The National
Mathematics
and Science
College

STEM COMMUNICATION PROGRAMME

JOCELYN D'ARCY

SEPTEMBER 2022

PROGRAMME BRIEF

The STEM Communication Programme spans 4 terms from September of Year 1 through until January of Year 2. Over the course of the programme, students will participate in lectures, seminars and workshops delivered by a combination of College staff and outside speakers and produce written and spoken content both individually and as part of a group.

AIMS

- introduce all students to established methods of communication in STEM including academic research and public engagement
- develop students' English communication skills; both general and STEM- specific
- provide challenge for all students through a differentiated super-curricular programme
- produce content in-line with the College's standing as a national beacon for STEM
- establish partnerships with academics and industry professionals

OUTLINE

By the end of the programme each student will have completed the following:

- *Individual and Paired research projects*
- *A formal research paper written in LaTeX*
- *A viva on the original research conducted*
- *Peer Review of original research*
- *An academic poster*
- *A TikTok style video on a STEM topic designed for the general public*

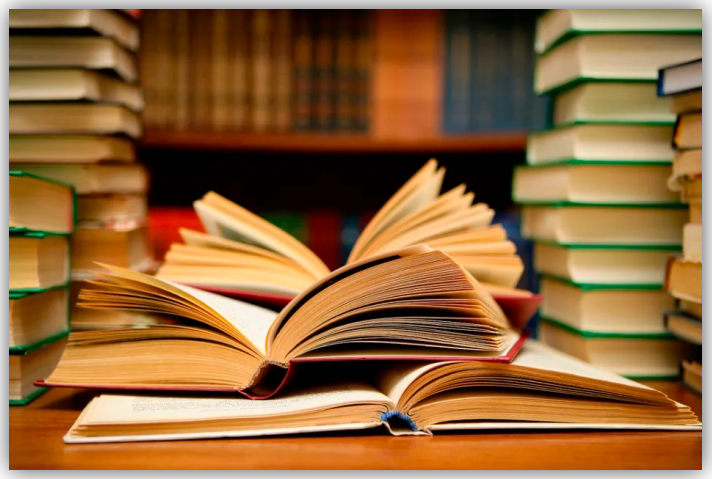
TERM 1 - WORKSHOPS

CONDUCTING AN EXPERIMENT

Students will be introduced to various lab equipment from Physics, Chemistry and Biology. The sessions will provide students with the opportunity to use apparatus to generate data so that they can record their results.

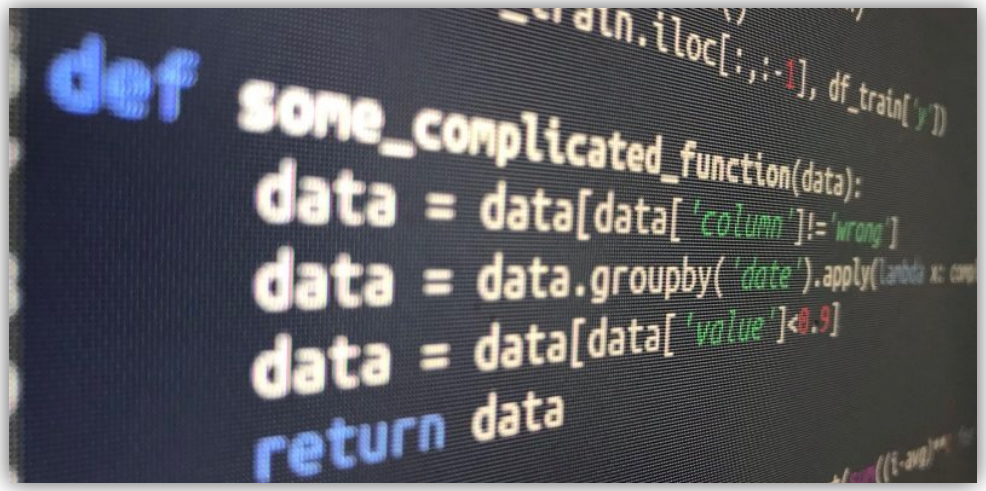
REVIEWING LITERATURE

Students will be taught how to conduct a basic literature review. The topic will be decided in advance by the instructors. Each student will be given the same two articles and required to find a third relevant and reliable article before summarising all three in the style of a literature review.



