

Tips for Critically Reading a Scientific Paper

Most scientific papers follow the IMRaD format, as outlined below:

1. Introduction. Here the authors describe the general subject, discussing what previous workers have done or said about it, and describing what is missing or needing to be done. The authors usually then imply or state explicitly how they will fill that need with the work presently to be described in the paper. In other words, they usually give a purpose or goal to be accomplished, set in the context of a general issue in the environmental sciences. If you can't find some such statement in the introduction, you may find it buried later on in the paper (but it should be in the Introduction).

2. Methods. The authors usually describe the techniques used, and, if the work was done outdoors, they describe the area studied. Theoretical papers often omit this section. As a scientist-in-training, you often cannot evaluate the methods without knowing a lot more about the specific research topic and statistics than you probably do at present. However, once you read further you may decide that the methods could have been better. Try to develop a list of specific problems. Don't make your comments so general as to be meaningless (e.g. "They should have worked harder" or "Their analysis was poor". What you should do is to evaluate specific points, not make vague overall assessments. Another characteristic of a good methods section is that the procedures are described in sufficient detail that someone else could repeat the basic study. Think about the elements of a good experimental design and discussed in class. Does this study have all those elements?

3. Results. Here is where you need to read carefully, to compare the statements in the text with the data in the tables and figures, and generally to read with a critical and suspicious attitude. You will have to accept the following things on faith: **1.** That the data presented were actually observed, not concocted out of the author's head to prove his or her point. **2.** That statements referring to previously published work are true.

Everyone has to accept point **1.** that the data weren't made up. However, it sometimes happens that the author makes observations that contradict other data in the same paper or previous ones. If so, you will need to decide whether you agree or not. Is the author trying to "explain away" data that don't fit, or has he or she done a good job of showing why the new data are at variance? Have the authors provided statistical support for their statements? To check point **2.** you will have to go back and read other papers. This is where your annotated bibliography will be very useful.

4. Discussion. Here the authors try to tie it all up, show that they have achieved their purpose, which is to increase our understanding of the general problem posed in the introduction. No matter how small or narrow their purpose may seem to you, the question is, have they achieved it or partially achieved it? If not, why not? Could it have been improved given a reasonable amount of time and a reasonable budget? Please be sure your suggestions are logical and to the point. Don't suggest measuring all the variables you can think of if these measurements don't help answer the question posed. But if your ingenuity suggests a better way, say so.

Basically, we evaluate scientific papers on four grounds:

1) Assumptions:

Do the authors clearly state their hypotheses? What are they?

What are these hypotheses based on? (literature, observations, models)

Are any alternative explanations / hypotheses presented?

2) Study Design: (Inference Space -> Conclusions):

What is the specific purpose / goal of this study? (What is the population of interest?)

How does it relate to the hypothesis listed above?

Is the experimental design described in sufficient detail that you could repeat the study?

3) Methods & Statistics:

Are the data / results clearly presented? Do they support the authors' conclusions?

Are there alternative explanations for some of the patterns they document?

If you found fault with the study's design, how specifically could it be improved?

4) Logic:

What general ecological or environmental issue is the study relevant to?

Do the authors make these connections in their Introduction or Discussion?

Do the recommendations / conclusions follow logically from the results?

Paper Critique Sheet

Is the hypothesis clearly stated, and does it relate to the question?

For example, "My study compared coral species abundance and composition in shallow / deep water to test the effect of water depth on coral community structure. I hypothesize that coral diversity is higher in more productive shallow-water habitats"

(The "question" in this case would be: "What is the effect of water depth on the diversity (abundance and number) of coral species?")

Does the introduction give relevant background information that helps you understand what was studied, and why?

Are the methods clearly stated so that the study could be repeated?

Did the study compare like (analogous) units? Or are they comparing apples and oranges? For example, studying the effect deep-water corals in Oahu and shallow-water corals in the NW Hawaiian islands would be a problem. Why?

Are all the variables (independent, dependent) clearly defined?

Are all graphs and tables labeled correctly, and do they clearly explain the results?

Is each graph labeled with the time frame, the location, and the units of measurement for both the x- and y-axes?

Does the data relate to the hypothesis/question? Did they collect data on all relevant variables to answer their question? What variables might you substitute or add if you were doing the study?

Were the results explained? Do the results support or refute the question or hypothesis? Did the authors consider any alternative hypotheses? Do you notice a pattern in their results (graphs) that they don't address in the paper?

Do you agree with the conclusions? What would you add or say differently? Did the author discuss the conclusions in light of other research, drawing upon the literature / other studies in this field?

Did the authors address any problems in their research, exploring how they might do things differently next time? Do they consider what future research might be done to further answer the question?