Patricia Gosling
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Mastering Your PhD

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Survival and Success in the Doctoral Years and Beyond

With 8 Figures

Springer

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Preface

Why read a book about getting a PhD?

As a general rule, PhD students and their supervisors tend to focus primarily, or even exclusively, on the content of the research that will go into the doctoral thesis. Other issues are often taken for granted: how to organize your work, give a presentation, work in a team, cope with your supervisor, and how to effectively manage your time. When asked, former PhD students usually claim that the general experience of being a graduate student, which includes learning how to solve complex problems and work well with others, was of greater value to their careers than the actual topic of their thesis.

The goal of this book is to help PhD students master some of the skills that have been proven effective in the world outside of academia, and to help PhD students gain mastery over the non-scientific aspects of getting a PhD. Hopefully, this book will help graduate students more fully enjoy their doctoral years, as well as provide some much-needed support as they prepare for their post-PhD careers.

Sink or swim

After hearing about this project, one professor had this to say: 'This book should not be published. Obtaining a PhD is like swimming across a big lake. Some students can't swim, so they will sink. That is the way the academic system selects those who will win. By providing students with a book on how to swim, they will pass and ruin the system.'

We can't think of a better endorsement for this book. And we believe, of course, that it is indeed possible to learn to swim, and even to do it well. In fact, we think that mastering certain skills along the way is just as important as swimming across the lake to get the prize – your PhD – on the other side.

Saving an Old Master painting from the ravages of time

To help illustrate some of the principles and suggestions we've outlined in this book, we've decided to follow a team of graduate students as they work together on an important project: saving a priceless Old Master painting from further deterioration.

The robe of the Virgin Mary in the middle panel of The Coronation of the Virgin by Lorenzo Monaco (ca. 1414) is currently white. Technical examination has shown, however, that the robe was originally a deep pinkish mauve. A restorer can retouch the painting with red paint, of course, but if the robe is still fading a colour difference will occur. Elucidating the correct chemical composition of the original paint, plus understanding the exact nature of the fading process will be critical for a proper restoration to be carried out.

Isabel, a chemistry PhD student, will be analyzing the chemical composition of the paint. Her challenge will be to use the analytical techniques currently available to study a sample from the painting, typically a tiny sample that is barely visible to the human eye.

Yousef is a PhD student in physics who will be focusing on calculations of the rate of fading of certain paint compositions, as well as the important issue of whether it will be possible to reconstruct the original colour of the painting. Another aspect of Yousef's project will be to develop new analytical techniques for gaining more information from the precious paint samples.

Peter is working on his PhD in art history. His project will include the interpretation of the painting based on its use of colour, particularly when the colour is thought to have a religious or symbolic significance. The use of colour may also be characteristic for this particular artist. The Virgin's white robe, for example, is symbolic of her purity as the mother of Christ, while purple is symbolic of her royal nature as the queen of heaven.

In order to solve the problem of the painting's degradation the team will have to work together and rely on each other's data. The three graduate students attend the same university, albeit in separate research groups. Isabel has joined a well-established group run by a senior professor. Yousef works for a world-renowned professor in a large group with many PhD students and several Post-docs. Peter works as one of two graduate students for a young assistant professor.

To finish the project successfully, the team will have to draw on many skills they hadn't really counted on using when they started out including good communication, proper planning, and effective time management.

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Chapter 1

Introduction

Nothing great was ever achieved without enthusiasm.
Ralph Waldo Emerson

Before you even get started on your PhD research, you have already made a decision that will have a major impact on the success of your project, and perhaps even on your future career. You have chosen to work in a particular research group, under the guidance of a particular thesis advisor or supervisor. While making this choice, you most likely spent a great deal of time thinking about the type of research you wanted to do. You addressed questions such as: do I want to continue the type of research I did for my senior thesis/Masters degree, or do I want to explore a new field? Do I prefer doing experiments in the lab or do I feel more comfortable with a theoretical approach? No doubt you've had to think long and hard about all these personal preferences. However, there is one more factor to consider for a productive and pleasant graduate student experience: the group you'll be working in.

In this chapter we describe four different types of research groups, ranging from a small group with an assistant professor as a supervisor, to a huge group led by a senior professor. We discuss typical advantages and disadvantages of each of the different types of groups. If you haven't already decided on a research group, you might want to take these considerations into account when making your final choice. If you've already made your decision, you'll be ahead of the game by being aware of some of the advantages and pitfalls of the type of group you've chosen to work in.

The start-up group

One appealing option for many potential grad students is to join a new group headed by a young assistant professor[1]. In this scenario you will belong to the first generation of PhD students and your supervisor will be full of energy and eager for data – data that you will have to acquire. Often in a group that is just starting up, you may have to build the equipment and apparatus that you need so that you can start acquiring data. Lacking the infrastructure of an existing group, you will probably spend a lot of energy in building equipment, designing new models or writing new computer codes. If you love this entrepreneurial type of work, a start-up group is a unique opportunity. Starting from scratch is definitely appealing because there is so much exciting groundbreaking work to do, but it has also some drawbacks. It might take a lot of hard work to get things going, so you must really enjoy your research topic to ensure you can see the task through to the end. Young supervisors have the tendency to design overly ambitious research programmes, and plans sometimes have to be simplified along the way when reality sets in. In such a small group you will have frequent and intensive interactions with your supervisor, particularly because his or her career will depend on the success of the first generation of graduate students. The lack of experience of assistant professors in supervising students is usually compensated by the enormous amount of time they spend with their small group. Moreover, your supervisor will have often fewer teaching and administrative duties. More time, therefore, can be devoted to working in the lab. It is a matter of personal preference whether you enjoy this type of intensive interaction. In such a setting it is absolutely crucial that you get along well with your supervisor. If there is no

[1] In this chapter we use terminology from the US academic world to describe academic ranks: assistant, associate and full professor. Each country has its own academic system with its own nomenclature. However, the career paths are similar. After completing a post-doctoral fellowship, one starts with a small (sub) group, as an assistant professor (in the US). In about five years the group grows in size, and the supervisor is promoted to associate professor. When the group matures and reaches the status of a completely independent academic group, the supervisor is usually (but not always) granted academic tenure and promoted to full professor.

common ground and mutual enthusiasm, your research trajectory is bound to be rocky. Working as a PhD student in a start-up group is often an inspiring and intense experience, but not without risks. Make sure you and your supervisor get along very well, and no matter how much energy and enthusiasm he/she has, be honest with yourself about how realistic your supervisor's research ambitions are.

The up-and-running group

Around the time an assistant professor has successfully delivered her first generation of PhD students into the world, she is usually promoted to the rank of associate professor. The young associate professor's initial research has made some impact on the scientific community, and as a result grant money is easier to come by and the group is able to expand. The investments made by the first generation of PhD students are starting to pay off. It may seem much easier for the second generation of students to do good research in such a receptive environment. However, the initial success of the group has its flipside: usually the supervisor spends less time on research, since she is invited to give more lectures, to attend more conferences, and invitations to all kinds of committees are eagerly accepted. How well the associate professor copes with this transition will depend on her organizational skills. As a graduate student you will have to work much more with your fellow researchers and guidance from your supervisor will be less intense than in the start-up group. Another important factor in such a growing team is the quality of the results established by the first generation. By looking at their work and the impact it has made in the field, you might get a hint as to the value it will have for your own research. In such a growing group it is as important to get along with your fellow graduate students as with your supervisor. If you feel comfortable in this type of environment and the first generation of graduate students has done well, joining such an exciting and expanding group offers a secure route towards your PhD, with fairly balanced support and interactions with your fellow PhD students and your supervisor.

The small but established group

After being a successful associate professor for several years, academic scientists are eventually promoted to the position of full professor. With the rank of full professor and the hurdle of tenure breached, their job is secure. Some supervisors feel they are finally able to relax after many years of extremely hard work. They may become more interested in the administrative aspects of running a research group, and their interest in academic research may start to fade. They have enough experience to keep a small group going, and still have decent results coming out every now and than. When you enrol in such a steady but small group, you may have to work extra hard to generate enthusiasm for your project. This may take some time, and interactions with your supervisor may be infrequent. In general, such a group may not be the most optimal choice as it often lacks the energy and enthusiasm you will need to keep you going. However, after talking to some of the current PhD students in the group you might decide that this is the right environment for you.

But not all small and established groups fit the description above. There are plenty of full professors who enjoy the science so much that they want to be deeply involved in the research at all times. This means that they choose to focus their attention on a small research group with just a couple of PhD students. They avoid administrative tasks as much as possible. These small enclaves of pure and intensive research are often a wonderful and stimulating place for graduate student work, especially if you can get along with both the professor and your fellow PhD students, you will thrive in this type of intensive environment.

The empire

Some successful professors let their group expand as far as their financial grants will allow, and as long as they continue to receive credit for *some* of the work from the group. Such groups can easily have 10 to 20 PhD students or more, along with several Post-docs. In fact, a good fraction of all PhD students work in such groups. Life for them is not bad at all, despite the fact that interactions with your 'famous' professor may be scarce to non-existent. Guidance will come from Post-doctoral fellows in the group and more senior PhD students. Not every topic investigated in these large groups is a sure-fire winner and some even fail altogether. However, the availability of sophisticated instrumentation and a vast skill base enable you to acquire data in an efficient way. If it happens that your particular project fails, the group will have enough fall-back options to rescue your PhD thesis from failure. More than in any other group, the interactions with your peers will determine your success and the amount of pleasure you experience in doing your PhD research.

In summary, the type of group you select will determine to a large extent the way you carry out your PhD research and the type and frequency of the interactions you have with your supervisor. Your success is not just a matter of having a good supervisor (or a supervisor with a famous name), but will also depend on your fellow graduate students. Make sure you take the time to talk to (former) PhD students from the group. Their stories will provide valuable insights into the nature of the group and assist you in the decision- making process of whether to join the group or not, and if you do, how to make the most of your time there.

Chapter 2

Getting Started

Don't judge each day by the harvest you reap,
but by the seeds you plant.
Robert Louis Stevenson

It's your first day in the lab. Undoubtedly you are experiencing a range of emotions: excitement, curiosity, anxiety. You will be working in this lab and with a group of people, as well as with your supervisor, for several years to come. This is the first day of a long commitment and, for some, a hard road ahead. Which is why it's important to get off on the right foot. Perhaps you're so anxious to get started and to prove your scientific worth to others, that you want to jump right in and do an experiment on your first day in the lab, but this would be unwise, to say the least. Give yourself a few days to get orientated, meet the people in your group, meet with your supervisor and to get to know the layout of the university, its facilities, and its graduate student services. You will probably have been assigned a lab bench and a desk, or some kind of personal space in which to work. In your first days in the lab, rather than jumping in with your first set of experiments, spend some time outfitting your work space with the equipment and materials you'll need. Make your desk a comfortable and personal place to work – you'll be spending a lot of time there. You may also need to register for a university e-mail account and fill in forms for the departmental secretary, etc. Make sure you take care of all these administrative tasks before you get bogged down in your experiments in the lab. The following are some suggestions to make your first few days as a graduate student as smooth as possible and to help you get off to a good start. We discuss some of these issues in greater detail in subsequent chapters, but this brief sketch is meant to give you an idea of some important things to think about early on.

Become familiar with your department

Use your first days as a graduate student to familiarize yourself with the inner workings of your department. If you haven't already done so, introduce yourself to the department Chair, as well as to secretaries, technicians, lab assistants, librarians, and other key personnel. This is not the time to be shy. Make a point of introducing yourself right at the start so that people are not still wondering six months from now if you're a grad student, an undergrad, a Post-doc or a lab technician. Be courteous and open-minded when meeting people for the first time. The people with whom you'll be working will be important to you in more ways than you might realise and first impressions count. You won't be able to work effectively unless you've familiarized yourself with your surroundings and met the key people around you, so be sure not to lock yourself up in the lab all day. Open up, mingle with your colleagues and make the effort to understand the ins and outs of your department. If you need information about the department or the university, ask senior graduate students and staff members. Be sure to introduce yourself to people who will be vital to your research such as those who are responsible for ordering research materials and equipment, operating technical equipment, and maintaining lab safety. Make sure too, to familiarize yourself with lab safety and evacuation procedures. Know where to go for help when you need it. Perhaps most importantly, try to identify someone who might make a good mentor (a senior graduate student in your group or in a similar group is an excellent choice). This individual can help show you the ropes and provide valuable professional guidance throughout your tenure as a grad student.

Formulate a working plan and set up a schedule

Before you even start that first experiment, you should establish a working plan and set up a reasonable schedule for yourself in which to complete the necessary tasks in your working plan. It is best to do this with the help of your supervisor to be sure that you are working on the same goals. Divide your project into manageable phases and have a timeline for each phase. Many, if not most experienced scientists will tell that you can't plan science, that you have to go with the ebb and flow of whatever comes at you. That may be true on many levels, but that doesn't mean you can't plan out a schedule and set targets along the way. While you're at it, be sure to set scheduled time off for yourself, because you can't work all the time. Once you've established your goals in conjunction with your supervisor and roughed out a timeline, sticking to your schedule is important for maintaining a sense of balance and control (see Chapter 3 for a thorough discussion of goal setting and time management).

Maintain a proper lab notebook

This may seem obvious, but it can't be stated often enough that a major factor in your research success lies in your ability to keep good records of your experiments. Don't fall into the trap of thinking that only a neat lab notebook is a good notebook. Tidy tables of data are not enough. You must write everything down, including everything that worked and especially what didn't work. Don't be afraid to jot down random musings or thoughts in the margins. Forget about being neat. No one is going to grade you on neatness. Meticulousness and completeness are more important attributes of a good lab notebook than perfect handwriting and tables drawn with a straight-edge. Make this a daily habit. Avoid rushing into an experiment without first writing down all the parameters (and, no, you won't remember all the details when the experiment is over). If you keep a proper record right from the beginning, making sense of your experimental data (and the logic behind your experimental designs) will be a lot easier.

Establish good reference keeping practices

As you do your research, you will need to keep a working bibliography: a list of publications you actually use as references for your research project. Start compiling this bibliography from day one and build it up as your work progresses. This will take away a huge part of the workload when you finally reach the stage of writing up reports, research papers – and your thesis. Once you have sufficient data for a preliminary report, get into the writing habit by writing up your work and submitting it to workshops or conferences. Presenting a paper at a conference or departmental meeting is good practice for graduate students. Establishing a track record through these types of presentations will help your career. Of course, every scientist's goal is to be published in high-impact journals. But that's something you can worry about further down the road. For now, the important thing will be to stay focused and to keep good records of your work in the lab and in the library.

Dealing with initial ups and downs

Life is filled with ups and downs and this is no less true than in your life as a graduate student. Experienced scientists know that research can be frustrating at times and not always go according to your well-made plans. Inexperienced scientists have a harder time managing their expectations and frustrations. So expect to go through periods of stress and anxiety, whether due to work, study, or personal matters. Taking a little time off to relieve stress when the pressure gets too high is always a good idea. Don't feel guilty about having to take a break from time to time – you'll come back refreshed and ready to get on with your work. Most likely you've moved away from familiar surroundings in order to attend graduate school, leaving friends and family behind. Take the time to build a social network and your own informal support groups. These could consist of people from your research team or just a group of peers, older colleagues or anybody you get along with. You'll need these people to share problems with and to go to for moral support when you need it most. Whatever you do, don't make the mistake of keeping problems to yourself. Everyone hits a difficult patch at some point in their graduate student years, so having problems is nothing to be ashamed of. Unresolved problems will not go away on their own. If you don't resolve them they will keep you awake at night until you are so ground down by stress and anxiety that it will be hard to find your way back on the right path. Find someone understanding to talk to when things get too much to handle on your own. Lastly, while graduate student life can be gruelling, take time out to have fun. There's more to life than the inside of a lab.

Chapter 3

Setting Goals and Objectives

Give me a lever long enough and a fulcrum on which to place it,
and I shall move the world.
Archimedes

Before you even start your first set of experiments in the lab, take some time (a few days if necessary) to write down your short-term and long-term goals and objectives. Yes, we know that your ultimate objective is to write your thesis and obtain your doctorate, but that goal is years away, so a little perspective and planning is in order. By breaking down the stages of your doctoral studies into manageable steps and committing them to paper, you will avoid becoming overwhelmed by the tasks ahead of you, and you will have a set of measurable and realistic goals towards which you can work. One of the best ways to identify your goals is to start by writing down an action plan. This type of activity usually involves the following steps:

1. **Clarify your goals and objectives**
   First, look at the bigger picture and then break things down into shorter time segments. What do you want to have accomplished by the end of the first six months of graduate study? The first year? Sketch these goals out broadly, as they are likely to change over time. Now, write down your objectives for the next three months, and then fine tune these for over the next month. Now that you've written your goals down, ask yourself two things: are my goals measurable? How will I know when I've achieved my goal(s)?

2. **Write down a list of actions**
   Now it's time to think about all the things you need to do to achieve your goals. What limitations and constraints do you have in terms of time, know-how, equipment, material, etc? Write down as many actions as you can that will help you achieve your goals.

3. **Prioritize**
   Take a good look at your list. Prioritize the actionable points so that you do first what is most efficient and what will most likely assist you in achieving your goals (in other words, if you need to build a piece of equipment before you can run an experiment, you will naturally have to do that step first).
4. **Organize your actions into a plan**
   Actions that are set into a time framework make up a plan. Make sure your plan is workable. Can you do the actions you have set up for yourself in the time frame you've allotted? Make sure you've ordered your actions into a logical sequence.
5. **Monitor and measure your progress**
   On a regular basis you will have to monitor your plan and make adjustments if necessary. It's important to remain flexible and re-state your goals from time to time as necessary and as you gain more experience with your project (for more details on how to do this, see Chapter 6: Monthly Progress Monitor)

In the business world, some people prefer to follow the SMART method when establishing – and achieving – their goals:

- Specific
- Measurable
- Attainable
- Realistic
- Time-related

In other words, there is no point in setting a goal that you can't measure, can't attain, or isn't realistic. If, for example you are not physically fit, the goal of climbing mount Kilimanjaro next week is specific and measurable, but unlikely to be either attainable or realistic in the time frame you have allowed yourself.

A word to the sceptics

At this point, we can guess what you're thinking: that planning and time management and goal setting are fine for other kinds of activities, but that science, by its very nature, resists all attempts to be neatly fitted into lists or time frames. After having logged many years in the lab, we couldn't agree more, but that doesn't mean that goal setting and planning have no place in the world of research. Good planning will give you a scaffold from which to work, as well as a way to monitor your progress. Faced with the daunting prospect of earning a PhD, many graduate students are overwhelmed by the magnitude of what's between them and their final goal. To keep yourself from feeling like you're drowning, we strongly encourage you to set reasonable goals and plan to achieve them in a reasonable amount of time – all the while recognizing and bowing to the vagaries of scientific research.

Effective time management

Once you've identified your short-term and long-term objectives, managing your time effectively will be key to keeping to your plan

and attaining the goals you've identified. Most of us are familiar with that desperate feeling that time is slipping through our fingers, or that we don't have enough hours in the day to do all the things we need to do. Often that feeling of a lack of time has more to do with poor time management skills than with an actual lack of time. We all have the same 24 hours in every day. How we make use of them differs widely among individuals and good time management is major factor in successfully completing the goals you have set for yourself.

One useful tool in effective time management is to keep a record of your activities. You will be keeping a lab notebook of your experiments, of course, but it is also helpful to keep a written record on a daily, or weekly basis, of *all* your activities. This will help you analyze how you actually spend your time. The first time you start writing down all the things you do in a day, you may be shocked to discover how much time you actually waste.

You may also be unaware that your energy levels vary throughout the day and night. In fact, the majority of people function at different levels of effectiveness at different times. Most people know whether or not they are a 'morning person' or a 'night owl,' but do you know at which times of the day or evening that your energy dips or peaks? Your productivity may vary depending on the amount of glucose in your blood, the length of time since you last took a break, routine distractions, stress, discomfort, or a range of other factors. Identifying your peak energy periods will help you to use this time more wisely, doing the things that count. By identifying your energy dips, you'll know when it's time to switch tasks, eat something to give you energy, or take a break for some fresh air.

Record your daily activities

Keeping a record of your activities for several days will give you a better understanding of how you spend your time – and when you perform at your best. Without modifying your normal routine or behaviour, write down all the things you do (as you do them) in the course of an entire day. Record your daily activities like this every day for a week. Every time you change activities, whether its reading e-mail, working in the lab, making coffee, sleeping, eating lunch, reading in the library, or attending meetings, note down when you do this and how you feel.

Learning from the record

Once you have noted the way you use your time every day for a week, go back and analyse what you have recorded. It is not unusual to discover that you spend a huge amount of time doing activities that are low down on your list of priorities! (See the 80-20 rule below). You may also discover that you have more energy during some parts of the day, and feel a bit listless and tired during others. Much of this variation in energy level depends on the breaks you take, the time and amount you eat, and the quality of your nutritional intake. Your written record will give you a basis for experimenting with these variables. Have you discovered that you have lots of energy in the morning and feel tired in mid-afternoon? Then get into the lab early and do your important thinking and/or experiments at this time. Use your low-energy time in the afternoon for more routine work such as searching the literature or writing up your notes. An even better solution to beat these periods of low-energy are to get out of the lab and go for a brisk walk in the fresh air.

Another useful tool for helping you get everything done is to draw up a to-do list. This can be done daily or weekly, whatever works best for you. A to-do list is a list of all the tasks that you need to carry out to reach the goal you have set for yourself. Once you've written your list, you can prioritize these tasks into order of importance.

There are people who make lists and people who don't. Perhaps you've never thought of yourself as a 'list' person before, but to-do lists are essential when you need to carry out a number of different tasks or different sorts of task, or when you have made a number of commitments that need to be attended to simultaneously (multi-tasking). Don't make the mistake of thinking that you can juggle all of this information in your head. If you find that you are caught out time and again because you have forgotten to do something, then you definitely need to keep a to-do list.

While to-do lists are a very simple tool, they are also extremely powerful, both as a method of organizing yourself and as a way of reducing stress. Often problems may seem overwhelming, especially if they're left to rattle around in your head; or you may feel you have a huge number of demands on your time. This may leave you feeling out of control, and overburdened with work. Writing things down in a list (and crossing the things off the list that you've accomplished) can help to relieve these feelings.

Preparing a to-do list

The solution to feeling overwhelmed is simple: Write down the tasks you need to do, and if they are large, break them down into their component elements. If these still seem too large too handle, break them down again. Do this until you have listed everything that you have to do. Once you have done this, run through your list and allocate priorities: A (very important) to C (unimportant). If too many tasks have a high priority, run through the list again and demote the less important ones. Once you have done this, rewrite the list in order of priority. When you are finished you will have a precise plan that you can use to eliminate the problems you face, one step at a time. You will be able to tackle all of these things in order of importance. This process will allow you to separate the important tasks from the many time-consuming trivial ones.

Multi-tasking: is it for you?

Multi-tasking is the ability to do more than one thing at a time. Talking on the phone while reading your e-mail, or eating lunch while recording data from an experiment. These are both examples of multi-tasking. The more tasks we juggle in an attempt to make the most of the time we have, however, the less efficient we become at performing any one task. And the more time you take to return to an interrupted task, the harder it is to remember where it was that you left off. Studies have shown that multi-tasking can greatly increase your levels of stress, so you'll have to decide whether it's the right approach for you. Some people are natural multi-taskers, others prefer to do one thing at time. Many people feel that multi-tasking, while a good idea in theory, diminishes their productivity and makes them work harder in order to feel that they're keeping up with all the things they're supposed to do. Increases in technology have made it harder than ever to avoid multi-tasking, so you might want to try to slow down a bit and work on one task at a time to see how this effects your work – and your mood. Your concentration and productivity will most likely increase and you will probably stop feeling like you're running in a million directions at once.

The 80/20 rule

Attributed to the Italian economist Vilfredo Pareto, the original concept of the 80/20 rule states that the relationship between input and output is rarely, if ever, proportional. When applied to your work, it means that only 20 percent of your efforts produce 80 percent of the results. Learning to identify the 20 percent that produces the majority of your results is the key to making the most effective use of your time. While simplistic in its conception, putting the 80-20 rule into practice is somewhat more difficult. So how do you recognize the crucial 20 percent?

1. **Take a look at the people around you.** Twenty percent of your colleagues probably give you 80 percent of the support you need. They are your true advocates. Take the time to learn from their example and to cultivate supportive relationships with them.
2. **Take a close look at your work.** Ask yourself, Which 20 percent of my work should I be focusing on?

How do I know if I'm focusing on the 80 percent or the 20 percent?

Let's look at the above statements in a bit more detail. The following are some indications of whether or not you're spending your time as you should.

You're focusing on the unproductive 80 percent if the following statements are true:

- You're working on tasks other people want you to do, but you have little or no stake in them.

- You're frequently working on tasks considered 'urgent.'
- You're spending time on tasks you are not particularly good at.
- Completing some activities is taking much more time than you expected.
- You find yourself complaining all the time about how little you seem to be accomplishing compared to the effort you put in.

