

Good Laboratory Notebook Practices

A tutorial on notebook best practices for maintaining organization of data and research integrity during the conduct of research

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The Purpose of this Tutorial

Maintaining a laboratory notebook is essential for anybody performing research. It is a means to document work that is completed in order to enable replication and validation. This tutorial is designed to provide some basic information and tips for good laboratory practices. These are merely guidelines, not policies. You should always check with your PI regarding specific policies.



Outline

- I. Introduction to the laboratory notebook
- II. Choosing a Laboratory Notebook
- III. Notebook naming conventions
- IV. What should be recorded in the laboratory notebook
- V. Who owns the laboratory notebook and intellectual property
- VI. Laboratory notebook ethics
- VII. Summary

I. What is a Laboratory Notebook?

- Written record of procedures, reagents, data, calculations, thoughts, explanations, and results of experiments
- Legal document used to defend intellectual property and accusations of fraud
- Knowledge for future researchers
- The foundation of a thesis and other publications



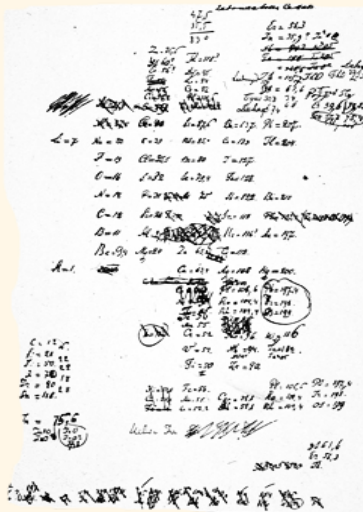
I. The Effort Spent is not Wasted

It takes time to produce accurate notebook entries, but it is worth the effort--consider famous scientists from history

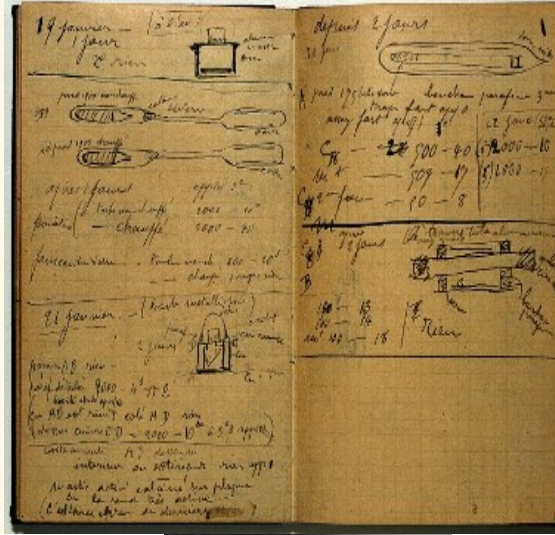
Leonardo Da Vinci



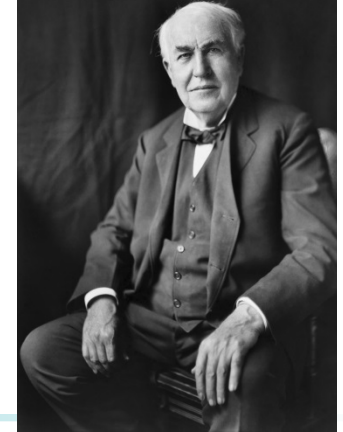
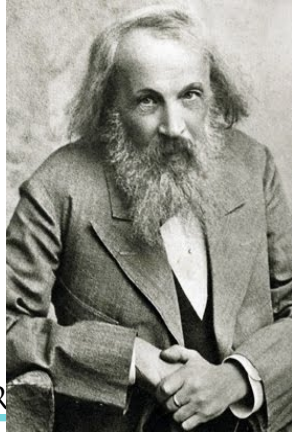
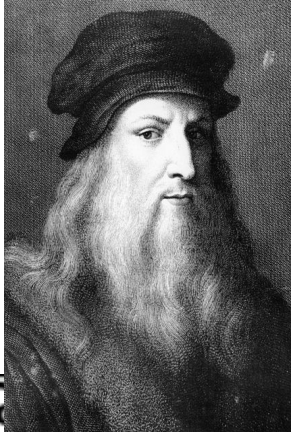
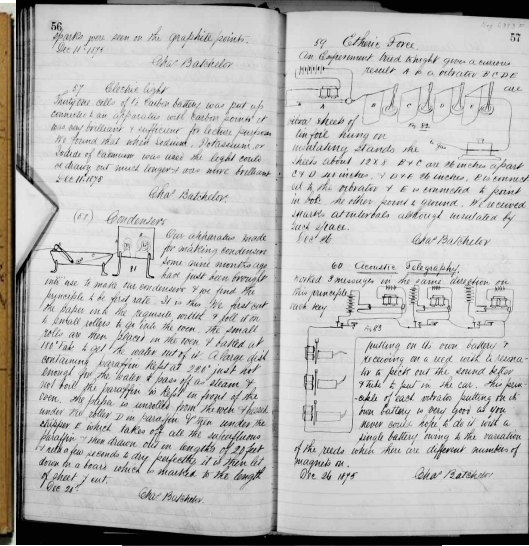
Dmitri Mendeleev