ANALYSING DATA

Students will generate summary statistics and conduct regression analysis from a large data set using Python



PUBLISHING WITH LaTeX

Students will produce documents using the science typesetting language LaTeX.

Code (text)

```
1 \documentclass{article}
2 \begin{document} % Main text goes here
3 \noindent Agricultural fields are usually rectangular. \\
4 Diagonal of a field ($L \times W$) is $\sqrt{L^2 + W^2}$.
5 \end{document}
```

Output (pdf)

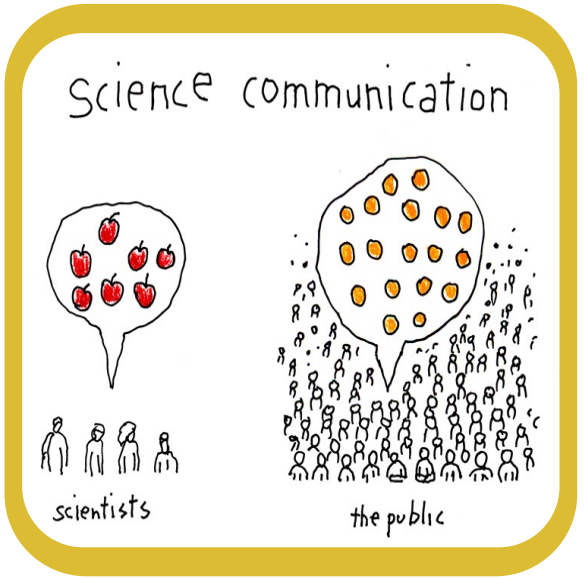
Agricultural fields are usually rectangular.
Diagonal of a field $(L \times W)$ is $\sqrt{L^2 + W^2}$.

”CVs written in LaTeX always go to the top of the pile.”

LECTURES

Students will also attend lectures on the nature of research in different fields such as:

- *Prof Michael O'Toole (Engineering, Manchester)*
- *Dr Richard Lissaman (Mathematics, Warwick)*
- *Dr Jeffrey C Barrett (Genetics, Nightingale)*
- *Prof Jeremy Smith (Warwick, Economics)*
- *Prof Max Van Kleek (Computer Science, Oxford)*
- *Dr Richard Diaz (NICE)*



TERM 2 – PAIRED PROJECT

TIKTOK CHALLENGE

In groups of 2-4, students will be challenged to create a short TikTok style video related to STEM. The challenge will be introduced during the first STEM Communication lesson of term 2, with students being given a full day off timetable the following week to create their video.

PAIRED RESEARCH PROJECT

Students will select the field in which they would like to conduct this minor research project from the choice of: Biology, Chemistry, Physics, Economics, Medicine, Computer Science or Mathematical modelling.

PAIRED RESEARCH PROJECT - POSTER

Myelin Thickness in the Temporal Lobe in Autism

Alexandra E. Carr, Thomas A. Avino, Ph.D., & Cynthia M. Schumann, Ph.D.
Univ. of California, Davis, MIND Institute, Department of Psychiatry, Sacramento, CA

Introduction

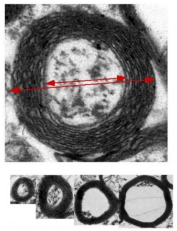
- Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by behavioral abnormalities that include difficulties with communication and social interactions
- A disorder of **connectivity**
  - fMRI studies showing reduced functional connectivity (Just et al., 2004; Kana et al., 2011)
  - DTI studies showing reduced fractional anisotropy (Travers et al., 2012)
- Hypoconnectivity in the brain of adults with autism may be due to **decreased levels of myelin** which is necessary to form proper brain connections (Zikopoulos & Barbas, 2010)
- Deviation of myelin thickness thickness provides a **neuroanatomical basis** for alterations to brain connectivity in individuals with ASD

