How to read a scientific paper

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Studying in the Sciences

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What are scientific papers?

Scientific papers (or articles) are documents presented to targeted audiences in an area of science. They are a way scientists communicate and share their work. This includes original research or review of the work of others. It helps the development of science by allowing the work of scientists to be built on by others in the field.

Some common types of scientific papers are listed below:

- **Original (or primary) research** – reports on studies carried out by the author/s.
- **Review papers** – these review and analyse the work of others. Commonly, these are completed as **systematic reviews** (SR), whereby the researchers (authors) use an organised method of locating and evaluating literature using a set of specific criteria. SR may include a meta-analysis: a statistical method used to pool data from the included studies.
- **Case studies** report information collected and analysed from work with individual or groups of real world cases.

Other types of scientific papers may also include **theoretical articles** that draw on research literature to advance a theory or **methodological papers** that present new or improved methodologies.

Scientific papers are typically published as journal articles, which are usually reviewed by peers prior to publication; and / or conference proceedings.

To get an idea on what different types of scientific papers look like, see the following examples of peer-reviewed papers from open access, scientific journals:

Original research: http://www.hindawi.com/journals/jeph/2012/636298/

Dohoo, C., Read Guernsey, J., Critchley, K., & VanLeeuwen, J. (2012). Pilot study on the impact of biogas as a fuel source on respiratory health of women on rural Kenyan smallholder dairy farms. *Journal of Environmental and Public Health*, 2012(Article ID 636298), 1–9. doi:10.1155/2012/636298

Systematic review: http://www.hindawi.com/journals/jeph/2013/896789/

Roya, K., Poursafa, P., & Jamshidi, F. (2013). Role of environmental chemicals in obesity: a systematic review on the current evidence. *Journal of Environmental and Public Health*, 2013(Article ID 89678), 1-8. doi:10.1155/2013/896789

Case study: http://www.hindawi.com/journals/tswj/2013/126428/

L., Lizuma, Avotniece, Z., Rupainis, S., & Teilans, A. (2013). Assessment of the present and future offshore wind power potential: a case study in a target territory of the Baltic Sea near the Latvian Coast. *The Scientific World Journal*, 2013(Article ID 126428), 1-10. doi:10.1155/2013/126428

Why read scientific papers?

When studying sciences at university you will be expected to read and critically evaluate scientific papers, including original research and systematic reviews. These papers are usually found in peer-reviewed journals, meaning that the papers have been through a peer review process. This involves reviewers, who are expert in the field, critiquing the work and providing feedback to the authors so that any concerns arising can be addressed before the work is accepted for publication.

It is important to read scientific papers from peer-reviewed journals rather than just text books because of this peer-review process and because scientific journals provide more up to date information on a topic. Additionally, it is the main way scientists communicate their ideas and findings to each other. As you are studying science/ applied science, it is also important to get an understanding of scientific methodologies and reading such research will help you to achieve this.

Note. Whilst for the reasons discussed it is important to read scientific papers, to start with it is often helpful to get background knowledge around a topic from textbooks.

Reading scientific papers

Understanding the layout or how information is structured will help you to navigate the paper as you read and know what details to focus on.

The structure of a scientific paper generally follows the approach to scientific method.

Table 1: Alignment of sections of a scientific paper with the processes of scientific method.

Structural sections of a scientific paper	Scientific method
Introduction	Ask a question
	Background research
	Construct a hypothesis ← *Hypothesis: Idea or proposed explanation for something that you test through scientific method, usually resulting in the collection of information/ data for analysis.*
Methods/designs	Test hypothesis
Results	Analyse data
Discussion (and conclusion)	Draw conclusion
Whole paper	Communicate research

Note. Although this alignment between a scientific paper and scientific method is typically more representative of original research, systematic reviews are presented in a similar format. While systematic reviews are likely to have research questions and aims, they tend not to test a hypothesis.

General layout of a scientific paper

The title of the paper, details of the authors, their affiliations and an abstract are provided first. This is followed by i) a background or introduction; ii) a section outlining the methodology of the experiment (methods/ design); iii) the results (presentation of the findings); iv) a discussion and conclusion; v) a reference list of other sources cited in the paper. Although headings for each section might vary between publications according to editorial requirements, this is the general structure the scientific information is communicated.

