How to Read a Scientific Paper: A Four-Step Guide*

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Reading research papers ("primary articles") is partly a matter of experience and skill, and partly a matter of learning the specific vocabulary of a field. First of all, DON'T PANIC! If you approach the paper step by step, even an impossible-looking paper can be understood.

1. **Skimming**. Skim the paper quickly, noting basics like headings and figures. This takes just a few minutes. You're not trying to understand it yet, but just to get an overview. Do not linger on the abstract! When a topic is not familiar, it is often better to read the abstract last, after Steps 2 and 3 below.

2. **Vocabulary**. Go through the paper word by word and line by line. Underline or highlight words and phrases you don't understand, especially those that appear frequently. Don't worry if there is a lot of underlining; you're still not trying to make sense of the article.

Now you have several things you might do with these vocabulary and concept questions, depending upon the kind of question each is. You can:

a. *Look up simple words and phrases.* Often the question is simply vocabulary - what's a thermocline, or a centric diatom, or the Exclusive Economic Zone. A science dictionary or textbook is a good place to find definitions (for example, Encyclopedia Britannica and Access Science, McGraw-Hill Encyclopedia of Science). Your ordinary dictionary is not a good source, because the definitions may not reflect the way scientists use a word (for example "efficiency" has a common definition, but the physical definition is much more restricted.)

b. *Gain an understanding from the context* in which a word or phrase is used. Often words that are used to describe procedures used in an experiment can be understood from the context, and may be very specific to the paper you are reading. An example is the "carotene extraction procedure" in a biochemical experiment. Be careful when deciding that you understand a word from its context, because it might not mean what you think.

c. *Flag the phrase as belonging to one of the major concepts of the paper.* It's bigger than a vocabulary question. For example, a paper about diet and cancer might refer to "risk reduction," which you would need to understand in context and in some depth. Likewise, the meaning of "global climate model" would at first seem apparent; further study would reveal that a "GCM" is a mathematical model of circulation, temperature and other factors that must be run on a supercomputer.

3. **Comprehension**, section by section. Try to deal with all the words and phrases, although a few technical terms in the Methods section might remain. Now go back and read the whole paper, section by section, for comprehension.

a. In the **Introduction**, note how the context is set. What larger question is this a part of? The author should summarize and comment on previous research, and you should distinguish between previous research and the actual current study. What is the hypothesis of the paper and what are the ways this will be tested?

b. In the **Methods**, try to get a clear picture of what was done at each step. What was actually measured? It is a good idea to make an outline and/or sketch of the procedures and instruments. Keep notes of your questions; some may be simply technical, but others may point to more fundamental considerations that you will use for reflection and criticism below.

c. In the **Results,** *look carefully at the figures and tables, as they are the heart of most papers.* A scientist will often read the figures and tables before deciding whether it is worthwhile to read the rest of the article! What does it mean to "understand" a figure? *You understand a figure when you can redraw it and explain it in plain English words.*

d. The **Discussion** contains conclusions that the authors would like to draw from the data. In some papers, this section has a lot of interpretation and is very important. This is where the author reflects on the work and its meaning in relation to other findings and to the field in general.

4. **Reflection and criticism.** *After you understand the article and can summarize it,* then you can return to broader questions and draw your own conclusions. It is very useful to keep track of your questions as you go along, returning to see whether they have been answered. Often, the simple questions may contain the seeds of very deep thoughts about the work. For example, "Why did the authors use a questionnaire at the end of the month to study premenstrual tension? Wouldn't subjects forget or have trouble recalling?"

Here are some questions that may be useful in analyzing various kinds of research papers:

Introduction:

- What is the overall purpose of the research?
- How does the research fit into the context of its field? Is it, for example, attempting to settle a controversy? show the validity of a new technique? open up a new field of inquiry?
- Do you agree with the author's rationale for studying the question in this way?

Methods:

- Were the measurements appropriate for the questions the researcher was approaching? Often researchers need to use "indicators" because they cannot measure something directly. For example, locations and types of fossils in marine sediments can be used to determine ocean circulation patterns in the geologic past.
- If laboratory experiments were done, do they represent conditions in the actual environment?

Results:

- What is the one major finding?
- Were enough data presented so that you feel you can judge how the experiment turned out?
- Did you see patterns or trends in the data that the author did not mention?
- Were there problems that were not addressed?

Discussion:

- What are the conclusions drawn from the data?
- Do you agree with these conclusions? Are they over-generalized or appropriately careful?
- Are there other factors that could have influenced, or accounted for, the results?
- What further experiments can continue the research or answer remaining questions?

TOOLKIT CREDITS:
Developed by Angela Gee, (Los Angeles Trade Tech Community College, CA) and Martin Diaz,(Los Angeles Trade Tech Community College , CA) with support by the rest of the C-DEBI Collaborative Toolkit Team.

WEBSITE:
http://www.coexploration.org/C-DEBI/toolkits_science_papers.html