HOW TO READ A SCIENTIFIC ARTICLE

> "Probably what you should learn if you are a graduate student is not a large number of facts, especially if they are in books, but what the important problems are, and to sense which experiments, work that has been done, probably aren't quite right."
> James Watson, of Watson & Crick (DNA fame)

When students in the sciences are first faced with using the primary research literature, the prospect sometimes seems overwhelming. Finding pertinent journal articles often seems to involve a maze of abstracting journals, indifferent librarians, missing volumes, CDroms from hell, and bound periodicals that refuse to flatten themselves for photocopiers (no matter how hard you press on them, CPR-style). Even once an article has been located--or, in the case of this class, provided--there is the problem of reading it. The *worst way* to assimilate a research paper is to read it word for word, title to literature cited, as if it were a textbook. This approach is a waste of time, because perhaps as few as 1 in 4 articles that find there way into your hands should be committed to your brain, and is deadly boring.

Before reading one word of an article, ask yourself: What am I looking for in this article? Knowing what I do about the subject, what gaps need to be filled, what knowledge needs to be expanded, and what controversial points need to be corroborated? Generate expectations of a journal article before you read it. This will help your analysis of the work in front of you, plus keep you more interested in the material. Then what:

1. Read the authors' names. Where and with whom are they working? What is their expertise? Names may mean little at first, but as you "wade through" a scientific subject or topic you will find familiar names cropping up, and you will develop those with whom you agree and those whom you question.
2. Read and digest the title. It should summarize the work of the article well, help you to clarify your expectations of the paper, and it should be an attention-getter (if you are reading the article, it has probably already accomplished that task!).
3. Read the abstract carefully and try to understand it (though it may be the densest prose you will ever encounter). Abstracts are as difficult to read as they are to write, because an entire publication must be summarized in an understandable way in only about 200 words. By now, you should have a good idea of what the paper is about and what you have gotten yourself into. At this point, it may be obvious that the paper does not answer your questions. If this is true, move on, but be conservative because the authors' interpretation of the research presented in the abstract may not be the same as yours after reading the full paper. **Never** cite an article after having read only the abstract!
4. Picture time--flip through the article and study the figures, illustrations, and tables, including the legends. It will probably become necessary to consult the Methods and Results section to clarify figures and understand the experimental design. If the article is closely related to your research, closely examine the techniques described in the Methods section. There may be problems there, but more likely there will be a new, perhaps better, approach to your own research. It should be clear to you by now whether this paper will be truly helpful. If so, now it is time to be critical (please, see the note below about this word).
5. Read the Introduction and be sure the author knows the field, has adequately researched past work, and understands where their work "fits into the puzzle". Generally, the Intro and Literature Cited sections go hand-in-hand. Most importantly, within the first paragraph or 2 of the Introduction the authors should have made it very clear what their objectives for the research were, and what their paper will tell you.
6. Check to see if the Results adequately and accurately describe the data presented in the paper. Are there additional points that should have been brought up? Is there something in the figures or tables that does not

substantiate the authors' claims that was not mentioned? Do the figures and tables clearly, succinctly, and attractively present the results of the paper? Remember that great data presented clumsily or sloppily will not be seen as great, only clumsy or sloppy.

7. Now read the Discussion. This is perhaps the most important section, because it is here that the results (the "what" of the research) are explained. That is, here is where the authors should [at least try to] explain "why" they saw what they saw. Beware of unsubstantiated speculation, though do not fault, off-hand, the presentation of hypotheses for future work or even expectations of findings from those future experiments. On the other hand, there are authors who are prone to timidity, understatement, or who are just plain invertebrate about their ideas. You should not be left guessing, or left to fumble to your own conclusions because an author was unwilling to take even a small step out onto a limb. As a moderate example of such understated conclusions, Watson and Crick ended their historic presentation of the structure of DNA with the sentence: "It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material." In fact, the complimentary base pairing they presented was no less that a quantum leap in our understanding of biological systems, in terms of both modern biochemistry and evolution!

Bear in mind that the ultimate burden of assessing published material lies with you, the reader. Take the time and energy to do this and you will gain more and be further along that the person who depends on the author for interpretation. Having just completed a critical reading and assimilation of a journal article pertinent to your work, you should be able to paraphrase the significance of this paper with 3 or 4 sentences free of technical jargon. You should also be able to both praise and criticize several points of the paper (*this is important--see note below*). A general rule of thumb, regarding what goes where, when both reading and writing a scientific article is:

Title: Short, succinct, eye-catching, all-encompassing

Abstract: Summary of Methods, Results, and Discussion starting off with a statement of **why** the research was done and with emphasis on **why** the results are significant.

Introduction: **When** was past work done, by **whom**, **why** was their work important, **what** you plan to do in your paper, and **why** what you did is important.

Materials and Methods: **How** you did what you did and **where** you did it--nothing more.

Results: **What** the data show you--nothing more.

Discussion: **Why** the data show what they show, and **how** your analysis relates back to your objectives from the Introduction.

Note: Some journals will allow the Results and Discussion sections to be combined. In this case, the data should be divided up into logical groups, and for each group (generally separated by a subheading) the **What** and the **why** are presented together.

A note on critiques: A critique "considers the merits and demerits of something and judges accordingly" (Webster). When critiquing an article (or anything, really), remember that there are positive points to be found, and made, about everything. To present only negative criticism is wrong. Never forget to acknowledge that, while we all make mistakes and do things incorrectly, we also all do things correctly sometimes. A pat on the back can go a long way.