

Appendix B A sample curriculum

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The material presented in this book lends itself well for a course for beginning graduate students. Such students are under time pressure when starting their research and taking courses in their chosen discipline. For this reason our best experience has been in teaching the course as a single-semester, 1-credit course, which amounts to approximately 15 classroom sessions. This appendix gives a sample curriculum aimed at offering instructors ideas for elements that could be included in such a course. The curriculum includes homework assignments that roughly follow the chapters in this book, but doing all assignments is unnecessary and might make the workload unacceptably high.¹ The suggested homework is intended to inspire instructors' ideas for helpful exercises.

Our experience is that it is best to teach the course to classes no larger than about 20 students. The material is conveyed most effectively in a discussion format rather than as a lecture that offers relatively little opportunity for student participation. Some topics covered are likely to touch on personal issues; many students find it easier to pose questions and share personal views and dilemmas in a small group.

Class 1. What the course and science are about. Since the course is most effective when there is ample discussion, it is important that students feel comfortable in the group. It is helpful for students to have the opportunity to introduce themselves in class and mention, for example, what they hope to learn in this course and any personal issues or questions they would like to share. Students benefit from an introduction in this class that conveys that the model of acquiring research skills by just working along with an adviser often is not the most efficient way to learn those skills. To this end, it is valuable to give them examples of the breadth of intellectual, practical, and personal skills needed for success in research. One aspect that many students find surprising and difficult to grasp is that doing science requires skills beyond logic alone (Section 2.3). It is useful to spend some time in

¹ Clearly, the content of this course does not present intellectual demands at the level of a typical disciplinary graduate-level course. Students, nevertheless, might be surprised to find, in this 1-credit course, a need to ponder with care issues they previously hadn't imagined require any attention.

class discussing this. We've found that a formal lecture on the nature of science, such as described in Chapter 2, is less effective than asking students to read that chapter and bring questions to the following class.

Homework. Find an example of a scientific discovery, big or small, where the essential step taken was not rooted in logic. *If you are in the position to do so, preferably give an example from your own personal experience. Write a brief essay of a few paragraphs and be prepared to talk informally about your example in the next class.*

Class 2. Choosing a research topic and adviser. Since many students who take the class don't have a research topic and adviser as yet, it is particularly worthwhile to cover the material in Chapters 3 and 4 early in the course, making students aware of considerations that can be helpful in choosing a research topic and adviser. It is an eye-opener for many students to learn that finding a research topic for which they have a passion is an essential ingredient in achieving a successful and fulfilling career. In their choice of adviser, many students tend to focus on the perceived scientific skills and reputation of the adviser, without knowing how properly to assess these traits. The importance of good personal rapport between adviser and graduate student is an issue worth emphasizing.

Homework. Interview four faculty members. *Typical for most students, you'll have occasion to talk with various faculty members in your quest to find an adviser and research topic. As an aid to discovering different styles of research, a running assignment for the course is for you to interview four faculty members about their career, their style of research, the way they combine professional and personal life, and career choices they have made. Look for both common themes and for differences. This exercise is most useful when the faculty members you choose have diverse backgrounds, experiences, and outlooks. Write a paper of approximately four pages about these interviews and hand it in at the end of the course.*

Class 3. Questions drive research. Perhaps surprisingly, many graduate students are unable to articulate *what the key question is* they aim to address in research on which they have already embarked. Worthy of interactive discussion is the role of questions as the driver of research. These questions fall naturally into a hierarchy, from large overriding ones that give direction to the research to more-detailed ones that drive daily research activities. That free association is a valuable tool for generating large numbers of questions comes as a surprise to many students, and we find it instructive to discuss the quote of Schiller in Section 5.1 in great detail. The questions thus generated can later be sorted or discarded. In the following

homework problem, we use free association to generate questions about a general research topic that all students in the class know at least a little about.

Homework. Use free association to arrive at questions. *Do this exercise in a location where you will not be disturbed. Take a blank sheet of paper and a pencil and write down any and all questions that you can think of about the research topic you have been given. Don't "filter" your questions, but freely associate and write down everything that comes to mind. Do this for just an hour, and then stop. Make sure to leave empty space between the questions. Hand in a copy of your list of questions at the next class and retain the original.*

Class 4. Setting and working toward goals. It is useful to start this class with a discussion and sharing of experience with the previous homework prior to moving on to the chapter about goals. Most students know about goal-setting, but don't have a good idea *why* setting goals is so important or how best to go about doing this (Section 6.1). It is useful to discuss the five steps towards reaching goals (Section 6.2) in detail. In this class, the focus is on exciting the students about goal-setting, delaying discussion of the distinction between being goal-oriented and process-oriented (Section 6.4) to a later time. If students are assigned the homework suggested below, it is important first to talk about the ordering and prioritizing of the research questions, as described in Section 5.2. In this exercise we order the list of questions made in the previous homework assignment. It is useful to do this as a group exercise because it illustrates how a group can combine and organize the creative ideas from its different members. Each group takes the combined list of questions from all its members, and, following the steps outlined in Section 5.2, organizes them either on a large sheet of paper or on a poster generated by a computer.