Methods – Subjects & Processing

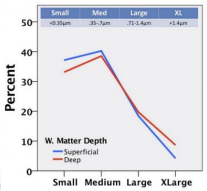
- 18 Subjects (8 ASD, 10 Neurotypical [NT])
  - Age range: 2 – 44 years old; age-matched
  - Post mortem human brains
- White matter dissections
  - <4mm away from gray-white matter boundary
  - Superficial = < 2mm; Deep = 2-4mm
  - Ultrathin sectioning: 75 nm
- Region of interest:
  - Temporal lobe (superior temporal gyrus & fusiform gyrus)

Electron Microscopy

Myelin Thickness (g-ratio): 8,400x

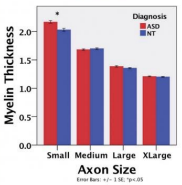


Axon Size Distribution

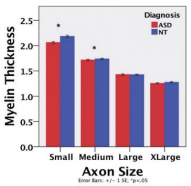


Results – Myelin Thickness across Axon Sizes

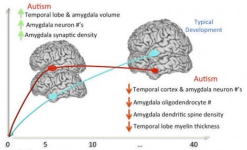
Thicker myelin in children with ASD compared to NT



Thinner myelin in adults with ASD compared to NT



Model of Temporal Lobe Growth in ASD



Conclusions & Future Research

- **Replicated previous findings** regarding neurotypical g-ratio and axon size distribution (Paus & Toro, 2009; Schmahmann & Pandya, 2006)
- Demonstrated **increased myelin in children with autism** in accordance with other findings (Schumann et al., 2004)
- Demonstrated **reduced myelin in adults with autism** in the temporal lobe; previously demonstrated in the frontal lobe (Travers et al., 2012; Zikopoulos & Barbas, 2010)
- These findings implicate a potential degenerative process in the temporal lobe in autism
- Further research will examine the function and regulation of **oligodendrocytes**

Acknowledgments & References

The authors thank Patricia Kysar and Xiao-Bo Liu for their assistance with electron microscopic processing. We are indebted to the donors and their families for providing this valuable resource. This research was supported through NIMH R01 MH097236-04 and NIMH R03 MH104735-01. Tissue was acquired through Autism BrainNet, NIH NeuroBioBank at UMB and the UC Davis MIND Institute BEARS tissue program.

Just, M. A., Cherkassky, V. L., Keller, T. A., & Minshew, N. J. (2004). Cortical activation and synchronization during sentence comprehension in high-functioning autism: evidence of underconnectivity. *Brain*, 1811-1821.
Kana, R. K., Libero, L. E., & Moore, M. S. (2011). Disrupted cortical connectivity theory as an explanatory model for autism spectrum disorders. *Phys Life Rev.*, 410-437.
Travers, B. G., et al. (2012). Diffusion tensor imaging in autism spectrum disorder: a review. *Autism Res.*, 289-313.
Uppal, N., et al. (2014). Cortical thickness and surface area in autism: an exploratory study of oxytocin receptor genotype and in utero androgen exposure. *Molecular Autism*, 5-7.
Schumann, C. M., & Amaral, D. G. (2006). Stereological analysis of amygdala neuron number in autism. *Neurobiology of Disease*, 7074-7079.
Schumann, C. M., et al. (2004). The amygdala is enlarged in children but not adolescents with autism; the hippocampus is enlarged at all ages. *Neurobiology of Disease*, 8392-6401.
Schmahmann & Pandya (2006). Fiber Pathways of the Brain. Oxford University Press.
Zikopoulos, B. & Barbas, H. (2010). Changes in prefrontal axons may disrupt the network in autism. The Journal of Neuroscience, 16943-16953.
Morgan, J. T., Barger, N., Amaral, D. G., & Schumann, C. M. (2014). Stereological study of amygdala glial populations in adolescents and adults with autism spectrum disorder. *PLOS One*, 1-14.

