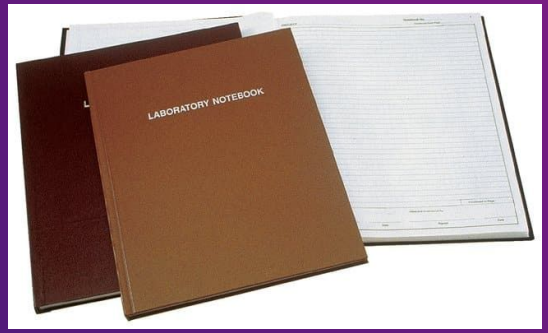
BASIC SKILLS IN RESEARCH EVENT

1. PLANNING AND IDEATION

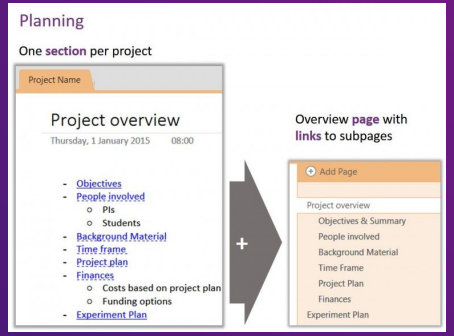
KEEPING TRACK OF IDEAS

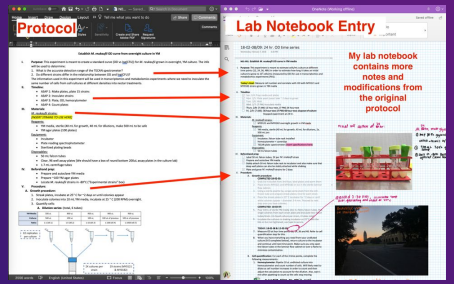


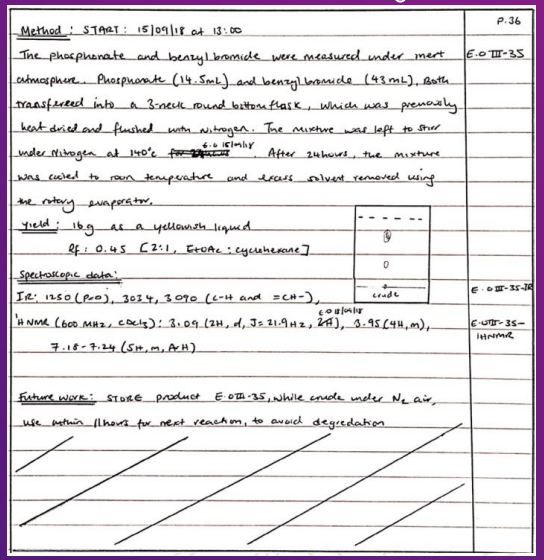
- Lab notebook is your best friend
  - Repeat experiments
  - Record data
  - Be specific!
- Don’t be afraid to take notes or modify procedures
  - Your lab notebook is first and foremost for you
- Keep things organized, and keep track of your documents
  - Filing system
  - Shared drive

FORMATTING YOUR LAB NOTEBOOK

- Can be electronic or physical
  - Actual notebook
  - OneNote
  - Google Drive
- Use a table of contents
- Date everything
- Cross out unused space
- Write your name on each page