Marie Curie



Thomas Edison



II. Choosing a Laboratory Notebook

- Paper laboratory notebooks should have the following characteristics:
 - Hard-cover, stitched binding
 - Numbered pages
 - Pages that are not easily removed
 - Durable
- If choosing an electronic lab notebook (ELN) or using a combination paper and electronic, the following should be considered:
 - Robust note-taking capabilities
 - Searchable
 - Embed data and image files
 - Link between pages
 - Secure login
 - Audit trail, including timestamp changes are made and by whom
 - Add witness signatures and lock notebook pages
 - Ability to export to a common file type (ex PDF)
- Columbia University has an enterprise license with LabArchives (an ELN software), learn more at labnotebooks.columbia.edu

The remainder of this tutorial is inspired by paper notebooks however these best practices can be incorporated into any ELN



III. Naming Your Laboratory Notebook

- Naming laboratory notebook allows for:
 - Easy identification to the owner of the notebook
 - Ability to easily reference collected data to a certain notebook entry
- There are many practices that are used in both industry and academia which include:
 - Use of name/initials of researcher
 - Assignment of a numeric or alphabetic code to each researcher, code may be unique for each notebook used by researcher

Prof. Smith's Notebook Code

Code	Researcher	Code	Researcher
AA	Sci N. Tist	AF	Grad S. Tudent
AB	Sci N. Tist	AG	Grad S. Tudent
AC	Sci N. Tist	AH	Grad S. Tudent
AD	Rea S. Cher	AI	Grad S. Tudent
AE	Rea S. Cher	AJ	Grad S. Tudent

**Notebooks coded:
AA, AB, & AC
belong to
Sci N. Tist**

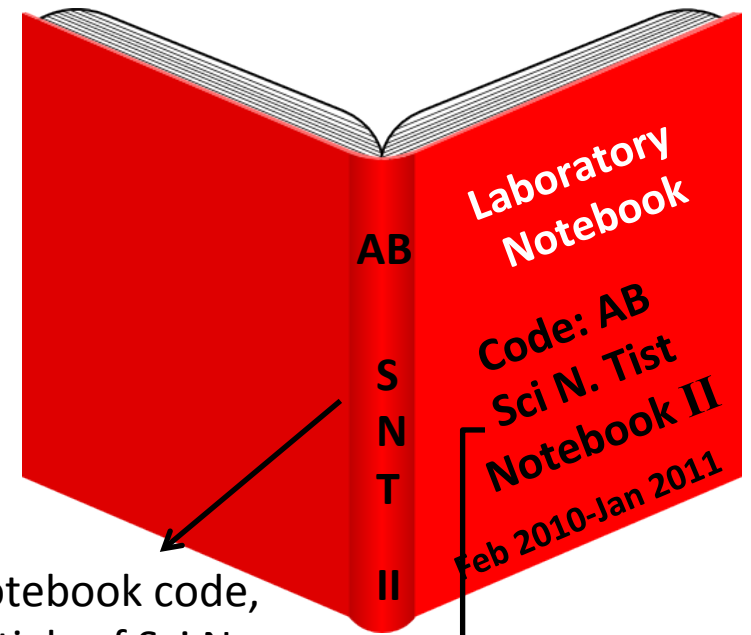
**Notebooks coded:
AD & AE belong to
Rea S. Cher**

**Notebooks coded:
AF, AG, AH, AI, & AJ
belong to
Grad S. Tudent**



III. Naming Your Laboratory Notebook

- Some research groups may have established notebook naming conventions, check with your PI
- Label your notebook clearly with your full name on the front
- If using a bound notebook label the spine
- During the course of research, multiple lab notebooks may be used, identify each one with either Roman Numerals or numbers
- Indicate the dates notebook is used
- If the notebook is specific to a particular project, include on the front cover



Notebook code, initials of Sci N. Tist and notebook number

Indicates the notebook code AB, belongs to Sci N. Tist and that it is the 2nd notebook used by Sci



