The Search for Research Papers

Getting started on finding and reading sources for a paper, debate, or project? Let us redefine your research process.

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1. Getting Started

1.1 - What am I supposed to do?

Before conducting any research, it's important to conduct a thorough literature review. A literature review is an exploration of what scholars and scientists currently know about your topic. It allows you to become knowledgeable in your field of interest and provides context as to how your work relates to the larger questions other scientists are asking. A good literature review is:

- Current: Although some key discoveries in your field may have occurred many years ago, the majority of the papers you are reading should be more recent. A good rule of thumb is that over half of your references should be less than ten years old.

- Relevant: The number of resources at your disposal is gargantuan (case in point: Searching "hepatitis b virus" on Google Scholar yields 1.7 million results in 0.06 sec). To avoid wasting your time, you need to be able to distinguish between topical, pertinent sources and those that barely address your work at all.

- Critical: Whenever you are reading, you should look at the sources with a critical eye. How credible are the authors and the journal? Do you agree with their assumptions? Are they over-exaggerating the implications of their findings? If you're not sure of the answer, work with your mentor to develop strategies on how to address these necessary questions.

Figure 1. Identification of the major differences distinguishing a popular journal from a scholarly journal. Figure above is modified from *Scientific American* and the *Journal of Hepatology* by author.

1.2 - Where should I start looking?

Journals are a very important resource and generally come in two flavors: Popular and scholarly. Popular journals present an overview of a specific scientific topic and are intended for a general audience (ie, _Scientific American_, _Wired_, _MIT Technology Review_). Although scholarly journals will comprise the bulk of your review, it helps to start out with popular journals (if any are available on your topic) to gradually work up to more complex ideas and methods. Scholarly journals contain articles with a narrow scientific focus that are meant for a specialized audience and undergo peer review (ie, _Journal of Virology_, _Journal of Hepatology_, _Virology_). Peer review is the process whereby other scientists and academics critically evaluate a paper before publication. You should always check to make sure the scientific papers you find are peer reviewed/refereed.

Once you are ready to tackle scholarly journals, it helps to note that scientific papers also come in two flavors: Research and review. Research papers share original research and the exact methodologies involved to arrive at its findings. The authors of the research paper are the ones who did the research included therein (ie, _Sodium taurocholate cotransporting polypeptide_). Review papers summarize the findings of different scientists and synthesize them to explore particular issues or limitations in a field (ie, _Hepatitis B virus infection_).
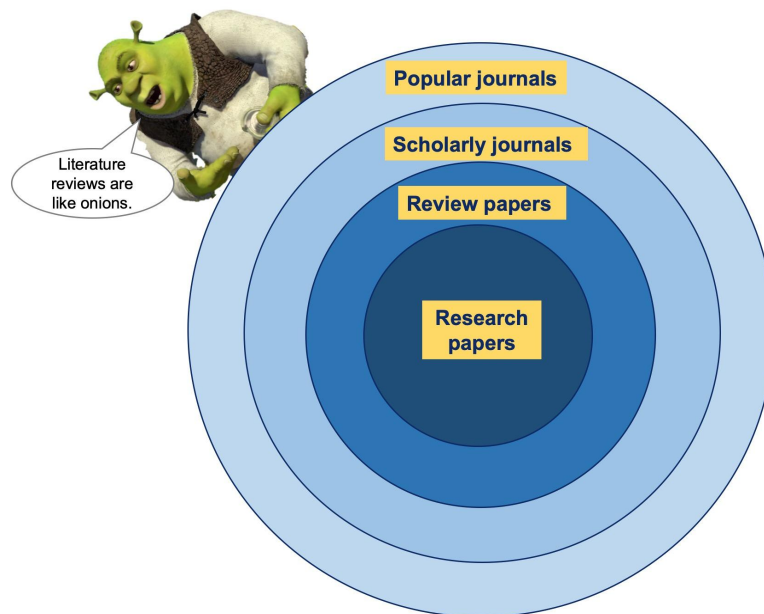

Figure 2. Summary of progression researchers should follow when conducting a literature review. Figure above created by author with Shrek modified from Dreamworks YouTube clip.