The following sections of this guide take you through how to read a scientific paper. You might prefer to take a brief online tutorial on the topic from Purdue University Library. Take an online tutorial on reading scientific papers: http://www.lib.purdue.edu/help/tutorials.To help you read scientific papers with purpose, it is important to understand the structure and what elements you should evaluate as you go along.

Section	Purpose	Relevance for critical evaluation
Title	Identifies what the paper is about.	Provides information on the paper's relevance to your purposes. If uncertain, see the abstract.
Authors	Identifies who did the work, their affiliation/s and who the contact is for the work.	Who the individuals are may not be particularly important. Knowing if the paper has been peer- reviewed and if there is any potential conflict of interest with the authors who did the research (for example, sources of funding from those with a vested interest in the results)).
Abstract	Summarises the paper, particularly the key findings and often the methodology.	Allows you to determine relevance and identify key findings. **Note**: you should read the full paper to critically evaluate the work.
Introduction	Sets the framework for the paper, identifying gaps in previous research, justifies why the current research is important and outlines aims, research questions and / or hypotheses.	Contributes to the credibility of the paper in terms of providing a sound background and justification for the research.
Method/ Design	Outlines the design of the study and method used in the experiment. Usually includes information on the population (subjects/ cohort) studied.	Highly important. You need to critically evaluate the methods to identify if the experiment is well conducted to control for things (biases) that might influence the results of the study that are not the things in the experiment being tested. Well-designed studies that have minimal sources of bias and use tools to measure outcomes that are reliable and valid, allow you to believe the findings are due to the experiment itself, rather than other influences.
Results	Report what the research has found. Results may be quantitative (data expressed numerical) or qualitative (descriptive observations) depending on the study design and type of data collected.	Highly important. Look at the results to determine the answer to the study's research questions (Do the results support or go against the hypothesis? Are the results inconclusive?) The results provide you with the findings of the research rather than the authors' interpretation of these findings.
Discussion	Provides the authors' interpretation of the results in the context of the research question and other research in the field. Relevance of the results suggested in a practical or 'real world' context. Reports on limitations and areas for further research.	Helps you to understand the results and the 'real world' applications of these findings. As you become more experienced and skilled in studying science, ideally, you should try to draw your own conclusions from the data in the results section. As the authors critique their own work here, this can help inform your critical evaluation of the paper.
Conclusion	Often included in the discussion section, but may be separate. Provides a take home message based on the aims and findings.	Ideally, the reader should try to draw their own conclusions from the results section. However, as beginning scientists this section can be very helpful for relevance.
References	Lists other sources cited in the paper (these are mainly cited in the introduction and discussion).	Evaluate to determine if the relevance and currency of the literature. This can also be a helpful source for finding other relevant literature in the area.

Now that you have an understanding of how scientific papers are structured and the content and relevance of each section, the following is to help to identify an approach to reading a scientific paper.

How to go about it

1. Screen the title to see if the paper is relevant for your purpose. If uncertain check the abstract for more detail to determine if the paper is relevant.
2. Once you have determined the paper is likely to be relevant, read the abstract in detail to get an idea of the key findings and how the research was approached.
3. Apply your knowledge on the structure and relevance of each section to interpret and evaluate the paper:
    iv. Read through the introduction to get an understanding of what is known in the area and the reason or purpose of the research (or paper). Ask yourself if the purpose is clear and justified from the background information provided in the introduction?
    v. Read the methods section in detail to understand and critically evaluate the design of the study. Ask yourself: is the study well designed?; have the researchers tried to eliminate things that may influence the results other than the variables of interest (i.e. minimised sources of bias)?; are the results likely to be reliable and can they be reproduced?
    vi. Read the results section in detail, including the figures and tables, to interpret what the results indicate in terms of answering the research questions/ aims proposed in the introduction. Draw conclusion from these results. (As beginners in studying the sciences, the discussion/ conclusion sections will be helpful to interpret the results of the paper).
    vii. Read the discussion with purpose to get an understanding of the authors' interpretation of their results in the context of other scientific literature. There may also be information about limitations of the researchers' work and directions for further research. A conclusion should be provided in terms of an interpretation of the key findings in the context of the research aims/ question (this may be in a separate section labelled 'conclusion').

Links to glossaries of research terminology

When reading scientific papers you will often come across research terminology that you are not familiar with. It is a good idea to look these up so you can understand what you are reading. Here are links to glossaries that you can use to help your understanding of new terms.

- http://undsci.berkeley.edu/glossary/glossary.php
- http://www.cochrane.org/glossary (for the health sciences).