You're focusing on the effective 20 percent, however, if:

- You're engaged in activities that advance your overall goals in the lab.
- You're working on tasks that you may not like, but you're doing them knowing they relate to the bigger picture.
- You're asking for help with tasks you are not good at doing yourself.
- You feel a sense of accomplishment.

Implementing the 80/20 rule

All of this may sound hopelessly simplistic, so if you're particularly sceptical, try applying the 80/20 principle for a few days just to see what happens. An increased awareness of the way you work and the time you spend on a variety of activities will help you learn to make use of this remarkably effective principle. You will feel that you have more time, that you are able to focus on what is essential and that you can reduce the amount of time you spend on meaningless tasks or those that won't help you reach your goals.

Saving an Old Master painting: Yousef establishes a set of goals

Not one to waste any time, Yousef decides to start off on the right foot by establishing some goals and objectives for himself during the first week in the lab. Some of these goals are non-research related, such as familiarizing himself with the department and the library and setting up his work space. Even though he's anxious to do his first experiment in the lab, he takes the time to write down some goals for his research. First, he needs to do some background reading as he knows very little about the chemistry and physical properties of paint pigments. Even though he is a physics student, he also wants to read up a bit on art history, so he can put the project into context and make it easier to talk to Peter with whom he is collaborating. He sketches out in his notebook his goals for the first month, and then for the three month, and six month mark, and then creates a realistic action plan for himself in the given time frame. Since he will be using a relatively new technique for studying paint samples (secondary ion mass spectrometry, or SIMS), Yousef has made one of his goals to do a thorough literature search on this technique. He also maps out an initial set of experiments, and highlights any possible pitfalls. Yousef is pleased that he now has a plan to work with and goes out for a coffee. In the hallway he runs into his supervisor and Yousef realizes that he has not discussed his plans with him at all. So he tells his supervisor about his ideas and asks for a brief meeting to be sure that his plans are in line with his supervisor's own ideas and vision. After some minor modifications they agree on the plan and Yousef communicates to his team mates the things he wants to work on in the coming months.

Chapter 4

How to Think Like a Scientist

Science is a way of thinking much more
than it is a body of knowledge.
Carl Sagan

By the time you've made it to grad school, you should be well acquainted with the principles of the scientific method. Most likely the concepts have been drilled into you ever since high school biology class. Even so, we felt it wouldn't be a bad idea to review some of the principles here, as they will form the core of your work in the lab. Over the years, well-meaning friends and family members have probably asked this deceptively simple question: "So what does a scientist do anyway?" or "Tell me about your research." You may or may not have a ready answer depending on who is doing the asking and how much explaining you want to do. But imagine you are sitting around the dinner table and have been asked this question by a family member or friend, someone who knows nothing about scientists or the scientific method. How would you respond in a way that was clear and made sense to the non-scientist?

Perhaps the simplest and most accurate answer you could formulate is that scientists observe and measure the world around them (yes, you may use this the next time you're asked, unless you have a much wittier answer and then we'd love to hear it). They gather information or data based on their observations, and when they think they have enough to answer the questions they have asked, they try to make sense of what it all means.

During this process, most scientists use a reductionist approach. Let's say one scientist is studying a complex chemical reaction, another is investigating the foraging behaviour of the ring-tailed lemur, and a third is researching the ocean currents around Tierra del Fuego. In order to make sense of these very complicated phenomena, each of these scientists must break down the particular problem into simple components. These four components are usually given as follows:

- Observation
- Constructing a hypothesis
- Carrying out experiments to test the hypothesis
- Formulating a theory

These four steps, taken together, are what is commonly known as the scientific method. If carried out correctly, the ultimate goal of the scientific method is to construct an accurate representation of the physical world. You may already have learned about the scientific method at some point in your career as a student of science, and while it may all seem very theoretical, it will be important to keep these steps in mind as you go about your own research.

Because scientists may be unduly influenced by personal and cultural beliefs and assumptions, which may alter their perceptions and interpretations of the natural world, the scientific method, if rigorously followed, can be considered an attempt to minimize bias on the part of the scientist. That doesn't mean, however, that the scientific method is without pitfalls.

Common errors in using the scientific method

Not proving the hypothesis by experiment

Perhaps the most fundamental error a scientist can make is to mistake the hypothesis for an explanation of a phenomenon *without* having performed any experimental tests to verify the hypothesis. Sometimes what we think of as common sense, logic, or intuition tempts us into believing that no experimental proof is necessary to prove the hypothesis because the answer seems so obvious from the start. Consider a classic mistake made by the philosopher, Aristotle, who many people consider to be the father of the scientific method. He emphatically stated that women have fewer teeth than men (probably to support his argument that men were superior). He never actually tried to prove this fact; he just used this misconception as a way to prove what everybody in ancient Greece accepted at face value anyway (that men are superior to women!). Now we all know that adult men and women have the exact same number of teeth – so don't fall into the same trap as Aristotle. Use properly designed experiments to prove your hypothesis, rather than rely on 'obvious' assumptions.

Discounting data that don't support the hypothesis

Another common mistake is to ignore data that do not support your hypothesis. In the ideal situation, the scientist is open to the possibility that the hypothesis is either correct or incorrect. If, for example, the researcher has a strong belief that the hypothesis is true or false, before collecting any experimental data, there may be a psychological tendency to find something 'wrong' with any data that does not support the researcher's expectations. It's hard to get rid of all our biases at once. The important point to keep in mind is that you need to treat all data the same way.

A third type of common mistake occurs when systematic errors are either over- or underestimated. For example, many discoveries were missed by researchers whose data pointed to a new phenomenon, but the data were mistakenly attributed to 'experimental noise.' Conversely, data that is part of the normal variation of the experimental process was taken as evidence for a new discovery.

How can this tendency towards bias be reduced? An important check on bias is to promote open communication among the members of a scientific field in the form of publications and conferences. In this way, the biases of individuals will most likely be cancelled out as other scientists try to reproduce their results. In time, a consensus may develop in the research community as to which experimental data has withstood the test of time.

Fact, theory, hypothesis – what's the difference anyway?

These terms are not interchangeable, even though they are often treated that way in popular usage. For a scientist, each of these terms has a specific definition:

A **fact** is a thing that is known to be true. Fire burns wood into ash. Water is solid (frozen) at temperatures below zero degrees Celsius.

A **theory** is a conceptual framework that can be used to explain existing observations and predict new ones. For example, the path the sun follows as it crosses the sky can be explained by the theory of gravity.

A **hypothesis** is a working assumption. Usually this assumption is formulated *before* experiments are carried out to test it. If the hypothesis holds up against existing and newly obtained data, the scientist may formulate it as a theory.

Is there ever a time when the scientific method is not applicable?

A frequent criticism of the scientific method is that it cannot accommodate anything that has not already been proved. This argument points out that many things thought to be impossible in the past are now everyday realities (such as space travel, for example: Two hundred years ago it was believed impossible for humans to fly to the moon). This criticism, however, is based on a misunderstanding of the scientific method. When a hypothesis passes the test, it is adopted as a theory, which can correctly explain a range of phenomena. This theory, however, can always be falsified by new experimental evidence. But it is not necessary for the hypothesis to have been previously proved for the scientific method to work.

Ockham's razor

In the fourteenth century, William of Ockham proposed the principle now known as Ockham's razor, which he stated as: *Pluralitas non est ponenda sine necessitate*. This can be translated as: Entities should not be multiplied unnecessarily. In other words, 'keep it simple'.

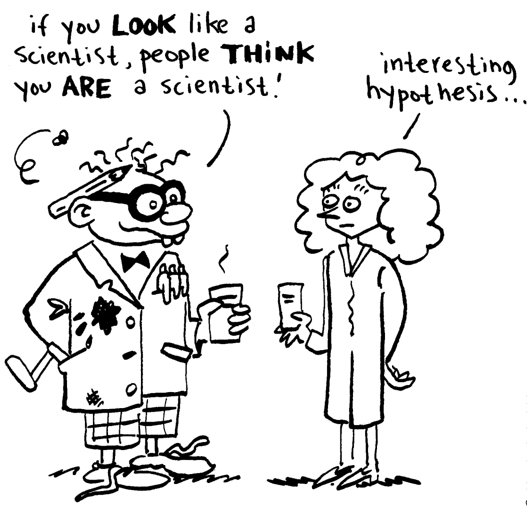
Suppose, for example, you have two theories that predict the same thing. In this instance, the principle of Ockham's razor can come in handy. Here are two sample theories that describe the same phenomenon:

- The tides on earth are influenced by the position of the moon.
- The tides on earth are influenced by the position of the moon, which is determined by the will of a powerful supernatural being.

Both theories make identical predictions, but Ockham's razor would discount the second theory as containing unnecessary information. The simpler theory works just as well. Ockham's razor does *not* guarantee, however, that the simplest theory will be correct, it merely establishes priorities.

A final comment

Biases aside, the scientific method is the best approach we have to accurately answer questions about the physical world in which we live. Without the scientific method, we might still believe in the idea of spontaneous generation (that flies, for example, are 'born' out of rotten meat), a theory that was disproved by Françesco Redi and Louis Pasteur in an ingenious experiment using the principles of the scientific method. As a result of his experiments Pasteur concluded that there is no life force in air, and organisms do not arise by spontaneous generation [from rotten meat] in this manner. "Life is a germ, and a germ is Life. Never will the doctrine of spontaneous generation recover from the mortal blow of this simple experiment."



Saving an Old Master painting: Isabel forms hypotheses about the whitish, transparent inclusions in the red paint

To prepare for her work in the lab, Isabel has been doing a lot of reading in the library on the chemistry of paintings and some of the problems that paintings undergo after several centuries of being exposed to light, air, humidity and extremes of temperature. In her reading she has discovered that some degradation can be the result of the formation of lead-soap aggregates of certain pigments, including red lead-containing paints. These lead-soap aggregates can expand and remineralize, changing their chemical composition. Because of some other evidence found on the painting, such as the break up of the overlying paint layer and whitish opaque material protruding through the surface of the painting, Isabel hypothesizes that aggregates have formed and have remineralized to lead carbonate, a remineralization product. If this is the case, she hypothesizes further that the red lead reacted with fatty acids released by the ageing of the oil binding medium. In order to prove her hypotheses, she elects to analyze the paint sample with a number of imaging techniques including FTIR, SEM/EDX and SIMS, selecting the appropriate technique to determine whether lead-soap aggregates have indeed formed, if they have subsequently remineralized and if this remineralization product is indeed lead carbonate.

Chapter 5

Designing Good Experiments

There must be no barriers to freedom of inquiry.
There is no place for dogma in science.
The scientist is free, and must be free to ask any question,
to doubt any assertion, to seek for any evidence, to correct any errors.
Robert Oppenheimer

In the last chapter we talked about what it means to 'think like a scientist' and how to successfully apply the scientific method to your work. A critical feature of this process involves testing your hypothesis with experiments. Good experimental design for each and every experiment you conduct will greatly enhance your chances for success in the lab. Even if you obtain a negative result, a well-designed experiment will give you confidence in your work and the reliability of your data. Designing a suitable experiment to test a hypothesis takes ingenuity and skill. Whether your experiment requires sophisticated equipment or not, there are a number of features that are common to all well-designed experiments. Try to keep the following in mind as you go about the intricate process of experimental design.

Discriminating between different hypotheses

A well-designed experiment should be able to discriminate between two different hypotheses. If you've poorly designed your experiment, you may obtain results that support more than one hypothesis. If you carry out an experiment and discover this to be the case, it's back to the drawing board.

Reproducing your results

When you carry out your experiment several times, are you able to reproduce your results? If not, there is either a serious flaw in your experimental design or in your experimental methods.

Proper control of variables

Experiments must be well controlled against each of the variables tested. It is important to eliminate the possibility that other factors in the overall experimental set up are producing the effect you observe, rather than the factor you are interested in studying.

Methods of measurement

Your method of measurement must be reproducible from day to day, between different researchers in the same laboratory, and between different laboratories. Many scientists do not consider a result to be valid unless a different researcher has reproduced the same results. Be sure to maintain the accuracy of your instrumentation and be vigilant about quality control in your laboratory practices.

Blinding

In Chapter 4 we talked about the problem of experimenter bias. Even under ideal conditions, researchers may unconsciously 'fiddle' their data to get the result they hoped to get. In order to avoid this type of unconscious bias, it may be a good idea for you to carry out experiments in which you don't know, for example, which drug is being tested in which laboratory rats, or which chemical reaction is taking place in a particular reaction vessel. This method is routinely used in clinical drug trials in which both the doctor and the patient are unaware of the treatment they are receiving. These so-called double-blind studies are meant to avoid any bias on the part of doctors and patients as to the efficacy of a drug.

Accuracy and precision

In almost any type of experiment, you will most likely be measuring something (the rate of a chemical reaction, the glucose level in blood, the orientation of molecules in reactive scattering). In order to obtain reliable results, it is critical that you know two things about your measuring device: its *accuracy* and *precision*. Measuring the length of a fruit fly with a yardstick will not be very accurate, although it would probably be quite precise. These two terms are not synonymous and it is important to understand the difference. *Accuracy* means the ability of a method to give a *true measurement* on average. *Precision* is a measure of the method's reproducibility. Your method of measurement should be both accurate and precise (in other words, have a low standard deviation). Sometimes one of these factors is more important than the other. If you are measuring changes over time of a particular quantity, it will be more important to have precise measurements than accurate ones. Accuracy and precision will determine the reliability of your data.

Good science and good experimental design go hand in hand

How can you be sure you're designing the best experiment possible? In order to assist you in designing good experiments, we suggest you follow these three steps:

- **Define your objective(s)**. What is it that you are trying to test in this particular experiment (which question are you trying to answer, which hypothesis are you trying to prove)?
- **Plan your strategy**. How will you achieve this objective? What is the size and scope of your experiment, and how many times will you try to repeat it?
- **Experimental details**. Sketch out the details of your experiment. Which tools and equipment do you need? How much time will your experiment take (one hour, one day, one month?).

If you are a biologist who is carrying out experiments in a population of plants or animals, or a clinician doing a clinical trial with human patients, a statistician would urge you to think about the statistical tests you will need to perform to analyze your data. This information will help you plan your experiment from the start. For example, you will need to know beforehand how large your study population needs to be to give you enough statistical power for your analyses.

Once you have identified your objectives and formulated a hypothesis, you now need to define the variables you will use to test your hypothesis. A well-designed experiment should have only *one independent variable*. If you change more than one variable at a time in a given experiment, how will you know which variable is causing the effect you observe? Keep in mind that some variables may be linked and can influence each other to create the same effect as one variable. As you embark on a set of experiments, try to choose variables you think act independently of each other.

Make a list of possible answers to any questions that arise during the course of the experiment. This can be a list of statements describing how or why you think the observed effects behave as they do. These questions should be stated in terms of the variables you are studying. Normally, you should formulate one hypothesis for each question you have. And you must do at least one experiment to test each hypothesis. Simple, right? Not exactly, but you'll get better at designing good experiments with practice. Part of your training as a graduate student is learning how to design good experiments that will give you reliable – and reproducible – results.

Design experiments to test your hypothesis

The next step is to design an experiment to test each hypothesis. In order to do that, you'll have to make a list of the things you need to do to answer each question. The list you create will be your experimental procedure. This procedure should include the appropriate methodologies, technologies, and equipment. For some types of experiment, you will have to have a 'control' to act as a reference.

A control is an additional experimental trial or run. It is a separate experiment, done exactly like the others, except that no experimental variables are changed. A control is simply a neutral 'reference point' for comparison that enables you to see the effect of changing a variable by comparing it the experiment in which you change nothing. Dependable controls can be very hard to develop, and are often the most difficult part of your experimental design. Controls are very important, however, in certain types of research, as it is the only way to be sure that changing the variable causes the effect you observe.

Prepare your materials and equipment

Make a list of all the things you need to carry out the experiment, including chemicals, glassware and reaction flasks, instrumentation, computer software, etc. Gather all the materials and equipment you need beforehand and make sure everything is in good working order, and that you have properly calibrated your equipment.

Record the data

Experiments are often carried out in a series. For example, you can perform a series of experiments by changing one variable by a different amount each time. A series of experiments is made up of separate experimental 'runs.' During each run you measure of how much the variable affected the particular system you are studying. For each separate run, you change the variable by a different amount. These changes will produce a different effect on the system. You measure this response and record the data in a table or chart. The data you record is considered to be *raw data* since it has not yet been analyzed or interpreted. Only when raw data is analyzed can it be thought of as *results*.

Record your observations

Record your observations during the experiment, remembering to make a note of any problems that crop up. Don't forget to keep careful notes of everything you do, and everything that happens from the beginning of the experiment to the end (no matter how trivial or unimportant it may seem at the time!). Careful data collection and observation are crucial to the scientific method. Your observations will be invaluable later on when it is time for you to draw conclusions, as well as for identifying any experimental error.

Analyze the raw data

Now it's time to perform the necessary calculations to transform your raw data into the numbers you'll need to draw your conclusions.

For example, if you weighed an empty reaction vessel, this weight is recorded in your data table as "weight of round-bottom-flask" You then added some sodium nitrate to the container and weighed it again. This would be entered as "weight of flask + sodium nitrate." In the calculation section, you need to do the calculation to find out how much sample was used in this experimental run: (wt. of flask + sodium nitrate) – (wt. of flask) = wt. of sodium nitrate used. This is obviously a very simple example, but you get the idea! The point we're trying to make here is that nothing is too trivial to record in your lab notebook. Don't rely on your memory. You will have long forgotten the details when it comes time to write up the experiment for publication.

Draw conclusions

Using the trends found in your experimental data and your observations, you can now try to answer the questions you asked at the start of the experiment or set of experiments. Is your hypothesis correct? This is the time to assess the experiments you performed. Ideally, you should be able to evaluate the relationship between the *predicted* result as stated in the hypothesis and the *actual* results, and be able to conclude whether the explanation on which the prediction was based is supported by the data. Or not.

Other things to take note of when summarizing your conclusions:

- If your hypothesis is not correct, what are other possible answers to your question?
- Summarize any difficulties or problems you had doing the experiment.
- Do you need to change the procedure and repeat your experiment? What would you do differently next time?
- List any other things you learned.
- Try to answer other related questions that have arisen. One of the exciting things about doing science is that the interpretation of data may lead to the development of additional hypotheses, the formulation of generalizations, or explanations of natural phenomena.
- Discuss any experimental errors.

Finally: can you trust your results?

You've designed your experiment properly (you hope) and carried it out according to the methods and procedures you devised. If you did not observe anything different than what happened with your control, the variable you changed may not have any effect on the system you are investigating. If you did not observe a consistent, reproducible trend in your series of experiments, experimental errors may be affecting your results. The first thing to check is how you are making your measurements. Is the measurement method questionable or unreliable? Perhaps you are reading a scale incorrectly, or the measuring instrument has not been properly calibrated. If you are able to determine that experimental errors are indeed influencing your results, carefully rethink the design of your experiments. Review each step of the procedure to find sources of potential errors. If possible, have a more senior scientist or fellow graduate student review your procedures with you. As the designer of the experiment, you can sometimes miss the obvious!

Spotting random errors

If your measurement method is not the cause of error, try to determine if the error is either systematic or random. Random errors are easier to detect as they result in non-reproducible data that doesn't make sense. In you have come up against such a case, you will discover that experimental runs with the same combination of variables, and even the control itself, cannot be duplicated. Because there will always be some degree of randomness in nature, no two measurements will be exactly the same. Therefore, you may have to decide if the differences in your data can be explained by the normal vagaries of natural systems.

It is possible, however, that random error is cropping up because you are doing something differently in each trial. For example, if you have not thoroughly cleaned your glassware or instruments, some of the chemicals you've used may be carried over from one experiment to the next. Various statistical tests may help you determine if the difference between experiments is due to randomness, or to human error.

Systematic errors

Systematic errors are more difficult to identify. At first glance your data and results appear to be consistent and reproducible, so you may be unaware that all your measurements are off by the same amount. For example, if your balance was off by 3 milligrams, all your measurements will be off by 3 milligrams. This type of systematic error will affect all your data by the same amount, which is one of the reasons it is so difficult to spot. A good way to check for systematic errors is to run experiments that have been designed differently, but are meant to give you the same answers. It some situations it may be a good idea to cross check your results with a variety of experiments. Another way to spot-check for errors is to ask someone else to repeat your experiments.

Linked variables

If your variables are not independent of one another, and you have failed to notice this relationship, your results may not be valid. Variables are independent if, and only if, they produce effects separately from each other. In other words, if a variable is truly independent, changing it will not influence the effects produced by another variable.

What if your experiment hasn't worked out as planned?

No matter what happens, whether your experiment was a success – or not – you will have learned something. Because science is not only about getting The Answer. Even if your experiment hasn't answered the specific questions you asked, it probably has provided you with ideas that can be used to design additional experiments. The knowledge that something didn't work as expected, is actually an important piece of the puzzle in its own right. Unsuccessful experiments are an important part of the journey towards finding an answer. Try to think of incorrect hypotheses as having a unique value, as they can help point you in the direction of further investigations.

Chapter 6

Charting your Progress Month by Month

If you fail to plan, you plan to fail.

After dealing with the initial problems and uncertainties of the first few months of graduate student life, you are most likely feeling more comfortable in your new environment. You've acquainted yourself with the working habits of your institute and department, your PC is up and running, you know how to acquire the data you need (doing experiments in the laboratory, or data mining in the library), and so on. You have been putting in long hours, and may even have been sacrificing your weekends. Some time ago you sketched out, together with your supervisor, the targets you hoped to meet in the first year. They seemed reasonable on paper, the planning looked realistic, and you're ready to make your first scientific breakthrough. Nevertheless, the gap between the actual progress you've made so far and the targets you set for yourself is growing wider every day. Somehow, in spite of all your hard work, you are not approaching your goals. Soon this may even become your daily mantra: Why am I not approaching my target when I'm running so fast?

The problem with getting trapped in this mind-set, is that it is often difficult to recognize the patterns that slow down or inhibit your progress. Your first thought may be that you need to work harder to catch up, but very likely you have discovered that this approach doesn't work. It may feel like you're making one step forward and two steps back. Perhaps it has already crossed your mind that it might be easier to just quit. Fantasies of starting a bed and breakfast in the south of France begin to drift through your mind. But back to reality. As an undergraduate, when your targets typically had a time span of a few weeks, you were doing fine. Now you're starting to discover that there is more to reaching your annual goals than just adding up hundreds of daily steps. You need some sort of monthly evaluation to bridge the very wide gap between your one-day and one-year plans. This chapter provides you with a tool to help: the monthly progress monitor.

Monthly progress monitor: four questions to keep you goal oriented

For a monthly evaluation scheme to be effective, we believe it should be simple and easy to use. So we developed a form (see the end of the chapter) that asks you to answer only four questions. The scheme has been tested extensively in various research groups in several countries including the Netherlands, Denmark, and the USA. The four questions are:

1. Of the results I obtained last month, which are the most important?
2. Did I deviate from last month's planning? If so, why?
3. What are my most important goals for the upcoming month?
4. What do I need to do to reach these goals? Which potential hurdles might I face, and how do I overcome them?

These questions are meant to help you understand the patterns inherent in your working style, so it's very important to be honest with yourself when filling in the answers to these questions, particularly prior to meeting with your supervisor. We suggest that you fill in the form every month throughout your doctoral studies. More frequently is impractical and imposes too much of a burden on your time. Less frequently makes the targets too vague for direct action and practical solutions. From our experience we have found that your answers to the four questions will reveal the following:

1. At first, you will think that you have done so many things last month that it will be hard to summarize them. But if you focus on the really important issues that pertain to your thesis, you will be able to come up with a short list. It can be a bit shocking to realize how much time you spent last month on issues that are not on the list of major contributions towards your thesis (see the 80–20

rule, Chapter 3). Most newly minted PhDs agree, with the power of hindsight, that they could have obtained their degree much faster if they had only followed the paths that were productive. Of course, the very essence of research is that you do not know the answers beforehand, nor the productive pathways, and not all your lines of inquiry will work out. But prioritization of your work can do no harm. If you are lucky you will pick more productive approaches than just randomly throwing darts at a dartboard (while blindfolded) and trying to hit your target.

2. Now for the really tough part. Compare the answer to Question 1 of this month's evaluation (what you have done) to the answer of Question 3 of last month's evaluation (what you planned to do). Most likely you will have accomplished only a small fraction of last month's ambitious plans. Try to write down why you were not able to do more. While it may seem obvious, by re-reading the answers to Question 2 of the forms from the last few months you will start to see patterns in how you work. Recognizing the problems in your working style is very often the first (and most difficult) step towards finding the solution.

