**Reading Scientific Papers**

Reading a scientific paper is a completely different process than reading an article about science in a blog or newspaper. Not only do you read the sections in a different order than they’re presented, but you also have to take notes, read it multiple times, and probably go look up other papers for some of the details. Reading a single paper may take you a very long time at first (hours). Be patient with yourself. The process will go much faster as you gain experience.

Most primary research papers will be divided into the following sections: Abstract, Introduction, Materials and Methods, Results, and Discussion. The order will depend on which journal it is published in. Some journals have additional files called Supplementary Online Information which contain important details of the research, but are published online instead of in the article itself .

As you read, write down **every single word** that you don’t understand. You’re going to have to look them all up (yes, every one. You won’t understand the paper if you don’t understand the vocabulary. Scientific words have extremely precise meanings).

**Step-by-step instructions for reading a primary research article**

**1. Begin by reading the introduction, not the abstract.**

*The abstract is that dense first paragraph at the very beginning of a paper. In fact, that’s often the only part of a paper that many non-scientists read when they’re trying to build a scientific argument. When I’m choosing papers to read, I decide what’s relevant to my interests based on a combination of the title and abstract. Once you get experienced reading in a particular field, this section is often skipped.*

**2. Identify the BIG QUESTION.**

“What problem is this entire field trying to solve?”

*This helps you focus on why this research is being done.*

**3. Summarize the background in five sentences or less.**

Here are some questions to guide you:

What work has been done before in this field to answer the BIG QUESTION? What are the limitations of that work? What, according to the authors, needs to be done next?

*The five sentences part is a little arbitrary, but it forces you to be concise and really think about the context of this research. You need to be able to explain why this research has been done in order to understand it.*

**4.** **Identify the SPECIFIC QUESTION(S)**

What **exactly** are the authors trying to answer with their research? There may be multiple questions, or just one. Write them down.  If it’s the kind of research that tests one or more null hypotheses, identify it/them.

*Keep in mind that not every paper will test a null hypothesis.*

**5. Identify the approach**

What are the authors going to do to answer the SPECIFIC QUESTION(S)?

**6. Read the results section. Write one or more paragraphs to summarize the results for each experiment, each figure, and each table. Don’t yet try to decide what the results *mean*, just write down what they *are.***

You’ll find that, particularly in good papers, the majority of the results are summarized in the figures and tables. Pay careful attention to them!  You may also need to go to the Supplementary Online Information file to find some of the results. With practice you can just look at the figures and skip most of the text.

*It is at this point where difficulties can arise if statistical tests are employed in the paper and you don’t have enough of a background to understand them.*

**THINGS TO PAY ATTENTION TO IN THE RESULTS SECTION:**

-Any time the words “significant” or “non-significant” are used. These have precise statistical meanings.

-If there are graphs, do they have [error bars](http://en.wikipedia.org/wiki/Error_bar) on them? Should they have error bars?

-The sample size. Has the study been conducted on 10, or 10,000 people? (For some research purposes, a sample size of 10 is sufficient, but for most studies larger is better).

**7. Do the results answer the SPECIFIC QUESTION(S)? What do you think they mean?**

*Don’t move on until you have thought about this. It’s okay to change your mind in light of the authors’ interpretation—in fact you probably will if you’re still a beginner at this kind of analysis—but it’s a really good habit to start forming your own interpretations before you read those of others.*

**8. Read the conclusion/discussion/Interpretation section.**

What do the authors think the results mean? Do you agree with them? Can you come up with any alternative way of interpreting them? Do the authors identify any weaknesses in their own study? Do you see any that the authors missed? (Don’t assume they’re infallible!) What do they propose to do as a next step? Do you agree with that?

**9. Now read the methods section. Draw a diagram for each experiment, showing exactly what the authors did.**

I mean *literally* draw it. Include as much detail as you need to fully understand the work.

*You don’t need to understand the methods in enough detail to replicate the experiment. Once you get enough practice this section can often be skipped. Sometimes it is more helpful to read this section before the results.*

**10. Now, go back to the beginning and read the abstract.**

Does it match what the authors said in the paper? Does it fit with your interpretation of the paper?