2. Finding Papers

2.1 - What are some tips for finding papers?

According to the International Association of Scientific, Technical, and Medical Publishers, approximately [28,100 active scholarly peer-reviewed journals](#) are currently in operation. In 2009, they also found that [over 2.5 million new scientific papers](#) are published every year.

Given these unforgiving statistics, it is vital that you develop the skills to efficiently, accurately, and rapidly identify important papers and discard papers that are tangential to your work. This involves tapping into several key strategies and resources.

Firstly, you should recognize that certain journals carry more prestige and generally publish higher-caliber work than others. At the moment, the top three most reputable journals are:
- <u>*Nature*</u>: Further subdivided into *Nature Communications*, *Nature Protocols*, and *Scientific Reports*. Papers go through an <u>especially</u> competitive and rigorous peer review process to be published in this journal.

- <u>*Science*</u>: Like *Nature*, *Science* branches out into several sister publications ranging from *Science Advances* to *Science Translational Medicine*. Papers published in any of these top three journals have a very high "impact factor" - they reach many scientists and are often seen as game changers in the field.

- <u>*Cell*</u>: Also branches out to address topics ranging from *Cancer Cell* to *Cell Host and Microbe*. Similar to the two journals listed above, *Cell* publications are frequently well-cited by scientists (meaning they use those papers to inform the direction of their research).

Additional respected journals include *Proceedings of the National Academy of Sciences (PNAS)*, *PLOS*, and *eLife*. When following the literature review progression specified in Figure 2, it helps to begin with a high-quality review paper from one of these journals. These review papers have been strongly scrutinized by experts and should represent the most updated and accurate scholarship available on the topic. As you progress in your literature review, it is natural and practical to move away from these publications into more niche journals. That being said, if you can't find a good

review paper in the above journals at first glance, look elsewhere and don't feel pressured to read a paper from *Nature* just so you have a paper from *Nature*. That's inefficient and counterproductive.

2.2 - OK, so how do I find a great review paper?

I have several strategies for identifying good review papers. The first thing I would recommend is setting up a system to keep track of your papers. There are several ways to do this:

1. Zotero: Free and relatively intuitive reference manager. Does not allow for digital PDF annotation. I used it mostly for its screenshot feature to keep track of a gene characterization problem I worked on.

2. Mendeley: Free and easy-to-use reference manager and digital PDF library. Also generates helpful and surprisingly accurate (to my experience) paper recommendations based on your library.

3. Qiqqa: Free reference manager that allows for digital PDF annotation. Haven't used, but have heard of it.

4. ReadCube: My go-to resource for PDF organization, annotation, tagging, and referencing. Was able to get it for free through university access and would not recommend purchasing, as there are many lovely alternatives available for free. Free thirty-day trial is available, though!

5. Desktop folders and bookmarks: Absolutely nothing wrong with this. No PDF annotation, but can print articles and mark up by hand.

Although I use ReadCube, there are honestly so many ways to structure your paper library that I wouldn't stress about which technique you use. Many of the above also do double-duty as reference managers, but I tend to rely on Noodletools for references and ReadCube for annotating documents without printing stuff *ad nauseam*.

Once you have a rough infrastructure for housing your papers, I would start looking for The One using a four-pronged technique. Several ground rules moving forward:
- Check out *Nature Reviews* series first (hit command and f, then type "reviews") and see what comes up. You might be done in the 0.08 seconds it takes for The One to load.

- If you are not so lucky, then your default browser for research paper retrieval should be [Google Scholar](#), NOT Google. Please limit dates according to standards set on page 1.

- After using Google Scholar and receiving naught for your troubles, go to [Google Images](#), enter the same search term, and see which paper figures show up. As a general rule of thumb, the better the figures and the higher up it appears, the better and more highly-cited the paper.

