How to Read Scientific Primary Literature

Reading a research article is not easy. The fact that it has been published means at least the editor and the scientists who performed the peer review believed that is contained information important to their field.

This handout describes the different sections of a standard journal article and suggests what to look for in each section. It finishes with overall advice on how to read a journal article, which usually involves going through the paper at least 2-3 times.

The Title & Citation Information:
Read the title carefully, it was designed to describe the article. From the title and citation information in the article header alone, you should know:

- What are the major ideas discussed in the article?
- Who were the authors? Do you recognize them as experts in this field?
- What is the affiliation of the authors? Do you recognize the university or research institution?
- Where was the article published? Do you recognize the journal? Is it a well-regarded publication in this field?
- When was it published? Will the information still be relevant or is it likely to have been superseded by newer research?

The Abstract:
The purpose of the abstract is to summarize the article: if well done, it should provide you with the theoretical motivation for the paper, the major results, and a brief general discussion. Because of its brevity, the abstract may also be more or less incomprehensible. Never cite a paper in which you have ONLY read the abstract. The abstract will help you determine:

- What variables were examined?
- What were the main / exciting results?
- Where the work was conducted (laboratory or field). If field, what location?
- Why this study is important?

The Introduction:
The introduction tells the reader the rationale: a description of the study and why it was performed. It usually includes a review of previous research on the topic to provide context. A well-written introduction should provide the answers to these questions:

- What is the purpose of this study (is it empirical, theoretical, or a review)?
- What is the topic (answering a specific question, trying to explain certain observations, presenting a model of some process, exploring the relationship between two or more variables, or something else)?
- Where is the article going?
  Skim the whole article to see the structure of subheadings: does the introduction cover each one? (If you know where the author is going, you will have an easier time placing each piece of the study in context, rather than being overwhelmed.)
- Why is this project interesting or worthwhile in its field of study?
• What is already known about the topic? What are the gaps in our knowledge and how does this study address them?
• What are the specific predictions or hypotheses that are being tested?
• What are the independent variables (what the author manipulated) and dependent variables (what the author measured)?

The Materials and Methods:

This is the section where the authors describe their study design and methods in detail, including organisms, equipment, materials and more. Theoretically, at least, this description should be detailed enough to allow other researchers to replicate the work. This section usually ends with an explanation of the statistics used to analyze the data and why they used that approach. Some of the top journals (Science & Nature) have an abbreviated materials and methods with most of it appearing in an appendix or paragraph at the end of the article. As you read this, you should ask yourself

• What research techniques are used? Could you reproduce the experiment from the details provided?
• Is the method used a valid test of the predictions or hypotheses?
  There is rarely (if ever) a single way of testing a prediction or hypothesis. The researcher will have made a choice between a number of possible research designs/sets of materials/procedures/sample groups, etc. You need to consider whether the choices made by the researcher will allow them to make valid claims about their predictions or hypotheses.
• Is there anything the authors overlooked or some variable that could complicate their results?
  Did the control provide adequate contrast to the variable being tested or should they have controlled for other things as well?
• How do the methods used compare to those used in similar studies?
  As researchers usually seek to make comparisons between their study and earlier studies, you need to consider whether or not the method employed allows the researcher to make valid comparisons between studies, and how much you feel they are entitled to generalize their findings.

The Results:

This section is perhaps the most important because it describes the outcome of the project in detail, providing numerical evidence. This section includes most data tables, statistical analyses, and graphs generated by the project. It does not, however, explain the greater meaning of the results or interpret the results; it simply reports the findings.

• Pay particular attention to the figures.
  Write down your interpretation of each figure before reading the interpretation provided by the authors. If you only had the figure and caption, without the rest of the article, would your answer change?
• Are the results reported and analyzed in an unbiased manner?
  The manner in which data are reported and analyzed could dramatically affect interpretation. For example, different types or formats of graphs can emphasize or de-emphasize the sizes of effects, and different inferential tests can yield different results.
• Do you think the results support or reject the project predictions / hypotheses?
**The Discussion:**

In this section, the data/observations outlined in the results are summarized (in relatively plain English), interpreted, and related to other studies in the field. While reading this section, you should try to answer:

- Do you agree with the authors’ interpretation of the results? Is there another way to interpret the results? Do you detect any bias?
- Based on this study, are the authors justified in the claims they make? Do they in any way overstate the results, ignore part of the results, or make inferences or connections that are not supported by the results?
- Did they actually address their hypotheses?
- What are the implications of the findings (what do they tell us about theory, research, or real life concerns)? Do we now know something new? What new questions are raised?
- What suggestions are there for future research?

(These last two bullet points are sometimes separated out into a Conclusions section.)

**So, How Do I Read This Stuff?**

Most people, when faced with their first scientific journal articles, try to begin at the beginning and read them straight through, as one might a novel or a textbook chapter. This turns out not to be the most effective technique, either for saving time or thorough comprehension. Most experienced scientists, who read a lot of journal articles, have a different strategy:

1) **Go from the general to the particular:**

   Do not waste time struggling with minute details if you do not first understand the big picture. Before you dive into the article, you should already know roughly what it is going to say! Get that information by reading the title, abstract, and headings and by skimming the introduction and discussion, and any tables or figures.

2) **Look for definitions:**

   Jargon is usually defined somewhere in the article, at least by subtle context if not explicitly. If you do not understand a concept that is being discussed at length, look around for the definition. It may be helpful to consult a textbook or even a dictionary. Do not just ignore terms you do not understand.

3) **Examine the tables and figures:**

   Briefly review the tables and figures to obtain a sense of the data presented in the article. Read the title legends to provide a context for the data presented. Note the important patterns that emerge from you review of the data presentation represented in the tables and figures. This review should provide a useful context when reading the methods, results, and discussion sections of the article.

4) **Selectively read the method and results:**

   Read these sections with certain questions in mind. How were the variables measured? Do those measures really capture the conceptual variable, or might they be measuring something else? What were the actual numerical results? Where are the findings that the authors discuss? Are there anomalies that they don’t address? What was the main hypothesis? What were the findings regarding those variables?
5) **Re-read whole paper:**

You usually need to read an article two or three times to understand its message. Often there is so much information presented that it cannot all be absorbed in one pass. Even experienced scientists need to read articles slowly, carefully, and repeatedly, SO DO NOT EXPECT YOURSELF TO BREEZE THROUGH THEM! After you have a good feel for the article’s results, go back and re-read the introduction, and finally, go back and read the general discussion to see how the author interprets the data.

Please note that this handout was modified from similar handouts written by Jeremy Quayle and others.