Bench philosophy (18): Laboratory notebooks

For the Record

The lab book is the most important, and yet usually the most neglected, piece of scientific apparatus we use. A well-kept lab book is not only an obligation, but an irreplaceable resource. A badly kept lab book (so badly kept as, for instance, not to exist in the first place) can be, indeed sometimes has actually been, a researcher's downfall.

Picture the scenario: your paper on histamine receptor expression is all but accepted by the referees, when one of them asks which vector you used. "I'm pretty sure it was pcDNA3 but I'll just check and get back to you," you tell your boss. You find your lab book. Now let's see. Here we are, June 26th, almost exactly a year ago. Right in the middle of the page, the phrase "new vector", followed by a question mark, and crossed out. Somewhere deep in the older part of your brain the needle on your threat meter starts quivering.

As professionals, the conduct of scientists faces ever-increasing scrutiny, yet scenarios like the one above happen all too often. Scientists are more likely than ever before to have to present their records to a patent lawyer or, perish the thought, a misconduct inquiry. Many of us are paid by the public and the public has a right to insist on an account of our activities. Keeping records is a big part of that duty.

Scientists are obliged to keep a well organised lab book.

Let's get one thing quite straight here. Forget the comic-book caricature. The sloppy lab book is not the mark of a "bright, but disorganised, mind". It is the mark of failing responsibility. To look at it from a positive perspective, think of a well-kept lab book (or more realistically a collection of well-kept lab books) not only as a record of our intellectual labours but also as a rich source of potential new insights. Maintaining a good lab book is not a question of personality or disposition. Rather, it is simply a matter of discipline. Neither is it difficult. The following suggestions are a mixture of the obvious and the not-so-obvious, which if followed, can transform your lab-book experience, or at least avoid the dreadful scenario described above.

Which book?

A lab book must be a properly bound book, not loose leaf. It must not be possible for pages to be easily removed without being noticed. For that reason, spiral bound books, though attractive for their ease of use and opening flat, must be excluded. The paper must be able to withstand the occasional spills without disintegrating. Large books mean you will be able to paste full-page printouts (A4 in Europe) without having to shrink fonts or cut off margins. But a small book has its advantages if you have to carry it in the field. Pages must be numbered. Even if you have to do this by hand. Choose a nice-looking book. Okay so it might be twice the price, but how much of the research budget is it? Isn't it arguably the most important part of your research? Besides, an attractive book may invite you to use it more.

Which pen?

Not as stupid a question as you might think. The ink must be permanent. Not Sharpies, because they bleed through the page and not felt-tip or anything whose ink runs if solvents get spilled on the page. Never pencil. You can erase it too easily. That makes lawyers and cynics very suspicious.

What to record?

Everything. Well, almost. But certainly much more than just what everybody does. Some will argue that over-recording clutters the information and makes it harder to find key information but you can always summarise and use highlighters, etc.

You think you are sure to remember a particular detail, but you will be surprised at how easily you forget something later, especially if you have moved on to other projects in the meantime. So write it down, even if you think you could never forget it. Here are a few specific details that ought to be included but are often neglected:

- **Dates**: Use unambiguous notation, such as 04Feb2009. 02-06-09 means "2nd June" in England but "6th Feb" in the US.
- **Times**: Record the time of the experiment or observation using 24h clock or at least AM/PM. Why record times? I know of one case where anomalies in results were attributed to the fact that some experiments were done in the morning when the sun was shining into the lab and increasing the room temperature.
- **Chemicals**: As well as the name, record the catalogue number and lot. Also record the purchase date (to the nearest month) if known. Sometimes qualities of lots can vary, even from the same supplier. In addition, there may be some detail of the chemical you thought unimportant but which later may emerge as being important. If you find out after the experiment that nicotine tartrate has a different effect than nicotine free base, and your lab book just says "added nicotine", you will be stuck unless you recorded "applied nicotine (Tesco Drug Supplies, catalogue #3340)".
- **Locations**: Record where you stored samples. "Used pcDNA3, aliquots in Mol Biol lab, freezer 6, bottom drawer, box 5". Make sure the entry in the lab book matches what is written on the storage box exactly.
- **Media and solutions**: Make reference to mixtures, media and solutions unam-