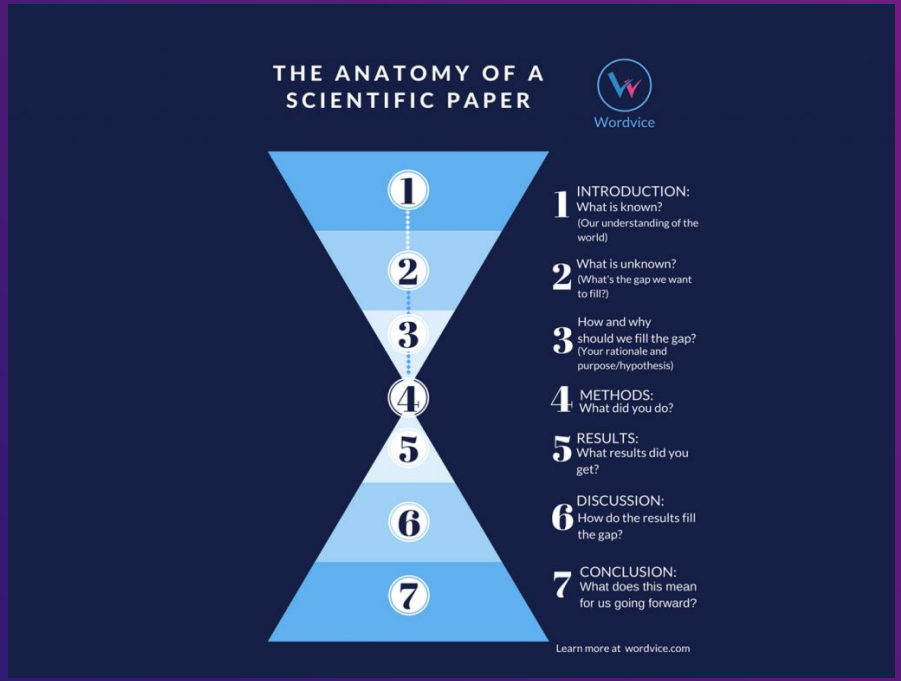


TYPES OF LITERATURE

- Primary literature - original data, discovered/measured by researchers, peer reviewed and published
  - Usually advanced knowledge in the field, represents some form of advancement of knowledge
- Secondary literature - summaries and reviews of primary literature, not by the original author
  - Helps you get a more background/context, might want to do more of your own research

STARTING OUT WITH LITERATURE

- Read review papers on subjects you're interested in
  - Examples of secondary literature
- Once you've found labs you like, look at the journals they've published in
  - Reading more articles in these journals will help you get a feel for the field
- Most importantly - get used to reading technical language
  - Research articles require active reading, extremely dense
  - Try reading 1 paper a week



Focus on 1, 2, 6, 7

IDEATION RESOURCES

01 GOOGLE SCHOLAR

02 GEORGIA TECH LIBRARY

03 PUBMED

04 SCIENCEDIRECT

KNOW WHAT TO SEARCH FOR

- Use specific language
- Skim abstracts
- Filter by date
- Check references of helpful papers

HOW DO I GET MY OWN IDEAS?

- All research is based on prior knowledge
  - Check “future goals” or similar sections of papers you read
  - Look at the research projects and goals outlined on lab websites
  - Use content from your classes
  - If you’re already in a lab, ask to see prior lab notebooks
- It’s okay if your work overlaps - it almost certainly will as an undergraduate

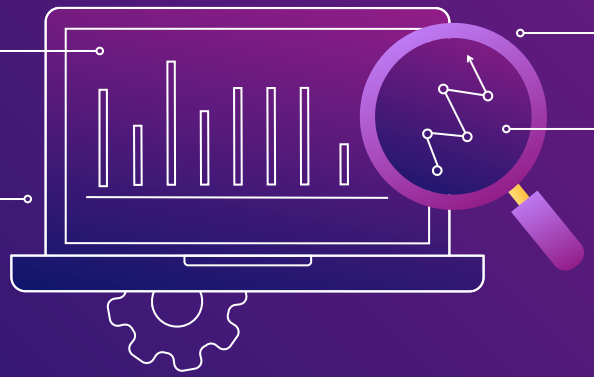
SUMMARY OF IDEATION ELEMENTS

COLLECTION

Look at previous experiments. What worked, what didn't?

CONTINUATION

Build off of previous work to make your own experiment



CONTEXT

Establish background scientific knowledge

CHECK

Did your experiment go as planned? Improve and repeat

2. EXPERIMENTATION

Utilizing data collection techniques, scientific method, and campus resources to accurately and efficiently run your experiments!

EXPERIMENTAL PREP

- A lot of experiments you conduct will be up to the discretion of your lab or mentor
- There are some general guidelines to follow:

Keep a lab notebook that's highly detailed (include pictures, measurements, times, techniques, observations, etc.)

If you're a first time researcher, always run by your steps with your mentor or PI (and even if you're experienced!)