- If all else fails, pester your mentor for a high-quality, seminal review paper.

Once you have obtained The One, you need to set aside several concentrated hours of time to dissect its relevance, meaning, and findings. For another layer of security, I would recommend forwarding the paper you found to your mentor before reading it to make sure it is the stellar choice you believe it to be. I would also suggest scheduling a time with your mentor after you've read the paper to go over any potential questions you have and to clarify any issues with understanding. Brace yourself, though; reading papers is rough. For some tips, skip to chapter 3 of this guide.

2.3 - Now that I've found The One, how do I find more papers?

This can be a daunting task, but there's a lazy way to address this challenge. Rather than redoing the steps laid out in section 2.2, I would suggest checking out the references of your superb review paper.

Ideally, your review paper should cite many, many sources comprising a mix of review and research papers. Since the review paper is reputable, their sources will also tend to be high-quality. Find places where you had questions or areas of the review paper that addressed your topic of interest and match them up with the appropriate journal reference. Hunt down the article specified in the references and use the strategies in chapter 3 of this guide to read and understand it.

After you have exhausted the references of your review article, simply repeat this process with another paper that originated from the references of your review paper. ReadCube runs through a program that enhances the PDF so its references automatically pop up when you hover over the in-text citation, which I've found particularly helpful. Obviously, if you have questions that extend beyond the scope of your superb research paper, you need to go back into the literature thicket and rough it once more.

Figure 3. Schematic representation of how to find and vet The One. Figure above created by author using promotional materials from ABC's *The Bachelor* and *Science* magazine.

2.4 - Obtaining research papers checklist

- ☐ Use the above schematic to find a comprehensive review paper in a reputable journal
- ☐ Check that the review paper (aka The One) is peer-reviewed. If yes, proceed. If no, abort mission and restart
- ☐ If there is a paywall, bug your mentor to get the paper for you (assuming they have access). If your mentor is incommunicado, then try emailing the paper authors or asking a teacher
- ☐ Check with your mentor to make sure the paper is reputable, high-quality, and pertinent to your research interests
- ☐ Once you've received the go-ahead, organize the paper according to whichever system most appealed to you from section 2.2 and begin the onerous process of reading, annotating, and understanding it (see chapter 3)
- ☐ Rinse, wash, repeat: Find more papers by combing through The One's references and redo checkbox #5

3. Reading Papers

3.1 - Overview of basic research paper skeleton

Research papers follow a generalized skeleton that you will become intimately familiar with over the course of your research career. When I say skeleton, I mean that although research papers may address topics as remote as the theoretical physics of the Big Bang versus the ecology of Floridian estuaries, they share fundamental structural homologies, those being:

1. Abstract - Brief overview of the problem researchers are addressing, how they addressed it, their results, their conclusions, and the relevance of their work. The written "elevator pitch" that helps you decide whether or not the paper is worth reading.

2. Introduction - Discussion of existing research, what is currently known and unknown in the field, the problem, and broadly why this group's work is important and topical. It answers the "So what?" question about why people spent so much time, money, and effort on this work and why you should care.

3. Methods - How the problems and questions raised in the introduction were experimentally addressed. Normally very dense and jargon-y, so it is a good section to review with your mentor (especially if you are borrowing or adapting methods from that paper). Here is also a good place to question assumptions and critically assess whether the research group applied the right approach and tools.

4. Results - What resulted from the methods section. Tends to be very dense and figure-heavy, but is an important section to review. If you are reading a paradigm-shifting, game-changing paper, the results is where those findings are visualized and described. Also pay attention to how these results are depicted - if the authors have similar data as you and it is a reputable paper, the group is likely using the visualization strategies and techniques that you should adopt in your own work.

5. Discussion - Spells out what the results mean in a larger context. Also discusses limitations, assumptions, and compares what the group discovered that hasn't yet been answered or clarified in the literature.

