How to Find and Understand Scientific Articles

There is a vast body of information that most people do not even know about – let alone use. It is called the scientific literature, and it is an invaluable tool for anyone who is interested in scientific questions. You may want to look into it because you have conducted your own informal experiements, or because you are dissatisfied with the level of detail you can get from the popular press. Each article in the scientific literature records one study, or one experiment with repetitions. Each paper has been subjected to scrutiny and criticism by at least two other scientists, to ensure scientific rigour (a process known as peer review). With a little background and preparation, anyone can read them.

The purpose of this article is to give you some of that background. Of course, it would be impossible in this one essay to teach all of the scientific terminology that you might encounter in your readings. However, the organization of scientfic papers is largely formulaic. I hope that if you read the information contained here, and you have a rudimentary knowledge of the field you are reading about, you will be able to follow what the scientists have to say – in their own words.

Finding Articles

Before you can read an article, you have to find it. This is not a simple task, but many people enjoy it. It's like a treasure hunt. I have no idea how many articles are written each year; let's call it a million for each of the major divisions of science, and probably much more. Anyway, if you are researching a specific topic, you probably only want to read between 5 and 50 of them. Needle, meet Haystack.

Fortunately, we have computer databases. Unfortunately, the best databases for scientific research require an expensive subscription, so some of your searches won't work from home. However, the libraries of any university will have access to these databases, and your local public library might as well. The reference librarian will be able to help you get started with these methods. Public libraries are of course free, but remember that some university libraries only give free access to students and faculty. However, if you are quiet and well-behaved they may not ask you for ID, and in any case you can usually buy access or get a guest pass. Finally, there is Google Scholar, a free search engine specifically for looking up academic papers, patents and government reports. It has limitations, but it is easy to use and worth a try for preliminary searches. Just point your web browser to scholar.google.com to get started.

When you are performing your search, keep in mind that there are three basic strategies for finding articles:

- You could look for every recent article on a subject.
- You could trace the history and development of a scientific debate
- You could try to answer a specific question or find support for a specific point of view.

Obvioulsy your goals may require a blend of these types. The point is that they will require different kinds of searching.

The first is the least focused approach. It's best used by people who just want to stay current, but don't have a specific problem to solve. To use this approach, simply type a keyword or two into your serach engine and read whatever looks interesting. You might want to limit your search to the latest year, or set your search engine to give you the most recent articles first. It might also be useful to find the names of a couple of journals that focus on your area of interest, and confine your search to them.

The second one is fascinating, but often overlooked. The history of a debate is like watching a slow-motion hockey game, but it can also be very useful if you want to know *why* we are in a debate or *how* the terms of the debate got framed. To use this approach, I strongly recommend that you find access to a search engine called Science Citations Index. Most universities will have it. It's extremely useful for this kind of search because it specializes in tracing chains of citations backward and forward

in time. in other words, it keeps track of all the papers that each paper refers to in its references section. So, for example, if you are looking for the seminal article in a field, you can use science citations index to find the article that is most cited by a group of recent authors. Or, you can use it to find everybody who has cited the seminal article.

The third strategy is useful for making decisions or finding strong positions. For example, do you wish to support the ban of some environmental pollutant? Was *Tyrannosaurus* warm blooded or cold blooded? These kinds of questions require you to look at both sides of an argument and the underlying logic behind them. They may require some historical depth, but they also need a braod survey of the available evidence. Here it may be very valuable to read several papers written by a single author, to make sure you understand his or her perspective. Fortunately, most search engines allow you to search by author name as well as by keyword or words from the title.

For all three strategies, your results will often contain either too many or too few articles. Most likely, you can fix this by adding or subtracting search terms. In this context, it might help to learn a tiny bit about "Boolean search strings."

In a nutshell, George Boole was a mathematician and logician who made huge contributions toward formal logic, which is used by all search engines. For our purposes, the important thing to know is that Boolean searches make special use of the words "AND" "OR" and "NOT." In effect, the word OR makes a search broader, the word AND makes it narrower, and the word NOT ensures that the word will not appear in your results. If you search for an article using the string "cats AND dogs" you'll get fewer articles than you would for just "cats" or just "dogs" because the engine will only show you articles that contain *both* words. On the other hand, if you search for "cats OR dogs" you'll get more articles than you would for just "cats" or just "dogs" because any article that contains either word will be shown. The AND search would be used to find articles that are about both animals or which compare and contrast them. The OR search would be useful if you are looking for articles about pets in general, and don't particularly care which ones are discussed. If you use NOT, you will find articles that do not contain that word. So the search "dogs AND NOT cats" would give you the dog articles, but exclude any dog articles that discuss cats. Beware: Google allows NOT (in the form of the "-" or minus sign), but it doesn't pay strict attention to it.