3. Ambitious as you are, you undoubtedly have numerous plans for the coming months. But after having pondered the answers to Question 2, you may perhaps be wiser and more realistic. Your list of goals for next month will now be rather short, otherwise you will not be able to finish them and you will end up with the same long list of projects started but not yet finished. In fact, what you are doing now is prioritizing your projects for the next month. Because prioritization seems so obvious, it is often not explicitly done. The lack of proper prioritization is one of the main pitfalls on the road to getting a PhD. Be sure to make your goals for the coming month truly actionable. For instance, an action such as *understanding more about the chemistry of paintings* is too vague. A more measurable target might be: read and understand 3 articles (such as …) and chapters 2, 3, and 5 of the book 'The Chemistry of Paintings'. After readings these books, try to formulate a hypothesis about what is going on in the painting you are investigating and what a good approach might be to test that hypothesis. Indeed, it will take a few extra minutes

to come up with such a refined plan of action. And don't hesitate to consult your supervisor or a more senior scientist about this if you need guidance. But stick with it, as this effort will pay off. Your original plan may have led to a conversation with your supervisor such as:

> "I have been reading some literature about the chemistry of paintings."
>
> "So what are you going to do next?"
>
> "Actually, I have no idea, maybe I should read more chapters in this book, I found the biochemistry sections quite difficult."
>
> "I do not believe the biochemistry is essential at this point, maybe you should take some mass spectra of your samples and analyze those first."

In short, you have wasted quite a bit time by just reading, your supervisor is correcting this; he/she is again taking the lead in your project. Instead, if your initial discussion a month earlier had been more precise, you would have been reading the relevant chapters and could have come up with some suggestions for the next steps. Even if you suggest the wrong set of actions, you will have learned from thinking about it. Taking a more pro-active role in your research starts with making an actionable to-do list for the month ahead.

4. You are a pro when you master the answer to Question 4. Knowing the potential hurdles and obstacles in the projects you have selected to work on in the coming month is far from easy. Finding solutions to circumvent these hurdles is even more difficult. Spending time on foreseeing the hurdles and taking proper measures to keep them from stopping you in your tracks is very rewarding. *Staying ahead of the problem* is a skill that will not only make your PhD a success, but one that will help you in all your future jobs. In fact, avoiding potentially wasted effort in your projects in the future will save you an enormous amount of time. Make sure you properly use the time you have saved by being more efficient. Do not run blindly onto another track. Balance

this extra time between: a) working fewer hours (an hour in the gym can be more efficient than another hour in the lab); b) thinking of other potential hurdles and how to circumvent them; and c) doing a little extra work on the relevant problems.

What you can learn from filling in the monthly progress monitor

Once you have been using the monthly progress monitor for a few months, you should go over the old forms again (file them properly – they make a great record of your research progress). You will typically find that:

1. At first, planned work for the month-to-come tends to exceed the progress made in the previous month.
2. After using the monitor a few times, your planning will become (more) realistic.
3. Expectations and goals are brought in line, thereby reducing conflicts and frustration.
4. The general progress of the project is improved as a result of the timely identification of possible hurdles.

Above all, be honest with yourself when evaluating your progress. An honest evaluation can help you identify patterns and obstacles that are slowing you down. If you have the courage to do so (as this will necessarily involve discussing weaknesses in your working style), discuss the overall picture that comes out of these forms with your supervisor. Alternatively, you can consult a friend or a sympathetic colleague about how to work best with your strengths and weaknesses.

Monthly Progress Monitor

Name PhD student: Name supervisor:

Date: Previous meeting:

1. Of the results I obtained last month, which are the most important?

2. Did I deviate from last month's planning? If so why?

3. What are the most important goals for the upcoming month?

4. What do I need to do to reach these goals? What are the potential hurdles and how do I overcome them?

Suggested date for next month's meeting:

General agreements:

a. PhD student fills out form prior to meeting with supervisor
b. At the meeting the answers are completed
c. Supervisor gets a copy of the final form after the meeting

Chapter 7

Dealing with Setbacks

Science has promised us truth.
It has never promised us either peace or happiness.
Gustave Le Bon

You're settled comfortably into your lab routine: your research project is well underway, you've established your goals and objectives, and you've been carrying out experiments for several months. You feel good about your progress and are convinced that you're on the right track. You've mastered the concept of thinking like a scientist by working through the classic progression of hypothesis, experiment, and results, and you are feeling confident that you have a good handle on your project and your life as a graduate student. Each month you have faithfully filled in the Monthly Progress Monitor and you're keeping open the lines of communication with your supervisor and colleagues. So everything is wonderful. Right? Wrong. Because one day you realize that *nothing is working.*

Your carefully planned experiments are not giving you the results you expected or need. Your cell cultures have become contaminated for the umpteenth time. The PCR machine or the HPLC or the UV spectrometer breaks down. Again. You can't get your chemical compounds to crystallize or you've injected your laboratory mice with a mislabeled syringe and they all die. Weeks or months of data is lost.

To top it off, you find out that you've made a mistake in your statistical calculations and half a year's worth of experiments are worthless. Gather a group of seasoned scientists together in one room and they will tell you horror stories like these and more. When something like this happens to you (and in all likelihood it will), what do you do, how do you cope?

Setbacks in the lab – and in life – are inevitable. It's how we deal with them that will turn a setback into an opportunity for growth. If you think of setbacks as not being failures, mistakes, or wrong turns, but rather a chance to learn and grow, you will be much better equipped to put yourself back on the right track.

The cold reality of trial and error

Your experiment worked beautifully the first time you tried it, but now you can't repeat it no matter what you do. You're tearing your hair out and losing sleep. The experiment was flawlessly designed, elegant in its construction, the results you obtained fit beautifully with your hypothesis. And now nothing, nothing you do produces the same result.

Now might be a good time to remember that much of science involves trial and error. It's an unavoidable fact that you will make a number of errors and false starts before you are able to uncover even a glimmer of truth. Science proceeds in fits and starts. There are no quick fixes, no overnight successes. The nature of scientific discovery requires that it proceed in its own time. Experiments that need to follow the timing of the natural world cannot be hurried, even if you do have a deadline looming.

Keep in mind, too, that it is virtually impossible to avoid surprises, unexpected results and setbacks in the lab. If all research proceeded without a hitch, scientists the world over would be able to skip the endless rounds of experiments and go straight from hypothesis to publication without breaking a sweat. Take heart from the fact that many things will go right, so try not to focus on all that has gone wrong. Also, it helps to remember that a negative result from one, or a series of your experiments, may be as informative as a positive result.

Part of your training in learning how to 'think like a scientist' involves dealing with the inevitable setbacks that will occur, and learning to cultivate the virtue of patience. And you must do this with a fine sense of balance: being able to see the big picture, as well as glory in the small steps forward along the way. So while the goal of your lab may be to find a cure for cancer or to understand the underlying mechanisms of a genetic disease, this goal is not going to be reached overnight or even next year, or very likely not even five years from now. Some scientific progress and so-called breakthroughs, occur over decades of hard, painstaking work. In spite of all this, if you feel that setbacks in the lab are taking their toll on your confidence, a logical approach to identifying the problems will help you put setbacks in perspective, turn them into learning experiences, and boost your confidence.

Identifying the setback(s)

A setback can be defined as an event or occurrence that prevents you from achieving your goal (a failed experiment, a string of failed experiments, contaminated cell cultures or animal models, badly calibrated machinery leading to loss of data, etc.). To help you identify what your setback is (and how to recover from it) try answering as best you can the following questions (it helps to write them down).

- What is your setback?
- What (in your own words) have you failed to achieve?
- Which mistakes have you made?
- Who, if anyone, has disappointed you? (your colleagues, supervisor?)
- What do you regret doing or not doing (in relation to the setback)?

Now review your answers and explore your negative emotions and thoughts (are you feeling overwhelmed, over your head, sad, frustrated, angry?). Try not to take it personally. In other words, don't let the fact that you are experiencing a setback make you think that you yourself are a failure.

Take action

When you're depressed or frustrated about your circumstances, it's easy to turn to self-destructive activities such as over-indulging in alcohol, eating too much junk food, or watching excessive amounts of TV. This is not to the time to eat your body weight in ice cream or drown your sorrows in drink.

First, ask for support from those around you. Talk to colleagues, friends, and family about your concerns. Then try to find concrete ways that will get you back on track in the lab. Talk to older scientists, your mentor, and your supervisor. Chances are, all of them will have similar stories of frustrations and setbacks. Hopefully, the setbacks you are experiencing are just bumps in the road, not full-blown obstacles that will prevent you from reaching your goal. When you feel better, try to put things in perspective. Frustrations and setbacks are a part of life. It's how we deal with them that counts.

Tips for recovering from a setback

You're halfway to a solution once you acknowledge that you're stuck and something has to be done to get your research back on the road to recovery. Here we offer a few practical tips for getting past the point of acknowledging there is a problem and moving towards a solution.

1. **Take care of yourself**. Most likely you have been putting even longer hours into your work in order to recover from your setback. But running yourself down physically and exhausting yourself mentally will only make you feel more miserable and hopeless. Regular meals, plenty of sleep and lots of stress-reducing exercise will go a long way towards getting you back on track.
2. **Think outside the box.** Creative solutions require out-of-the-box thinking. So far, what you've been doing has not been working, so it's time to take another tack. You may need to change your experimental plan and work on something different. Perhaps you will even need to take more time to finish your PhD work than you had planned. Perhaps you will need the help of a Post-doc or more senior scientist to help you get your complex experiments going again.
3. **Involve others**. Although it will take some courage to admit to others that you are experiencing serious setbacks, you need the people around you now more than ever. Friends and colleagues can offer the moral support you badly need.

Having someone who can listen to your problems (and even better, offer useful advice) will be invaluable on the road to recovery.

4. **Cultivate the art of patience**. It takes time to recover from a setback. Your problems will not disappear overnight, so it's important to cultivate the art of patience. Be kind to yourself. Accept that it will take time to get back on track again. Focus on the things that are already going better, rather than on all the things that still need to be done. Take one step at a time and remind yourself that 'Rome wasn't built in a day.'

A difficult dilemma: should you stop all together?

You wake in the middle of the night – night after night – and a single thought careens like a boomerang through your mind: "*Things are not working out. Grad school is not what I thought it would be. I don't really want to be a scientist after all. Maybe I should just go ahead and quit.*"

Life is fluid. Peoples' ideas about themselves and their place in the world change from one year to the next. You started graduate school all fired up, anxious to get on with your research and your career, but now you're not so sure anymore. It's not just a question of a few lingering doubts that drift through your head at the end of a bad day. We all have those. But if they are persistent and impossible to ignore, you may need to consider the possibility that going all the way to the end of your PhD may not be right for you. Should you quit? The answer to this question will be different for everyone. So much depends on who you are as a person, what your goals are in life, and how much you've already invested in the process of getting a PhD. If you're still in your first year and you're having serious and persistent doubts that you've made the right choice, it would be a good idea to sit down and talk about your feelings with someone you trust (not your supervisor at this point – why set off alarm bells if you don't have to?). It's not too late to change your mind and move on to something else. If you're more than halfway towards your PhD, however, your decision will be more complex. You'll have to weigh the balance of losing the time you've already invested with your desire to change careers. Keep in mind that having a PhD doesn't mean you have to go on in life as a bench scientist or work your way up the ranks of academia. There are many different career paths you can follow (see Chapter 16), from jobs in policy making, journalism, communication, teaching, and consulting. The list is practically endless. So if it's just a matter of having decided that you don't really want to be a scientist after all, it may still be worth getting your PhD and making use of the degree (and the title of 'doctor' that goes along with it) in another job area altogether. You may be surprised how much value your PhD has, even outside the world of science.

Saving an Old Master painting: a set of experiments fails and the team faces a major setback

For several months, Yousef and Isabel have been making measurements on a paint sample using the SIMS technique. Isabel has also been performing other types of spectroscopy, including IR spectroscopy and UV spectroscopy. When they begin to analyze their raw data, however, both discover that the results they had been hoping for have not materialized. This represents a major setback for the team and both of them need to rethink their approach. Even Peter is suffering from this delay as he will not be able to make any further progress with the restoration until he learns more about the composition of the original paint and its degradation products. Isabel takes the setback personally and feels that the poor results are due to her own failings in the lab. Yousef is more philosophical about this downturn in events. 'You win some, you lose some' is his take on the situation. Better to just get back in the lab and get on with it. Isabel starts to have some serious doubts about her own abilities and is not sure that spending more time in the lab will fix the problem. Rather than jump back into things, she decides to take a couple of days away from the lab. She spends some time with friends and doing some fun activities to help recharge her batteries. Her friends convince her that setbacks are common and that she should not take it personally. When she is ready to get back into the lab, she finds that Yousef has drawn up an action plan for how to proceed. Peter has dealt with the situation by reading up more on the chemistry of paintings. Even though he's not doing any work in the lab himself, it helps him to feel more a part of the project. It also makes it easier for him to talk to Yousef and Isabel about their frustrations in the lab.

Chapter 8

The Art of Good Communication

or

How to get along with your lab mates et al.

I used to think anyone doing anything weird was weird.
Now I know that it is the people that call others weird that are weird.
Paul McCartney

Preparing a doctoral thesis requires collaboration with others. Your supervisor, a Post-doc in your group, fellow PhD students, the lab assistant, the computer expert, the technician from the workshop – they will all contribute to your thesis in one way or another. No man or woman is an island, so you'll have to deal with the people around you, whether you like them or not! With some of them you will have a natural fit, and the collaboration will be pleasant and productive from the start. Other people, well – they may be harder to deal with. They may have different opinions about planning, be more outspoken than you are (or less), stick too much to the details, or are unimaginative when looking at the big picture. With the aid of a simple tool this chapter aims to help you understand others (and yourself) better, how they operate and what makes them tick. We also talk about how your work can benefit from the inherent differences among people. Creating a pleasant and productive environment for collaboration with both your natural friends and those you are more or less obliged to get along with will make your life as a graduate student that much easier.

How to get the help you need from the others on your team

To make your thesis research a success, you'll need the help of others. If you assume this support will happen automatically, or without any effort on your part, you may end up disappointed. Not everybody will line up at your doorstep to help you of their own accord. Despite all your efforts, it may seem that some people are incapable of being any help to you because their way of doing things is so different from yours. Usually we blame these differences, or frictions in temperament, on people having different characters. Often we just accept the lack of rapport and cooperation from another individual (and usually blame the other person in the process – after all, it's never *our* fault!) and look elsewhere for help, or we try to do everything by ourselves. But trying to go it alone will only slow your progress and the final result of your efforts might be of lower quality. If you learn the secrets of communicating and working well together, other individuals – each with his or her own unique character – can be the key to your success. Once you understand what drives other people (and yourself), and accept that we are unique individuals with different strengths and weaknesses, your collaborative efforts can be extremely powerful. In fact, we believe that the progress of your PhD research will be even more efficient when you collaborate with people that are different from you, rather than with those you have a natural affinity with and who share similar strengths and weaknesses.

What a character!

There will always be a few people you just can't seem to get along no matter what you do, perhaps because they seem to have a whole different agenda than you do – maybe even an axe to grind. For some reason they are not interested in being cooperative and making the project a success. This chapter is not about them. Dealing with true problem characters is outside the scope of this book. More often, however, some of your lab mates will be just different enough from you to cause a bit of friction. While they are just as willing to make the project a success as you are, they go about things in a different way.

These differences might cause so many problems that you are unable to function effectively as a team, and the progress you expect fails to materialize. If only they would change, you think, then everything would be better. But no matter how hard you try, the chance that you will ever be able to change the behaviour of another person is very slim. It is equally unlikely that you will be able to significantly modify your own character and personality traits. What you can do however, is learn to be aware of what motivates other people (and yourself) and respect all the ways that different people approach the same problem.

So what is it that makes people act differently in a team? Each of us is unique, but all of us are aware that we feel more comfortable with some people than with others. In order to make sense of human behaviour, psychologists have attempted to categorize these key aspects of character in a variety of ways. For practical purposes we have chosen to illustrate the categorization of team members' personalities using the four personality-preferences as introduced by Myers and Briggs in the 1950s. By following this somewhat oversimplified, but practical scheme, we can gain greater insight into others and ourselves. In the following sections we discuss the different features of our preferences. Next we discuss how to identify which personality type you are and which type can be assigned to those around you. Finally, and most importantly, we discuss how you can get along with different personality types and even benefit from the fact that other people are different from you. In this way, you can build on your complementary skills rather than trying to turn everybody into a carbon copy of yourself.

MBTI: getting at the heart of character

In the 1920s the psychologist C.J. Jung made the observation that people are fundamentally different, and suggested that "for all practical purposes we can be categorized by 'function types'". In the forties and fifties Jung's ideas were further refined by Myers and Briggs. They came up with four qualifiers that determine the basis of our behaviour (Myers–Briggs Type Indicator®). In the course of our lives these qualifiers do not fundamentally change. A component of this theory is that people are fundamentally different and will behave differently when operating in a team (a team can be two people). Here is where you, as a PhD student, come into play. In order to make your PhD project a success, you will need to work with others. Whether you like it or not you will have to cope with people who are different from yourself. Understanding the different ways people behave is a first step in working together. As discussed in some detail in this chapter, Myers and Briggs devised the following categories to describe character: individuals are either (1) introvert (**I**) or extrovert (**E**); (2) driven by intuition (**N**) or sensation (**S**); (3) a thinker (**T**) or a feeler (**F**); and (4) you are either a planner who wants to draw conclusions (**J**udge), or are you more comfortable in a chaotic environment and want to keep things open (**P**erceiver). Altogether there are 2 × 2 × 2 × 2 combinations possible, hence 16 Myers–Briggs types. Scientists are often (but not always!) found in the NT subclass of this scheme. For further details (and to determine your type by taking the test) take a look at this website: www.personalitypathways.com.

How you cope with the world: extrovert versus introvert

The definition of introvert and extrovert is slightly different than the one you might be familiar with. In the MBTI classification the key question here is how you deal with the world, or how you derive a sense of well-being. Do you get energized at the end of a long day by a social event (E), or do you recharge best by having some quiet time to yourself (I)?

In meetings we all alternate between (inter-)actions and reflections. We talk, listen and think, and talk again. Some of us (E's) have a tendency to act first, and then reflect, followed by action again. While others (I's) start with reflection before they go into action. So E's talk, think and talk, while I's think, talk and think again.

How you think: intuition vs. sensation

The way you think about things is split into two preferences: sensation (S)-preferring people are fact based. They recall facts from the past, rely on facts in the present and want to know the facts for the future. This is in stark contrast with those preferring iNtuition (N, the I-label is already given to introvert). They recall the past in terms of patterns, and dream of exploring the future with all its possibilities, the details of the present interests them very little. While sensation-driven people look for practical solutions based on past experience, those who are driven by intuition are more interested in exploring new ways to get towards the goal. Intuitive thinkers are not hindered by the fact that their thoughts are based on assumptions rather than facts.

Are your decisions driven by objective arguments or feelings?

When it comes to making a decision, we tend to combine factual arguments and value judgements. Thinkers (T's) are more likely to choose or make decisions based on impersonal information. The logic behind the decision is more important than the impact the decision might have on others; conflicts are natural for thinkers. In contrast, feelers (F's) instinctively take into account the impact a decision may have on others. Factual (and unfeeling) data have little influence on their decision-making process. Avoiding conflicts is an important motivator in a Feeler's decision-making process.

The MBTI preferences are not gender specific in general. The F versus T preference is the only exception. Slightly more women are Feelers than Thinkers, while for men the opposite holds true.

Chaotic team members vs. planners

The fourth and last category in the MBTI classification scheme concerns the way a person organizes his or her actions. Some of us like to plan our actions in terms of tasks and targets and those people are classified as having judging (J) characters. Others have a preference to multitask and plan along the way. Those characters are known as perceivers (P) and enjoy the chaotic process in which the final goal only becomes clear towards the end. While J's dislike stress and try to avoid it by planning their activities, P's work best under some time pressure and become more revved up as the deadline approaches. Mid-term results are most easily measured for the J's. They tend to have finished half of their tasks according to plan. In the meantime, P's have gathered lots of information and may have been working on many tasks, but it is difficult to see how far they have gotten in reaching their targets.

Which type are you?

Now for the fun part. In order to benefit from the MBTI classification scheme you'll first need to know your own type. The short description given above might give you an initial hint. To make a more thorough check, you can answer the official MBTI® instrument questionnaire at www.personalitypathways.com.

How to collaborate with your counterpart

Although the MBTI is meant to classify individuals in one of the sixteen categories, and every category or type is different from the fifteen other types, we're going to take a little shortcut here. For the four classifications we'll restrict ourselves to discussing the differences between team members with opposite characterizations, thus E vs. I, S vs. N, T vs. F, and J vs. P. Once you know the differences between yourself and others, our suggestions on how to get along best with each different type will help improve your working relationship with many different types of people.

Extroverts vs. introverts

The different ways other people think and act will already be apparent during your first group meeting. Once some new issue is put on the table, the E's in the team start immediately discussing it. They develop their opinion while the discussion is going on. The I's in the team need to think first before they discuss the issue. This state of affairs might lead to mutual irritation. The extrovert team members have the feeling that the introvert team members are not involved, since they are not yet participating in the discussion. At the same time the I's may get irritated by the E's because they start shouting out all kinds of ideas before they have even thought them through. To solve this difference in style, each type needs to respect the others' approach. So let the E's talk, it is their way of developing an opinion. What E's say in the beginning of the meeting may not reflect their final point of view. Give the E's a chance to change their minds. At the same time E's should ensure that the I's get a chance to contribute a little later after they have done some initial reflection on the new issue. If the leader of the discussion is an extrovert, she/he might overlook the quieter introvert team members. Since they have a hard time breaking in during the meeting, the I's keep thinking and listening. Eventually when the I's have an almost complete picture, they start talking. This style of communicating is often less appreciated than it should be. The others feel that the I's should have put their ideas on the table earlier in the discussion. It is almost arrogant not to say anything and throw in a full solution at once, feel the E's. Both E's and I's should make sure that introverts get involved early on during the meeting. By nature, introverts find it difficult to contribute right from the beginning, but the delay should be minimal. During the break, everybody needs to energize again. The fact that the I's are going to sit aside with their coffee does not mean that they are not interested, they just need to charge their batteries in isolation or perhaps with one other person. The E's are motivated by the outside world and usually talk in groups during the break. Whichever type you are, be respectful of the other type and try to see the world through their eyes.

Intuition and sensation: both are necessary for success

Misunderstanding and poor communication between intuitive thinkers and more sensation-oriented people are often the source of conflicts in teams and consequently result in a lack of progress. This is a particularly difficult situation because most projects need both types of people to be involved. The absence of sensation-type characters on a project can still yield nice results in terms of the big picture, but the project will be desperately lacking the necessary scientific data or facts upon which such a picture should be based. On the other hand a team of only sensation-type people will often fail to discuss issues such as what the data is good for or what they are out to prove in the first place. The reasons sensation- and intuition-type characters have difficulties working together is quite simple. The dreams and schemes of possible future projects of intuition-driven people are constantly being interrupted by factual information brought forward by sensation-driven people. These facts may prove that the big picture is impossible. On the other hand, the carefully obtained facts based on scientific findings by the sensation-type scientist are downplayed by the intuition-driven researcher who considers them just a bunch of details.

The bottom-up approach from the sensation researcher would benefit quite a bit from the global top-down picture of the intuitive mind. At the same time, the facts brought forward by the S's can be essential to verify or falsify the initial hypothesis from the N-type team member. Again, respect and understanding for people with the opposite preference is key to avoiding conflicts in a team. Appreciating that the best solution can only be found if team members with opposite preferences work well together is a major step towards success.

In science feeling is more important than thinkers want to believe

Science is based on facts, so facts are essential in the eventual result of the scientific process. It goes without saying that thinkers are probably more attracted to this type of work. However, as has been argued before, to make progress in science, teamwork is needed. For teams to work well together many compromises will have to be made. Such solutions are not only based on the average point of view but will be affected by personal relations and personal perspectives. A Feeler can play an important role in making sure that the team works in harmony.

Science can seem very objective at first glance: results are results and should not depend on the way you feel about them. The conclusions you make are fact based. However, the impact your conclusions have on the scientific community can very much depend on your presentation. Presenting conclusions is quite a subtle thing, in particular if you want to get some recognition for your work. If you are too modest, the scientific community will not notice your contribution, and you will get little credit. If you present your findings with too much enthusiasm, and you down-play the work of others in the field, you might easily make enemies. These people, in turn, probably won't credit you for your contributions. Again, the contributions of a Feeler can make a big difference in how successful you are in your work, no matter how objective and analytical you think a successful scientist should be.