biguous and systematically. This is particularly important with stock solutions that you or others might use later. Describe how the stock was made, and allocate it with an identifier that can link it to the actual bottle on the shelf. I have developed a system which works particularly well and is easy to implement. Every solution that is going to be used or referred to later is given a ten digit number composed of the last two digits of the year followed by the month, day, hour and minute. A final digit can be added to distinguish two stocks made at the same time. This is written on the bottle along with my initials. (Of course a user-friendly title should also be written on the bottle, such as "M3 medium"). This is matched with an entry in my lab book "prepared fresh M3 (0904251128-1) and calcium free medium (0904251128-2), stored on top shelf...". It is easy to generate these numbers and they are almost certain to be unique. Anyone using these solutions can unambiguously trace them to the entry in the lab book.

Darwins thoughts on the origin of species captured in his notebook.

Show your calculations in the lab book, even the most obvious ones, such as working out how much sodium chloride to add to 1 litre of water to make 0.1M stock. Errors can then be traced and hopefully corrected.

Record your thoughts. Many people assume the lab book is only for what you did, but writing down speculations, interpretations of data and ideas for new projects has lots of advantages. It forces coherent thinking – ideas can look sound until we commit ourselves to writing them down in coherent sentences, when we are forced to give them proper shape. And it proves when we thought of an idea, should there be any question raised about who thought of something first.

Put your name and other contact details on the first page, just in case you leave it somewhere.

How to record

Always record in neat writing that a stranger can read. Idiosyncratic abbreviations need to be spelled out. Remember, it is not your book – it is usually the property of your employer and its purpose is not just to remind you, it is also to inform others. Some people prefer one book for each project, others prefer one book for all. I opt for the latter because the sequence of thoughts and actions over time is preserved, and the development of thoughts, whose input spans more than one project, can be easily traced.

Paste photographs, printouts, Western blots, graphs etc into your lab-book. A good lab book has all the narrative of the project in its pages. Annotate freely: if you have plotted your results and pasted them in the book, write down what data are included, where the file is on the computer etc. Include your own interpretations of the data. This pasting must be done with glue. Tape goes yellow and brittle and stuff will fall out. Staples stick through the paper and the material can come loose.

Don't be afraid of redundancy. Your lab book is not a database and having the same information in different forms is a safeguard against unintentional errors, omissions and ambiguities. You never know which comment or link to a file will prove valuable years hence.

Some datasets are too large to print out and glue in. If this is the case, make a reference in the lab book to the electronic and physical location of the file. If it is a computer file, say which volume (computer, share drive or server for example) it is on and give the directory path. In doing so you will become aware of a problem here: what if it is moved? This highlights the need for careful policies in computer file storage. Files should be backed up onto discs that are stored in a special place, other than just left on computer hard drives, and reference to these locations must be made in the lab book.

Never erase. If there is a mistake, draw one thin line through it so that it can still be read. It may prove later not to have been in error at all and you may want to recover it. Otherwise, someone may think you are hiding something. For the same reason, white-out is right out. At the end of each day, draw a line across the page just below the last entry. Don't leave any pages empty.

Electronic or paper?

Paper. Sorry to be so dogmatic in an age of equal opinions but, much as I love computers (and I do), here is one case where there is simply no contest. In many settings, such as industrial research and development or large-scale projects, electronic lab books are clearly the way to go. But I think most of us, even if lab policy forces us down the electronic route, need to have a traditional paper lab book. Many unexpected discoveries or insights come when we suddenly see connections between apparently unrelated things; and the highly structured nature of electronic records does not so easily favour this.

Don't go electronic unless you have a proper, tested and approved electronic lab book system in place. There are issues to do with security and intellectual property that will not be addressed if you are just using a word processor and its electronic storage as your lab book.

The key test of a lab book is this: if you were to die (but hopefully not) tonight, would someone you haven't worked closely with be able to write up your work into a paper? A perfect lab book would contain all the information needed for someone to do this, and in a form that allows them to do it. Few of us will reach this goal, but we could all make it our aim.

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