IV. Contents of Laboratory Notebook

- Notebook name and researcher(s) it belongs to
- Inside cover or cover page
 - Dates used
 - Project name(s)
 - The address of the laboratory or office of researcher
- Table of contents
- Main text of notebook (experimental records)
 - Dates and titles of experiments
 - If multiple researchers using same notebook, name of researcher creating notebook entry
 - Hypothesis/goals/specific aims
 - Background information
 - Protocols, calculations, reagents, equipment used during experiments
 - Observations: anything planned or unplanned, raw data, permanently affixed information with reference to data location
 - Conclusions

IV. Table of Contents

Table of Contents

Page #	Date	Title of Experiment
1	2/4/2011	Synthesis of Fe ₂ O ₃ nanoparticles
2	2/5/2011	Raman of Fe ₂ O ₃ nanoparticles
3	2/7/2011	Synthesis of Ru(bpy) ₃
4		
5		
6	2/9/2011	Calculations for citric acid buffer pH=6
7	2/9/2011	NMR analysis of bipyridine ligand

- Table of contents help you (and present and future researchers) quickly find previous experiments
- If there is not a space provided for a table of contents, make your own within the first few pages of the notebook
- Write down the date and title of experiment
- If completing an experiment that is multi-page, record the entry on the first page used, then use arrows to show the number of pages devoted to that entry



IV. Main Text of Notebook: Experimental Record

- What should be included:
 - Objective/purpose of experiment
 - Plan, outline, or flow diagram
 - Step-by-step procedure, including conditions such as temperature, equipment, reagents, it is important to remember to **be specific**
 - All important test conditions/parameters
 - Supplementary information including citations
 - Observations: everything that occurs either planned or unplanned
 - Raw data, calculated data, and any transcribed data
 - Results including graphs, tables, figures, and data analysis (permanently affixed if a print-out)
 - Units
 - Conclusions: if objective was met and/or suggestions for future experiments

IV. Data Within Notebook Entries

- Raw data: original information, including handwritten notes and print-outs from instruments
- Calculated data: any data that is derived from a calculation, include equation
- Transcribed data: data that is copied from another source, indicate the location of the original copy
- Indicate if numbers are estimated or exact (ex: ~ 2 mL vs 2.00 mL)



IV. Supplemental Documents

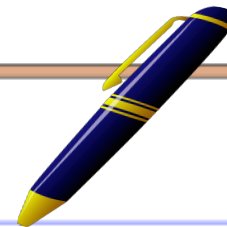
- Attach forms/printouts with either tape or glue, ensuring that it remains intact, and fully exposed, sign and date printouts if required by discipline and/or PI
- Do not cover any previously recorded entries
- Some researchers collect mass amounts of data in one day and it is common to use additional methods of storing hard copies of data
 - Three-ring binders
 - Additional notebooks
- Cross-reference to supplemental sources that contain collected data
- Use a similar naming convention for supplemental sources that is easily referenced to the researcher and notebooks
- Use of external hard-copy data storage does not replace well-written notebook entries

IV. Use of Abbreviations

- Many abbreviations are common and can be understood by researchers in the same discipline
- Some abbreviations are created by the individual researcher to reduce characters in saved file names and simplify long names
- For abbreviations that are unique to the project and regularly used, reserve the last few pages of the notebook to define the abbreviations, or create a code book or data dictionary



IV. General Notebook Housekeeping



19 August 2013

Using the procedure outline on page 15 on this notebook.

However, using ~~30 mL~~ 50.0 mL of acetone (ACS grade, lot #123)

Observed the solution turned cloudy after 30 minutes stirring (40 rpm) at room temperature (~25°C)

After 1 hour of stirring, used roto-vap At 100 rpm rotation with hot water bath set at 35 °C to remove extra solvent

Used spatula to transfer solid from flask to weigh paper and massed solid

Amount of product collected: 0.0156 g

~~27~~

~~Butler~~

~~08/19/13~~

- Use an ink pen to write in notebook
- Write as you go: the likelihood of remembering a procedural step decreases as time elapses
- Cross out any blank space not used (> 3 lines)
- Complete notebook entries in consecutive page order, avoid blank pages or X-out unused pages, do not remove pages
- Begin new experimental entries on a new page
- Draw a single line through errors, and write the correct information adjacent
- Never use white-out to fix error
- Sign/date entries