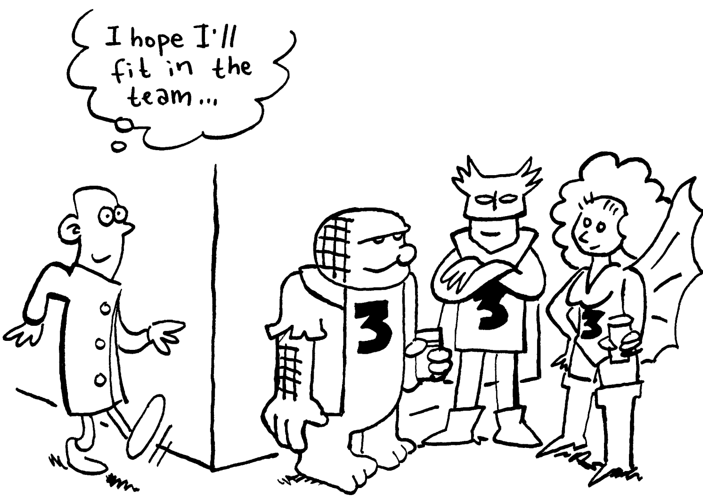
Judgers and perceivers have crucial roles at different times

Judgers and perceivers will use different approaches in planning a new project. They might get irritated by the approach of their counterpart, but in a respectful collaboration a mixed team has an enormous advantage over a team with just P's or J's. Before they even start on a project, Judgers will want to make a plan in which the goals are defined and the routes towards that goal are outlined. For instance, the count-down plan described in Chapter 15, will probably appeal more to Judgers than to Perceivers. Typically Judgers are restless at the beginning of a project when the plan is not ready. Once they know how they want to execute the plan, J's will start feeling more relaxed. With Perceivers, the opposite is true. In the beginning P's start gathering information, seemingly without a plan. They are quite flexible and relaxed. Towards the end of the project, when J's have already finished 90% of the tasks and move on towards the last bit, the Perceivers are only just moving into high gear as they wrap up all the loose ends.

These differences in approach can easily be a source of conflicts. Perceivers might get irritated by Judgers jumping in early to force the outcome (by making a rigid plan), while Judgers might feel that

Perceivers have accomplished very little halfway, since they have not produced tangible results. Perceivers can benefit from the structure that a Judger brings to a project in the beginning. However, if the final goal is changed when the deadline is approaching, Judgers tend to panic: all their hard-won results may have lost their value. At that point Perceivers are at their best, their adaptive and flexible way of working allows a reorientation of the plan even as the deadline is approaching.

More formal team meetings tend to have an agenda. Such an agenda is very important to J's, while P's will pay little attention to it. If the Chair of a meeting has a Perceiving character, she/he might forget to stick to the agenda, or even to make one. This makes Judgers quite nervous, and unproductive. A J has a hard time starting on any project or meeting if there is no plan. In contrast, if the Chair of the meeting is a J she/he might stick quite exactly to that plan, while the contributions of the Perceivers, who like to digress a bit, might fit less well into the rigid scheme.



A varied mix makes a good team

In the above sections we discussed *individual* preferences and how they interact, rather than a *combination* of preferences (known as temperaments) such as SP's and SJ's. We refer the reader to the literature for this next level of MBTI classification. The discussion of the role of opposite characters in a team has already illustrated the idea that team members with different preferences contribute in different ways to the final result. Knowing your own strengths (and weaknesses), as well as those of others, is the first step in getting the most out of your team. Respecting each other and your unique working and communication styles will result in a successful team relationship. It may help to know that some organizations charged with setting up professional teams to execute complex tasks make a point of creating a team of people with different preferences.

The Golden Boy Syndrome
(he – or she – who can do no wrong)

Okay. So much for personality types. They're a great tool for helping you identify your own working style and that of the other people (including your supervisor) in your lab. But there is often a situation, more common than many people think, that can cause friction in your research group and understanding personality types will not do much to help solve it. This is the Golden Boy, or Golden Girl Syndrome. In many groups, one of the PhD students (or sometimes a Post-doc), tends to stand out. The Golden Boy or Girl produces data that go straight into high-impact journals. During group meetings, he or she seems to come up with all the bright suggestions. The head of the lab (your supervisor), praises this individual to the high heavens, and tends to spend all of his time with him or her. This further improves the contributions of the Golden One, leaving the others trailing in his wake. So how to cope? First you need to accept that we are not all created equal and that the Golden Boy or Girl may truly be exceptionally talented. Much of the attention this individual receives, however, may be due less to talent and more to the force of their personality. There is no point in fighting this or trying to get an equal amount of praise and attention for yourself. This strategy will most likely backfire on you anyway. However, since you do deserve a fair share of your supervisor's undivided attention, make a point of asking for regular meetings to discuss your work. These could occur every month after you've filled in the monthly progress monitor and have concrete issues to discuss. During your meetings with your supervisor, make clear to him or her that you appreciate their help. Make clear that you, too, are making progress in a particular area. Don't mention the Golden Boy, and certainly don't try to complain about this individual or put him down. On the other hand, don't allow him to steal the spotlight and the credit all the time. You deserve respect from your supervisor, as well as the other members of your group. So stick up for yourself and make sure you get your share of the limelight.

Saving an Old Master painting: the team learns how to overcome their different styles of communication and work effectively together

At some point early on in their collaboration, Isabel, Yousef, and Peter realize they are a special kind of team. They do not belong to the same research group and each has a different supervisor. They have been brought together by their common research goal, and the ability to work together in a cooperative manner will be key to their success. Isabel points out that they should understand and respect each others' different working habits and approaches to solving scientific problems. Their fragile collaboration, without a formal structure, could easily fall apart due to conflicts. Yousef agrees with Isabel, and suggests they use a model to understand their behaviour and internal driving forces. So they decide to do the MBTI test and discuss the outcome.

Of the three, Isabel is the least interested in taking such a test to characterize their personalities. She does it anyway, because she likes the idea of discussing together their behaviour as a team.

The test indicates that **Isabel** is an **ESFP**, an extrovert, sensing, and feeling perceiver. Initially Isabel disagrees with being identified as a perceiver (score 60% P, 40% J). Isabel argues that she organizes her office properly, a typical sign of a Judger. On second thought, thinking about her private lifestyle, she realizes that being well organized doesn't come naturally. Isabel feels compelled to organize things to do the complex experiments properly. Anyway, she recognizes herself in the description of ESFPs, who are open and enthusiast towards the world around them. They seek the company of others and have a deep concern for friends.

Yousef, who introduced the MBTI test to the team, enjoys taking it. According to the test **Yousef** is an **ENTJ**, an extrovert, intuitive and thinking judger. Being classified as an extrovert surprises him somewhat, since he does not think of himself as having an extremely outgoing personality. However, in terms of acting first and then thinking (E), versus thinking first (I), he feels he is definitely an E. Yousef recognizes himself quite a bit in the description of ENTJs: he enjoys being in charge and managing his projects with conceptual models. For instance, the goal setting strategy used in the monthly progress review especially appeals to Yousef.

Peter is curious to find out why some things seemed to work very well in their team, while others fail. He wants to fill out the questionnaire alone, however, despite the suggestion of the other two to do the whole exercise together. The MBTI test indicates that **Peter** is one of the few **INTP**s, an introvert, intuitive and thinking perceiver. The thinking part is new to Peter, who never realized that his seemingly detached behaviour can be described by the thinking type. Peter has no problem with the typical INTP description: as he is driven to conceptually understand phenomena, is a little detached as far as people are concerned, but is an excellent teacher, in particular for advanced students.

Once they all know their MBTI classification Isabel, Yousef and Peter discuss their differences and how to make the best use of them, including how to cope with the 'think first' (I) attitude of Peter, the 'attention to details' (S) characteristic of Isabel as well as her open and enthusiastic attitude towards others (F), and Yousef's tendency to organize things up front (J). What they learn most from the whole exercise is that it is essential to the success of the team that they be different, and to recognize that they are stronger when combining their individual strengths.

Chapter 9

The Art of Good Communication,

Part 2

Presentation Skills and Group Meetings

The newest computer can merely compound, at speed,
the oldest problem in the relations between human beings,
and in the end the communicator will be confronted
with the old problem of what to say and how to say it.
Edward R. Murrow

Many people rank public speaking as their greatest fear. But talking in front of a group doesn't have to be the scary prospect that many people think it is. The trick is to be prepared, know your stuff, and practice until it feels completely natural to talk about your work in front of an audience. Whether you feel ready or not, at some point your supervisor will ask you to present your research findings to others. Perhaps your first presentation will be in an informal setting with other members of your group during a weekly or monthly group meeting. Or you may be asked to give a presentation to the entire department. At some point as a graduate student, you may even be invited to present your research at a large regional or international conference.

While this may seem daunting, taking the time to prepare for a presentation will take a great deal of fear out of the process.

Let's talk first about the art of giving a presentation to a fairly large audience. This type of talk is by nature more formal than a group meeting and requires a more structured approach.

Formulate your objectives

Before you start designing fancy PowerPoint slides on your computer, take some time to sketch out on paper the basic structure of your presentation. Make sure there is a logical reason and appropriate framework for any information you wish to present. So before you create that first slide ask yourself three things:

- What are the objectives of my talk?
- Which main points do I want to make?
- Which core message do I want people to remember after my talk is over?

Make a list of the answers to these questions as the starting point for your presentation.

As you do this, keep in mind that the whole point of good communication is not the *transmission* of information, but the *reception* of it. This means that the preparation, presentation, and content of your talk must be geared towards the needs of the audience.

Once you know what your objectives are, it's time to write out your presentation in draft form, using key words and bullet points rather than complete sentences. After you have done this, review what you have written. Is your presentation logical and consistent? Are there extraneous and unnecessary pieces of data and information that can be left out? Are you trying to present too much information for the amount of time you've been allotted?

Identify your audience

Now that you've established your objectives and made a rough outline of your talk, the next thing to consider is your audience. How can you achieve your objectives given the knowledge level and interest of your audience? How well do they know the subject of your talk? If the audience is made up of people in your own research group, their knowledge level will be very high; if the audience includes other people in your department, the level might be somewhat lower. With a general audience their grasp of your particular subject will be even lower still.

Many graduate students make the mistake of assuming that they need to tell the audience everything they have done in the lab from the very beginning of their project. Nothing could be further from the truth. In fact, this is a common error and you risk confusing people if you overwhelm them with too much information at one time. Keep your talk short, simple, and to the point. It is not necessary to wow the audience with your productivity by telling them everything you've done so far. Your main message will just get lost in a tangled thicket of unnecessary details and digressions.

Now that you've identified your audience, fill in the basic message of your talk with the appropriate supporting details. Do not be afraid to give context or background information where necessary, or to explain the meaning of any acronyms – even if they seem obvious to you. This will be immensely appreciated by the people in your audience who do not know your subject as well as you do. There is nothing worse then sitting through an entire presentation in which KVA, for example, is written on every slide and the presenter has neglected to tell the audience what it means.

For your first couple of presentations, it isn't a bad idea to write out your entire talk to make sure you don't leave out any crucial information. Whatever you do, though, do not read from a script during the presentation itself. This approach is guaranteed to put everyone to sleep. It is also not a good idea to have your whole presentation written out as a prompt sheet. You won't be able to spot the key words you need, and no matter how nervous you are, reading from a script is a disaster rather than a help. You will talk in a monotone and your audience will be bored after just a few minutes and will tune out everything you say.

Rehearse your presentation out loud

The trick to a relaxed delivery is to know your material well enough that you know what to say without the need for prompts. If you must have something to jog your memory, make yourself some prompts on small index cards with one or two keys words only. These cards should correspond to your slides or other visual aids, so remember to mark the cards with the appropriate slide number.

Now rehearse your presentation out loud. First to yourself (this will feel strange at first, but it is very effective for putting you at ease and for getting used to the sound of your voice in a quiet room). Then practice your talk in front of a few fellow students or other trusted colleagues. Use these practice sessions to rehearse the pacing of your talk, and to master the effective use of visual aids. Ask your colleagues for their comments and honest assessment of your performance at the end of the presentation. Productive criticism from friends is useful for making improvements, and it's better to hear it from them rather than suffer the grumbles and complaints of strangers.

Giving the presentation

Whether your presentation is formal or informal, in front of a large audience or a small one, the following suggestions apply:

Greet the audience and tell them who you are (don't assume that everyone knows you, even in an informal setting). These introductory remarks have the additional purpose of getting the audience to settle down and direct their attention towards you.

Clear presentations usually follow a standard formula:

- Tell the audience what you are going to tell them
- Tell them
- At the end of the talk, tell them what you have told them

The first part of this formula helps you to prep the audience. By briefly stating in a sentence or two what you are going to talk about, you set the stage for your presentation and place it into an appropriate context. Next, give them the details of your talk as you practiced, using your visual aids to support your words. Finally, sum up what you have told them, keeping your objectives and core message in mind and what it is you want them to remember after they have left the room.

Keep to the time allotted to you. If you've been given 20 minutes for your talk, then talk for 20 minutes. Fifteen minutes is even better so that you can allow some time at the end of your presentation for questions and/or discussion. As a general rule, allow two minutes for each slide. And remember: less is more.

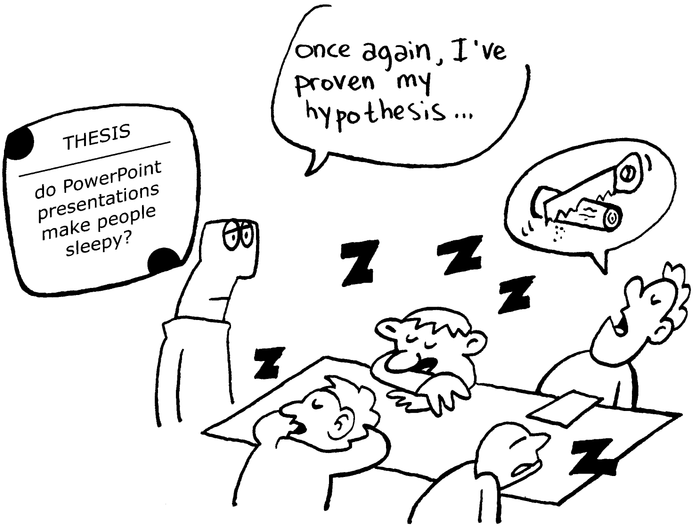
No matter what happens during the talk, or how nervous you may feel, keep to your original presentation plan. Don't be tempted to digress or go off on a tangent with irrelevant stories or anecdotes.

Tips for a perfect delivery

Public speaking is an art. Some people are great at it, others less so. But certain skills that will greatly enhance your ability to give a good presentation can be learned. Everyone loves to listen to a great speaker. Aim to be the kind of speaker you have enjoyed listening to in the past.

During your presentation, your voice, facial expressions, and body language are your most important attributes.

- *Be conscious of how you use your voice*. *How* you say it is as important as *what* you say. Speak clearly and project to the back of the room. Don't rush. Use a natural pace, but don't be conversational. A monotonal voice is boring and will put people to sleep, so it is important to vary the pitch and speed of your voice as you talk.
- *Pause at key points* to allow the audience to absorb your words.
- *Look at the audience throughout your talk*. You will create a rapport with the audience by establishing eye contact with as many people as possible. Just be careful not to fix your gaze on one individual as this can be unnerving. At the same time, be aware of your facial expressions. If you look bored, the audience will be bored. If you are animated and alert, the audience will be interested in what you have to say.
- *Don't talk to the projection screen behind you*. Address your remarks to the audience. Pay attention to the audience's body language and non-verbal reactions to your remarks. Know when to stop and when to leave out part of your presentation if you begin to sense that you are going on too long and the audience is losing their ability to pay attention.
- *Avoid these annoying habits:*
  - Blocking the screen with your body
  - Gesturing excessively with your hands or moving about too much, such as pacing up and down
  - Mumbling and turning your back to the audience
  - Reading from your slides word for word



Visual aids

Giving a presentation on scientific data is complex, so you will most likely use some kind of visual aids: slides with charts, graphs, and tables will most likely form the core of your presentation. Using visual aids effectively will be as important to the success of your talk as your delivery. There is nothing worse than sitting through a presentation and being forced to look at slides that are badly made, indecipherable, unreadable, or have so much information crammed onto them that they are impossible to understand.

Visual aids can be of many types:

- Overhead transparencies
- PowerPoint slides
- Video and film
- Flipchart or whiteboard
- Molecular models or other 3-D aids

Whatever you decide to use for visual aids, keep it simple. Avoid switching from overheads to slides during the same talk. This is confusing and distracting. While it may be an obvious point to make, do be sure you know how to operate the equipment you'll need beforehand.

Slides and transparences should contain the minimum amount of information necessary to get your point across: no more than three lines of bullet-pointed text, one graph or one table (with entries large enough to be read from the back of the room). Try to limit the number of words per slide to a maximum of 10–12. Use a minimum 20 pt Times Roman or Arial font for easy readability. Larger fonts are even better for titles and bullet-pointed information.

Avoid photocopying graphs or diagrams from published reports for your slides. They will not reproduce well and will be difficult to read. Redraw them so that they will be easily viewable.

Be careful with using colour on your slides. The most readable slides use a dark blue background with white or yellow text. Be aware of the room lighting. If there is too much light near the screen, it will be difficult for people to see the detail on your slides. Don't make the room too dark, however, or you risk having your audience fall asleep!

Whatever you do during your presentation, remember to relax and try to enjoy yourself. If you are visually relaxed and in control of the material, you will greatly enhance the reception of your talk by the audience and the information you present will make a much bigger impact.

Group meetings

If your research group is typical, the person who heads up the lab will organize either weekly, bimonthly, or monthly group meetings, usually depending on how big the lab is. When it's your turn to discuss your work during the meeting, don't assume everyone in the group knows the exact nature of the problem you're working on. When it's your turn to talk, put that week's or month's problem in context so that everyone in the meeting is on the same page. Be sure to give credit where credit is due. If a student or colleague has contributed to your data, acknowledge their work. Listen carefully to your colleagues when they are speaking. Show them you are interested by asking pertinent questions.

Even if you're having difficulties in your project, try not to focus on the negative. Ask your colleagues for advice and support in an open and non-defensive way. Don't be afraid to admit you don't know something. Everyone is there to learn. No one can know everything about everything.

Chairing a session

If you are asked to lead a group meeting, this is your chance to sharpen your organizational and communication skills. Keep the following in mind and you will impress your supervisor and lab mates with your professionalism:

1. **Chairing a meeting requires preparation.** Every minute of preparation and planning you do before the meeting is well spent. Try to anticipate what might happen during the meeting and plan for any unanticipated obstacles. If you can anticipate (and eliminate) surprises in advance, you can deal with the core issues of the meeting more efficiently.
2. **Start on time.** This is a courtesy to those who made an effort to show up at the meeting on time and sets a tone from the start that you and your group are serious.
3. **Stick to the planned agenda**. Everyone should have a copy of the meeting agenda. An agenda keeps the meeting on track by ruling out unrelated discussions. Everyone should have the opportunity to place an item on the agenda. Allow group members to submit agenda items in advance of the meeting.
4. **Make sure each person has a chance to participate.** Some people tend to dominate discussions. As Chair, you need to make sure that everyone has a chance to talk (see Chapter 8), so that no one will leave the meeting feeling that their opinion and ideas were not heard.
5. **Stick to the time frame.** Respect everyone's busy schedule by ending the meeting on time. If a discussion is becoming long-

winded or is unresolved, ask the group members if they would prefer to extend the meeting or to continue the discussion during a follow-up meeting.

6. **Keep to the rules of conduct during the meeting.** The rules of conduct for the group should be agreed upon by everyone and they should be adhered to. As Chair, you need to keep control of the discussion and disallow any discourteous or disrespectful behaviour.
7. **Chair the meeting properly.** Your job is to monitor the meeting and make sure the agenda is adequately discussed. Do not abuse your position as Chair to dominate the discussion with your own ideas and opinions. In most cases, your role will be to guide and summarize the discussion. It is your job to make sure that the agenda issues are discussed and the necessary decisions are made.

A final observation

Learning how to give a good presentation and conduct a successful meeting are important skills that will be useful to you no matter which career path you eventually take. Take advantage of the opportunities to you as a graduate student to give as many presentations and run as many meetings as possible. Don't be shy and volunteer if necessary, as the more presentations you give, the easier it will be to stand in front of a group of people and make a lasting impact with your words.

Saving an Old Master painting: Peter gives a presentation to the Art History department

Two years into his PhD work, Peter has been asked by his supervisor to give a presentation to the Art History department on the progress he has made so far with the Lorenzo Monaco painting, *The Coronation of the Virgin*. Peter has given small presentations before in front of just a few people, but never for the entire department. He spends a great deal of time preparing his slides as the visuals will be important when discussing the painting. He prepares full-colour slides of the whole painting as well as various close-ups. He also makes copies of other Lorenzo Monaco paintings as well as those of his contemporaries for comparison. In addition, he talks to Isabel and Yousef for some detailed information on the chemistry and physics of the degradation of the pigments. He starts the presentation off well, giving a brief introduction to the painting, putting it into historical and cultural context and then outlining the problem. Peter is excited to show the members of the department the knowledge he has learned about the chemistry of paintings, so for the rest of the presentation, he launches into a highly technical talk (with the help of cue cards) about the chemistry of pigments and their degradation products. He is so enthusiastic about showing off his knowledge in this area, that he doesn't notice the puzzled looks or fidgeting from the audience (he hasn't even bothered to explain what the acronym SIMS means). Furthermore, he has so many slides that he goes over his allotted time by ten minutes. When the presentation is over, Peter is disappointed that there are no questions. The next day Peter asks his supervisor for some feedback on the talk. His supervisor tells him that the talk was interesting but that he tried to present too much information. Peter has made the common error of trying to talk about everything he knows about this painting and the chemistry of painting in general, all in one go. He also failed to gauge the level of understanding of his audience and ended up dazzling them with complex chemical information that they were unable to fully understand and appreciate. Peter knows now that he must keep the knowledge-level of his audience in mind when preparing his next talk and only present enough information to support his key message.

Chapter 10

Searching the Scientific Literature

The history of science knows scores of instances where an investigator was in the possession of all the important facts for a new theory, but simply failed to ask the right questions.
Ernst Mayr

Before you carry out even your first experiment in the lab, you would be well advised to spend some time in the library doing a thorough literature search of your research topic. Perhaps you worked on a project in this same field as an undergraduate, or think you are familiar with the field because it is related to other work you have done. Even if you have some knowledge of the literature on your project, you shouldn't skip this step. The investment of time in the library will pay off many times over in the lab. You don't want to risk doing work that someone else has already done, or going down the same worn path that others have traveled before you. Science is not carried out in a vacuum. It is about steady forward progress over long periods of time and wise graduate students will take the time to read and benefit from the research findings of their predecessors.

As you embark on your literature search, you may feel quickly overwhelmed by the pile of papers you accumulate, so keep in mind that is impossible to read all the research ever published in your area. Being selective about what you read is key to getting a thorough overview of a particular field, without drowning in too much information.

But whatever you do and however you decide to go about it, *do not skip this step*. You will live to regret it.

Getting started in the library

Get comfortable with the layout of the library and with the research tools available at your institute. Introduce yourself to the reference librarian(s) and explain that you want to carry out a literature search on your thesis topic. These individuals are great sources of information and are there to help you in your search. You'll be spending a lot of time in the library so take the time to become familiar with all its services.

What kinds of scientific literature exist and which ones will be most important to you? Broadly speaking, scientific literature can be divided into two types of articles: peer-reviewed and popular.

Most of the articles published in scientific journals, both primary (original research) and secondary (review articles) have gone through a stringent process called peer-review. Before an editor will accept a paper for publication, he/she will send it out for review to at least two experts in the field. The identity of the reviewers is always kept secret from the author so that any comments made on the manuscript will be impartial.

When the paper comes back with comments from the referees, it is the author's responsibility to correct any errors or discrepancies in interpretation before the paper can be accepted for publication. This process, while not infallible, insures that most articles are scientifically sound and as free from error as possible. Articles published in popular scientific magazines are not subject to peer review, and are therefore not always reliable sources of information.

Secondary literature is published in the form of review articles. As the name suggests, these articles are often very comprehensive in nature and provide an overview of the scientific findings in a particular field over a particular period of time. Reviews do not present new and original data, they are compilations of other people's work, but very often written by a big name scientist in the field. Review articles can be a goldmine of information and will significantly help you with your literature search by cutting down on the amount of time you spend on searching out individual (primary) research articles.

Using the Internet

By now you have already identified the scope of your research project (see Chapter 1: Getting Started). Take advantage of the breadth and scope of the Internet and do an electronic search on your research topic (use key words wisely, or this type of search can get quickly out of hand). Start by searching popular and comprehensive databases such as MedLine, PubMed, GeoRef, and ScienceDirect. Your university library should have a subscription to some of these and other databases that are password protected. Download and print out the articles that are the most pertinent to your research. As you become more involved in your search, you will start to a get a feel for the important researchers in the field. Mark down their names and research institutions.

Another excellent way to get started with your literature search is to read recent review articles published on your topic. Think of this as a bit of a short cut. Someone, somewhere has done much of the work before you and compiled at least a part of your literature search in a comprehensive review article that may contain up to 200 references.

Another tip is to photocopy the earliest papers in the field. These papers represent the seminal work in your area of inquiry. It is critical to know how the field started, which experiments were done, and who the principal players were. As you search databases, identify review articles and key publications, you will begin to create a chronological picture of your research topic. It's very important to have an understanding of the early stages of the inquiry into your topic. As you read the papers chronologically up to the present, you will develop an understanding of how the current knowledge of your particular research field developed. Surely in fits and starts as science tends to go, but as more research is carried, more pieces of the puzzle will have been filled in.

Perhaps now you are beginning to understand why this process is essential. You need to be familiar with all the work that has been done on your topic, not just as a tool for learning, but to avoid repeating work that others have done before. Imagine the graduate student who spends six months doing a series of experiments only to discover (belatedly) that someone else has done them ten years ago. This happens more often than you think, so don't let it happen to you.

