Reading Scientific Papers

How a paper is read depends on the person reading the article:

Scientists: Start by looking at the figures, make their own interpretations of the figures, then read the results and conclusion. If a scientist disagrees with the author, they would then usually go on to read the methods section or look up the references to check them in order to determine the source of the perceived problem.

New to the field: Begin by reading the introduction, then the methods section, and then the results and conclusions. Most papers in a specific field will put the same information in the introduction, so eventually someone new to the field will stop reading the introduction every time, signaling that s/he is becoming more familiar with the field.

Keeping this in mind, you should try to make each section of your paper self-standing. This is one reason that there is sometimes a lot of redundancy between sections, particularly the results and discussion sections.

In addition to being read in a specific order, the material that is in a scientific paper also has a specific order. Note that the order of the sections should be Intro, Methods, Results, and Conclusion, but they are rearranged here.

Introduction: An introduction is like a funnel—you begin with a rather broad topic and narrow it down until you have a very small, specific area that you will address. Thus, you start out big (cancer) and end up small (one signaling molecule that may sometimes cause cancer under very specific conditions).

Conclusion: The conclusion is almost the exact opposite of an introduction. Here, you lay out the specific area that you have addressed and then explain its broader significance. So, you start out small (these are the experiments I did) and end up big (one day we could use this information to treat some cancers).

Methods: The methods section has a very basic order; each method gets its own paragraph and goes in the order it comes in the paper. Generally, any tissue culture and plasmid construction goes first.

Results: The results section presents a more interesting challenge. Should they be put in chronological order or in story-telling order? Frequently, experiments are done out of order (perhaps you make an observation, formulate a hypothesis and test it, and then later go back to rule out something else that could have occurred that you remembered later). However, when writing up a paper about them, authors typically will rearrange the experiments so that they make sense *logically*. This is sometimes referred to as telling a story, where each experiment builds on the previous one. For your paper, you should try to put your experiments in the order that makes most sense, whether that is chronological order or logical order.

The hypothesis or hypotheses of a study can be written in a variety of ways. Sometimes, the hypothesis is spelled out directly:

- "The purpose of the present study was to test the hypothesis that growth rate differences produced by sustained mechanical loading of rat tail vertebrae are associated with alterations in the increase in the height of hypertrophic chondrocytes in the direction of growth."

Sometimes, the hypothesis is combined with the methodology:

- "To investigate genetically the relationship between GH and IGF1 in postnatal growth, we sought to generate double-mutant mice lacking the actions of both GH and IGF1 and compare their phenotype with the phenotypes of the respective single mutants."

Sometimes, the hypothesis is hidden in a summary sentence at the end of the introduction:

- "Our simulations as well as the analysis of real data suggest good properties of the proposed method and demonstrate that the proposed modifications of the mBIC may help to increase the power of QTL detection while keeping the proportion of false discoveries at a relatively low level."

Your hypothesis should be stated in the way that makes most sense for your experiment. If you have an easily describable hypothesis, you would want to spell it out in your paper. If you are doing a comparative study or "fishing expedition" (where you don't know exactly what you are looking for yet), you may want to combine your hypothesis with your method. If you are doing a computational project with a hypothesis that is very hard to describe, you may want to hide your hypothesis in a summarizing sentence. The important thing is to choose the method that will work best with your study.

Another extremely important consideration for both reading and writing the results section is the use of proper controls. The basis of most experiments is to hold everything constant except for one experimental variable that is manipulated to prove that it causes some effect. A control is when the experimental variable is not manipulated, thus providing a basis for comparison. An experiment without a control is essentially useless because no interpretation can be made—no change can be assessed. Thus, make sure that the experiments you are performing have good controls.

- There is no one control that is used in every experiment—the use of controls will be dependent upon your specific project. Talk to your mentors to find out what controls are used in your experiment and ask questions if you don't understand how they help you interpret the results.

- For your paper, you should explain any controls that you write about in your paper. Don't just say the controls were good; go through each control and explain what it means with regard to that particular type of experiment.

For this exercise, put the following sentences from a real abstract in the correct order.

(1) A total of 41 genes are affected by the Runx2 deletion in both intramembranous and endochondral bone, indicating common pathways between these two developmental modes of bone formation.

(2) Bioinformatics analysis indicated that Runx2 not only controls the processes of osteoblast differentiation and chondrocyte maturation, but may also play a role in axon formation and hematopoietic cell commitment during bone development.

(3) In this study, we analyzed the role of Runx2 during intramembranous and endochondral bone development, by comparing gene expression profiles in 14.5 dpc wild-type and Runx2 (-/-) mice.

(4) In addition, we identified genes that are specifically involved in endochondral ossification.

(5) In conclusion, our data show that a comparative genome-wide expression analysis of wild-type and mutant mouse models allows the examination of mutant phenotypes in complex tissues.

(6) A major challenge in developmental biology is to correlate genome-wide gene expression modulations with developmental processes in vivo.

(7) A total of 1277, 606 and 492 transcripts were found to be significantly modulated by Runx2 in calvaria, forelimbs and hindlimbs, respectively.

Vaes BL, Ducy P, Sijbers AM, Hendriks JM, van Someren EP, de Jong NG, van den Heuvel ER, Olijve W, van Zoelen EJ, Dechering KJ. Microarray analysis on Runx2-deficient mouse embryos reveals novel Runx2 functions and target genes during intramembranous and endochondral bone formation. *Bone* 2006: Jun 13; [Epub ahead of print].