The list of articles that you get will probably look like the entries in a bibliography. You will be given some combination of the following attributes:

- The article's title
- The author's name or names
- The year and possibly month of publication
- The journal in which it was published.
- The volume and/or issue of that journal in which it was published.
- The page on which it began.

Usually, to identify a single article, you only need the volume, issue and either starting page, author or title.

Once you have a list of articles you want to read, you will need to get copies of them. If you are at a library, you may be able to print them out or make photocopies yourself. Bring plenty of pocket change! If you are searching from home, though, beware: many journals charge exorbitant rates to view their articles. It may be best to make a list of the articles that you want and bring them to the library for printing.

Reading Scientific Literature

Once you've acquired your articles, you will be confronted by something annoying: they look very weird. Some parts seem repetitive, while other sections seem dreadfully boring. You probably won't

need (or want) to read them all. The reason is that all scientific articles have a special anatomy, designed to help scientists to find the information they need quickly. It can help you too, if you understand it. Not all scientific fields use the same format, but usually you can expect some variation on these sections:

- Abstract
- Introduction
- Methods
- Results
- Discussion
- References

The **Abstract** is the first part of the article that you will encounter. Sometimes it is the only part that you will need. It is a quick summary, telling you what they did and why, what the most important results are and what conclusion they reached. Usually, it is a single paragraph or not more than a few hundred words. Before we had databases, some research companies would collect all the abstracts published in a field every year, index them all and bind them together. Researchers could then look through the index and abstracts to find the articles they needed. For this reason, there are still some search engines today that use the word "Abstracts" in their titles. Abstracts are usually free for the public to view on the web.

The **Introduction** lays out the rationale for the article. It tells you a bit of history for the question, suggests what research was missing and what motivated the article. The introduction is where you will find out what question the author was trying to answer and why. However, the author usually discusses earlier articles that are similar, so it can be a good place for you to look for other papers to read. It is usually written in a formal but readable style.

Next, the author has to describe what exactly he or she did in the experiment or study. The section that conatins this information is the **Methods** section (sometimes called Materials and Methods). It is very densely written, but usually it contains the most intersting parts of the story. Often, the popular press omits any real description of how a scientist arrived at his or her conclusions. If you want to fill in those gaps, be sure to wade through this section (and the next).

The Methods section is curious in that it sets up the conditions of the experient, but does not tell you what happened next. The **Results** section shows you the observations that the scientists made in his or her study. If the Methods section allows you to follow the scientist's hands, the results section lets you follow the scientist's eyes and ears. Usually, this is the dullest, driest section, because it mostly consists of numbers and tables, and it makes no sense at all if you haven't read the Methods section. Of course, you'll often want to read it anyway, to see how strong the author's evidence is. If you find yourself bogged down by the statistics that are usually found here, I recommend reading The Cartoon Guide to Statistics by Larry Gonick, which does an excellent job of conveying the basics.

Finally, we have the **Discussion** section. Here, the writing becomes lively again, as the scientist begins to consider the ramifications of his or her observations. In the Results section, the author simply gave us raw data: this test tube turned green, that skull was 29cm long. It was purposefully dry so that observation is separated from interpretation. Here, finally, the author feels free to interpret what he or she saw, maybe even speculate or make recommendations for the future. If you want to cut to the chase, you can often skip everythig else and just read this section. Sometimes these ideas are summarized in a Conclusion section.

Did I say finally? Well, not quite. After the Discussion (and Conclusion), you will always find a list of **References**. In school, you learned to call this section the bibliography, but there is a slight difference between the two terms. A bibliography includes all the books that the author cracked open when writing or planning his or her work, whereas the citations include only those articles (or books)

that are directly mentioned in the article. As you read the article, you may see either numbered footnotes, or author-year combinations, in parentheses, like so: (Katz 2012). Each of these citations refers to an article listed in the References section. This second format allows the reader to see at a glance who is being cited. They also make it easier for you to find more articles to read, because the citations can be listed in alphabetical order.

With a little effort, anyone can read and understand scientific papers. If you try it, you will find that you are able to learn much more about your field of interest than you could from just reading the popular press. But more importantly, you will learn more about how science is done in general.