Growing trees in tubes

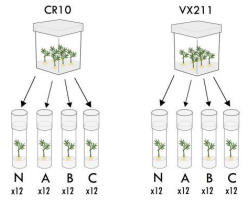
Comparitive *in vitro* propagation of walnut using BA and mT

Erin B. Hsu
Department of Plant Sciences at University of California, Davis 95616

1. Why Walnuts?

Walnuts from *Juglans regia* L. are globally consumed for their nutritious contents. The plant is often grafted onto a hybrid *J. regia X J. hindsii* 'Paradox' rootstock, which grows vigorously and is more resistant to soil-borne pests and diseases. Propagating walnuts in vitro is vital to produce uniform plants and improved varieties. In tissue culture, shoot formation is usually promoted by adding the cytokinin 6-benzylaminopurine (BA), but BA can cause growth abnormality and inhibit root formation in walnut (Amoo et al. 2011, Werner et al. 2001). Another cytokinin, *meta*-Topolin (mT), has been shown to produce fewer abnormalities and improve root number and quality in *Prunus* rootstocks (Amoo et al. 2011, Gentile et al. 2014). Successful replacement of BA with mT may increase the efficiency and success of walnut germplasm culture. **This project aimed to compare the effects of BA and mT on micropropagation of a 'Chandler' scion (CR10) and a 'Paradox' rootstock (VX211).**

2. Methods



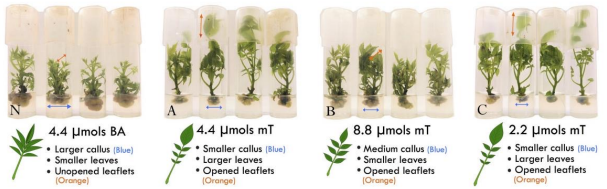
Treatments: **N:** Control - 4.4 µmols BA **A:** 4.4 µmols mT
B: 8.8 µmols mT **C:** 2.2 µmols mT

Time Period: 2 subcultures, 3 weeks each
Duration: Jan 24 - March 7

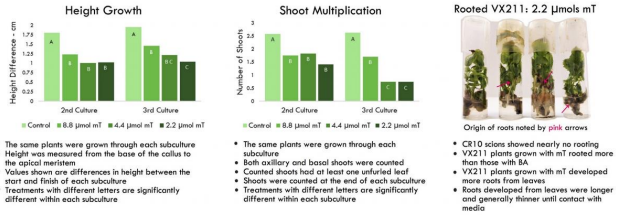
Rooting: 1 week in the dark, then moved under light
Began: March 14

Analysis: ANOVA with Tukey's Honestly Significant Difference with separation of $\alpha = 0.05$

3. Leaf Morphology of CR10 Scions



4. Shoot and Root Development of CR10 and VX211



- The same plants were grown through each subculture
- Height was measured from the base of the callus to the apical meristem
- Values shown are differences in height between the start and finish of each subculture
- Treatments with different letters are significantly different within each subculture

- The same plants were grown through each subculture
- Both axillary and basal shoots were counted
- Counted shoots had at least one unfurled leaf
- Shoots were counted at the end of each subculture
- Treatments with different letters are significantly different within each subculture

- CR10 scions showed nearly no rooting
- VX211 plants grown with mT rooted more than those with BA
- VX211 plants grown with mT developed more roots from leaves
- Roots developed from leaves were longer and generally thinner until contact with media

5. Conclusions

- Plants grown with mT had fewer shoots and were shorter
- Leaf morphology of CR10 scions was significantly affected by presence and concentration of mT
- VX211 rootstocks grown with mT rooted more, with the majority rooting from leaves
- **mT may be preferable to BA for walnut micropropagation, but at the expense of reduced shoot proliferation**

Literature Cited

Amoo, S.O., Finnie, J. F., & Van Staden, J. (2011). The role of meta-topolins in alleviating micropropagation problems. *Plant Growth Regulation*, 63(2), 197-206. doi:10.1007/s10725-010-9504-7
Gentile, A., Gutierrez, M.J., Martinez, J., Frattarelli, A., Nota, P., & Caboni, E. (2014). Effect of meta-Topolin on micropropagation and adventitious shoot regeneration in *Prunus* rootstocks. *Plant Cell Tissue and Organ Culture*, 118(3), 373-381. doi:10.1007/s11240-014-0489-1
Werner, T., Motyka, V., Strnad, M., & Schmulling, T. (2001). Regulation of plant growth by cytokinin. *Proceedings of The National Academy of Sciences of The United States of America*, 98(18), 10487-10492. doi:10.1073/pnas.171304098

Acknowledgements

The resources and facilities that were necessary for this project were provided by the Walnut Improvement Program and Lab at University of California, Davis.
Assistance from Chuck Leslie, Wes Hackett, Linsh Chen, and Steven Lee of the Walnut Improvement Lab and UC Davis faculty Richard Evans was greatly appreciated.