Make sure you're aware of any variables that may affect your population or sample groups

VARIABLES

01 INDEPENDENT

Researcher changes this variable to induce a change/effect to study

02 DEPENDENT

This observed variable responds to the independent one (often more than one)

03 CONTROLLED

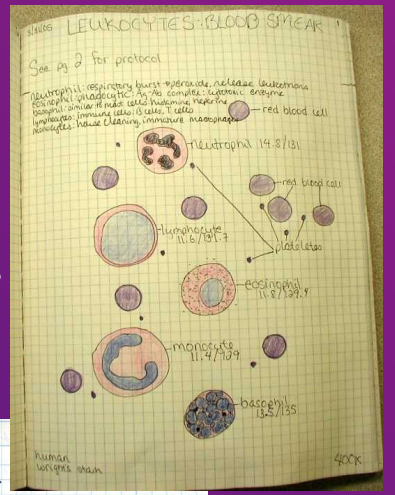
Other factors you keep constant to minimize variance

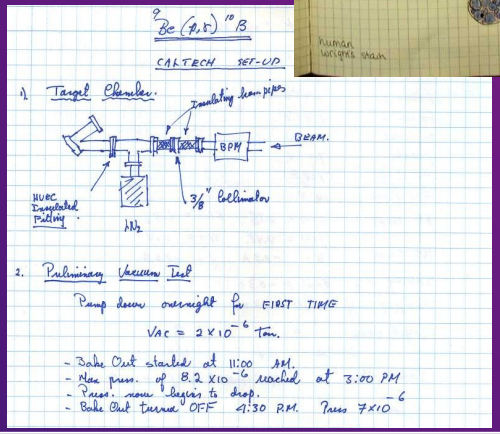
04 CONFOUNDING

Separate factor that is also associated with the independent/dependent

EXPERIMENTAL NOTE TAKING

- Lab notebook format covered in Planning and Ideation
- Important to write in your own words so you understand the thought process from the protocol
- Ask other lab members or your mentor to follow your reasoning by themselves and ensure it's understandable across different modes
- Sometimes it's easier to jot down data during an experiment and format it neatly later
- Drawing pictures, graphs, and diagrams can help visualize experiments





DATA COLLECTION

HAND WRITTEN

Very accessible if you have paper/notebook

PYTHON

Requires some experience/training but can be used to visualize and streamline data

MICROSOFT EXCEL

Used for data collection, organization, and charting

FLOW CHARTS

Easy to draw out processes and relationships

CAMPUS RESOURCES

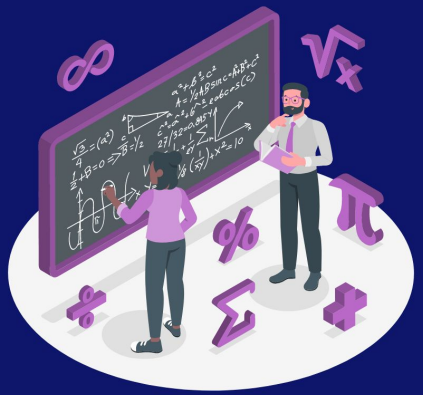
- Your research lab will be your biggest resource but there's lots of opportunities around campus!
- Engineering Maker Spaces:
  - The Invention Studio
  - BME Design Shop
  - The MILL
  - The Hive
- Department or Major workshops
  - Training on programming, research, other software
- Symposiums/Conferences

3. DATA ANALYSIS

Employing mathematics, programming languages, and specialized software to interpret and assess the quality of experimental data in order to form meaningful conclusions.

MATHEMATICS OF DATA ANALYSIS

A foundational understanding of **statistical methods** is key to understanding when data is meaningful and what information to extract when writing code or using specialized software.



- ★ **Summary statistics** (mean, range, standard deviation, etc.) can help you determine how much variation is in your experimental data.
- ★ Summary Statistics can be used in **hypothesis testing** to determine if experimental results are significant with a specified degree of confidence.

Khan Academy course on statistics!

MATHEMATICS OF DATA ANALYSIS

A foundational understanding of **statistical methods** is key to understanding when data is meaningful and what information to extract when writing code or using specialized software.