Making good use of the Science Citation Index

The Science Citation Index (SCI®) provides access to current and past author abstracts and cited references from some 3700 science and technical journals. This important tool can help you weed through literally hundreds of research articles to find the most cited, and hopefully, the most important articles in your field. Once you've gathered a solid collection of articles, you will need to scan through them and summarize and record the pertinent information. How best to organize all this information? We suggest that you keep a written record for the purpose of building your bibliography.

For each article you've selected, write down the author, title, name of journal and year of publication. Then jot down a few words about each of the following:

1. Statement of the problem
2. Hypothesis
3. Theories and assumptions
4. Research methods
5. Data collection tools/procedures
6. Research design
7. Methods
8. Interpretation of data (did data support or reject the hypothesis?)
9. Conclusions/suggestions for future research

If this sounds daunting and like a massive amount of work, just remember that investing time now in a proper literature search will save you vast amounts of time later on when you start writing up your own research articles (see Chapter 12), not to mention your thesis. You won't want to spend days and weeks in the library hunting down papers or finding out (oops!) that you've duplicated experiments that someone else has already done, just when you're getting ready to write everything up.

How do you know when your literature search is successful and complete?

You'll know you've made a comprehensive literature search when you have performed the following tasks:

1. Identified the most recent articles (last 10 years, plus seminal articles) on your research topic.
2. Skimmed each article and prepared a brief summary of each one.
3. Assessed each article for the strengths and weaknesses of the experimental setup, methods and procedures used, data collection and analysis.

It is up to you to develop an organized method for storing and retrieving this information. Many people copy each paper and then attach a cover sheet with the summary and assessment points to it. It may also be wise to record this information on your computer and type the name of the author, journal, etc. of each article in standard format. This will save you oceans of time when you go about writing up your own articles and have to refer to these references.

Libraries are great places to spend time. They can offer a much needed refuge from the lab and help you place your own work into context by reading about the work of others. Don't feel you're wasting your time if you find yourself in the library when others are in the lab. Remind yourself that you might just know something they don't.

Chapter 11

Your First International Conference

Human beings, by changing the inner attitudes of their minds,
can change the outer aspects of their lives.
William James

For a long time you've been working in relative isolation. Interactions with the wider academic community have been limited to reading articles in scientific journals and perhaps hearing some anecdotes about other groups from your supervisor or more senior PhD students. But that's all about to change. Soon you'll be meeting some of these big-name scientists at your first international conference. Your excitement about the trip is probably mixed with some apprehension, since presenting your own results is a requirement of attending the conference. You are not just going to listen to the big-name scientists, you will also be participating by reporting you own work to them, probably in the form of a poster presentation, or maybe you've been lucky enough to be asked to give a brief talk. Moreover, just organizing the details of the trip is taking more time than you expected. This chapter aims to help you sort out all the things you need to know to make your first international conference a pleasure, rather than a pain, so that your experience of the conference is what it should be: one of the perks of working in academia.

Making the most of your first conference

Going to a conference is a valuable investment in your career as a graduate student and beyond. In addition to your personal contribution to travel and other expenses, you will be investing quite a bit of time at the conference. Altogether a conference visit will take about two weeks: one week to prepare and travel to the conference, and another week in attending the meeting. Fortunately, your investment will be well spent as you should get out of the conference as much as you put in. So take the time to prepare well. At a minimum, your attendance at the conference will bring you up to date on the latest research findings in your field; you can start building your network within the academic world; and the feedback you receive at the meeting will give your research additional momentum. Finally, attending a conference has some aspects in common with a short holiday – particularly if the conference is held in an interesting location. But in order to get the most out of this potentially enjoyable investment, you will have to put some effort into preparing for it. This chapter guides you through the main issues to consider in making the most of your first international conference.

First things first

Selecting the most appropriate conference to attend is crucial. Your supervisor may even have suggested that you attend a particular meeting. However, in spite of what your supervisor may have suggested, you should also consider attending the one that is most useful to you. Selecting an appropriate conference can be based on a few criteria. If you want to go to a conference that was not suggested by your supervisor, good arguments based on your criteria might help to persuade your supervisor that your preference is the better choice. We discuss here four criteria to help you decide which conference is best for your entrée into the world of international scientific meetings.

First of all, it is important to make sure that your research fits well within the scope of the conference. This is a must. If the work presented at the conference has little relevance or overlap with your own work, the chance is remote that you will get any practical tips and inspiration out of the meeting. If your work is a good fit, you will naturally enjoy the meeting much more. Especially when you realize that others are also interested in the type of scientific questions you are addressing, and you will become engaged and inspired by their response to your work.

Second, make sure you will be able to present your work in some form, whether as a talk or a poster presentation. The fact that you haven't completed your research project should not stop you from making a progress-report type of poster. By presenting your work at the meeting, you change your role from that of a passive spectator to that of an active participant in the field.

Third, a conference is more than an endless series of scientific presentations and poster sessions. Interacting with others and networking with the conference attendees are equally important. Workshops and small conferences with less than 100 participants are best suited for getting to know other researchers in your field. Once you have established a network and have some feeling what others are doing in your direct proximity, you might want to consider attending a larger conference.

Finally, try to pick a conference in a pleasant location. After all, enjoying a conference can provide additional inspiration to continue your research. In a pleasant setting interactions with others tend to go more smoothly. Even the top scientists in your field will be more relaxed and perhaps even willing to involve you in scientific discussions. Make sure the location is somewhat isolated. On a mountain or small island everybody will stick around the conference site, while in a major city other diversions will offer too many distractions for you and the other attendees.

You may imagine that organizing your trip will be straightforward, and indeed it is a simple matter to register for the conference and book a plane ticket, but the list of other details to be taken care of can be rather long. In our experience we've found that there is a little bit more involved than buying your ticket and showing up at the airport. Without some organization, preparing for the conference can be quite time consuming. Two tips to help you organize your trip: work with a checklist, and pay attention to things that require some lead time. On your checklist, write down put all the preparations you have to do including finding the best way to travel to the meeting, buying the tickets, registering for the meeting, sending your abstract to the organizers, making your presentation (either oral or a poster), bringing pre-prints of your work and an A4-sized handout of your poster presentation, defining the goals for the meeting, packing your stuff, and so on. Some of these things you can do on your own at any moment. Others require interactions with other people and will, therefore, have a (often underestimated) lead time. For instance, prior to sending your abstract to the conference you should show it to your co-authors for their comments. They might not respond immediately, which may cause you to become nervous and irritated as the deadline for submission approaches.

Keeping things running smoothly while you are away should be an item on your preparation list. Leave a note on your desk that informs others when you will be back and how you can be reached if necessary. Put your e-mail in “out-of-office” mode if you will have no e-mail access at the meeting. In addition to these small courtesies, you should also think of the projects that will be ongoing while you are away. Give proper instructions to an undergraduate student or lab technician who can operate equipment, or keep experiments running in your absence. Order materials from the stock room so that they will be available and ready to use as soon as you are back.

There are so many things to do at a conference, and so many possible distractions, that we suggest you write down a short list of goals you would like to reach during the meeting. Such goals can be related to your own presentation (such as asking the audience for input on a particular experiment, or showing that you have performed the first experimental demonstration of a particular effect); or faithfully attending the presentations that are key to your research, or building your network (talking to a member of another research group to find out how they prepare their samples, for instance). During the meeting you will find that there are many more interesting things to do, none of which you had anticipated. Nevertheless, check your short list of goals every now and then just to make sure you are staying on target, and then consider how to execute your original plan.

Making sense of the conference programme

How to handle the overwhelming conference programme is an art in itself. A large conference will have plenary lectures, keynote speakers, parallel sessions, multiple poster sessions, industry booths, etc. Prior to the conference you have most likely been browsing through the booklet that summarizes the programme. Now that you’ve arrived at the conference site, you are enthusiastic about attending the first Monday morning session. You will probably enjoy quite a few of the lectures, while some may be less interesting and of less relevance.

The Monday evening poster session seems only marginally relevant to your research. But you go there anyway since you're determined to get as much out of the conference as possible. By Tuesday afternoon you've faithfully attended every presentation and are beginning to feel tired. You may even be having a hard time following the lectures, no matter how interesting they are. You're so tired now, and have already absorbed so much new information, that you even lack the energy to interact with others during the breaks. In the second half of the week the amount of information you actually absorb has shrunk considerably. Too bad you missed the very interesting and relevant talks on Thursday. You realize, perhaps too late, that a week at a conference can be a very long time indeed. Our advice is simple. Follow the tactics of a marathon runner and do not start out at full speed. Pace yourself and carefully plan your attendance at presentations. You are not being graded on how many lectures you attend. It may seem obvious, but save your energy for more important things by choosing not to attend presentations that have little relevance to your own work. Our advice for getting the most out of the full week of presentations and interactions is to skip a good fraction of the programme right from the beginning. Use that time to relax, talk to others and digest all the information you have taken in so far.

As stated previously, we believe that building a professional network is one of the major reasons for going to a conference. That is why the coffee and meal breaks can be as important as the presentations themselves. Presentations usually highlight what has worked in a particular line of research. In other words, at a conference people tend to showcase their successes. It is only during the breaks that you will find out about the attempts that were made that did not work out. In retrospect, newly minted PhDs often realize that most of their efforts during their PhD research did not contribute to the work reported in their thesis (see also the section in Chapter 3 on the 80/20 rule). During informal discussions you can learn from others about what not to do, as well as strengthen your sense of community and to realize that you are not working on a problem in isolation. The kind of information you discover can be mundane, or it can be as important as learning that the type of sample preparation you've been attempting is worthless. By sharing failures and setbacks with others, you will also receive useful feedback on your research project. A second reason to work on your network is that wild ideas about new research directions and collaborations on that research often get their start during conference breaks at the bar or coffee table. In addition, when you're finished with your PhD you might want to continue doing research in another academic group as a Post-doc. Meeting people from research groups in different countries will allow you to make a more informed decision about where to go next. You might also collect a few interesting stories about former PhD students who have left academia. Finally, informal chitchat can be a welcome interruption from staring for hours at all those PowerPoint presentations. So we'll remind you again: don't forget to enjoy the meeting. Having a cappuccino on the steps of the conference building can be more productive and enjoyable than fading away in boredom at yet another incomprehensible or irrelevant lecture.

Making your presence count

Most likely you will be presenting a poster rather than giving an oral presentation at your first conference. It might seem to you that poster presentations are a minor aspect of the conference and not very important to focus on. During these sessions, however, there is a great deal of personal interaction and they can be extremely rewarding. In oral presentations given in front of a large audience, there is often little response to the work presented, aside from a question or two from the audience. The interactions and discussions that occur during poster sessions might yield a couple of valuable suggestions for moving forward in your research, either at present or in the future. At smaller meetings the posters are often displayed throughout the meeting in the same area where coffee is served. In this case your poster will get quite a lot of exposure. Naturally you cannot stand by your poster at all times, so be sure your poster is self-explanatory, with a clear introduction, methods and results sections, and clearly stated conclusions. Make up a stack of A4-sized sheets of your poster and place them in a folder that is tacked to the bulletin board to which your poster is affixed so that people can take a copy with them. Also, it's a good idea to put your photograph somewhere on your poster. This will help people find you later on if they want to discuss your research with you.

Choosing which presentations to attend from the myriad on offer requires some strategy. Before even entering the lecture hall, decide whether this particular presentation will be of interest to you. If you've chosen unwisely, or find yourself listening to a presentation that has little relevance to your research, do not despair or leave the lecture in frustration. Trying to follow the lecture at this point will just be a drain on your energy, so the best tactic is to ignore the presentation altogether and just let your mind wander. Some of the bigger conferences have parallel sessions and if you will not be too obtrusive, you might try to slip out a side door so that you may attend another presentation.

If, however, you find yourself listening to an interesting presentation that has great relevance to your work, make an effort to focus your concentration on the message and key points of the presentation. Two things can help. First of all, take notes. By writing down the key points, it will become clear what you understand and what you do not. Secondly, prepare a question. Possibly the session chair will not allow questions due to time constraints, or perhaps you won't have the courage to raise your hand. Nevertheless, you should prepare a question anyway. It will make you a better listener. Later on, during the break, there might be an opportunity to discuss the question with the speaker (most speakers love it when people approach them after their presentation), or, if not, someone from the same research group.

If you've put a lot of effort into reading the programme, you might be tempted to zigzag through the programme so that you can attend all your favourite talks. We strongly advise you to hop as little as possible from one parallel session to the other. The session chairs seldom stick to the schedule, and you might feel frustrated if you enter the lecture hall after, rather than before, the start of your favourite talk.

We hope you've been having a good time at your first international conference. But no matter how enjoyable you find the conference to be, remember that it is distinctly different from a vacation. Do socialize at the bar, but do not become so caught up in the conviviality of the moment that you are tempted to skip the first interesting lecture in the morning. Organizers know that people tend to straggle in late so they try to schedule the most appealing talks for the first session of the day.

Post-conference reality check

Finally, the conference is over and you're back home again. You need to take care of an overwhelming number of things now that you're back at your desk and in the lab. Your inbox has way too many e-mails; you have to teach a class later this week; you want to socialize with friends you haven't seen for a while. In short, within a day you have almost forgotten the whole conference, in particular all the new ideas you picked up while you were there. Before the conference becomes a distant memory, take the time to go back through the conference programme and look at your notes. Keep, in a convenient place, the business cards you have collected. As an added incentive, offer to hold a group meeting or departmental talk, if possible, in which you summarize the highlights of the research findings presented at the conference. Those who were unable to attend will highly appreciate this gesture on your part and it will provide an opportunity to discuss with others some of the research findings that sparked your interest.

Saving an Old Master painting: how Peter submitted his conference proceeding on time

Peter is planning to submit an abstract to a large international conference. Based on the submitted abstracts, the conference organizers will decide whom to invite to participate in the conference or give a presentation at the meeting. As planned, Peter wrote a first draft of the abstract and gave it to his supervisor. Peter's supervisor agreed to look at it as soon as possible. Then an emergency came up and the supervisor had to put his abstract aside. Unfortunately, Peter's supervisor is not very well organized (most likely the cause of the emergency in the first place), and has many other things to do. So, after fixing the emergency, he forgot about Peter's abstract, which is now lost on his desk, or at the bottom of a pile of other things to do. At the end of the month Peter has not only not submitted the abstract, but he has also lost quite some time in chasing after his supervisor. Even worse, because Peter is irritated by all this wasted energy, he is less effective in carrying out other projects. The irritating obstacle of the conference abstract has to be overcome. It would be a shame if Peter missed out on attending the meeting just because his abstract had not arrived in time. Now that he has identified the hurdles, a solution might be to confront his supervisor with the deadline and ask his permission to send it out without his review, in the event he has no time to look at it.

Such a direct approach has two drawbacks. First, most supervisors do not like to be told what to do, so some sort of indirect gesture needs to be made. Second, without input from others, the abstract might not be good enough to be accepted by the conference organizers. Someone has to read the abstract to improve it. Therefore, Peter asks Isabel and Yousef to read the abstract as if they were the supervisor and to come up with suggestions. He approaches his supervisor and tells him that he understands that he has little time to look at his abstract, and that the abstract can not be sent out without his permission. Peter mentions his solution and repeats the useful suggestions made by Isabel and Yousef. Peter wonders what else he can do to ensure his abstract would be on time. Now his supervisor looks briefly at the abstract (which he miraculously picks out of a seemingly disorganized pile), and agrees to submit the paper. Peter has not only managed to finish the abstract but he also identified routes to make it happen. He is more in control of the situation and his pro-active and constructive behaviour has made it much more likely that his abstract will get submitted on time and be approved.

Chapter 12

From Data to Manuscript:
Writing Scientific Papers That Shine

> *The scientist is not a person who gives the right answers,*
> *(s)he's one who asks the right questions.*
> *Claude Lévi-Strauss*

You've completed a series of experiments and have collected enough data to write up your findings in a scientific article which you will submit to a peer-reviewed journal in your field. At this point in your career you have already read dozens of scientific papers and are familiar with the format. Following this format and tailoring it to your own work is easy enough if you keep the following points in mind as you write.

A scientific article is a written document of your work in the lab or in the field. Keep in mind that its purpose is to disseminate your research to the scientific community and to provide researchers in your field with specific kinds of information including the following:

- Which questions did you ask?
- Which experiments did you perform to answer these questions?
- Which kinds of data did you collect and how did you collect them?
- Which conclusions did you draw from your data and what suggestions have you made for further research?

But before we get into the particulars, a few general points should be kept in mind while you are writing. You already know that research demands accuracy and precision. Scientific writing should reflect this in the form of clarity and conciseness. Unfortunately, if you glance at almost any scientific journal you will discover that clarity and concise writing is often in short reply. Many of the complaints by non-scientists of obscurity and elitism within the scientific community partly stem from the fact that many scientists are incapable of expressing their hypotheses and conclusions clearly and simply. Don't allow yourself to fall into this trap. Part of being a good scientist is not just designing good experiments, but being able to present your work and to write it up in clear and simple language. Obscure language will not make you sound more intelligent, it will only confuse others. As a result your work will have much less impact on your intended audience.

A well-written scientific article will answer all of the above questions. The standard format found in nearly all peer-reviewed papers will help you organize your material into a logical order. Take a look at any paper from a respected journal in your field and you will see that it is organized into the following components:

- Abstract
- Introduction
- Materials and methods
- Results
- Discussion/Conclusion

Title

A good title is an art in itself. Give your article a strong title for maximum impact.

Abstract

The abstract is a one-paragraph summary (approximately 200 words) of the work that is described in the article. It should be a self-contained summary that is complete enough for the reader to understand the research and results without having to read the entire article. The abstract should contain the following elements:

- The central question (purpose) of the study
- A brief statement of what was carried out (methods);
- A brief statement of the results found
- A brief statement of the conclusions

Note that many computer search engines make use of the information in the abstract. Make sure, therefore, that you have the relevant key words in your abstract and title so that your article will be easy to find by Internet search engines.

Introduction

For many people, this is the most difficult part of the paper to write. Deceptively simple, the introduction must contain a great deal of information in a short amount of space. This means you will need to write crisp and concise sentences to put your work into the proper context. It's important to include enough background so that a reader not familiar with the field can understand the relevance of your work and put it into context with other work that has come before.

The purpose of the introduction is to explain to the reader why you decided to conduct your research. So this is the place in which you clearly state which questions were you attempting to answer. You also need to state any information about previous related research or existing knowledge in the field. How, for example, did the information that already exists help you in planning your own experiments? In other words, the reader of your article wants to know: why did you, the researcher, do this work? Finally, be sure to clearly state your hypothesis and objectives. Read the introductions of several well-written papers to get an idea of the content and style. Some journals allow you to write the main conclusion at the end of the introduction. Make use of this convention when you can as it will prepare the reader for the main body of your article.

Materials and methods

In the materials and methods section you will provide a detailed description of exactly what you did and how you did it. This section is extremely important and accurate details count. What was your experimental setup? Which type and brand of equipment did you use to collect your data? How and when was the equipment calibrated. Which chemicals did you use (sometimes even the company you ordered them from and the batch number can be important). Keep in mind as you write up this section that you will need to provide enough information so that other researchers can understand exactly what you did and will be able to duplicate your work. Again, study several well-written articles from respected journals to get a sense of what to include in this section and the style that other authors adopted. Remember that it is common practice to describe methods using the passive voice: "The pigment sample was heated to 50 °C" rather than "We heated the pigment sample to 50 °C."

Results

The Results section follows logically from the Materials and Methods section, being the place where you present the data you collected. Not data in its raw form, but analyzed data, which is usually displayed best in graphic or tabular form for ease in presentation and interpretation. Particularly if your data collection resulted in a lot of numbers, determining the best way to present it is vital to getting your results across. A combination of tables and graphs usually works best, so that the reader can see both the numbers and a graphical presentation of the relationship between variables. As you write, be aware that the Results section must closely match the Materials and Methods section. For example, if you present temperature data in the Results section, then the Materials and Methods section should say when and how you measured the temperatures you obtained.

A note on tables and figures

Tables and figures are an excellent means of conveying data in a more efficient way. They must be able to stand alone, however, and should be accompanied by an explanatory caption that enables them to be understood without having to read the body of the paper. Do not repeat in the body of the manuscript information that is in the captions of tables or figures as this would be redundant. Do refer to the information in the figures and tables, however, when appropriate.

Tables

To avoid being redundant, don't repeat information in a table that you have already depicted in a graph or histogram; include a table only if it presents new information, or the exact value of the measurements is relevant to your results.

It is easier to compare numbers by reading down a column rather than across a row. Therefore, list sets of data you want your reader to compare in vertical form. Provide each table with a number (Table 1, Table 2, etc.) and a title. The numbered title is written above the table.

Figures

Figures can be graphs, histograms, spectral traces, etc. Provide each figure with a number (Fig. 1, Fig. 2, etc.) and a caption that explains what the figure illustrates. The numbered caption is written below the figure.

Graphs and histograms

Both of these graphic presentations can be used to compare two variables. Graphs, however, show continuous change, whereas histograms show discrete variables only. Decide which is the best way to represent your data. You can compare groups of data by plotting two or even three lines on one graph, but avoid cluttered graphs that are hard to read, and do not make the (all too common) mistake of plotting unrelated trends on the same graph.

For both graphs, and histograms, plot the independent variable on the horizontal (x) axis and the dependent variable on the vertical (y) axis. Be sure to label both axes, including the appropriate units of measurement.

Tips for making great graphs

At first glance, all graphs look great, but make sure yours don't have complicated axes or extrapolations that claim more than they should. Here are a few tips for making graphs that are both accurate and 'honest'.

- Whenever possible, begin your axes at zero and use appropriate scaling. Sometimes a valid trend will disappear on a graph with a zero axis, and all the data points will bunch together at that top. In a case such as this, inform your readers that the graph's axis is not zero, either by stating this in the text, or with a break in the axis.
- If a data point represents the mean from a number of observations or experiments, indicate the variability by a vertical line through each point and state whether this is standard error of the mean or standard deviation. Be sure to specify the number of observations or sample sizes.
- When comparing two graphs, be sure to draw them both to the same scale for ease of comparison. If possible, place them side by side in the article.
- Be aware of the limitations of your data. Extrapolating a line or curve beyond the points shown on the graph may mislead the reader.
- Be especially careful with line graphs. A false impression of your data may be given if successive points are connected by lines. It may be better to present the data as a histogram, or to leave the points on the graph unconnected by a line.

Drawings and photographs

These pictorial forms are used to illustrate anything from organisms, experimental apparatus, models of chemical structures, cellular and sub-cellular structure, and results of procedures such as gel electrophoresis or electron-microscopy. Preparing such figures can be time consuming as well as costly, so be sure that each drawing/photograph adds enough value to your article to justify its preparation and publication. On the other hand, a good illustration that shows the key result in your article can be of great value. You might even try to get such an illustration on the first page. It will make a handy reminder for others when they are flipping through a pile of articles in search of yours.

Discussion

In this section of your article you present your interpretation of the analyzed data presented in the Results section. You are allowed a little leeway here, but don't get too carried away with assumptions and wishful thinking. Be prepared to back up your analysis with solid evidence as presented in the Results section. Be careful that you don't include in your analysis a piece of data that you neglected to mention in the Results. Journal editors and reviewers are trained to look for these types of discrepancies. In a nutshell, the Discussion section explains the meaning of the results. For example: Did temperature affect the rate of fading of a particular pigment? Don't make the common mistake of confusing the Results section with the Discussion section. The Results section contains only the data you obtained from measurable parameters. The Discussion section explains the relationships observed in these data. Any patterns that you discovered in your data are described in the Discussion section.

In addition, the Discussion section provides space for you to answer the questions that were posed in the introduction (and that arose in readers' minds as they read your article). In other words, did you discover what you thought you would (did your experiments prove or disprove you hypothesis?) Were the results different from what you expected? What have you learned from your analysis? How does your work relate to other work in the field? Does it confirm or refute existing information? What kinds of conclusions can you draw from the results?

The Discussion section is also the place for suggesting ideas for future research. You may have answered some of the questions you started out asking, but most certainly the work you carried out has led to new questions. Pose those new questions here. It will provide possible new leads for other researchers as well as for yourself.

Literature cited

Cited literature is provided in the last section of the paper. Be sure to follow the style for citing references as described in the Instructions to Authors for the journal to which you will submit your paper. Within the body of the text, you must cite another researcher whenever you refer to his or her results, conclusions, or methods in your paper. The reference in the text is made only to the author's name and date of publication. There are three common ways of doing this:

1. Placing both the author's name and publication year inside parentheses, as the name is not actually part of your sentence. Not all journals include the comma between author and year.
2. The parentheses with the author and year is placed at the end of the sentence or clause containing the reference. Any necessary punctuation comes after the citation.
3. Another way to cite a study is to make the last name of the researcher the subject or object of the sentence or clause and follow it immediately with the date of the study in parentheses: Holloway (1993) found that cobalt-containing pigments degrade in UV light. Because Holloway (1993) showed that cobalt-containing pigments degrade in UV light… These data support the conclusions found by Holloway (1993).