Homework. Organize and prioritize questions. *Organize the questions generated by the group members in different themes, distinguish between major questions and more-detailed secondary ones and prioritize them. Include a box labeled "garbage can" with questions that you choose not to use. Use lines or color to indicate connections among questions so that the chart you produce begins to take on the character of a research plan. This exercise is about ordering of questions. It is not a beauty contest; therefore focus on content rather than form. Prepare to present the work of your group in the next class.*

Class 5. Present research plan. By spending an entire class on the presentation of the research plans made by the different groups, students find it interesting to see how different are the approaches taken by the various groups. This exercise can naturally lead to a discussion about planning of research. Students often are surprised and impressed by the added value of doing this homework in a group.

This can be a good starting point for a discussion about teamwork and the value of using others as a sounding board in research.

Homework. Because the previous homework is intensive, focus on your faculty interviews.

Class 6. Turning challenges into opportunities. Chapter 7 covers common challenges that researchers encounter in their work. It is instructive to discuss these challenges in class. Many beginning graduate students think their professor knows everything and does not encounter any such difficulties. To counteract this myth, it is beneficial for instructors to share with the students their own anecdotes, illustrating problems they have run into while doing science. Also, when students share their research challenges in class, they learn that they are not alone in encountering such problems. What a relief it is for many students to discover that this is a normal part of doing science!

In the class after this one we will have a scientist come visit. Students can ask any questions that come to mind. (It is a good idea for the students to know in advance who this visitor will be and have some background information about the person.)

Homework. Make a list of questions to pose to a visiting scientist. *Prepare a list of questions that you would like to ask the visitor to next week's class. These questions can be either personal or professional.*

Class 7. Asking questions of the visitor. Since different researchers have different work habits and lifestyles, and to avoid the bias of the instructor, it helps to have a scientist other than the instructor visit the class. In fact, a few classes could be devoted to different visitors. Having prepared a list of questions in the previous homework assignment, students pose these questions in this class. Students may ask whatever they like, no matter how personal the question, but the visitor of course has the option to decline to answer any given question. Having one of the visiting scientists be a woman invariably raises its own set of questions about the combination of professional and personal life.

Homework. Write an essay about your life as a scientist. *The previous class likely gave much food for thought about the life of a scientist. Write a one-page essay about your preferred life as a scientist. What would you like to achieve? What are your dreams? Where would you like to work? What balance would you like to strike between work and personal life?*

Class 8. Ethics of research and the meaning of work. One could readily teach ethics for an entire semester (indeed, such full courses would be a valuable addition to

the curricula in any discipline), so discussion of this topic in class unavoidably needs to be limited. Chapter 8 gives ideas for topics that are most closely related to the daily activities of a scientist. Discussion of a few case studies is a great way to stir student interest in this important topic. The booklet *On Being a Scientist; Responsible Conduct in Research*² contains useful material for this class, including numerous case studies. This class also offers a good moment to discuss the underlying meaning of our work (Section 6.5) and the importance of being aware of larger potential consequences of the science that we do (Section 8.7). These topics can be combined in a natural way.

Homework. Write your own ethics statement. *Chapter 8 starts with an example of an ethics statement. Write your own ethics statement in such a way that this statement reflects your values as a scientist and any higher purpose to which you might aspire.*

Class 9. Visit to the library. Many students think of the library as a repository of books and are unaware of the help that the staff and facilities of the library can provide. In this class we visit the library, and one of the librarians gives an overview of different types of literature searches, the different databases that are available, and the help in accessing information that the library staff can offer. Library staff usually are delighted to assist in such a class.

The next exercise forces students to start using a database of references, as described in Section 9.3.

Homework. Create a database of references. *For the remaining duration of the course, create a database of the articles and books that you have read for your own research. First choose the database system that you want to use for archiving references. Ask your adviser and fellow students for their recommendations. If this does not help you, use zotero, which can be downloaded for free from www.zotero.org. Add to your database any relevant paper or book you envision that you might ever want to cite or read in the future. At the end of the course, provide a printout of a representative part of your database in a readable form that is ordered by the keywords that you have used in the database.*

Class 10. Oral communication. We've found it less effective to tell students how to give oral presentations than to demonstrate the difference between a good and bad presentation. We show them in class two versions of a five-minute presentation. In one version (without alerting the students in advance) we do everything deliberately wrong, while the second version is as good as we can make it. The slides in

² <http://www.nap.edu/html/obas>.