- ★ Other calculations such as **percent error/difference** can give an idea of the extent of difference between control and experimental trial data.
- ★ **Questions to ask** when performing statistical analysis:
  - How much variation in the data is acceptable?
  - How confident must I be that my data falls within a given range?
  - What percent difference between data sets is expected/acceptable?

Khan Academy
course on statistics!

MATHEMATICS OF DATA ANALYSIS

In addition to statistics and probability, **linear algebra** is another core mathematical subject for data analysis.

- ★ Employing coding languages to analyze data generally requires you to work with **matrices and vectors** that store data sets.
- ★ **Examples** of data stored in matrices/vectors:
  - Images as 2D matrices of RGB color values
  - X and Y values for plots stored as 1xN vectors
  - Videos stored in a 3D matrix with time as the third dimension

Khan Academy linear algebra review!

MATHEMATICS OF DATA ANALYSIS

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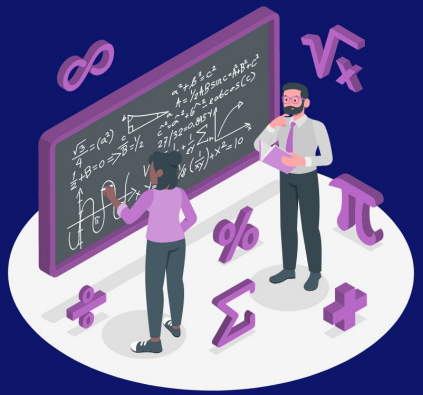

- A fundamental understanding of **matrix operations** is useful to ensure you are manipulating data sets correctly:
  - Multiplication
  - Dot products
  - Determinants
  - Inverses
  - Transposes
- Manipulation of matrices can be used to perform important analytical techniques such as **linear regression** and **dimensional analysis**.

Khan Academy linear algebra review!

PROGRAMMING FOR DATA ANALYSIS

★ **Which programming language should I learn?**
- Is there a required or suggested CS course for your major? What language does it use? This can be a great place to start!
- Ask friends in research- do they use a particular language?
- Google popular coding languages in your research area of interest!

★ Ultimately, **learning any language as your first coding language is valuable** as it will teach you the fundamentals of coding such as functions, variables, data structures, loops, and operators.

★ **Choose the language that is most accessible to you!**
- Are there free tutorials to help you get started, or a class you can/must take that helps you progress in your major?

Web illustrations by Storyset from www.storyset.com/web

PROGRAMMING FOR DATA ANALYSIS- DEFINITIONS

VARIABLES

Storage units for data (numbers, matrices, logicals, etc.) represented by a given name[1]

DATA STRUCTURES

Organized groups of data values, such as matrices or tables[1]

API'S

Application Programming Interface

DATA TYPES

Different classes of data such as integers and floating point (fractional) numbers, characters, strings (character sequences), and logicals (true/false)[2]

CONTROL STRUCTURES

Structures that allow different outcomes to happen based on a set of given conditionals; includes sequential, conditional (if, else), and loop (while, for) structures[1]

OPERATORS

Symbols that perform specific data manipulations, including arithmetic (adding, multiplying), relational (greater than, equal to), and logical (and, or, not) operations[3]

FUNCTIONS

Pieces of code that run when called to produce an output or perform specified tasks based on given inputs[1]

1. https://www.educative.io/answers/what-are-the-basic-fundamental-concepts-of-programming
2. https://press.rebus.community/programmingfundamentals/chapter/data-types/
3. https://www.tutorialspoint.com/computer_programming/computer_programming_operators.htm
4.

SOFTWARE FOR DATA ANALYSIS

- **Get familiar with the basics**
  - Excel/Spreadsheeting Software
- Do you work with any **specialized software** in your coursework?
- **Equipment-Specific**
  - How to interface with data collection devices in the lab?
- Different labs use different tools to collect data
  - However, **being comfortable with the basics** like Excel or software used in your coursework…
  - And **understanding general math and coding principles** behind data analysis…
  - Will allow you to pick up new software more seamlessly!