If you wish to emphasize the date of the cited study, you can omit the parentheses:

As early as 1968, Jackson showed that UV light can severely degrade cobalt-containing pigments.

This strategy is often effective for presenting a historical perspective of the problem, which can be useful in the introduction.

Note that it is never correct to separate the date of publication from the author's name: Holloway found that UV light degrades cobalt-containing pigments (1977).

If you wish to cite more than one study per reference citation, i.e., if more than one author has reached the same conclusion or worked on the same problem independently, you may list them together in the same parentheses and separate their names by semicolons: UV light has been shown to degrade cobalt-containing pigments (Jackson 1968; Holloway 1993). By convention, these citations are listed in chronological order.

Revising the first draft

Once you have written the entire article in the format described here, it's time to take a well-deserved break. So walk away from the computer and take a breather. But you're not finished yet, you have written only the first draft. Print out your article and put it away for a few days so you can get some much needed distance from the process, because in the next stage, you will have to switch hats: from that of writer to editor. When you're ready to return to it in a few days, read it all the way through with a cold and critical eye (just like a reviewer and eventual reader will do). Don't be lazy about this step as you'll just delay publication. Any sloppiness on your part will be spotted by your peer-reviewers and the paper will be sent back to you for corrections and alterations. An extra round of reviewing can take several months. While not easy the first time around, the best way to write a good scientific article is to try it first on your own. Input and feedback from your co-authors and your supervisor, in particular, however, are essential for presenting your work in the best possible form. When you've given the paper a good read through, be sure to allow the other authors on the paper (including your supervisor, of course) to read it and give you their comments.

Chapter 13

Celebrate Your Success

Success is not the key to happiness. Happiness is the key to success.
If you love what you are doing, you will be successful.
Albert Schweitzer

Finally, after a great deal of effort and hard work, you have obtained the results you were trying to get for such a long time. You may be so busy (and tired) that you don't even realize that you have indeed achieved a certain measure of success. Perhaps it will take a few more months before you can present your work at a conference or submit it to a scientific journal. But what you present or submit for publication will be based on the results you have just obtained. You have reached an important milestone, so it's time to celebrate! All too often success is not celebrated properly, and you just set your nose back to the grindstone without even taking a moment to pat yourself on the back. In this chapter we make an argument for the importance of celebrating your success, as well as taking the time to thank others for their contribution and support. So whatever you do, close your lab notebook, turn off the Bunsen burner, and take a moment to bask in the rewards of hard work.

The art of celebrating success

Striving for the best requires a lot of effort. You will encounter many hurdles on your way to the top. Such platitudes hold true for many areas of life including research and athletics, for example, that are performed on the highest level. There is, however, one major difference between athletes and researchers. In the sports world they know how to celebrate success. No matter what you know about the sporting world, or whether you happen to care about it at all, you are familiar with the way that athletes celebrate their triumphs. We have all seen pictures of overflowing champagne bottles or athletes cavorting with glee as they cross the finish line ahead of the pack. In fact, every sport has its own tradition, where the research world seems to be at a loss about how to throw a proper party. We are serious scientists, after all! But sometimes it's necessary to 'let your hair down' and have a party. Apart from the fun involved, it is a great way to celebrate your success.

Why celebrate your success?

Scientific research can be a long and tedious process. It starts with ideas and brainstorming, followed by research protocols and experiments, and ends with a report to the scientific community. But it shouldn't stop there. Here are three reasons why proper celebrations should be an integral part of the research life.

1. **To acknowledge co-workers for their contribution to your success.** We make progress in life and work because we stand on the shoulders of others. It goes without saying that we make use of collaborative networks established by others; we use equipment built and designed by others; we analyse data using software written by others; we do research based on concepts sketched by others, use questionnaires developed or validated by others, and so on. In spite of this, it is natural to feel that your work (and your work alone) made your recent progress possible. We all have a tendency to underestimate the contribution of others. By celebrating your success with the people around you and thanking them for their contribution you acknowledge, in an explicit way, their contribution to your success. They deserve it, and by thanking them in a visible way, they will be more willing to help you again as you work towards your next milestone.
2. **Because reflection is an important part of the learning process.** You've probably already discovered that you can learn valuable lessons about a process by studying what went wrong. But it is equally important to reflect on your successes. Why did it work

(against all odds)? Why has nobody else performed these experiments? What triggered the research? What helped you in getting the data first, before anyone else? Who's assistance has been critical? Analyzing the reasons for your success might help you in the next phase of your research. Luck is for those who know how to find it.

3. **Celebrations create a positive atmosphere.** When you and your co-workers celebrate progress on a regular basis, you will create a winners' mood within the group. In such an atmosphere your team will find more inspiration to tackle the next problem, helping to pave the way to the next milestone.

What defines success?

Of course winning the Noble prize is a good reason to throw a little party. But that should not be the standard definition of success. After all, few people actually ever win the Nobel. But during your PhD years there will certainly be a couple of occasions for thanking others for their contribution and support. A very natural moment to celebrate your success is the acceptance of a manuscript by a scientific journal. At some institutes, it is a tradition for the first author to bring cake for the whole team on such occasions. In other research programmes it might take much longer before the publications appear, for instance, because new equipment or methodology has to be developed and tested. In that case you might celebrate when the equipment is ready (don't forget to include the people from the technical workshop) and fully operational.

How can you celebrate your success?

Celebrating success works the same way as giving someone a thank you present. It is important that you do it immediately and with the best intentions. Just as you would give someone a nicely wrapped present the day after someone passes an exam, you might bring a cake and other celebratory goodies to the lab the day after you obtained the key data for your article. Whatever you do, use your imagination and do something fun for yourself and those around you. Everybody enjoys a good party. So take a moment to raise your glass and toast yourself and those around you for a job well done.

Chapter 14

How to Cope with Your Annual Evaluation

If you don't learn from your mistakes, there's no sense in making them.
Anonymous

One way or another, no matter which programme or department you are in, you will most likely be subject to a yearly evaluation from your supervisor. This chapter will help you prepare for – and survive – that all-important assessment of your performance, as well as give you some advice in getting the most out of what can be a stressful situation.

Very often the yearly evaluation is a requirement orchestrated by administrators in the upper echelons of the system. In all likelihood, even your supervisor won't be able to do much about it. You may even feel that it is a waste of time and just another bureaucratic hoop to jump through. But if you approach it in a positive frame of mind, you might be able to see the benefits of this kind of yearly assessment, as it will help you come to grips with your progress and performance in the lab.

There is no standard type of evaluation. Although some universities and institutes have standard forms and procedures that must be followed, most likely these forms are rarely used properly and the official procedures will not be followed to the letter. At other institutes, there may be no formal annual evaluation at all. If this is the case for you, don't feel that you're off the hook. Even in the absence of a formal requirement, it would be a good idea to schedule a regular evaluation session with your advisor to discuss the long-term perspectives and goals of your PhD programme. No matter how casual these discussions might appear, they are very important as the road map of your PhD and your performance in the lab will be discussed. In the suggestions given throughout this chapter we have assumed you will have some sort of a formal discussion with your supervisor on a yearly basis. But most of the suggestions still apply in situations where the discussions are less structured.

Keep it in perspective

Don't forget that most supervisors tend to dislike these evaluations just as much as you do. First of all, your supervisor is a scientist, not a trained human resources manager. Most scientists value professional freedom very highly, which is a perk of academic research, and they dislike the paperwork associated with universities and government organizations and the type of planning and structure which they believe is typical of the corporate world. Secondly, as a result of such an evaluation, commitments will be made by you and your supervisor – commitments that you are more or less obliged to adhere to, including commitments about the type of research you will be doing, and the frequency of your progress meetings, etc. Your supervisor may feel that all these additional commitments will absorb his or her last bit of spare time for doing research, on top of teaching obligations and writing grant proposals. This state of affairs has a way of raising the stakes on both sides of the table, so it may help to keep in mind that the evaluation is not just about you, but will also involve commitments of time and energy from your supervisor. Finally, during such an annual evaluation you will very likely receive criticism about your work and your performance in the lab. Most supervisors have not been trained in giving constructive criticism, so you may come away from the experience thinking that the criticism you received was unduly harsh and not constructive at all! Nobody likes to be criticized, so try to keep in mind that your supervisor may be just as uncomfortable as you are and that at the end of the day he/she is only human, and is certainly not the last word in who you are as a person or in determining the value of your work and contribution in the lab.

Some supervisors announce the evaluation a few days in advance, as they should do. Others may spring it on you at the last minute. Whichever approach your supervisor has taken, you should take the time to prepare yourself for this discussion. If your supervisor does not make a habit of announcing the evaluation, or there is no formal evaluation requirement at your institute, it's probably a good idea to prepare for an evaluation anyway, so you'll be ready no matter what happens.

Be prepared

First and foremost, coming prepared to an evaluation session will help you feel relaxed and confident. Make a list of everything you have accomplished in the past year. Experiments done, course-work completed, skills learned, students supervised, classes taught, etc. Then make a list of the areas in which you think you could have done better. This will let your supervisor see that you have spent time thinking about the areas in which you can improve. If you don't admit to these things yourself, before your supervisor points them out to you, it will be difficult to avoid the all too human reaction of becoming defensive and inflexible in the face of criticism.

When you sit down with your supervisor, take the lead by presenting an outline of your accomplishments of the past year (make a copy of your list for your supervisor to refer to during the meeting). This way, you start out on a positive note and bring to your supervisor's attention the fact that you have done quite a lot during the year. A list of accomplishments will erase from your supervisor's mind the idea that the project is going nowhere. Next, while discussing last year's progress, be sure to name a number of hurdles that prevented you from making even more progress (data was not available, equipment broke down, collaborating individuals hadn't delivered what they promised …), but be careful not to make these sound like excuses (it's easy to fall into the trap of blaming outside circumstances and other people's failings for falling short of your goals). Finally, discussing what should be done in the coming year will establish a road map that will take you closer towards your PhD. Make sure your plans are not too ambitious and be realistic about next year's progress, which will probably be of the same order of magnitude as the previous year's accomplishments. Making a workable plan for the coming year, and sticking to what has been agreed, is very important for keeping a good relationship with your supervisor. Not to mention managing his or her expectations by keeping a firm hold on what can realistically be accomplished. Be an active partner in the process, not a passive participant.

In addition to being a platform for future plans, evaluations should also focus on the things that have gone well and the things that haven't. Frequently the positive things are ignored and only negative issues are discussed. In order to prevent this, you should make a list of the most important things that you have accomplished. Moreover, praise your supervisor for the things you appreciated about his or her role in your work. Compliments can work wonders (as long as they are sincerely expressed) and by stressing your supervisor's pleasant qualities and work habits, you will motivate him or her to keep behaving that way. Next on your list should be a few issues you are currently struggling with, some of which your supervisor probably hasn't noticed yet. These can be technical problems, but also social problems, in fact anything that stops you from doing your best work. Remember: addressing a problem is halfway towards a solution, so don't be shy about bringing up any troublesome issues.

You might believe at first that the conversation that occurs during the evaluation is not in your hands. However, you can control the tone of the evaluation in many ways. You do not have to wait until your supervisor comes to you to discuss your long-term plans and last year's progress. Go to your supervisor and tell him or her that you have being thinking about your recent progress and what to do next and that you would like to make an appointment to discuss this. Almost every supervisor will welcome such a pro-active PhD student. During the meeting you will want to make sure that both of you have constructive intentions.

How to ensure that the evaluation has a long-lasting impact? Once you have gone through the hassle of the evaluation, you'll want to make sure that the impact does not fade away the next day. Therefore you should focus on a few topics and assure that by the end of the meeting you have decided on actionable conclusions to these topics about which you both agree. In the absence of official forms you might formalize these conclusions by sending your supervisor an e-mail in which you list the agreed upon actions. "*We should talk more often*" is not a truly actionable conclusion. "*Let's sit together every Friday for half an hour after lunch*" is a much better actionable result of your evaluation (you might want to make a SMART plan as discussed in Chapter 3).

Altogether, an evaluation is not as bad as it might seem. When properly prepared and carried out, with positive intentions from your side and concluded with actionable steps for the future, you will get much more out of it than you probably expected at first.

The surprise attack: how to act when you're caught off guard

It might happen that you are taken by surprise. Out of the blue your supervisor comes to you with a list of things that have gone wrong, or at least that is his or her interpretation. To you this criticism is all new; you never received even so much as a sign that things might be going wrong. The annual evaluation has suddenly turned into an unpleasant attack on your abilities and performance in the lab. If you find yourself in this scenario, you may react by becoming angry and defensive during the ensuing discussion: why has she or he never told me this before? Why has my supervisor not highlighted the things that have gone well? The way he/she talks to me makes me feel like a failure.

What can you do about these unfair allegations? Because of the heated atmosphere, it's unrealistic to expect that the problem between you and your supervisor will be solved during the evaluation. It is not very likely that you will convince your supervisor on the spot that she or he is wrong. Neither will the problem go away by just ignoring it. Probably the best thing to do is (1) try to summarize the criticism, (2) agree to disagree, and (3) ask for a follow-up meeting in a week or so. In the meantime you should prepare for the follow-up discussion, and you might want to talk to a friend or one of your colleagues to get their input. At the follow-up meeting, be sure to discuss the following issues:

1. **You and your supervisor have a communication problem.** Somehow your supervisor has not been able to communicate your shortcomings during the year and has bottled up and kept to himself all that has gone wrong with your project. It might very well be that your supervisor feels that this yearly evaluation was exactly the right occasion to tell you the truth, with no holds

barred. Someone in such an aggressive mood will probably not be willing to listen to counter arguments, so you need to save them for the follow-up discussion. At the follow-up discussion, you need state the fact that the two of you have a communication problem and discuss ways to solve it. In all likelihood, you have no proper monthly progress review (see Chapter 6). You might suggest to your supervisor that you start having monthly discussions. Mention that you are willing to prepare the homework for these monthly discussions by filling in the monthly progress monitor. Be pro-active and offer to do the work to take some of the burden off your supervisor, but make it clear that you require more regular discussions in order to improve communication between the two of you.

2. **Establish the things that have gone well**. During the initial discussion, all the attention was focussed on things that have gone wrong. It is important to rein in your emotions and to build a basis of mutual trust with your supervisor. On this renewed basis you can and should proceed with your PhD programme. So for the follow-up meeting prepare a short list of the most relevant things that have gone well. Try to be honest with yourself when making this list; overstating your qualities will not help establish new common ground with your supervisor.

3. **Come to the follow-up meeting with a few practical suggestions**. Be prepared to admit to the most important (perceived) shortcomings in your work as a PhD student and have a plan for improvement. No doubt you believe that some of the issues raised by your supervisor are not completely irrelevant or incorrect. For those issues it should be possible to put a positive spin on things and identify ways in which you have made progress. Remember, building common ground to continue your PhD is just as important as resolving the issues you have. On second thought, you might even admit that some of the issues raised by your supervisor have some grounding in reality. If you have a plan about how to work on a specific issue, tell your supervisor about it. If you have no clue how to improve on some of the issues raised by your supervisor, be honest about this. He or she has a stake in your success and should be willing to help you work on those issues,

particularly since you have demonstrated your commitment by coming up with a solution for other problem areas. Your supervisor will be happier upon realizing that in telling you the truth, while painful, has indeed set some positive things in motion.

Saving an Old Master painting: Isabel in the hot seat

Wednesday morning, just after teaching his classes, Isabel's supervisor drops by her office. After some chit-chat about how unprepared the first year students in his classes seem to be, he suddenly announces that they should talk about the progress of Isabel's project and what she should do in the coming year. Although Isabel very much wants to have such a discussion, she is absolutely not prepared at this moment and feels very nervous. She manages to suggest that they have their discussion the next morning rather than right away.

That afternoon Isabel thinks about the things she feels are most important about her project and comes up with three[1] items she wants to discuss: (i) she likes the interdisciplinary team work with Yousef and Peter and wants to ensure that she can continue to work in that setting (remember that confirmation of things that are going well is an important aspect of such evaluation discussions); (ii) she wants to go to a major conference on art restoration next year; (iii) she is anxious to start on a new project as she anticipates long lead times in the preparation of samples.

During their meeting the next day her supervisor asks whether Isabel would like to say something first. Being prepared, she takes the opportunity to do so. The conversation starts on a good note when Isabel mentions that she is really enjoying the teamwork. On the other two issues raised by Isabel her supervisor is not

[1] For practical purposes, three topics or issues is an important upper limit for the things you want to discuss. Restricting yourself to the things you want is always good. Restricting yourself to three topics is important because few people can remember more than three arguments, or recollect more than three issues at a time.

willing to answer immediately. After some polite pushing by Isabel, her supervisor does set clear goals about what should be done to register for the conference and what needs to be finished first before a new project can be started. When Isabel mentions the long lead time of some parts of the new project, her supervisor is pleased to hear that she is staying ahead of the problem and agrees that she should work on the new project for half a day a week.

Towards the end of the meeting her supervisor asks the usual question: do you have anything else to say? A few minor points cross Isabel's mind, but Isabel decides to drop them in favour of the crucial point: that they agree on a short list of conclusions that came out of the meeting (later to be written down by Isabel and e-mailed to her supervisor for his approval). This way, Isabel will have a written record of their conversation and an agreed upon plan of action. By planning ahead, Isabel has escaped being put on the spot by her supervisor and coming across as flustered and lacking in confidence. She has turned the situation towards her favour by asking for time to prepare and presenting her wishes in a firm and confident manner.

Chapter 15

The Final Year:
Countdown to Your Thesis Defence

There is no happiness except in the realization that we have accomplished something.
Henry Ford

You're nearly there. One or more articles are already in print, and another one is in the publishing pipeline. Moreover, you have masses of promising data that still need to be analyzed. It is not yet clear, however, how these analyses might be integrated to create a cohesive body of work. Finally, there is one last project your thesis advisor wants you to work on. Altogether, there are several bits and pieces that fit into your thesis, while other things don't seem to have a logical place. You feel confident that you will be able to pull everything together within a year's time. But at the back of your mind a lingering question arises: how do I get from here to there? This chapter provides you with a framework to help support you in the crucial last months of your doctoral work.

Establish your achievements

The first step in planning the route towards your final goal is often neglected as unimportant, but it is essential to get a clear picture of where you are right now. In order to make explicit what you have achieved so far, you need to make a list of two types of research projects.

Start with the projects that are finished. For example, the part of your research that has already been published as journal articles and needs only a bit of editing to fit into your thesis. Next, list the unfinished projects you are currently working on. Try to identify the steps you'll need to take to finish those projects. These might include tasks such as sorting out the relevant data, writing and running a data analysis programme, synthesizing a message from the analyses, or searching the literature (again) to find out in detail what type of conclusions, closely related to your own research, that have already been reported. Do not forget to estimate any potential hurdles you will have to overcome to finish these ongoing projects.

Verify your achievements

Now that you have a good idea of what you've accomplished so far, it's time to make an appointment to discuss your insights with your supervisor. She or he might have a slightly different perspective on what you have achieved. For example, your supervisor may feel that not all of your finished research projects are appropriate to include in your thesis, or perhaps he will suggest that you include in your thesis some research that you have done in collaboration with others. Concerning the ongoing projects, your supervisor will probably not have the same detailed insight into their status as you do. She may underestimate what needs to be done, or bring up additional aspects of the projects that you haven't thought of. So ask for a meeting with your supervisor in which you want to discuss all the results you have achieved so far. Present your analysis in the form of a brief written report to your supervisor prior to your meeting. In this way your supervisor will be motivated to prepare for the meeting as well and can reflect on the state of your research results ahead of time. The key outcome of such a meeting is to establish a common understanding on what you have achieved for your thesis so far, and what still needs to be done.

What else should be included in your thesis?

Most likely you and your supervisor will agree (after a productive conversation) about what has been accomplished so far, and what still needs to be done to complete your ongoing projects. Opinions might diverge, however, when it comes to additional material that should be included in your thesis. Sometimes there will be stakeholders in addition to yourself and your supervisor. For instance, it might be that your direct supervisor is not your thesis advisor, or there may be a thesis committee that is actively involved in defining the content of your thesis. For the remainder of this chapter we will assume you have both a direct supervisor and a thesis advisor.

It might well be that while you believe that finishing the ongoing projects will provide sufficient material for a thesis, your direct supervisor might want you to include a minor addition, while your thesis advisor, being only remotely involved so far, wants you to start a new ambitious project. Debating and agreeing on these issues will not be easy. But you will need to make up your mind about what you believe is a proper balance between the quality and quantity of the content, on the one hand, and the additional time investment it will take to complete more work, on the other hand. Do this before you start discussing these issues with your thesis advisor. This preparative work involves a two-step process: first describe the final (as yet unfinished) project that needs to be included in your thesis, and second, make a countdown list (see below).

Describe your final project

To facilitate your discussion with your supervisors on what remains to be completed, your brief description of the (potential) final project should address at least three issues: First, prepare a brief project description that includes the means of acquiring the data, your plans on how to analyse the data, and your best guess on the type of answer you might get from your research (the hypothesis you are testing). Secondly, you should make an estimate about the types of hurdles and pitfalls you might encounter on the project and how you plan to overcome them. Base your estimates on the experience you gained in your previous projects. Once you know the required actions to finish the project, you will be able to estimate the time it will take to finish it. Again, try not to be too optimistic or unrealistic. It is best to base your estimate on your past performance in similar projects. This exercise will provide you with the missing information you need to complete your countdown list.

The countdown list

An example of a typical countdown list is shown in the inset and consists of two parts. The first part describes the content of your thesis (your ultimate goal), while the second part describes the planning strategy for how to get there. Writing down most of the chapter titles should be straightforward, once you've had a proper discussion with your supervisor about your achievements and results to date. The chapter on the new project may be an open-ended issue. By including that chapter both in the content list and planning section, it will become clear what the consequences will be if you add this project to your thesis. In the countdown list, time is allocated to each task. In reality you will not be executing one task at the time, but rather working on a few tasks in parallel. To get an impression of the total time the run-up to your thesis defence will take, you can write down the tasks sequentially. The best way to estimate how long a particular task will take is to use of your own experience from executing similar tasks. Otherwise, it may be a good idea to consult your peers.

The Countdown List

Part I – Contents of your thesis

Chapter 1: Introduction to the field of research

Chapter 2: Methodology, research instruments

Chapter 3: Research project 1 (already published as journal article)

Chapter 4: Research project 2 (manuscript submitted for publication)

Chapter 5: Research project 3 (data available, no conclusions drawn yet)

Chapter 6: Research project 4 (the new project??)

Chapter 7: Conclusions/summary

List of references

Part II – Planning
(the order of these actions might be different in practice)

Week 1	Transform your journal article into chapter 3
Week 2	Transform the submitted manuscript into chapter 4
Week 3–4	Write introduction (chapter 1)
Week 5–6	Write methodology (chapter 2)
Week 7–10	Analyse data for chapter 5
Week 11	Conference preparation
Week 12	Conference
Week 13–14	Draw conclusions for chapter 5
Week 15–17	Prepare final project (chapter 6)
Week 18–20	Write chapter 5
Week 21–22	Vacation
Week 23–29	Data acquisition for chapter 6
Week 30–33	Analyse data for chapter 6
Week 34–35	Draw conclusions for chapter 6
Week 36	Start job search
Week 37–39	Write chapter 6
Week 40	Write summary (chapter 7)
Week 41–43	Buffer (at least 5%–10%)
Week 44	Finalize draft thesis for thesis committee (*)
Week 45	Approval of thesis (*)
Week 46	Printing final version of your thesis
Week 47–48	Continue job search (see Chapter 16)
Week 49	Prepare thesis defence
Week 50	Thesis defence *

* Note that the actual procedure for the final approval and thesis defence will be different for different universities. Check with your thesis advisor about how much time it typically takes at your university.

Typical things you might learn from the countdown list

Once you have made such a list, you should reflect on the consequences of your planning. The first thing you may discover is that time has a way of slipping through your fingers. You may have already made a mental estimate of how long it might take you to finish your thesis, but now that you have made your list explicit by writing it down, you may notice it will probably take longer than you thought. Also, tasks you may have ignored initially, but are now clearly important, will also eat into your timeframe. But don't panic. This is the time to hone your time-management skills and your ability to focus on what is important. Your schedule is tight, so good planning will count. You can control your own time management, but be sure to take any necessary measures to make sure that any delays, such as waiting for others, will be minimal. If you are working in a team and need crucial data from other people, now is the time to plan a meeting to discuss exactly what needs to be accomplished in the (limited) time that is left. Finally, towards the end of this period, you will have to deal with the often complex procedures that come with submitting your thesis for approval. Make sure you know well in advance exactly what needs to be done and when.

Handling uncertainties

Probably the biggest uncertainty in your planning scheme will be the time you need to allocate to execute your new project (7 weeks in our example). Note, however, that if you exceed the allocated time by 4 weeks, the total planning (of 50 weeks) changes by less than 10%. Your total margin of error could indeed be larger. However, you might be in the unfortunate situation that the time it takes to execute one of your tasks is very uncertain. For instance, for the new project you have to rely on a sample that needs to be prepared by other people. Without that sample the project will be impossible to complete. In the event you foresee such problems and other potential bottlenecks, it may be useful to make two countdown lists. One, assuming that the sample is going to be delivered to you on time, and another one in which that project will be impossible to complete. Estimating these risks upfront will enable you to have a valuable discussion with your supervisor about these possible scenarios. Most importantly, this type of forward planning will minimize the uncomfortable feeling that you have a potentially critical problem ahead of you that is completely unanticipated and outside your control.