V. Laboratory Notebook Ownership

- As a researcher, it is your responsibility to maintain your laboratory notebook in a format that is intelligible to yourself, your PI, and future researchers. Your notebooks and supplemental resources should remain in the possession of your PI after leaving the University
- As a federally funded research institution, the University must assert ownership over research data for project conducted at the University or under its auspices. (1) The PI should retain possession of the data on behalf of the institution (2)
- Collected data in the form of laboratory notebooks and supplemental resources are owned by the University as outlined by regulations and/or sponsors as well as intellectual property rights (3-5)

Laboratory notebooks should not leave the laboratory

(1) OMB Circular A-110, Sec. 53, *Retention and Access Requirements for Records*

(2) *Managing Externally Funded Research Programs: A Guide to Effective Management Practices*. Council on Governmental Relations, July 2009

(3) Columbia University Office of Vice President for Research Sponsored Projects Handbook, June 2013

(4) Columbia University Faculty Handbook, 2008



V. Intellectual Property

University policy is as follows:

“Unless it has specifically waived its rights, the University holds the intellectual property rights to patentable inventions and discoveries, and any associated technology, that result primarily from the use of its facilities or from the activity of its officers while engaged in its service. Similarly, the University claims the copyright on any work of authorship created with the substantial use of its resources beyond the level commonly provided to faculty, for its use, or subject to contractual obligations requiring the copyright be in the name of the University.”

-Faculty Handbook, 2008

- Always consult Columbia Technology Ventures about any potential patentable research <http://techventures.columbia.edu/>
- Laboratory notebook is proof of intellectual property
- In laboratory notebook,
 - Sign, date, and have a person witness the invention
 - List all co-inventors



VI. Laboratory Notebook Ethics

- All data needs to go into notebook, even if the results are bad or the experiment failed
- Do not remove pages or mistakes. Simply draw a line through error and give correction. Consider writing initial and date of correction
- Record facts, not opinions (ex: no reaction occurred under these experimental conditions vs. this reaction will never work!)
- Be honest!



VI. Don't Become a Statistic

- Tufts University immunologist Thereza Imanishi-Kari admitted that her poor-record keeping led to misconduct allegations regarding falsification and fabrication of data in her 1986 paper in *Cell* with co-author Nobel Laureate David Baltimore (1)
- December 2011, a paper about Sleep Apnea was retracted from the New England Journal of Medicine due to the authors' inability to locate original data (2)
- A survey of 90 major research institutions' Research Integrity Officers showed that 38% of 553 misconduct cases involves some degree of poor record keeping (3)
- In a 2007 NIH survey of 1,479 researchers, 27.5% admitted to inadequate record keeping (4)

(1) Kaiser, J.; Marshal, E., 1996, *Imanishi-Kari Ruling Slams ORI*. *Science*, 272, 1864-1866

(2) Retraction Watch (<http://retractionwatch.com/2013/10/30/nejm-paper-on-sleep-apnea-retracted-when-original-data-cant-be-found/>)

(3) Wilson, K.; et. al. 2007, *Research Records and the Resolution of Misconduct Allegations at Research Universities*. *Accountability in Research*, 14, 57-71

(4) Shamoo, A.E.; Resnik, D.B., 2009, *Responsible Conduct of Research (2nd Ed.)*. Oxford University Press



VII. Summary

- Always check with your PI regarding practices that are appropriate within the research group
- The laboratory notebook is a legal record of experiments as well as the foundation for thesis and publications
- Use a naming convention that uniquely identifies the notebook to the researcher
- Be as specific as possible when writing experimental records
- Include all data that is collected during the course of experiment, when necessary use supplemental sources to store hard-copies of data with cross-reference in notebook entry
- Honesty is the best policy



References

- Good Laboratory Notebook Practices- Mississippi University by Lucy H. Senter
 - <http://www.research.msstate.edu/search/index.php?q=notebook>
- NIH Office of Intramural Training and Education's Webinar on Keeping a Lab Notebook: Basic Principles and Best Practices by Dr. Phillip Ryan
 - https://www.training.nih.gov/nih_resources
- Thomson JA. 2007. How to Start—and Keep—a Laboratory Notebook: Policy and Practical Guidelines. In *Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices* (eds. A Krattiger, RT Mahoney, L Nelsen, et al.). MIHR: Oxford, U.K., and PIPRA: Davis, U.S.A.
 - www.ipHandbook.org

Additional Resources

- Other Rascal Trainings:
 - *Research Data Management TC2800 and TC2801*
 - *Best Practices for Data Management When Using Instrumentation TC2650*
 - *Sample Labeling and Storage Tutorial [TC3250](#)*
- LabArchives for Columbia University researchers:
labnotebooks.columbia.edu

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