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PhD survival guide

Some brief advice for PhD students

Leonardo Almeida-Souza & Jonathan Baets

By now you have secured your place on a PhD programme, your project is beginning to crystallize and you have a paid position or a fellowship to support you financially during your time in the lab. Time to put your brain and body to work at last. But beware, although your PhD will have many thrilling moments of discovery and insight, there will also be many pitfalls and perils to overcome or avoid. Here, we hope to summarize some of those challenges and offer a few tips that might help budding PhD students survive the bad times and enjoy the good.

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First and most importantly, a PhD is not just a project to be completed and written up. It is a training period during which aspiring scientists must learn the right way to do science. You cannot always control the various and erratic factors that will contribute to your eventual success, but you can ensure that you acquire knowledge and skills that will always be an asset, regardless of your future career path. A PhD is a singular opportunity to learn. In fact, during the years to come, you should seize every opportunity to learn about every topic, both scientific and non-scientific, that either interests you personally or is important for your current project—bioinformatics, advanced microscopy or quantum physics—or your professional future—writing and presentation skills—or life in general.

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The single most valuable skill that you will develop during your PhD is the capacity to tackle problems scientifically—to adopt a state of mind that allows you to look at things objectively, logically and factually. A PhD is a great training camp to hone your skills in critical thinking, hypothesis formulation and experimental design. You can also learn a lot by observing how your colleagues and other scientists from different backgrounds apply the scientific method to solve problems.

A scientific way of thinking is also extremely valuable outside the academic environment [1]. After all, PhD graduates are usually employed by companies because of their capacity to solve problems and not necessarily because they know everything about eye development of *Drosophila*.

Although your boss—usually a primary investigator (PI)—or other senior scientists in your lab will supervise your doctoral work, you will soon find out that you are expected to work independently on your project. This 'mental solitude' can be intimidating, but it teaches you to take charge of the task without expecting others to troubleshoot every mishap for you. Of course, PhD students are not usually marooned without help, but on the other hand, you do have to learn to take responsibility for your own project.

When performing scientific research, one is inevitably confronted with unknown terrain, both in terms of factual knowledge and technical approaches. This means that failures are inevitable. This might seem a daunting prospect to a junior researcher, but this challenge will help you to develop a tolerance for frustration that is essential to becoming a successful scientist. In science—but not only in science—we often learn the most from failure. As a scientist, you must constantly question yourself, your experiments and your data to find out what you might have overlooked, why the experiment did not work or why the results contradict your initial assumptions. This lengthy and inescapably frustrating process is the very heart of scientific discovery and it cannot be avoided without coming up hard against the damaging repercussions of research misconduct. You will be sorely tempted, late at night and facing a deadline, to 'make the data fit', 'fudge' the results or ignore the inconvenient outlier, but you will be doing a disservice to yourself, your supervisor and to science itself. Moreover, it could get you dismissed.

Serendipity is important in science and to be able to see and understand the unexpected requires knowledge, time and an open mind

The right thing to do is to embrace not knowing. In most cases we perform an experiment to answer a specific question and we therefore look at the data from a relatively narrow perspective: "Is the band of my protein in this blot stronger or weaker?", "Which genes are being up- or downregulated?". However, the most exciting results are usually the unexpected ones. Serendipity is important in science and to

be able to see and understand the unexpected requires knowledge, time and an open mind. It is therefore essential to take the time to analyse your results carefully, paying close attention to every single detail and checking how your results compare with those in the literature. More importantly, you should develop a habit of going back to your results from time to time to take a fresh look. Exciting new insights might be waiting to be unveiled in the light of new knowledge and perspectives.

Publishing is an integral part of science. All new scientific insights are, by definition, unproven until they have been validated and elaborated or refuted by the scientific community. This process is most effectively achieved by publishing your work in a peer-reviewed journal. However, to achieve this, you will have to master the particular scientific style in which papers are written. You might find that, owing to time pressures, your PI or postdoc will write the papers that cover your work. You should accept their help, but it is an essential part of your education that you write your own papers and master scientific writing. It is a skill that requires a lot of practice and the fortitude to face failure and respond positively.

Aligning your expectations with those of your supervisor and your lab will make everyone's life much easier

Although a scientific article is a technical document written for a particular expert audience, the most compelling papers are those that lead the reader through the story of the research and make the data and discussion accessible to those outside your immediate field. Like any good tale, your manuscript requires careful construction: a compelling protagonist (your protein/gene) and antagonist (the hypothesis), dramatic action leading to some sort of climax (your results) and the message or meaning of the story (your discussion). You will have to shape your work into a concise, convincing and readable document and adequately cite the literature, all within the particular constraints of the journal to which you plan to submit. This implies that you will have to re-evaluate your initial hypothesis and often list your experiments in a different order than that in which they were actually performed to present a convincing argument for the reviewers.

Most research labs are under significant and mounting pressure from universities, research institutes or grant organizations to demonstrate progress. As a consequence, there is an insatiable hunger for publications and a preoccupation with journals with high impact factors (IFs) that too often turns the intrinsically enjoyable process of scientific publishing into a nightmare of terror, frustration, disappointment and reprimands. Nevertheless, you should keep in mind that the 'gold standard' in scientific publishing is a well-written story with a new and interesting hypothesis supported or disproven by solid results and a convincing analysis. The impact of your own work can either be higher or lower than the rank of the journal in which you publish, and either way, your findings will remain valid, no matter the IF of the journal. Note also that selection panels are increasingly aware of the limitations of judging a scientist by the IFs of the journals in which they have published, and now often use alternative metrics in combination with the IF to assess a candidate's impact.