TERMS 3 & 4– INDIVIDUAL RESEARCH PROJECT

INDIVIDUAL RESEARCH PROJECT - INTRO

- The Individual Research Project allows students to use the skills they have developed through the programme to produce a genuine piece of academic research. In addition to publishing the research papers in our own journal, students will be encouraged to submit their papers to external journals.

INDIVIDUAL RESEARCH PROJECT - EXAMPLES

Examples of individual research projects might include:

- How does changing the limits of the integral impact the accuracy of Simpson's rule in approximating the integral of sin(x)?
- Do students who vape emit more radiation than those who do not?
- Why is inflation in the UK so high?
- Is the functionality of salivary amylase related to BMI?

INDIVIDUAL RESEARCH PROJECT - REPORT

A Minimal Example for Junior Lab Reports Using LaTeX

Fiz A. Cist*
MIT Department of Physics
(Dated: July 23, 2014)

This paper is a minimal example of a written summary for use by MIT Physics Junior Lab students. It uses LaTeX (pronounced *lay-tek* or *lah-tek*, but never *lay-teks*) and the REVTeX macro package from the American Physical Society to produce a professional quality document. A more extensive example template which demonstrates many more common LaTeX "tricks" is a available from the Junior Lab web pages, but the present document may be easier for first time LaTeX users. In regards to content, the individual summary you hand in should show evidence of your own mastery of the entire experiment. It should also possess a neat appearance with concise and correct English. The abstract of the paper should briefly mention the motivation, the method, the quantitative result, and the result's uncertainties. The length of the paper should be no more than two double-sided pages including all figures.

An important part of your education as a physicist is learning to use standard tools such as LaTeX which enable you to share your work with others in a widely accepted professional style. Spending a few hours studying and altering this document will allow you to develop sufficient mastery of LaTeX to easily generate all manner of technical documents. Specific instructions for compiling LaTeX documents on various operating systems are contained in the Appendices.

This is the introductory section of the paper. Your introduction should *succinctly* report the motivation, purpose, and relevant background to the experiment in way that is accessible to your audience. For Junior Lab, the appropriate audience is a stereotypical Junior Lab student who has background knowledge and experience similar to your own, but is totally unfamiliar with your experiment.

I. PROBLEM AND RELEVANT THEORY

The body of the summary should include a brief discussion of the movtivation or theoretical issues addressed by the experiment. This should be done at a level such that another 8.13 student could follow your development.

The report should be type-written in a form that would be suitable for submission as a manuscript for publication in a professional journal such as Physical Review Letters. One helpful resource is the *APS Physical Review Style and Notation Guide* [1]. Another is the *AIP Style Manual* [2]. Figures (created as PDF or PNG files) should be inserted into the text in their natural positions.

If you are individually writing up results you obtained with a partner, use "we" and "I" appropriately. Note the following admonition from the *AIP Style Manual* [2, Section III.A.9]:

> The old taboo against using the first person in formal prose has long been deplored by the best authorities and ignored by some of the best writers. "We" may be used naturally by two or more authors in referring to themselves; "we" may also be used to refer to a single author and the author's associates. A single author should also use "we" in the common construction that politely includes the reader: "We have already seen. . . ." But never use "we" as a mere substitute for "I," as in, for example, "In our opinion. . . ."which attempts modesty and achieves the reverse; either write "my" or resort to a genuinely impersonal construction.

Use the past tense for your procedure and analysis, the past perfect for preparation and the present for emphasis or conclusions. For example, "Since we had previously measured constructive and destructive interference, we concluded that electrons are waves."

