticed. Remember that at this point in your life it is difficult to make a fool of yourself. Just having the courage to speak up is really applauded!
12. **Make the most of any opportunities to attend a conference or workshop.** If you are lucky enough to do so, don't treat them like a holiday; they are *work*. Make sure you go to every talk, no matter how relevant you think it is, or isn't. You will always learn something. Between talks, use every minute to meet new people, find out what they are doing, tell them what you are doing, and remember that this is where you are most likely to find a good post-doc lab. Don't spend all the time speaking only to people you already know or socialising with your lab; you can do that when you get back. Receptions and dinners are not optional; these are where most networking takes place and you need to be there mixing with new people, not hanging around the ones you already know. Likewise, don't take your partner with you and spend all the free time with them; they can join you before the meeting starts, or after it finishes, but during the meeting, including the social events, you are at work. If you are hung over from all of the socialising, don't miss the next morning's session, just take a bucket in with you. And when you come back, tell your supervisor (who

has probably paid for all or some of it out of their hard-won grants), and others in the lab, what you got out of the meeting.

13. **Take a notepad and write down the action items when you meet with your supervisor**, unless you have a perfect memory, and make sure they get done – or go back to explain why they can't be done.
14. **Practise your writing in any way you can.** Most students with a recent Australian education have very poor writing skills, and this will severely impact on your ability to write a satisfactory thesis, get a grant, and get a paper accepted. Do a course in writing (if you can find a good one), *use* the grammar and spell checks on Word, try to learn from people around you who write clearly and concisely, and get feedback on everything you write from colleagues or even friends and family. Plan your project so you can get at least 3-4 good (or 1-2 extremely good) papers out of your PhD. Don't leave thesis writing until after your scholarship or candidature has expired. Start writing from Day 1, even if nothing you write in the first or second year ends up in your thesis, the experience will be invaluable. It will help to broaden and deepen your knowledge, prioritize experiments, and significantly increase your chances of publishing during, rather than after, your PhD. It will also make writing your thesis much, much easier. In addition, a good literature review is often publishable, so that can be another option that will help to make your name, particularly since reviews get good citation rates.
15. **Buy yourself a lap top if you can possibly afford it**, even if the lab is well supplied with computers. That way you can work easily between work and home, and if the lab gets busier you are still independent.
16. **Make the most of any opportunities to talk about your work.** Use it as an excuse to read additional papers and to think long and hard about what you have (or haven't!) achieved and where your project is going. A shoddy presentation, even at a lab meeting, makes you look bad and is a wasted opportunity. Try your hardest to pre-empt questions that you might get and try to have prepared answers. If you don't know the answer to a question, say so; people will invariably see through a 'bullshit' answer! Talk about your work with family and friends – they sometimes have useful insights (and as tax payers are ultimately your employers).
17. **Appreciate that most biomedical research is very expensive and is mostly funded by taxpayers' money or private donations.** You therefore have a responsibility to use these funds carefully and not to waste them on ill-conceived or poorly-performed experiments. Think carefully about *everything* you do and always seek advice if you are uncertain. Be aware that your productivity also has implications for others in the lab. If you take it easy and are unproductive this will affect the productivity of the lab, which in turn will affect the chance of the lab getting grants that support your research and pay the salaries of your colleagues.
18. **Look ahead.** What are you likely to be doing 3, 6 or 12 months from now, and are there any steps you can take now to pave the way (e.g. HREC applications, collection of biospecimens or reagents, learning new techniques)?
19. **Set yourself deadlines and try to keep them** – it is good training for the days when you *have* to adhere to grant application deadlines etc.
20. **Plan to work abroad at some point**, not because Australian science isn't world class, but because of all the benefits of working with some real stars (it is a fact that the USA has more Nobel Laureates than any other country), and to get a better perspective of where you

fit into world science. If you end up in the lab where the head gets more invitations to speak than he/she can cope with, some might be passed on to you, which is a major advantage for career advancement.

21. **Think very early and very carefully about what you plan to do after your PhD.** If you hope to stay in research you should be aware that you will be judged almost exclusively on your publication record. This judgement includes the *number* of papers, your *position* in the author list and the *quality* of journal in which the work is published. Without a good publication record your chances of getting a fellowship, or even a grant funded position, in research are remote. Salaries are hard to come by and are therefore *very* competitive. If there is one job and six (or more!) good applicants, the job will always go to the person who has achieved the most.
22. **Start collaborations.** Don't wait for your supervisor to start them for you. It only takes a conversation or an email to someone else who is working on a very similar topic to you, to start the ball rolling. Whether it is the Nobel prize-winning lab head, or a PhD student or anyone in between, you can talk or write to them and see if they are interested in collaborating by sharing samples or ideas. It is probably best to discuss this with your supervisor first, not least because a joint email is more likely to bear fruit, but there may be occasions when you want to at least initiate the discussions alone. In addition to external collaborations, collaborate with your lab colleagues. PhD students who seek collaborations with their lab colleagues often get more publications, and finish their project much earlier than those who work by themselves. We are all very protective about our projects but sometimes we can't do everything. It may be helpful to get someone in the lab (who may be expert in a specific technique) to do an experiment for you which saves lots of time.
23. **Talk to Sales reps.** They can sometimes bother you when you are busy doing something, but if you make appointments to talk to them, you might learn something new, like a new method or a new reagent that will make your life much easier and maybe even make the lab head's budget look much healthier. Conferences are a good place to talk to them, and don't forget to pick up the free pens.
24. **Look for opportunities to write small grants,** such as travel grants, and small society grants as you gain more experience. You will learn a huge amount, and you might even get lucky. Nothing impresses more than your ability to get your own funding (well, except *Science* or *Nature* papers I guess).
25. **Join professional societies.** They all have very cheap student subscriptions, and you will gain something by being involved at any level (cv-building, cheaper registrations at conferences, getting to know who else is working in your field, a society journal, newsletters etc).
26. **Take courses,** in statistics, bioinformatics, English or whatever you think you need extra help in. They take extra time and extra effort, but it is time and effort well spent.
27. **Get involved in institute or department events,** such as organising student seminar series or conferences, though not at the expense of your project. It is all good experience, and looks good on your cv.
28. **Work out if you are a good collaborator, or more suited to working alone.** Both are perfectly acceptable, but plan your career accordingly. Good collaborators (particularly in large consortia which are all the rage now) need very good communication skills, as well as

diplomacy and patience, but if you are naturally rather non-communicative or anti-social (or paranoid or selfish!) it might not be for you.

29. Ultimately, to be a successful research scientist (e.g. join the NHMRC Fellowship scheme) you need to be at least four of the following:

- **extremely motivated**
- **creative**
- **very smart**
- **very hard working**
- **very skilful in the lab (or at the computer)**
- **very lucky**

Since you can't depend on luck, you'd better focus on the others. If you don't think you can meet most of the expectations above, this is the wrong career path for you, so think again!

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