Discuss your planning with your supervisor/advisor

Now comes the hard part. You need to discuss your planning with your supervisor and thesis advisor, although you might feel that this is more a negotiation than a discussion. At one end of the table is you, the hard-working PhD student, who wants to wrap up the work in a reasonable amount of time (after all, you don't want to be in graduate school forever!). At the other end of the table is your thesis advisor, hungry for more research results that can be used in a future presentation or publication. And your daily supervisor stands somewhere in between. However, you are well prepared to back up your arguments by having made the countdown list. Perhaps your supervisors are not skilled communicators – they have been trained as scientists, after all. But your carefully structured plan will probably appeal to them. Give them your plan well before the meeting so they can think about it. In the event that you have a major disagreement during the meeting, keep your cool and avoid getting angry. Summarize the issues you don't agree about and ask for some time to reflect on their point of view. Sometimes these planning discussions cannot be finished in a single meeting, but they are worth doing properly. You will save yourself quite a bit of thesis preparation stress if you manage to structure a countdown plan on which all parties can agree.

The countdown is not carved in stone

Once you have made a countdown list that your supervisor and thesis advisor have agreed upon, you should try to stick to it. However, while working on the tasks in the countdown list you may notice that you are deviating from the planning. Even worse, trying to regain lost time is a losing proposition. If you find that you are really getting off track or that things are taking much longer than anticipated (remember, as much as we would like it to be, science cannot really be planned and it is unlikely your experiments will go according to schedule), your first reaction may be to work even harder and longer hours, or to go into denial about how much time you really need to finish. Rather than sticking your head in the sand, face your situation, make a new plan and discuss it again with your supervisor.

Saving an Old Master painting: Yousef wraps up his final year

Yousef is well into the last year of his PhD programme. From the start of his PhD project he has explored a new line of research in a large, well-established research group led by his supervisor, Paul, and his thesis advisor, Prof. Davis. At several meetings, including a prestigious international conference, Paul reported on his plans for a new ambitious project. Although some results have been obtained already, major breakthroughs have yet to materialize. In particular, they have had difficulty preparing the high quality samples that are required for this type of research. All kinds of problems have cropped up that were not anticipated. Yousef has often felt uncomfortable about the situation. At this late stage in the game, finishing in time almost seems impossible. Even if he gets the six month extension he has applied for, he has just over a year to complete his thesis research. Yousef vaguely knows that writing his thesis and submitting it to his thesis advisory board will take quite some time as well. Taking into account all these factors, Yousef realizes that only a few months remain for him to do the actual research. Some of Yousef's peers suggest that he make a countdown list. But even though Yousef, as an ENTJ type (see Chapter 8) is a strong believer in lists and structures, he is afraid that a list will be of little help in his case. The uncertainty of finishing the new project, in particular obtaining the high quality samples he needs, goes far beyond the planning of tasks on a weekly basis as required by the countdown list. Yousef ends up spending more time thinking about what to do than he does actually working on the project. His supervisor, Paul, notices the slow down in progress and sees that Yousef is spending most of his time hanging around in the hallway chatting with colleagues rather than working in the lab. On several occasions Paul passes by and urges Yousef to speed up the work, reminding him of the deadlines that are looming. This passing communication between supervisor and student is of little help. Yousef decides to talk to his mentor in the department. The mentor suggests that Yousef talk to Paul and Prof. Davis about establishing a Plan B, one that involves some simple experiments, just in case the more ambitious project fails. Yousef and his mentor realize that Paul is probably not yet willing to give up on the project, because if successful, it will bring so much glory to the group, and aid in his own climb up the academic ladder – as well as to Prof. Davis' reputation in the field. Therefore, the mentor suggests that Yousef do two things. First, convince Paul and Prof. Davis that at some point a Plan B is the only way to rescue the thesis. Second, that a logical moment should be defined when it is time to switch over to Plan B. In order to structure that discussion Yousef created two scenarios, as described in the countdown list. In the first plan it is assumed that the much desired breakthrough is made in a reasonable amount of time (e.g. 3 months). The second plan describes how to continue, if, despite all the effort, the sample preparations do not work out.

Yousef decides to take the risk and goes to see his supervisor and advisor with the two versions of the countdown list in hand. Paul, the ambitious supervisor, is upset about the idea of quitting the project when Yousef makes a suggestion along those lines. Wisely, Yousef decides not to reveal the countdown plans just yet. A few days later Paul and Yousef meet at the coffee machine. Paul admits that the project may be a little too ambitious for Yousef to successfully complete. Yousef finds it difficult to accept this subtle attack on his skills, when the judgement of his supervisor about the feasibility of the project's success has also played a role. Yousef suggests that they talk again and that he will think about alternatives. At that second meeting he brings the countdown plans and shows them to his supervisor and advisor. After some discussion, Prof. Davis and Paul and Yousef agree to do the utmost in the coming ten weeks to make the project a success. If, by that time, the sample preparation still hasn't worked they will switch to Plan B. After the meeting Yousef feels relieved. Now he can start concentrating on his work. Much to Paul's surprise, he rarely sees Yousef hanging around in the hall anymore. Yousef is much too busy in the lab working towards the completion of his thesis research.

Chapter 16

Putting it all Together:

A PhD … so What's Next?

Science is a wonderful thing
if one does not have to earn one's living at it.
Albert Einstein

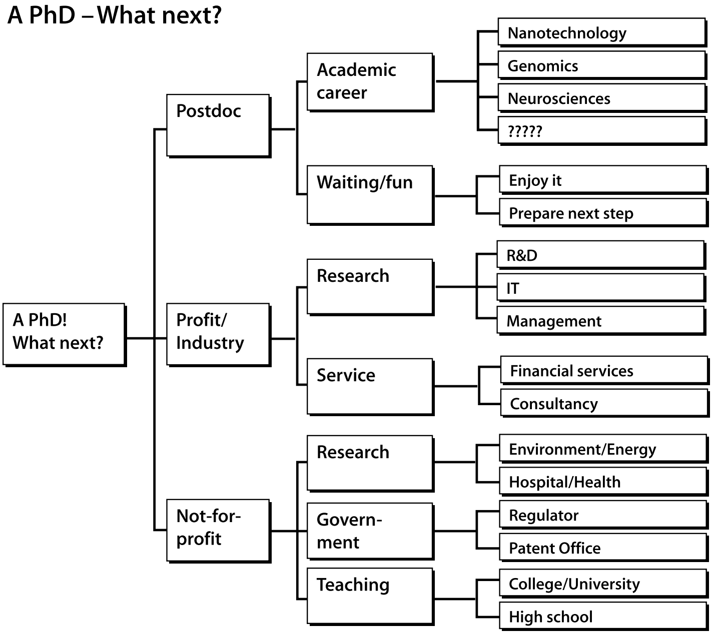
You're about six months away from your thesis defence. After spending so many weeks and months at the computer writing your thesis, it is probably hard to imagine that there is life after grad school. Perhaps you are so intent on finishing your thesis and getting through the defence, that you have avoided the fact that after the defence ceremony, a true milestone in your life if there ever was one, that you will have to find a job. Deep down, however, you are aware that you will have to make some important decisions – and you can't keep putting them off forever.

For example, do you want to stay in academia? Or would you rather pursue a career in industry? Should you stay in your own country or would you like to explore new opportunities abroad? These questions are not easy to answer and you will probably not be able to answer any of them overnight. This chapter aims to get you started in the decision-making process and to assist in guiding your thoughts. Two issues will be addressed: Which kind of job suits you best, and how to go about getting your dream job.

Opportunities for a newly minted PhD

Once you start thinking about the type of job you'd like to have after successfully obtaining your doctorate, you will soon discover that the possibilities are overwhelming. Somehow you will have to find a way of making sense of all these potential opportunities – and discovering which path will be the right one for you to take. A decision tree like the one shown in Figure 1 can be of help in narrowing down the choices.

This tree assumes you have a PhD in the natural sciences, but keep in mind that it is just an example, and, depending on your discipline and interests, may look quite different. This model tree should inspire you to make your own personal decision tree. For many of you the first question you might try to answer is: do I want to do a Post-doc or not? The no-Post-doc category can be further broken down by splitting it into two categories: positions in the corporate sector and positions in government and other not-for-profit organizations. In the following sections we discuss these three options in some detail.



The next logical step: a Post-doctoral fellowship

You are trained as a lab scientist, your supervisor is a scientist, and perhaps a professor you met at a conference has offered you a position as a scientist. So what's stopping you from taking the natural next step: accepting the offer to work as a Post-doctoral fellow? Post-doc positions are relatively easy to come by and accepting such a position saves you the hassle of going through several job interviews. But there are at least two better reasons than this to continue your career by taking on a Post-doc position: 1) being a Post-doc is the logical and expected next step for those who wish to follow an academic career; and 2) as it is less stressful than getting a PhD (you've got no impending thesis hanging over your head like the sword of Damocles), it is a good way to really enjoy doing science.

An ambitious PhD with his or her eye on doing a Post-doc will often wonder which school is best for them and how to choose a research area that will optimize their chances of working their way to the top of the academic ladder. No doubt it helps to go to a top school and work in a field that is currently in fashion (nanotechnology, genomics, neurosciences, etc.). But there are many other ways to become successful in the long term. Whatever you decide, make sure you do what is right for you, and that you are making decisions that are realistic and will help you reach your goals.

Looking further down the road, when you apply for an assistant professorship (after being a Post-doc for a few years), the search committee will want to see what you have achieved during your post-doctoral period. If the science you have done is impressive, the rest is less relevant. Ask the senior scientists around you which choices they made to get them where they are now. As you will probably discover, they have most likely all done good research, some at top schools, on trendy projects. If you decide to do a post-doctoral fellowship as a sort of stop-gap measure and without the intention of pursuing an academic career, make sure you choose a position, location, university, and/or lab that you will enjoy, and start thinking about what you will want to do afterward, such as work in industry or for a not-for-profit organization. Also, you might want to consider getting involved in some extra-curricular activities that might be relevant to your future new field.

The corporate sector: where business and science meet

We'll start with the most important message first: if you think you want to work in industry as opposed to academia, do not wait. Get started on your search right away. Jobs that most PhDs have in the corporate sector can be classified into two types of industries 1) research-related companies that hire skilled experts and 2) service companies that need analytically skilled staff.

Research-related industries either make high-tech products (e.g. Microsoft, Philips, Siemens, IBM, GlaxoSmithKline, Merck) or need high-tech people to make their products (Shell, Exxon, Unilever, Springer-Verlag). These industries tend to be large and multi-national. Jobs in small and medium-sized enterprises (SMEs) are scarce these days, but not impossible to find if you have the right connections. Often scientists start in the IT or R&D branch of the company, and then move on in the course of 5 to 10 years to management positions. Sometimes you can start immediately in a management-type position. Many PhD students are put off by the idea that they will not be able to do research forever within a company – after all, isn't bench science what you've been trained to do? However, very often you will find that your interests change over time. For the real scientific diehards, and those who can't imagine working outside the lab, almost all companies have some senior research positions.

Companies in the service sector tend to be less interested in the actual content of your PhD research and value instead your analytical and problem-solving skills. Quite a few PhDs find jobs as financial analysts, risk assessment analysts or management consultants. All major financial institutions and global operating consultancy firms hire talented people with a PhD in the natural sciences, as well as in other disciplines.

Not-for-profit organizations – the best of both worlds?

Several years in the lab have most likely taught you one thing: you like doing science and using your analytical skills. But it could be that you also want to avoid both the insecure academic track and the acutely business-oriented approach of the corporate world. If this sounds like you, a not-for-profit organization may offer an appealing career alternative.

Actually, there are a wide variety of jobs that welcome PhDs in the natural sciences, that have either more or less emphasis on doing research. We discuss three of them in decreasing order of their research component.

1. **Government labs.** Rather than concentrating on the fundamental aspects of research, government-sponsored laboratories tend to focus on areas of research that have a broad impact on society, such as future energy sources and technologies, public health, and the environment. Their research goals are often long term, and relevant to society's needs. By focusing on the long term, the pace in these laboratories is often less hectic than that in industrial laboratories. The nature of the topics, however, and their relevance to real life issues, often helps researchers feel highly motivated about their work.
2. **Governmental organizations.** These types of organizations offer a wide variety of jobs for which a thorough understanding of science and technology is often required, but no active research is carried out. National patent offices and regulatory bodies are examples of such institutions. Setting rules and prices for electric power, telecommunication, and so on require technical insight in the subject, understanding of the market economy and how the government regulates it. Big companies depend heavily on this relationship between government and industry. Also, their Regulatory Affairs departments welcome PhD's with technological backgrounds and analytical skills.
3. **Educational institutions.** Finally, let's not forget to mention the fount of all scientific progress: education. While you must have Post-doc experience to be able to teach at the university level, colleges and high schools are desperately seeking highly qualified teachers. If you like the idea of shaping young minds, it can be a rewarding experience to educate and inspire the next generation of scientists.

Is your final decision carved in stone?

Many PhD students believe that once you have chosen between academic, industry, or not-for-profit you'll be obliged to stay on that career path forever. Since these choices are often thought of as being carved in stone, the decision can seem overwhelming and is often postponed. But how final is that decision really? How difficult is it to swing from one branch of the career tree to another? To give you some idea of what this might look like, we'll describe an average situation that could have occurred any time during the last ten years, noting that the flexibility of the job market can play an important role.

Just because you may choose to take a position as a Post-doc, it does not automatically mean that you have to follow an academic career path. Many Post-docs end up in industry or in not-for-profit careers. However, the older you are as a Post-doc, the more difficult it may be to find a job in one of the other branches. Corporations are notorious for wanting to hire young and hungry PhDs for their entry-level positions. So if you are sure you ultimately want to pursue a career in the corporate sector do not hang around working as a Post-doc for more than a year or two.

Switching from the corporate sector to a not-for-profit organization is a move that can be made at any time. Going from industry back to the academic track, however, is more difficult. In practice, only those who work in a research department of a multinational company manage to make the transition to senior academic positions. Finally, the not-for-profit jobs have the (undeserved) reputation of being a dead-end; once you are in, you will never get out. This is certainly not true for all jobs. For instance, once you are an experienced employee for a patent authority or regulator you are also a very attractive experienced hire for the corporate sector.

From searching for opportunities to getting the job

Congratulations. You've figured out which type of job is right for you. Now what? Suppose you have selected a job type based on a decision tree like the one shown in Figure 1, the next move will be figuring out how to get that job. A toolbox of skills to help you in applying for such a position includes writing an effective cover letter and curriculum vitae, learning how to emphasize your strong points and deal with your weaknesses, etc. There are many books, workshops, and courses available on how to acquire the skills you need to get a job, we felt it would be superfluous to discuss them here. Three specific issues related to PhDs will be discussed here, however: a) When to start your job search, b) How to use your network (yes you have one!), and c) How to prepare for a job interview.

When to start your job search

The key to the numerous steps involved in getting a job is the ability to see things from the employer's perspective. Suppose you are a recruiter for a large company that hires 30 scientists a year. Two candidates come into your office. Candidate number 1 tells you that he got his PhD six months ago. Right after his PhD he took a trip around the world for four months. It was while he was unpacking that he realised he needed a job and that's why he's here. Candidate number 2 says: "my PhD defence is in two months, after which I plan to take a month's holiday. I am here to find out whether you will have an opening for me three months from now." Which candidate would you be more interested in hiring? For many jobs planning is essential, and you can demonstrate that skill by timing your application properly and showing your interest ahead time. It should be obvious, unless you are independently wealthy, that you should start your job search well before you obtain your degree.

How to leverage your network

Although the website of your preferred future employer can provide you with a wealth of information, it lacks the richness, essential details, and the necessary inside information that you can only get from a real expert: a former colleague who happens to be working there. Go and talk to him or her. You will get a feel for the company culture, find out what type of job opportunities exist, and get a sense of whether you will like working there once you've accepted a position.

Every career coach will tell you to use your network, but where is it and do you even have one? It seems you know almost no one who has the type of job you are looking for. However, many PhDs have graduated from your institute in the past five years and your supervisor or other staff members most likely know how to find them. Contact these former colleagues. They have been in the same position that you are now, and probably they'll be very happy to discuss the pros and cons of their current employment.

As a PhD student, which typical skills do you possess?

More than you probably think! Suppose you apply for a position for which a PhD is not mandatory. The recruiter will probably perceive that you, having a PhD, have certain competitive advantages over other candidates. What are these advantages and how can you demonstrate them? To help you get a better sense of who you are and all that you can do, make a list of the skills you developed during your doctoral training. Don't forget that your training as a grad student has taught you much more than science. You have acquired valuable skills in problem solving, analytical thinking, time management, project management, supervision, giving oral presentations, communication, and teaching to name just a few.

How to prepare for an interview

It goes without saying that being properly dressed and behaving politely are important when you meet your prospective future employer for the first time. There are many books and workshops available on how to make a good impression during an interview. Make use of everything that is available to you regarding this important phase in the job hunting process. At some point, you'll move beyond talking to the people in personnel and have to start talking to the people in the department to which you are applying. Keep in mind that these people are not professional interviewers and meeting new applicants is just one of their tasks. First they will ask what you have done in the past, what you expect from your new job, and what your long-term plans are. Since you have already prepared the answers to all these questions, you have nothing to worry about for this part of the interview at least. But now comes the hard part: you have to become an excellent listener and pay attention to the interviewer when he/she tells you about their job. For the purposes of the interview, he is an expert in the field and you are completely ignorant, so be careful to act accordingly and not to come across as someone who knows it all. Sometimes you'll be lucky and happen to know one or two things about the work being described. Most likely this part of the interview, and how well it goes, will play a major role in the final decision to hire you or not.

One of the best ways of impressing an interviewer is by being a good listener. So pay attention, try to summarize what he has been saying (So if I understand you correctly, you are doing…) and most importantly ASK QUESTIONS. They know you are not an expert so feel free to ask if you do not understand things. Most applicants ask too few questions because they're afraid to show their ignorance. You have to practise asking questions, so try to do that before the interview, either alone or with a friend. Good opportunities for getting accustomed to asking questions can be found at the colloquia you are attending. Force yourself to ask one question at each colloquium. At some point you will get used to it and asking questions during your interview will feel as natural as breathing.

Do you want the job?

During your job search, you might become so anxious about getting a job, any job, that you may forget to ask yourself whether you really like the position that has been offered to you. Again, stay in the lead. Make sure you have made an active decision based on what you want (e.g. by making a decision tree). Use the interview to get a better feeling for whether you would like to work for that particular department/company. Also, make a realistic estimate regarding any other positions you might be offered if you decide to decline an offer.

In summary, don't wait too long to start thinking about what kind of job you want after your PhD. Before you write your CV and start sending out applications, you need to become familiar with the opportunities available and have a good idea of which job will be the right one for you.

Swinging from branch to branch on the career tree

When starting out in your post-PhD career, the system may seem to be rigid and inflexible. PhDs looking back on their career usually notice that they have actually been swinging through the career tree quite a bit. Here is what the members of our team decided to do once they'd obtained their degrees:

Saving an Old Master painting: career tracks with a touch of art restoration

As a child **Isabel** was fascinated by paintings, in particular the Old Master paintings in which some of the figures were mysterious and barely visible. Having studied chemistry as an undergraduate at university, she still wanted to do something with art. She learned about the scientific aspects of art restoration at a chemistry conference on polymerization processes. Then she embarked on her PhD programme as discussed elsewhere in this book. As the end of grad school draws closer, Isabel begins to realize that it is time to start looking for a job. Unfortunately, she fears that the chances of finding one in the field of art restoration are slim, especially for a chemist. So what to do? Isabel makes an attempt to analyze what she likes most about doing a PhD. After some discussions with friends, Isabel realizes that she appreciates in particular two aspects of her PhD programme. First, she enjoys using multiple analytical techniques (X-ray, mass-spectrometry, IR imaging) to reach scientific conclusions about the nature of the paint pigments. Second, she likes interacting with experts outside the world of natural sciences, who put the scientific results into a broader context (the art historians' perspectives were essential for obtaining a complete picture of the original painting). She likes working with real masterpieces of art, but it was a less essential part of her work. But once she has in mind her two favourite aspects of the research, no particular job comes to mind. One night, while watching a forensic series on television, Isabel realizes that a job in such a laboratory is actually a perfect match for someone with her ambitions. To Isabel's surprise her professor knows the head of the analytical research department and he arranges for Isabel to meet with him. During that visit Isabel learns that they indeed use a wide range of analytical techniques at the forensic lab, most of which she already knows how to perform. Furthermore, she finds out that interactions with non-scientific experts, such as police inspectors, is an important part of the job, and for solving criminal cases. Now that she is well motivated and prepared, Isabel applies for the job. Five years later, she is head of the analytical services department of the forensic laboratory in her state.

After obtaining his PhD in physics **Yousef** accepted a position in the R&D department of a multinational oil company. After a few years of basic research on oil derivatives, he moved to the consultancy branch of the same multinational. Now he is responsible for in-house advice on regulatory affairs, together with a lawyer and a marketing consultant. When asked whether working on a PhD was a valuable investment Yousef always replies: 'Yes! In particular the skills I learned from structuring and solving complex problems within an interdisciplinary team turned out to be very valuable'.

Initially, **Peter**, a talented art historian, did not want to pursue an academic career. After a short Post-doc he joined a leading ICT company. Although he was working on demanding and complex problems, he missed the explorative nature of basic research in art restoration. At an alumni event his former supervisor mentioned that there was a starting position available in art history at a nearby university. Peter goes to the job interview and suggests to the search committee that they hire two assistant professors rather than one, and that the additional assistant professor have an analytical chemistry background. The university likes the idea and contacts the dean of the natural sciences department. With some extra money from an art restoration foundation they set up this unique interdisciplinary team. Peter is enjoying his new job and is happy to be back in the world of art history and restoration and working again with the chemical side of this challenging field.

Chapter 17

Writing Your Doctoral Thesis with Style

If I have seen farther than other men,
it is because I stood on the shoulders of giants.
Sir Isaac Newton

All the raw material for your thesis is ready – at least it should be if you've successfully worked your way through the countdown plan as described in Chapter 15. So now it's time to wrap things up and write your doctoral dissertation. This is easier said than done, of course, and you cannot hide from the fact that you still have a lot of work ahead of you. But don't let the thought of writing your thesis paralyze you into a state of inertia. Like any big project, writing your thesis is easily doable if it's broken down into smaller steps. In fact, you have already done this by having written at least a couple of articles that are ready to be transformed into chapters. Keep in mind, however, that a research article written for a peer-reviewed journal is not the same thing as a chapter in your thesis. Even if you've published several articles, you can't just staple them together and – voilà! – create an instant dissertation. There are some fundamental differences in these two types of writing which we will discuss in detail in this chapter.

Although you may be feeling a bit stressed (or even a lot stressed) that the deadline for completing your thesis is approaching, writing a thesis will be a new (and hopefully exciting) phase of graduate school. See it as a challenge, and whatever you do, don't think of quitting now. Too many graduate students leave their programme after having done everything but write their thesis. Maybe you think that those two little letters in front of your name won't matter, but one way or the other, your degree will be of help in your further career. It would be a shame to have done so much work and leave graduate school without that coveted degree. Likewise, you may be the kind of person who loves working in the lab, but hates sitting down to write. In this chapter we present a few suggestions for making the process as straightforward and painless as possible.

First things first: decide on the table of contents

If you didn't make a countdown plan as described in Chapter 15, there is at least one aspect of it that you need to address before you start writing: make sure you and your supervisor agree on the table of contents of your thesis. This might seem obvious, but we have seen too many students start working on chapters without discussing it with their supervisor, only to find that those chapters had to be tossed out. As soon as you have agreed upon the table of contents, you should start talking with your supervisor as soon as possible, and in more detail, about what you are going to put in those chapters. We've repeated here the schematic table of contents that was presented in Chapter 15.

Table of contents

Chapter 1:	Introduction to the field of research
Chapter 2:	Methodology, research instruments
Chapter 3:	Research project 1 (already published as journal article)
Chapter 4:	Research project 2 (manuscript submitted for publication)
Chapter 5:	Research project 3 (data available, no conclusions yet)
Chapter 6:	Research project 4 (data available, not analyzed)
Chapter 7:	Conclusions/summary
List of references	

Cut the problem down to size: write an outline

Now that you've agreed on your table of contents, it's time for the next step: writing an outline. For a written document as complex as a doctoral thesis, it is essential to work from an outline to keep you on track and provide you with a framework for the text. Writing an outline will also force you to break up the writing process into manageable pieces. Your outline should consist of several pages that contain chapter headings, sub-headings, figure and table titles and some keywords and essential comments. Once you have created a comprehensive outline, you will have a framework or scaffold from which to work. In addition, an outline is a great tool for preventing writer's block, as you only need to fill in one section at a time of your outline, rather than face the enormous task of writing a document that will be well in excess of a hundred pages. When you sit down at the keyboard, with your outline in hand, your aim is no longer to write an entire thesis – a daunting goal without a doubt – but something much simpler. Your new aim is to write a paragraph or section about one of your subheadings. When you first start out, it helps to begin with an easy section: this gets you into the habit of writing and gives you self-confidence.