6. Conclusions - Spells out what the results mean in the context of the experiment and immediate research question.
7. References - Where authors attribute ideas that aren't theirs and acknowledge the work of others in the field who led them to where they are now. Great place to find more papers related to your work.

For a more detailed breakdown of each component, check out [this website](#).

3.2 - How to go through a research paper, step-by-step

For now, you should use your understanding of the basic structure of a research paper to quickly ascertain whether it is worth your time and effort. Procedurally, this is how it breaks down:

1. After locating your paper, skim through the abstract and check the keywords. Does this sound like it is related to your topic or could help you answer questions raised by your research? Does it seem credible?

2. If the answer is yes and you are familiar with your topic, you can skip past introduction and delve into the figures and results. Note interesting trends, findings, and potential avenues for future research.

3. If the answer is yes, but you are not familiar with your topic, carefully read the introduction before jumping to the figures and results. Be sure to take your time here. If you need to stop every other word to Google a concept, do it. There are no shortcuts to understanding a paper, and reading for completion is a different beast from reading for comprehension.

4. If the results section generates any questions on how the authors arrived at those findings, go to methods to clarify what assumptions and techniques were used. Even if you have no questions, it's a good idea to skim methods to know what people are doing in the field.

5. Next, check out conclusions and then discussion. I personally find that it is easier to start with discussion and then move on to conclusion when I am confused. However, if you're feeling good about the paper, find out what the results mean and then how they play out beyond the scope of that experiment.

6. Lastly, I skim through references for interesting papers to read next.

But to summarize what it means to read *and* understand a paper, I defer to the words of [Marie desJardins](#):

"To really understand a paper, you have to understand the motivations for the problem posed, the choices made in finding a solution, the assumptions behind the solution, whether the assumptions are realistic and whether they can be removed without invalidating the approach, future directions for research, what was actually accomplished or implemented, the validity (or lack thereof) of the theoretical justifications or empirical demonstrations, and the potential for extending and scaling the algorithm up."

3.3 - Quick reminders and tips

1. There is almost always a way to get around the paywall. Ask your mentor, teacher, the paper authors, or even me to get it for you. If you have questions on how to format a letter to the paper authors, please see [this template](#). Don't let a paywall stop you in your literature review quest!

2. Reading a paper should always be followed by a conversation. Make an effort to develop a dialogue with your mentor about the paper you just read. Science doesn't occur in a vacuum, and it will be exceptionally difficult for you to develop strong paper-reading skills unless you hone them in the company of a seasoned scientist. That being said, there are two sides to a conversation - bring questions, thoughts, notes, and an understanding of the relevance of the paper to your work. Use your mentor as someone to check your analysis of the paper - did you choose a good paper? Are you noticing the right things? Are you too critical, or not critical enough? Did you understand this methodology fully, or has your reading left something to be desired? Why did the authors present their data *x* way instead of *y*? Good scientific paper reading skills are constantly in development and a large gap between you and your mentor is natural. The only way you can screw up here is to not care and not show effort.

3. Devote time and effort into curating your "research library" and ensuring papers are accessible and cited. It is not excusable in science to confuse your ideas with those of another scientist. Transparency (and a detailed reference section) are a must. To accurately attribute ideas to the scientists who had them and avoid being overwhelmed, you should studiously cite and organize your papers using one of the systems specified on page 4. After ascertaining that a

paper merits your attentions by skimming the abstract, cite it before you continue (generally, APA style is recommended).

4. <mark>Keep track of which paper found what by creating an Excel spreadsheet.</mark> Whenever I try to parse through a paper, I find that periodically updating an Excel spreadsheet as I read helps me significantly. I have a record for future reference. I have a conversation starter when I meet with my mentor. It takes a while to do, but it really deepens my understanding of the paper, both in a granular and big-picture way. Check out this sample for ideas.

Hopefully this guide is helpful to you in your literature review. Please send any questions to stemredefined@gmail.com and best of luck in your research!

3.4 - Supplementary reading

1. Overview of different techniques for reading a paper
2. Humorous description of the paper-reading experience