

Keeping a Laboratory Notebook

All data and observations recorded in the laboratory should be kept in a duplicating notebook and written in indelible ink. Data should never be recorded elsewhere for later recopying into the notebook. In particular loose scraps of paper are not permissible for records, since such loose scraps are often lost.

The purpose of a laboratory notebook is to keep a running account of all occurrences, procedures, and observations during an experiment. The need for properly kept notebooks and the emphasis on adequate notekeeping have several origins. Normally, reports or published papers will be based on the data in the notebook. Therefore, the more complete the data the better the final report. In addition, a good complete notebook allows discrepancies and unexpected results to be traced to their sources. In a broader sense, a notebook is essential in any research or industrial laboratory where review of data months or years after they were taken may be necessary.

The following are the **minimum** requirements for any good notebook:

1. Up-to-date table of contents
2. All pages should include a number, a date, and the title of the experiment. A pledge signature should appear on the last page of each investigation.
3. Complete observations, including:
 - numerical data with units and uncertainties
 - all observations including colors, masses, temperatures, pressures, etc.
 - any unusual occurrences
 - each step of procedure, noted as it is done
 - statement of equipment used and sketches of the apparatus
 - rough graphs of data
4. Mistakes should be crossed out with a single line and left legible. A reasonable level of neatness and organization is expected. As a general rule, someone else (your lab group for example) should be able to follow your notebook.

Some of the rules about lab notebooks (e.g., using pen but not pencil, numbering all the pages) may seem somewhat arbitrary to you. However, these rules exist for a reason and have to do with the purpose of a laboratory notebook.

In a working scientific laboratory, the lab notebook has two primary audiences: First, the researcher's future self and other members of the continuing research group (this is the usual audience for nearly all notebooks) and, second, lawyers, auditors, and similar investigators. Having your notebook reviewed by such auditors is rare, but when it happens, the stakes are high. These two audiences create various requirements for the notebook.

Your Future Self

This is the audience you care most about. Imagine yourself a week, a month, a year, or even a decade after you did an experiment. Your lab group is writing the final version of a paper based on your investigation. You are checking that the data in the paper are correct, so you are looking at the pages in your notebook where the data are recorded. Can you read them? Do you still understand the abbreviations you used? Did you record whether the wavelengths are in nanometers or centimeters, or are you now desperately trying to remember because you didn't write it down? Do you have occasional numbers like "0.127" recorded with no hint of what the number is supposed to represent (mass of a chemical? Absorbance of a sample?? Volume of a solution???)

Be kind to your future self. Make sure your data are *complete*. Don't become compulsive about neatness (notice that neatness was *not mentioned* earlier in the list of requirements for the laboratory notebook!), but do make sure that the entries are at least legible - if you can't read your own writing, your future self is in trouble. Label the various entries with what they are, what the units are, etc., so you'll know what all the numbers mean. Record your observations (e.g., how long a reaction took, what the product looked like - anything that strikes you as the experiment proceeds), *not* because people have been telling you since 3rd grade that science is based on "observations", but because these are notes to remind your future self what *really happened* in the lab that day. These notes often turn out to be very helpful in interpreting the data.

Lawyers and Other Strangers

In addition to being your own personal record of your work, a lab notebook is a legal document that can be used in court and other formal proceedings. Some examples:

- a. You invent a new drug to cure the common cold and have filed for a patent so that you control the rights to (and profits from) your amazing discovery. Your arch-rival, by a strange and suspicious coincidence, files for a patent on the same drug at the same time. The Patent Office asks to see your notebook as evidence of when and how you made your discovery; if your notebook shows that you were truly the first to make the new compound, the patent is yours.
- b. You are accused of scientific misconduct, and your accuser claims that you made up data to fit your hypothesis. A panel of scientists is appointed to review your case. In your notebook, they find the record of what experiments you did, your successes and failures, how the results of each experiment led you on new ideas and experiments, etc. By showing the real, day-to-day progress of your work, the notebook will save your scientific reputation.
- c. Your research reveals that a chemical manufacturer is responsible for pollution in the local river that is killing off the trout population. You publish your data, and the manufacturer sues you for defaming the corporation's character, injuring their reputation, and making false and malicious claims. Your notebook is introduced as evidence in a court of law to prove that the data support your published claims and were honestly obtained.

A true story: Andrea Pavlick graduated from Allegheny with a chemistry degree in 1993. She went to the Oregon Graduate Institute (OGI) for graduate school, where she worked on a project that showed that additives in cigarettes increase the amount of nicotine in the smoke. She (together with five other scientists from OGI) published the results in *Environmental Science and Technology*. The tobacco companies sued, and Andrea found herself testifying about her work in court. Her notebooks were among the key pieces of evidence that led to victory for the OGI scientists.

The legal implications of the notebook account for many of the specific requirements for the notebook format:

- Every page must be numbered so that missing pages (which might have been removed to conceal information) can be easily detected.
- Bound notebooks (rather than spiral or loose-leaf) are used, again so that missing pages can be detected.
- Every page is dated to demonstrate that the data were recorded as they were collected, not added after the fact.
- Pencil is not used because it can be erased and changed; pen is more permanent.

Although these legal requirements will likely not be an issue for the notekeeping that you do in class, following these guidelines now will instill good habits for your future work in science.