Getting down to fundamentals: what's a PhD thesis anyway?

Whether you call it a dissertation, a doctoral thesis, or a PhD thesis, it all boils down to the same thing: a massive undertaking and a serious and substantial piece of written work. Depending on whom you ask, you'll probably get a different answer to the question of what a PhD thesis is. But before you get heavily involved in the writing phase it may help to get a grasp of what it is that you are attempting to accomplish. Most people tend to agree on the following definition of a what a PhD thesis is (and is not):

A PhD thesis is:

- A formal piece of writing, quite substantial in length, that presents original data in support of a particular thesis or supposition.
- A comprehensive body of data. The scientific method requires you to state a hypothesis and then gather data to support or negate

your hypothesis. Before you can write a thesis defending a particular hypothesis or hypotheses, you must gather *sufficient data* to support it.

- A thorough analysis and interpretation of the data you have collected. This analysis forms the heart of your thesis.
- A document in which *every statement* is supported either by citing the scientific literature or your own (original) work.
- A document in which every statement must be correct and defensible in a logical and scientific sense. There is no room in your thesis for suppositions and conclusions that you pull out of thin air.

A PhD thesis is not:

- A diary of your days in the lab. You must present your work in a way that demonstrates your mastery of a given topic. You will not be awarded a PhD just for writing down everything you did in the lab over the course of several years.
- A collection of published articles. A PhD thesis is similar to writing a book. While you can take your published papers and turn them into the core of your thesis, the thesis as a whole should stand alone and be cohesive in presentation and scope.
- Written in solitude. It is important to have other people involved in the thesis writing process, if for nothing else than for checking your first drafts and proof-reading your final ones. You also need to involve your supervisor so that he/she can tell you when to stop writing. As the person doing the PhD, you are too closely involved in the process – you must, therefore, ask for expert and third-party advice. Remember, too, that a good thesis, just like any well-written text, is designed for the benefit of the reader. So try to get several people to read your thesis and listen to their suggestions for improvements.

As you work, be sure to keep the above points in mind. It may also help to re-read several dissertations from former PhD students in your group or department in order to get a feel for the appropriate style and tone.

Pick a straightforward format and layout

You can spend an endless amount of time designing a special format and layout for your thesis. If you are not an expert in desktop publishing, however, we suggest you save yourself a great deal of frustration and time by copying the format of another student whose thesis layout appeals to you. Make sure the format is easy to use, however, as you do not want to find yourself spending many days on learning a new and fancy software programme – at least not at this stage. Once your thesis is sent to the panel or committee for review (a process that usually takes several weeks or months), you might want to consider upgrading your layout. For the time being this should not be your major concern.

Transforming (published) articles into thesis chapters

You most likely have a few articles already published in peer-reviewed journals or at least submitted for publication. So it may seem like a straightforward matter to transform those articles into thesis chapters. But transforming articles into thesis chapters isn't just a question of copying and pasting the appropriate text. The following are some suggestions for creating cohesive thesis chapters from your published articles or submitted manuscripts.

- First of all, you will have to rewrite the introduction section of each article to put the chapter into perspective with the other chapters in your thesis. There is no reason to repeat in each chapter introduction what you have already explained in your general introduction and literature survey in Chapter 1 of your thesis.
- Also, the Materials and Methods section can be shortened since you have already presented most of that information in the chapter on methodology. Don't make this section too brief, however, since the reader must be able to read each chapter independently without having to flip back and forth to other chapters for important information.
- Update your references. If your published article is somewhat out of date, you should include the latest literature in your list of refer-

ences. Moreover, refer to the other chapters of your thesis, where applicable, rather than just referring to your published journal articles. The thesis must be a cohesive piece of work in its own right that can be read and understood without having to refer to additional literature.

- Avoid repeating figures already used in preceding chapters. No matter how useful it was to illustrate in each article a (slightly modified) version of your experimental set-up, for example, in a thesis such a series of illustrations is often unnecessary and redundant.
- Adapt the format of your article to that of your thesis. For instance, if you transform a short article or letter into a chapter, insert the headings (introduction, results etc) at the appropriate positions.
- Include paragraphs that did not make it into the final version of the article. Often there are space restrictions on your article set by the journal editors. So you may have had to sacrifice a couple of interesting paragraphs to meet the journal's requirements. Now you can use these paragraphs (and figures) at your own discretion, since they will be a valuable addition to your thesis.

Chapter Two: the first piece of new text

Now that you have transformed your published articles into chapters your thesis is starting to get some heft to it. Although you probably realize that the tough part is yet to come, take a moment to enjoy the progress you have made so far. From now on, you will have to write new text for the remaining chapters and that will slow down your progress quite a bit. Since writing the methodology chapter is relatively straightforward, we suggest you start with that one. You have already written several methodology sections for your articles so you probably won't need much help in making a first draft. Since a thesis has fewer space restrictions, you should take the opportunity to describe some of the details of your work that did not make it into the articles. In a thesis, it is better to err on the side of being too detailed than risk leaving out crucial information. Be generous

to the next generation of researchers. A detailed description of your progress and failures, in terms of your materials and methods, will save them a lot of time.

The last set of data: chapter or article first?

Now that you have worked your way through the initial chapters and have written most of your thesis, it is time to tackle your final project. In this particular case you probably haven't written an article yet and you will need to decide whether to write the article first and transform it into a chapter or do it the other way around. If there is stiff competition in your field to get results published as quickly as possible, your supervisor will probably insist that you write the article first. If this isn't the case, we suggest that you write the chapter first, as this approach will allow you to describe your work, including all the details, from which you can select the appropriate parts for an article later on. While the thesis is out for review with your dissertation committee, you can transform the chapter into an article and submit it to a peer-reviewed journal.

The introduction: the final hurdle

A good introduction to your thesis is crucial for putting your work into context and it is probably the most difficult section of your a thesis to write. This is your opportunity to describe your work in a broader perspective, including an explanation of why the research was relevant (to the scientific community and society in general) in the first place. Although you will probably write this chapter towards the end, you should start thinking about it long before then. During your last year as a PhD student you should create a file in which you collect ideas and article clippings that might fit into the introduction. Once you start writing the chapter you will have a ready source of ideas, some of which might fit in well, while other notions may be harder to incorporate. This strategy of collecting ideas for your introduction requires some discipline, but it will save you from writer's block when faced with writing the introduction. It can be highly stressful if you have no clue what to write, all the while with a deadline hanging over your head. Having a file of good ideas will be of help in writing a comprehensive and elegant introduction when the pressure is on.

The summary

You may not be required to write a summary for your thesis, but even if you're not, a good summary is essential, so take the opportunity to write a high quality one, as this is the one section of your thesis that is sure to be widely read. In a few pages you will have to describe the main findings of your thesis research, so it is best to write this part after you have finished all the other chapters. Do not, however, try to describe all your results in the summary. If the density of information is too high, people will stop reading your summary, and probably put your thesis aside altogether. Also, be sure to clearly designate in which chapters particular findings are described in more detail.

Going for gold: writing an error free thesis

Since a thesis is usually written under severe time constraints, it is difficult, and probably not realistic, to write a thesis that is completely free of typos and other minor errors. Spell-checkers do help, but they have limited use in a document that, by definition, will contain numerous scientific and technical terms that will not be recognized by the spell-checking software (you can build these into a glossary on your computer, of course, but this takes time). In addition, errors of grammar and syntax are not always highlighted and minor scientific errors can be easily overlooked. Your goal, of course, is to have the minimum number of errors in your thesis as possible. We suggest you do two things to help make this a reality. First, put the manuscript aside for a short while after you've written the first draft. Once you're feeling refreshed and have gained some distance from the material, read it over again with a sharp eye, not for content, but in the guise of a proof reader who is only looking for typographical errors. Second, you should give a copy of your thesis to one or two trusted peers to read and devise a creative way to reward them for every error they find (free cups of coffee, beer, or pizza, for example). This will give them an incentive to go through your thesis with a fine-toothed comb.

Be generous with acknowledgements

Some universities allow you to thank and acknowledge co-workers at the end of your thesis. Take the opportunity to do so and thank whole heartedly all those people (don't forget family and friends), including other students, Post-docs, your supervisor, and lab technicians, who have made your work possible

Ten tips for a stress-free dissertation

1. Don't save data analysis to the very last minute. Plan ahead.
2. Confirm your table of contents with your supervisor.
3. Write an outline (and stick to it as you write).

4. Don't reinvent the wheel: transform your published articles into thesis chapters.
5. Create a time frame (and deadline) for yourself and stick to it.
6. Find a quiet place to write where you will be free from distractions (the lab is usually not a good place to write a thesis – work from home or in a quiet place like the library).
7. Assign yourself a number of pages to write each day and stop when you are done. This will prevent you from spending 24 hours a day at the computer, agonizing over your progress. When you've written your assigned 4-5 pages, then you're finished for the day. Turn off the computer and do something else.
8. Take plenty of breaks, and be sure to spend time with friends and family. Just don't bore them, however, by constantly talking about your thesis and complaining about how hard it is to write.
9. Get some exercise, eat well, and take care of your health.
10. Don't work in utter solitude. This is not the time to turn into a hermit. If other PhD students in your lab or department are writing their theses at the same time, consider creating an informal support group where you can share the stresses of writing a thesis and have people at hand who are willing to read or proof read certain sections or even the entire manuscript.

Chapter 18

The Final Act:
Defending Your Thesis with Panache

> *The aim of science is not to open the door to infinite wisdom, but to set a limit to infinite error.*
> *Bertolt Brecht*

The day has arrived and you are almost ready for the final act. You have completed your *magnum opus*, submitted it to your thesis committee, and received permission to move onto the next and final step: defending your doctoral thesis. Whether you like it or not, it is show time. You may have been working towards this day for several years, but defending your thesis will require a different set of skills than you are used to using for your regular research and writing activities. The prospect of this 'oral exam' may seem extremely daunting (not to mention frightening) at this time, and you may be wishing you had already passed through the whole thing and were holding your coveted degree in your hands. However, if you think of your thesis defence as a rite of passage, a necessary test of knowledge and competence, and the final challenge that you must undergo before you reach your final goal, it will not seem all that insurmountable. And if you take the time to prepare for your thesis defence, you will feel strong and confident going into it. In this chapter we offer a few suggestions to help you defend your thesis with panache.

Depending on where you carried out your PhD research, there will be quite a range of formal procedures and regulations connected to your actual thesis defence. In some countries, and at some universities, the defence is almost a formality, with no tough questions fired in your direction, and no prospect of failing. If this is the case at your institute, your thesis defence will consist of an hour or two of non-aggressive questioning in front of your friends and relatives. At other places, the candidate is endlessly interrogated behind closed doors by an international committee and there is a small, but finite, chance that the candidate will not pass, and not be awarded with a doctorate. For the remainder of this chapter we assume that you will have to deal with a situation that lies somewhere in between these two scenarios: an oral defence that is open to the public in which serious questions about your thesis will be posed by a committee of examiners, but the chances of failing are minimal. Although our advice assumes that you will be participating in a mild form of thesis defence such as this, our suggestions should also be of help to those who are required to undergo a more rigorous defence.

In our opinion there are only three things you need to do to ensure that your thesis defence is successful: prepare, prepare, and … prepare.

Familiarize yourself with the formalities

A thesis defence has the characteristics of both an exam and a ceremony. All ceremonies, from PhD defences to weddings, tend to have a set of formal rules that must be followed during the ceremony itself (such as standing when the committee enters the room) and things that must not be done (address the examiners by their first name.). Since you are probably not intimately familiar with these rules, you will need to pay extra attention to how you behave, all while having to answer difficult questions and keep your composure.

Combining these two tasks is not easy and may even require a little 'sleight of hand' to pull off. One thing that can really help put your mind at ease, in terms of the formalities, is knowing the formal procedure by heart beforehand, so you can focus all your concentration on answering the questions posed to you. To that end, you might want to go to a few thesis defences of your peers prior to your own defence. You will get a feel for how the rules work in real life and there won't be any surprises during you own thesis defence (at least in terms of rules and procedures). In short: don't go into your thesis defence unprepared. Familiarize yourself beforehand with the rules and regulations such as how to address the examiners, when to stand and sit down, what the dress code is, and anything else that will be expected of you during the ceremony.

Prepare yourself scientifically

There is no doubt that *you are the expert* on the science you'll be discussing and defending during your thesis defence. After all, you'll be talking about work that has been the focus of your time and attention over the past several years. Do not, however, underestimate the committee's knowledge of your subject. Moreover, in the formal setting of a thesis defence, you have one truly big disadvantage: while your examiners have been able to prepare their questions beforehand, you have to reply to them on the spot. Some of your examiners will be very good at finding a few delicate or controversial issues in your work and they will certainly question you about them. Remember, it is much easier to ask a difficult and probing question than to answer it on the spot, with hardly a moment to collect your thoughts. While standing in the spotlight, you may even realize (*quelle horreur!*) that it has been quite some time since you even thought about some of the issues now being pointedly addressed. So we advise you to *read your thesis again*, this time with a critical eye and perhaps with a highlighter in hand, in the week or two before your thesis defence in order to refresh your memory about the experimental details, experimental setups, results and conclusions that are described in your thesis. As you read, put yourself in the role of the examiner. What would *you* ask the writer of this thesis? Where are the trouble spots, the unresolved issues, the shaky conclusions? If you can guess some of the questions you will be asked beforehand (and prepare the answers), you will be much better off and more prepared for the defence itself.

No matter how well you know your own research, and how well you've prepared beforehand, it is not always easy to phrase the answers properly in public. To improve your skills in responding in public to all kinds of incisive or roundabout questions, we suggest you take part in a fun exercise. Invite a couple of colleages from your institute to have dinner at your place. Make sure that you invite both experts in your field (e.g. a Post-doc you worked closely with) and those who are less familiar with your work (the PhD student working in another group down the hall). While you serve and eat dinner (the multitasking aspect of the exercise) your guests will ask you questions about your thesis. Some of these questions may trigger you to read a particular part of your thesis again, while other questions will train you to bring your work into the context of an outsider's perspective. No matter what kinds of questions you are asked by your dinner guests, however, you are training yourself to respond right away – and with poise – all the while staying cool and collected as you serve and eat a meal.

Prepare your act

Since a thesis defence is a formal ceremony as well as an examination, you will have to act accordingly and play the highly scripted part that is expected of you. It will not be sufficient to mumble a brief reply to a question while staring at the floor. From experience, we can assure you that the examiners will not be pleased if you keep replying to their questions with, 'yes, no, no idea,' and so on. Answering a question properly is a three-step process.

1. First, you need to listen to the question carefully. Too often PhD candidates stop listening halfway through a question because they believe they know what the question is all about, or they are so nervous they start preparing the answer in their heads while the question is still being asked. Sometimes the real question only comes at the very end of a long exposé (in which the examiner may be trying to show off a bit), so you have to listen carefully the entire time the examiner is speaking. To ensure you maintain your concentration throughout a long monologue, you might want to take simple notes, or jot down key words as they are spoken by the examiner.
2. In the next step, you should begin your answer by rephrasing the question briefly and politely (remember it is also a ceremony) such as *'esteemed professor your question on the research described in Chapter 4 addresses the issue of the ageing of paint pigments from an interesting perspective. If I understand your query correctly you wonder why …'* This rephrasing has a twofold purpose, first to establish whether or not you have understood the question properly. Second it will give you a moment to collect your thoughts and to prepare the best possible answer.
3. In the final step you should *answer the question*. This might seem obvious, but too often the candidate makes no serious attempt

to answer the question, and starts going off on some related or unrelated tangent or long-winded explication to make it appear as if the question were being answered. Some questions may be just too difficult to answer right away, or you may be caught off guard and have no idea how to answer the question that has been posed to you. In this case you have two options. First, you could start talking about the research in the chapter while not giving an answer at all, and try to bluff your way through it. A better solution is to admit to the examiners that you probably will not be able to provide the full answer to the question raised, but that you will discuss a few issues that can contribute to finding a proper answer. While the public will not notice the difference, the experts (and most of the examiners are experts) will understand the distinction between a candidate who is prevaricating and sidestepping the question, and one who makes a real attempt to address the question, as thorny and complex as it may be. The latter behaviour is what the examiners will expect from someone who is worthy of being awarded a doctorate.

Your physical condition at the actual defence

No matter how well prepared you may be, there is a fair chance that you will be a little nervous – or a lot nervous, before and during the actual defence, depending on how you operate under stress. After all, you have been working towards this point for years and a lot is at stake. Each individual reacts differently to upcoming stressful situations. You may or may not have already discovered which strategies work best to help you perform well under stressful circumstances. You may have had some experience with this before (such as in sitting examinations), but the scale of defending a PhD thesis puts the circumstances of a thesis defence into a different class altogether. So in the days before your thesis defence, try to find a proper balance between (i) focussing on your research by reading your thesis again (and again) or going for a long and relaxing walk; (ii) drinking lots of coffee to activate your brain or imbibing in a cup of herbal tea to relax; (iii) preparing your thesis defence locked up in a room alone (this may work for introvert candidates) or sitting in a café with a couple of friends. Whatever you do in the run-up to your defence that will help you feel more poised and relaxed, try not to develop a completely new strategy at this stage for managing stress. It may be best at this point to do what has worked for you in the past. Get some sleep, go for a walk, eat regular meals, talk to friends. Breathe.

Our advice for getting through your thesis defence with a minimum of discomfort and the best chance for success? Prepare, prepare, prepare, and then just let it go and do your best. We hope you sail through your defence with flying colours.

Chapter 19

Lessons Learned

The first step in the acquisition of wisdom is silence,
the second listening, the third memory,
the fourth practice, the fifth teaching others.
Solomon Ibn Gabirol

This book describes numerous situations that graduate students will commonly encounter as they work towards the goal of earning their PhD. Starting from your very first day in the lab, to the beginning stages of your post-PhD job search, to writing your dissertation, we've tried to offer you sage advice on how to handle particular situations as they arise. Although individual circumstances are never the same for everyone, we aimed to give you some general guidelines about what we believed would help you make the most out of your years in grad school. Most of the advice we focused on is of a practical nature and dedicated to the problems typically encountered by most PhD students. If you glance back through the various chapters you will notice that we have tried to suggest a general strategy for tackling particular issues. In may seem paradoxical, but usually similar actions are required to solve inherently different problems – no matter what stage of learning and life you happen to be in. And the good news is that many of the skills you have learned throughout your PhD years, regardless of the topic of your thesis, will be useful in later stages of your career.

In this final chapter we summarize, in general terms, the key lessons we hope you have learned along the way. Perhaps the two most important, and the ones that run through all the chapters like a common thread, are that *proper planning* and *good communication* are the keys to your success. If you've recognized the importance of these two skills and have managed to put them to good effect, you have probably come to the end of your graduate study with a sense of accomplishment, as well as pride in yourself for having successfully survived the course. In fact, the strategies you have acquired in learning how to master your

PhD will be useful in every job you have from here on in. To repeat a statement that we included in the introduction: former PhD students claim that the communication, planning, and problem solving skills they acquired during their PhD research are as useful to them, if not more, as the actual content that went into their thesis.

Planning is essential

Scientists tend to be sceptical by nature. It goes with the territory. Many of them will emphatically state that you simply can not plan science. Research, after all, has a life and rhythm of its own. So some of these individuals may feel that trying to plan your time in the lab is a wasted effort. Indeed, you can not plan the outcome of your scientific efforts. But we still believe in the importance of proper planning (and this includes time management) and that good planning will maximize your chances of getting the most out of your time in the lab. There's more to grad school than research. All kinds of 'fringe activities' will take up your time and pull you away from the lab bench. Attending conferences, discussing work, preparing presentations, reading the literature, searching the Internet, and handling your e-mail, are all essential activities. With proper planning you can optimize the results of those fringe activities so that you spend as little time as possible on things that are essential, but take time away from your thesis research.

Every now and then it helps to take a step back and look at your world with an impassioned eye. If you can honestly assess the productiveness of everything you did, you may realize that you could probably have skipped a good fraction of those activities (the 80/20 rule). Truly wise planners know how to stay one step ahead of their problems. By reflecting on what went wrong in the past, and being honest about what might go wrong in the future, you will be able to take appropriate measures that will save you a lot of time. Therefore, we have repeatedly suggested that you identify the potential hurdles you might have to leap over, and pitfalls that you need to avoid – for instance, during your monthly progress review. Once you have identified potential problems you can consider alternative approaches for obtaining the result you want.

People with a more chaotic approach to projects (perceivers in MBTI terminology), often find that things do eventually work out the way they want in the end – despite their lack of good planning. This may work only if your actions, and yours alone, are required to obtain the result you want. But doing a PhD always requires, to a greater or lesser extent, the help of others. So teamwork is essential and getting the people around you to work in harmony takes time and effort. Very few people will start marching to the tune of your drum, even if you think that's the best way to proceed. You have limited power to change the behaviour of others, so in order to ensure that they deliver on their promises, you will have to plan carefully and be realistic about lead times for all the things (and the list is long) that are not under your control. Of course, for a plan to be successful, you will need to communicate the planning to others. This brings us to the second valuable skill that we hope you have picked up and refined along the way.

Communication creates harmony

Even if it's only your name that appears on the spine of your printed and bound thesis, remember: you are part of a team. You might not find that your team mates are active or visible at all times, but they are there. From librarians to roommates, from undergraduate students, to your supervising professor, they all contribute to your research in one way or another. Share your good news with others (celebrate your success), and ask for help and advice if you are making less progress than you expected. Be able to admit it if you don't know the answer to something. Ask questions. Listen to the answers. If you have an open attitude and make clear what you expect from others and what they can expect from you, your years as a graduate student will be more productive, not to mention a great deal more pleasant.

Misunderstandings that arise from a lack of communication are the source of many conflicts and much unhappiness. Solving conflicts is essential to moving forward with your team. The first step in solving interpersonal problems is communication. A key aspect of good communication is active listening, a skill that is also of great value during job interviews and meetings. As you make steady progress in your project, you might forget to communicate frequently. When work needs to be done, it may seem to you that talking, and especially listening, is a waste of time. But it's essential to keep communicating your progress, as others might have interesting suggestions to speed up your research or to redirect your experiments a bit, so that your results have a greater scientific impact. A plan not communicated with your team is bound to fail. The converse is also true: communication that is not planned loses much of its value. Of course you already know that you have to prepare in advance your presentations at conferences and group meetings, but your yearly evaluations, as well as any other meetings you have with your thesis advisor, will have a bigger impact if you are thoroughly prepared beforehand. Think how important something as trivial as a proper subject line is when you write an e-mail. Words carry a great deal of weight. A well thought out subject heading will have a much better chance of being acted upon by the receiver. So it is with talking and listening to the members of your team.

A final thought

The research and effort that go into a PhD degree require hard work, dedication, and the ability to recover quickly from setbacks. This may sound like all hard work and no play, but working on a scientific project also has many upsides. Enjoy and celebrate your successes – such as the occasion when you are the first person to obtain novel data about a particular topic and are able to draw conclusions from it. Doing science in a research institute is a job, certainly, but a special one. Some even say that it is a calling. You are surrounded by young, hard working, and ambitious people. So don't forget that there are also many opportunities to have fun with your fellow students. You're all in this together, so don't be afraid to inject levity and humour into the day-to-day seriousness of your work. A PhD programme is much more than obtaining research results and writing a thesis. It is a period in your professional life in which you will learn many new skills and make professional and personal contacts that will last a lifetime. Allowing yourself to master those skills, as well as have fun in the process, is the sagest advice we know.

About the Authors

Dr. Patricia Gosling obtained her PhD in Organic Chemistry at the University of Nijmegen, The Netherlands. Prior to her PhD work, she studied Biochemistry as an undergraduate in the USA and worked as a research assistant in Neurophysiology. From 1996–2002 she ran her own communications consultancy, with a focus on science journalism and medical writing. She has also translated and edited numerous books and articles for industry and academia, and is the author of two guidebooks on Amsterdam. A U.S. native, Dr. Gosling has lived and worked in the Netherlands, Morocco, and France. She is currently employed as the Research Manager of the European Neuromuscular Centre.

Prof. Dr. Bart Noordam obtained his PhD degree in Physics at the University of Amsterdam, The Netherlands. After a brief stint as a Postdoc in the USA, he headed up a research group at the FOM-Institute for Atomic and Molecular Physics (AMOLF) in Amsterdam, where he studied ultra-fast interactions between light and atoms. Prof. Noordam has supervised 9 PhD students and published over 120 scientific papers. He interrupted his academic career for two years to work as a management consultant at McKinsey & Company, and returned to AMOLF in 2002 as director of the Institute. Since 2005 he is director of a Regional Audit Organization and Professor of Physics at the University of Amsterdam.

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