

On Reading Scientific Papers: Some Suggestions for Novices

Reading your first scientific papers can be daunting. Research papers and review articles are part of the scientific conversation in their fields, and so starting to read these papers can be like joining a group of people who are talking about a topic that they have discussed for years, and about which you know little or nothing. Fortunately, there are things you can do to get more out of the experience. Here are some suggestions that might be helpful as you tackle a scientific article in an area that is new to you.

Write as you read.

Write questions and comments in the paper's margins as you read. Writing your comments on the paper as you read makes you a more active participant in the scientific conversation, and it will help you develop your thoughts about what you're reading. This does not require you to print the paper out: there are apps for many different devices that allow you to mark up PDFs as you read. I've been reading scientific papers using the GoodReader app on an iPad for years, and I highly recommend it. I can zoom in on the details of figures, I can write comments with a fingertip, there are lots of colors available so that I can color-code my highlighting and comments, and erasing is a breeze. And if I want to read the paper again in a few years, I'll have all of my notes in one convenient place...

Read the sections of the paper out of order.

Research articles are divided into sections, and the order in which you read them matters: reading from start to finish can take much more time than reading sections out of order might.

If you are reading a research paper in an area that is new to you, you should read the abstract first, as it summarizes the paper's important take-home messages: the abstract will provide essential orientation as you read the rest of the article. If the paper has a visual abstract, look at it carefully, too, and read the supporting text.

Next, read the introduction: often, the introduction provides useful background information that will help you understand why the work described in the paper is important. The references cited in the introduction might be useful in understanding the larger context of the research described in the paper, too. Use Google Scholar and the Swem databases to find and access the references that look as though they might be useful.

Next, skip to the end of the paper and read the discussion/ conclusion. This section will help you understand what the authors have reported in the paper, and will often discuss questions that need to be answered next and/or describe the limitations of the work described in the paper. Like the introduction, the discussion helps the reader appreciate the context into which the research fits.

Finally, you'll be ready to tackle the Results section. Look carefully at the figures and tables and their legends as you go through the text that discusses them: words and pictures together can be easier to understand than words alone. If the Results section discusses data that is presented in the Supplementary Information section, and that material seems likely to be interesting or important, look at it, too; this might require going to the online version of the article, as not all PDF versions of scientific papers contain

the supplements. Refer to the relevant portions of the Materials and Methods section as you go through the Results section to understand exactly what the researchers did.

As you read the Results section and look at the data, think: is what the authors say in the text of the Results section consonant with the data they provide in the figures and tables and supplementary information? Is what they say in the Discussion section consonant with what they've presented in Materials and Methods and the Results sections? Or are there discrepancies?

Use online resources to teach yourself things you need to know to understand the paper.

Biology papers are full of names of cell lines and reagents and techniques, and they use many cryptic abbreviations. Much of this material is common knowledge for researchers in the article's field. To an outsider, though, these bits of scientific shorthand can be a formidable barrier to understanding. Fortunately, there are many resources that are just a few keystrokes away that can help you decode these mysteries.

Use Google and Google Scholar! Typing the mysterious abbreviation into the Google search box can take you to a page that explains it: even three-letter abbreviations can be decoded quickly. If you need to know what *E. coli* Nissle 1917 is, a quick search will tell you. For lab techniques that mystify you, Wikipedia can be a good place to start, but the scientific papers that you find through a quick Google Scholar search might provide the most useful information.

Use review articles! Reading a recent review article in the field you're trying to teach yourself can orient you quickly. Yes, you will need to look a lot of information up, but the time you spend reading a recent review article could pay off richly. Often, your article's authors will refer to good recent review articles in the Introduction, so look at the papers they cite.

Read the authors' sources! If you read the sources they've cited in the places in the paper that confuse you, you'll have a better idea of what they are doing. And if the sources they cite don't seem to say what the authors seem to imply that they've said, you will have learned something useful, too...