Fig. 10.1 are, in fact, taken from the presentations that we use in class. After these presentations, we ask the students to articulate why the second presentation was better than the first one. It is interesting that, no matter how clownish and ridiculous we make the first presentation, we always get the same response. Students at first don't believe that speakers sometimes (in fact, too often) actually behave in such an unprofessional way, and then, over the following weeks, they express amazement at how many of the mistakes in the "bad presentation" they witness in listening to actual presentations that are meant to be professional.

Homework. Make a list of good and bad habits of speakers. *Compile a list of habits of speakers that you find pleasing and productive, and a list of habits that are ineffective and irritating. Write a plan with at least five action items for how you will train yourself to acquire the good habits and avoid the bad ones.*

Class 11. Writing and publishing a paper. Most junior students have no idea as yet about how the publication process works and how to choose a journal for publication. The considerations and practices described in Chapter 11 are new to many students. When presenting this material, anecdotes can be useful in illustrating salient points. Some students in the class might be in a position to share some of their experiences in publishing papers.

The following exercise serves to introduce students to the important journals, *Science* and *Nature*.

Homework. Find and discuss a paper published in *Science* or *Nature*. *Find out how to access these two journals electronically and browse some recent issues. From either of these journals, select a paper that you found truly interesting or exciting. Hand in a copy of the chosen paper along with a brief description of why this paper appealed to you.*

Class 12. Time management. "Not having enough time" is a disease of our times, and graduate students struggle as much with managing their time as do other professionals. The material of Chapter 12 forms a good basis for a discussion about this topic. Figure 12.1 is an eye-opener to many students. Be aware that many students spend an inordinate amount of time dealing with email and surfing the internet. Advice and tips on how to use these tools effectively without being the slave of the tool are badly needed.

Homework. Analyze how you spend time in the coming week. *Throughout the coming week write down your activities and the amount of time you spend on each of them. Place each activity in the appropriate quadrant of Fig. 12.1, and annotate with the amount of time spent on the activities in each of the quadrants.*

Make a decision as to whether or not you want to change the way you spend your time, and, if you perceive the need to change, formulate five steps for change that you can take over the coming month. Hand in an overview of the time spent on activities in the four quadrants, a brief description of what you want to change, and the five steps that you will take to make those changes.

Class 13. Writing proposals. Most students are keenly aware of the need to write proposals, but don't know how funding agencies work and what are the elements of successful proposals. The material of Chapter 13 is a good starting point for a discussion. It can be illustrative for students to be given a copy of a proposal that was funded and use it as an example to structure the discussion.

Homework. Find a funding agency and program for your research. *Go to the websites of funding agencies and find a program that is appropriate for your research project. Write a memo to your adviser with a recommendation for a program and funding agencies that match your research, and outline why you think this is a good match. Hand in a copy of the memo.*

Class 14. The scientific career and applying for a job. Graduate students often are apprehensive about the competitiveness of the scientific career. It is important to emphasize that, while competition indeed does exist while pursuing a career in science, the rewards of the pursuit, particularly when done in cooperation with others, greatly outweigh drawbacks. Sketch in class some examples of scientific careers along with the challenges and rewards that come with these different careers. A great way to cover this topic is to invite to class a panel of scientists who have followed different career paths, but this might not be easy to realize.

Homework. Think up questions and discussion items for the next, final class.

Class 15. Closing session. The above-suggested curriculum covers much ground, so it can be helpful for students to have ample opportunity to raise any questions, concerns, or comments they have, and devote the final class completely to this purpose. Many junior graduate students are apprehensive about the road ahead. The final session can be given a light note by doing something fun, for example, by having the students out for lunch or drinks together.

Comment for instructors. As an instructor you will find it a rewarding experience to interact with students in a course similar to the one outlined here. A side effect we've encountered is that students who have taken the course have generally shown extensive willingness to come to us, seeking advice. Not unlike graduate students everywhere, a significant number of these students had experienced distress in one aspect or another of their graduate career. It can happen that, when

graduate students encounter problems, their adviser might not offer the help and support that they need, especially when the adviser is part of the problem. With other faculty members being busy, students often feel there is no one else in the faculty to talk with. This leaves them without the counsel that they need at such critical moments. Students might see the instructor for this course as the natural person with whom to talk. We have found these discussions useful and rewarding for us personally. More important and more generally, instructors do students a great favor by offering them the informal advice and support that they need.