Important considerations for PhD research, or How to make your research successful

By Jim Rusling, Univ. of Connecticut, Storrs, CT

Below I list important guidelines for becoming an independent researcher, which of course should be a major goal of your PhD studies. These have been taken from my own research experiences and from 30 years supervising an academic research group.

1. **Self-training** and **self-education** are probably the most important factors in building the technical skills you need to do high quality PhD research. This involves extensively reading the literature, especially review articles related to your work and related papers in high quality journals. If you are faced with an unfamiliar procedure, start reading about it right away, before you do any experiments. Learn the basic principles of your planned procedures. Start with textbooks if available, then proceed to review articles. Keep reading even after you have begun the initial experiments; this creates a learning feedback cycle between experiments and reading that speeds your understanding. Read the manuals of unfamiliar instruments, and learn the fundamental principles involved. Do not rely on someone else who already uses the instrument. While they have important information to impart to you, their knowledge may be incomplete. Train yourself on newly encountered instruments by first doing experiments with well-know quantitative results, and do not proceed to new experiments until you can achieve the expected results with high quality. When you do this you are developing a detailed knowledge of the tools that you need to do the research. You are building an "intellectual toolbox" for your future research that will be used throughout your career. Without this, success will be difficult or impossible to achieve.
2. **Know your materials.** Read and fully educate yourselves about the properties and functions of any new biomolecules or particles you are working with. For proteins, know the isoelectric point, physical size, MW, secondary structure, if there is a crystal structure, etc. Download the structure from NIH websites and have a look. Bioconjugate materials such as nanoparticles with attached antibodies, enzymes and chemical entities need to be fully characterized and how many molecules are present per particle must be determined.
3. Take **full responsibility for your project**. Its your job to make the project a success. Learn everything you can to help you make it succeed. If you encounter problems, do your very best to solve them, or devise alternative solutions. Get help from other lab members and collaborators when needed. Strive for the very best results and the highest novelty. Make sure you understand the big picture – why are you doing this research, and what is the global benefit to others. Know where project funding comes from, and how can you help ensure that the funding continues.
4. **Innovation and ideas**: Devise new projects on your own. Think of ways you can make your existing projects better by introducing more advanced or simpler procedures, automation, new concepts, higher throughput, etc. Be a leader in your laboratory in introducing advanced technical concepts and procedures to other lab members.
5. Don't talk yourself out of high-payoff experiments. If you are uncertain, try it! Devise **simple proof-of-concept studies** that can be completed in a short time (i.e. a few

hours to a few days) that will tell you if the study is worthwhile or not. If it is worthwhile, you can improve your procedures later.

6. Spend time improving your **speaking and writing skills** to the highest levels. You could be doing the best research in the world, and if you can't explain it to others, your efforts have been wasted. Take courses in technical communications as well as writing workshops (often given at meetings like PITTCONN and ACS). Write up and summarize your research results continually as you proceed in your project, so that you can easily produce the first draft of the paper when the time comes. A good goal is to have your paper ¾ written the day you are doing the last experiments! Write papers promptly and complete and submit them before beginning new projects. Share drafts of papers with all co-authors and collaborators and get their input.
7. Keep a detailed **laboratory notebook**, that can be paper or electronic (I prefer electronic). Document and date all your work and results in the notebook. Especially, be certain to date and sign novel new results and even untested ideas as these could be useful in patent applications. Back up <u>all</u> electronically stored data.
8. Form **collaborations** with experts who can help you in your projects, or when you can help them. Be proactive! If your advisor has collaborations in projects in which you are involved, **interact with the collaborators directly** by phone, email, and visiting their labs. Ask their advice when needed. Discuss your project and results with them. Encourage them to visit your labs. If you need skills that are available in other labs, arrange to go there and learn them. If it involves travel, ask your advisor for financial help. This is how modern research is done. The time of one researcher working in isolation to achieve top-level research of high significance is long gone. Most novel modern research is simply too complex and too multi-disciplinary for one person to do it all.
9. Strive for **excellence** in all things: knowledge, ideas, experiments and communication.