Some further tips:

- Be sure your figures have comprehensible captions.
- Make a complete estimate of your errors — not just statistical — even if it is crude.
- Trace the origin of formulae you use (*e.g.* Moseley's law) to well known physics (in this case, to the Bohr atom). Do *not* derive: just indicate what new assumptions are needed.

Lastly: Remember to *proofread your paper for spelling and grammar mistakes.* Few things are as offensive to a reviewer as careless writing. Such mistakes will count against you!

One of the great powers of LaTeX is its ability to typeset all manner of mathematical expressions. While it does take a short while to get used to the syntax, it will soon become second nature. Numbered, single-line equations are the most common type of equation in Junior Lab papers. For example,

$$\chi_+(p) = x^2 + \frac{\partial y}{\partial z} \times \sqrt{\langle\psi|\alpha^\dagger|\phi\rangle} - \sin\theta. \qquad (1)$$

* nobody@mit.edu

Be sure there is *no empty line* in your LaTeX source code between `\end{equation}` and the following body text unless you want a new paragraph to start there (and be indented). Also, remember to punctuate your equations according to their usage as parts of sentences.

Mathematics can also be placed directly in the text using $ deliminators: the energy E is related to the mass m via $E = mc^2$, where c is the speed of light. As in the previous sentence, you should use this construction not just for whole equations in running text, but also for referring to individual variables by name: otherwise the variables will be set in different typefaces when appearing in text versus equations.

Infrequently, you may wish to typeset long equations which span more than one line of a two-column page. A good solution is to split up the equation into multiple lines and label all lines with a single equation number, as in Equation (2). See the LaTeX source to see how this is done using the `multline` environment.

$$\sum |M_g^{\rm viol}|^2 = g_S^{2n-4}(Q^2)\ N^{n-2}(N^2-1) \times \left(\sum_{i<f}\right) \sum_{\rm perm} \frac{1}{S_{12}}\frac{1}{S_{12}} \sum_\tau c_\tau^f. \qquad (2)$$

Since LaTeX does not know mathematical grammar, you have to tell it the appropriate place to split the input using the \\ sequence.

II. EXPERIMENTAL SKETCH AND SALIENT DETAILS

Here is an example first sentence of an experimental section: The experimental apparatus consists of a specially prepared chemical sample containing $^{13}CHCl_3$, an NMR spectrometer, and a control computer, as shown in Fig. 1.

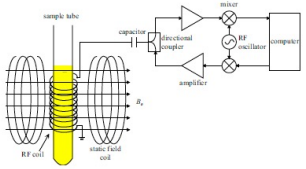


FIG. 1. This is a schematic of the main apparatus. Use the caption space to elaborate on specific issues, complications, or operating procedures. This is especially valuable given the limited amount of space in the main body of text. Adapted from [3, 4].

This section describes the main components of the apparatus and procedures used. It always makes reference to a figure(s) which contains a block diagram or schematic of the apparatus and perhaps includes the most important signal processing steps. The figure should be referenced as early as possible in this section with the placement of the figure as close to the descriptive text as is possible. It is usually necessary to place additional information within the figures themselves or in their captions for which there is no room in the main body of text. This will help you stay within the four page limit.

III. DATA PRESENTATION AND ERROR ANALYSIS

Graphics, such as Fig. 2, should be well thought out and crafted to maximize their information content while retaining clarity of expression.

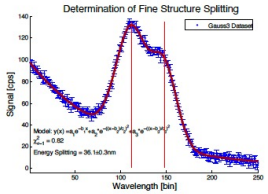


FIG. 2. Sample figure describing a set of data, fit procedures and results, created using the Junior Lab MATLAB template script at http://web.mit.edu/8.13/matlab/fittemplate11.m. Use the caption space to provide more details about the fitting procedure, results, or implications if you do not have sufficient room in the main body of text.

All papers should have at least one graphic showing an assemblage of raw data. Often these primary data are analyzed in a specific way that needs to be clearly communicated to the reader as another graphic. For example, a graphic demonstrating a typical analyzed result, functional model, and reduced χ^2 is shown in Fig. 2. Finally, there should be one graphic which summarizes the experimental data, and which conveys the primary finding(s) of the laboratory exercise. You may find that you need more, but these three should be a minimum. Finally, it can be useful in *some* circumstances to have a table of results, see Table I.

