How to read scientific papers – Part II
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So now you understand how papers are structured and how to find them (see part I). We can now get to the meat of matters. The most important thing you look at first is typically the abstract. This is a concise statement of the overall questions, goals, and importance of the paper. This usually gives you a good idea if the paper is up your alley of interest. If the abstract is too cryptic, unfortunately too common, I sometimes “cheat” and skip to the last section about conclusions and discussion to get a better idea of what they discussed from the wrap up.

If you have found a paper you want to read, now you can get started. First, make sure you understand the paper. What I usually do is leisurely read the paper from start to finish. By leisurely I mean grasping the key concepts and aim of the paper, its methods, and the purported conclusion. This first read through does not have to be thorough as in being able to understand or derive every equation and step from start to finish. This first read through accomplishes several things:

1) You get a good idea of the flow of the paper and its general ideas. By understanding the general ideas you can better appreciate the different sections of the paper on subsequent reads.
2) You get a good idea of the methods including theories, experimental design and methods, mathematical tools, and the level of data analysis such as confidence intervals, tests of significance, etc.
3) You can see where you need to do more reading. Usually you may not understand every equation or tool used. You will need to possibly do some background reading in order to fully understand the paper.
4) Understand the strengths and weaknesses of tools used. There is a difference between someone running a least squares linear fit in Excel and running a full significance test with 95% confidence intervals. With study and over time you will understand these differences and be able to evaluate the soundness (or lack thereof) of the paper’s methods.
5) REFERENCES! All papers are based on prior work in part and in order to understand the paper’s methods and precedents the reference section is importance. When I first started reading papers I would not print out the long reference sections to save money. This is not good! I have often been able to see through a “strong” and publicly lauded paper by looking at the reference which established the method they used. The older reference fully aired doubts and assumptions behind a certain statistical methodology which later authors neglected to mention.

After the first read through, write down what you don’t understand. These could be words, equations, experimental designs, math, etc. Never be embarrassed by a lack of understanding and more important, do not try to skim over lack of knowledge. You may need to look at textbooks or prior papers to understand the methods. In the case of math
or heavy equations, you may need a specialized textbook to look up the methods used. In some cases, Wikipedia can give a good general description though I warn against relying on Wikipedia in general.

One of the best ways to get into a new field of science including its methods, prior research, and theoretical underpinning, is via review articles. Review articles are usually long (20+ pages) and have hundreds of references but are specifically written to give an overview of a field for both the seasoned and non-expert. Well-written reviews discuss the history, major works, and major analysis methods of a particular field in problem. They are not as specialized as regular articles but are not as long and general as textbooks or monologues. Whenever I wanted to learn something about a field, I look for review articles first since they are a good starting point.

I have a background in physics, and most of the papers I have written and published have their own share of math, some more than others. Most people think I have a natural love and aptitude for long, complicated equations. The truth is since I was an undergrad I have always unfortunately had a reflex against math in papers I read. I am better now but the sight of a double integral or advanced method in probability or stochastic processes is enough to make my eyes glaze over and my brain say “this is hard”. Nonetheless after reading it a few times and working out the math for myself I often understand it and realize it was not as bad as I worked it up to be. But you need to read up on math and attack problems methodically. They can be key to understanding the paper and understanding methods are often the best BS detector you have in research. Even if there is not much hard math, a basic knowledge of statistical analysis should help you analyze a paper readily. If two standard deviations of a data set are large, even compared to the mean, how confident is the data? Do you understand p-values and t-tests and know when they are (or aren’t) applicable? Often these tests assume a certain underlying distribution. Does the data correspond to this? There are many questions you can ask. Always remember, large claims require large proof and analyze accordingly.

Finally, you should understand basic rules of reasoning and logic to understand if evidence points to a certain conclusion. Logic and reasoning have come a long way since Aristotle but looking up good lecture notes on logical fallacies and how to set up and solve syllogisms can help. Finally, know the difference between deductive and inductive reasoning. In the first, you directly prove something is true by proofs and evidence while in the latter, you prove something is true by proving all other alternatives are (likely) false.