Advice on reading scientific papers

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Preliminary remarks: These notes are intended to help Doctoral Students in Science in general, with the possible exception of the Life Sciences which have different traditions and needs[1]*. Since my field is Physics, it is possible that what follows may be less useful for other disciplines. I apologize for that in advance. Any remarks or comments are welcome, as well as suggestions for additional or better sites to recommend.*

During discussions with Doctoral Students (through Ph.D. Thesis follow-up sessions) I have had the opportunity to notice the need for some help in reading research articles. Reading the literature is a skill that needs to be learnt, as it is indispensable for scientific research. But it is vital even beyond the (admittedly restricted) scope of research because, if you embark on a different career after your thesis, one of your most important transferrable skill is the ability to read, understand, put in context, summarize and rielaborate information that you have obtained from reading already available materials.

The art of critical reading has become an indispensable skill in today's World and your acquired expertise will put you in good stead. It is therefore indispensable to learn how to read large amounts of literature, and advice is always useful to get. However, one must never forget that learning is a personal experience and no amount of "teaching" can take the place of personal engagement, no matter how good the instruction may be. In other words, practice is the only effective means of achieving the goal. The scope of advice is to render the job less difficult, more effective and, why not, pleasant along the way.

There is a large amount of material available online, thus there is no point in repeating it. I am sharing below some of the links, among those I found, which appear to me most useful. Again, some of you may find others even better, and you will be more than welcome to share them to your Peers (or even send them to me, if you think it suitable, for an update of this list).

As you will see by reading the web pages, recommendations differ, at times very widely. There is no perfect recommendation, as good advice may vary depending on your specialty and what works well for one science may not for another. In addition, everyone has a somewhat different technique. Thus, your personal inclinations may make you prefer – and find useful – advice that others dislike.

Before delving into the short list of links – and letting you look for more, if you wish – I would like to insist on one point, which is obvious but often neglected: take notes when you read a paper! The form that your notes take is, again, quite personal and with time you

[1]The last site mentioned in this summary is actually specific to the Life Sciences, but the number of specific sites discussing how to read medical and biological literature is quite large. Interested parties are invited to specifically search the web for them.

will develop your own system. Some people like annotating the text directly; the disadvantage of this choice is the amount of memory space that this requires and, mostly, the difficulty in easily retrieving the content. The possibility of searching for information (e.g., papers where a certain kind of data appears) is a definite advantage which requires some centralized (and homogeneous) way of storing and organizing your notes.

This may sound like a daunting task: how do I start organizing something if I have never done it before and don't know what I will need? While the question is legitimate, I recommend a pragmatic approach – the same you use when you do your research: start with something reasonable, you will adjust it as you go along. If you wait for a perfect system (or even just a "good" one) you'll never start. Thus, it is better to begin with something acceptable and then let the system evolve. It will be easier to go back and review some of the early notes than never start and repeat the work of searching through all papers to seek for information every time you need it.

A *research assistant* to collect references is a good starting point, especially if it allows you to include your notes in it. Most Universities nowadays offer courses in different bibliography organizers. A free system is Zotero, but there are many others which are as good. In addition, there are traditions which depend on your science specialty: the reference management software which is well-suited to one discipline is not the best for another one. In addition, consider using the same tool as your colleagues as it allows for easier link or notes sharing. So it is a good idea to ask your Thesis Advisor or your Colleagues for a recommendation on the piece of software to use in your field.

With these considerations in mind, here are web pages that I found useful: consult them, form your own opinion, then start (or get back to) reading your literature, hopefully a bit better armed for the task:

https://web.stanford.edu/class/ee384m/Handouts/HowtoReadPaper.pdf

https://www.eecs.harvard.edu/∼michaelm/postscripts/ReadPaper.pdf

https://towardsdatascience.com/how-to-read-scientific-papers-df3afd454179

https://towardsdatascience.com/guide-to-reading-academic-research-papers-c69c21619de6

https://medium.com/researcher-app/how-to-read-a-research-paper-1022fbe904ab

If you look on Youtube you will also find some videos with advice. I haven't tried them, but they may also be good.

I am leaving for last a site, "particular" because it is geared towards the Life Sciences. There, as in medical research, there is a "preformatted" way of writing to which authors have to conform. It is known under the acronym "IMRD", which stands for "Introduction, Methods, Results, Discussion" and corresponds to the standardized article sections which appear in all (or at least most of the) publications. Most journals will not accept anything else. You will notice by reading the text that the paper posted on this site even considers *odd* the fact that there are journals which do not conform to the IMRD rules.

While this makes it easier for readers, it is a format which is mostly unsuitable for the other sciences, where authors are free to report on their work according to the needs of the investigation. Similar content will be found in many papers, but under more informative titles, rather than "Methods" or "Results", and in a less stifled form. The reason for pointing this "anomaly" – from the point of view of the other Sciences – is that part of the advice offered on

this site will not be relevant outside the Life Sciences; thus consider disregarding it immediately. However, in the last part of the recommendations you will find a good list of useful tips on how to take notes and what to look for when reading a research article. Anybody can benefit from this advice, and this is the reason I included it in this collection:

https://www.owlnet.rice.edu/∼cainproj/courses/HowToReadSciArticle.pdf

I hope you will be able to gleam some useful tips from this wealth of information and that you will get back to your literature enjoying the task even more.