Anecdotally, there are several articles that were published in small journals but eventually turned out to be landmark discoveries. An interesting example in our own field is the 1991 finding of a segmental duplication containing the *PMP22* gene on chromosome 17, which causes the most common form of inherited peripheral neuropathy [2]. It was the first gene duplication to be shown to cause disease in humans. This highly cited article was published in the first issue of *Neuromuscular Disorders*, a journal that is still considered modest in terms of its IF. Some of the authors—who were PhD students at the time of publication—later became leading scientists in the field of inherited peripheral neuropathies.

Good communication is essential in any career, but it is particularly vital to avoid misunderstandings and conflicts in a lab. You do not have to be friends with everyone you work with, but a bad atmosphere can make your PhD miserable. Things as simple as who cleans the glassware, or issues as complex as the level of independence your PI expects from you can all be addressed and resolved through good communication. Furthermore, each lab or department will have its own policies and rules governing the way things work, both officially and informally. Spending some time talking to people at different levels can help you to grasp the *modus operandi* of your department and research group. The final factor in the equation is what you want from your PhD project and what your plans are for the future. Aligning your expectations with those of your supervisor and your lab will make everyone's life much easier.

The only constant in science—and in life—is change. Keep in mind that as time goes by, your views about science will mature and possibly change. Similarly, owing to the high turnover of people and ideas in an academic environment, the *modus operandi* of your department might also change. Thus, efficient communication implies keeping the information in your policies/unwritten rules/expectations 'folder' up-to-date.

The secret to surviving a PhD is proactively avoiding common problems and learning to enjoy what you are doing

You inevitably encounter difficult characters in any professional environment, and the scientific world is no exception. The chances are that one of them is working very close to you or might even be your boss, which will make your journey more troublesome and, at times, next to impossible. Two generic strategies might be helpful to you to deal successfully with a difficult boss. The first is to be prepared: be aware of the working environment in your lab and know your peers and supervisors. The second is efficient and professional communication.

You might find that your PI has a very self-centred view of his or her students and projects. To an extent, this viewpoint is understandable given that your work is probably a part of the 'bigger picture' and needs to be conducted appropriately. One way in which this kind of issue can manifest itself is if your boss insists on being in control all the time. In this instance you need to earn your boss's trust and respect, perhaps by showing them how much you respect them also. Present your ideas by starting the conversation with something positive. Do not directly counter your boss's arguments; acknowledge them and present your own as a parallel approach. Do not imply that your idea is better, instead present your

results and some evidence from the literature to guide your boss into connecting the same dots that you have.

You will often be under intense pressure to produce results. This is not all bad—we all need some degree of incitement to perform well—but productivity drops rapidly when pressure becomes unrealistic. This is a main threat for PhD students and might even end a scientific career prematurely. A PI should know where this threshold is for a particular project and student. In case of problems, the best option is to have a frank and professional chat with your boss, using as a starting point your sincere concern about the progress and general well-being of your project and the quality of your scientific education.

Do not be tempted to think that your boss actually knows what is going on—either in terms of your research or in terms of problems you might be having—and is just ignoring you. Your boss is supervising a lot of people and also has his or her own concerns; he or she might not have noticed a problem or might not remember the specific details of your work. Assuming your boss is in the loop can cause months of suffering and delay. It is your obligation to talk to people and explain your research or discuss your problem in a clear and professional manner to find a solution. It often happens that a certain problem that has been bothering you for weeks could be solved in a five-minute conversation.

Even assuming you have a good boss who supports you, teaches you and cares about you, do not make the mistake of only relying on his or her opinion. If you are to develop as a scientist, you need to start having your own ideas and making your own decisions. Some years ago, one of us was talking to an acclaimed scientist who suddenly stopped mid-conversation and said: "Can I give you some advice? Learn to ignore your supervisor." This initially seemed a weird and awkward piece of advice, not least because the supervisor mentioned was participating in the conversation. Nevertheless, the eminent scientist went on to explain that during his career he had all too often seen students abandon projects or ignore results because their supervisors had told them to, only to have someone else explore the same results some time later and discover something very interesting. Ultimately his advice rang true for us and ignoring the advice of a supervisor led to the most interesting results of one of our PhD projects.

It would be rather foolish to think that this anecdote is valid for every conversation that you will have with your supervisor, but the important point is to stand up for your ideas and pursue what you feel to be right. In truth, your supervisor will be your primary source of ideas and advice and his or her experience will be essential to guide you through your research. Just be sure to balance his or her wisdom with your own growing expertise and knowledge of your subject and research. Begin to trust yourself.

In starting a PhD, you have embarked on a highly competitive, family-unfriendly and badly paid career path. In most parts of the world, the number of PhDs seeking a job greatly exceeds the demands of industry, let alone that of academia [3,4]. On the other hand, science is one of the most exciting career options for those hooked on the thrill of discovery or the desire to make a difference. The single most rewarding moment in science is seeing something that nobody has seen before. This high more than makes up for the mundane lows that are ultimately easily forgotten. In a way, science is more of a vocation than a regular daytime job [5]. The secret to surviving a PhD is proactively avoiding common problems and learning to enjoy what you are doing. Nothing in life is worth doing without passion, and a career in science is an exemplary case.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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Leonardo Almeida-Souza [left] is at the Peripheral Neuropathy Group and Jonathan Baets at the Neurogenetics Group, Department of Molecular Genetics, VIB and University of Antwerp, Belgium.
E-mails: leonardo.souza@molgen.vib-ua.be; jonathan.baets@molgen.vib-ua.be

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