Appendix A: LaTeX on Windows

For students who would like to use a Windows platform, MiKTeX (pronounced *mik-tek*) is a freely available implementation of TeX and related programs available from www.miktex.org. Note that MiKTeX itself runs from a command line prompt and is not terribly convenient unless you are comfortable with the Windows shell. Luckily, MiKTeX comes packaged with the TeXworks editting environment as a front end to LaTeX. Many beginners find TeXworks easier and more intuitive to use than the alternative of a generic text editor and command line compliation. Advanced users may prefer a more powerful editor like Emacs or vi instead of a LaTeX-specific editor like TeXworks.

Note that due to some "bad" distributions of LaTeX floating around the internet, some Windows users may need to update their LaTeX installation to the latest version of REVTeX-4.1 and the required `natbib` package. Alternatively, they can use the older REVTeX-4 by changing the `\documentclass` declaration at the beginning of the source file. You will know if you need to do this if you attempt to compile this sample document and receive errors about bad bibliography entries.

Once you have installed the above software, you will need to download the source files listed in the next section and put them on your Windows machine in order to "rebuild" this document from scratch.

Appendix B: LaTeX on Athena

For students wishing to utilize MIT's Athena environment, the process to create your documents is quite simple. You can use the following commands verbatim or tweak them to suit your own organizational system.

In your home directory on Athena, create a convenient directory structure for all of your Junior Lab work by typing:

```
> mkdir ~/8.13
> mkdir ~/8.13/papers
> mkdir ~/8.13/papers/simple
> cd ~/8.13/papers/simple
```

Once this (or similar) directory structure has been created, copy all of the files needed to compile the template from the Junior Lab locker into your own Athena account by typing:

```
> cp /mit/8.13/www/Samplepaper/simple-zipped/* .
```

The final period above places the copied files into the current directory so make sure you are in the correct directory! You can see where you are by typing:

```
> pwd
```

The following files should now be in your current directory:

```
simple-paper.tex
simple-paper.bib
simple-paper.pdf
sample-fig1.pdf
sample-fig2.pdf
```

Additional files may also have been copied but do not worry: these get regenerated when you build your PDF document.

Now build the file (omitting the `.tex` suffix in the following steps):

```
> pdflatex simple-paper
> bibtex simple-paper
> pdflatex simple-paper
> pdflatex simple-paper
```

The repeated calls to `pdflatex` are necessary to resolve any nested references in the final PDF file. The `bibtex` call reads in the bibliography file `simple-paper.bib` allowing citation references to be resolved.

Remember to "`ispell -t filename.tex`" to perform a LaTeX-safe spell check before handing in your paper!

Appendix C: Graphics Utilities

Students should become proficient with a simple vector based drawing program such as Inkscape. Every written summary should include one or two simple schematics, based on your initial hand sketches from your lab notebook

It is easy to convert images from one format to another, *e.g.* a scanned JPEG or bitmap image into a PDF file for inclusion into a written summary. A useful utility, available on some Unix machines, is imconvert. Typing `imconvert` without any arguments will show you the accepted file types. Other useful conversion utilities include ps2pdf, eps2pdf, and a variety of similar programs.

Matlab is perhaps the most common tool used by Junior Lab students for data analysis and representation. Matlab figures can incorporate LaTeX symbols in their titles, axes labels, and text labels. Figures can be saved directly into PDF or PNG format, obviating the need for any further format conversion.

INDIVIDUAL RESEARCH PROJECT – PEER REVIEW

In Academia, articles are peer-reviewed before publication.

Your report will be reviewed by your peers, and you will have the opportunity to review others' projects

Students will also participate in a Viva (usually part of a PhD where your supervisor questions your research and you defend it.

INDIVIDUAL RESEARCH PROJECT – BENEFITS

Benefits:

- University admissions
- EPQ possibility
- Publication
- Networking opportunities

GO FURTHER,
COME RUN WITH
THE SWIFT