Drafting Journal Articles
The **Introduction**

The primary purpose of the introduction is to provide the education that the reader needs to understand the results and discussion. The level of explanation needed will depend on the level of knowledge that you assume in your audience, which will in turn depend on the journal to which you are submitting.

The secondary purposes are

1) To give credit for work that has already been done
2) To enable the reader to find details about previous work (citations)
3) To convince the readers that you understand the material well enough to study it
4) To maintain the readers' interest in the subject matter, and specifically your paper.

Most articles include an abstract, which summarizes the purpose, results, and importance of your work. Your introduction does not *need* to summarize the paper, but some writers use the first paragraph to make a newspaper-type summary.

Styles vary, but a common one leads the reader through the cognitive steps from an existing problem to the research that you will report. For example,

- The existence of a problem, phenomenon, or relationship
- The impact of the problem/phenomenon
- Ways that the problem currently is addressed/treated
- Weaknesses in the current method
- The potential offered by a new method
- Proposed research to achieve the potential improvement.

The emphasis would be changed if you want to lead with a recent discovery instead of a problem (and then discuss possible application), or if the weakness with the status quo is a lack of basic knowledge about a system.

If the proposed research involves esoteric concepts, arcane terms, or abbreviations, these should be explained or defined next. The last statements make a transition to Methods.

The introduction can be the hardest section to write, especially for a new topic. It does not have to be written first, but it can be a good vehicle for studying the existing literature and formulating your work plans. It might even lead you to pursue a different course of action!

Things to avoid in an introduction (and in conclusions):

- ☹ Overreaching or non-topical statements
- ☹ Vague statements
- 😐 Complete literature reviews (arguable)
- 😐 Complete recapitulation of published methods & results

Remember, 1) your advisor is as right as he/she wants to be, and 2) there are many ways to write a good introduction.

The **Methods** section

The methods section contains considerable detail about the procedures you used, and will not be read by everyone who peruses your paper. Two groups of people *will* read it thoroughly: scientists who wish to recreate the experiment, and reviewers who are checking the paper for accuracy. The reviewers, in particular, would like to decide whether a) you did the procedure correctly, and b) the conclusions that you draw from your results are valid. This last point is significant, because small details in your procedure can change the implications of your results dramatically.

You might also find that writing the complete procedure teaches *you* something about your experiment.

General guidelines:

- Include only the methods used to produce your results. Your project evolution, missteps, and alternative methods can go in the Discussion.
- Use the same terminology as previous authors, unless it is wrong.
- If a detailed procedure has been used before, you may cite the source and provide an abridged version. Your readers will appreciate it if you cite a source that really does provide the details, not just another summary.

  > Laminin was covalently ligated with polylysine using previously described techniques [15]. Briefly, a solution containing 100 μg/ml laminin (EHS-mouse laminin; Boehringer Mannheim, Indianapolis, IN), ...[1]

- Note that Methods often comes after the Results and Discussion. If this is so, write your Introduction and Results with the assumption that the reader will not read the methods.[2]

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1 *Biomaterials* 22 (2001) 1049-1054

[2] *Science* magazine puts procedural details into footnotes, which are often skipped over as well.

When citing your sources of material & equipment…

- Provide a level of detail that is proportional to the impact that variation in the item affects your results.
- Emphasize information that will allow the reader to replicate your experimental conditions, not necessarily your experimental setup. Standard equipment that produces a condition does not need a detailed description: incubator, fume hood, biological safety cabinet.
- Describe generic items sufficiently to reproduce them: dry nitrogen, 5% CO_2 in air at 37° C, 0.2-μm filtered water, distilled water. If you mix your own solutions, give or cite the recipe.

  > "Single-unit recording probes consisted of a bundle of eight tungsten wires (25 μm diameter; 150–250 kO) inserted into a 28-gauge stainless steel cannula."[3]

- Provide sources for commercially available tools/reagents that are possibly unique or that can vary by lot: CO_2 laser cutter (model M20, Univeral Laser Systems, Scottsdale, AZ); Texas Red (Molecular Probes, Eugene, OR; lot # xxxxx).
- Cite the exact type and source for each cell you use: 3T3 mouse fibroblasts (ATCC, Bethesda, MD). If known, give the method of harvesting, culture conditions (e.g., growth medium), growth phase, and number of passages since harvest (for mortal cells).

[3] Goosens, et al., *Neuron*, Vol 40, 1013-1022, 4 December 2003

Writing Results

There are two hard parts about writing results:
1) Getting good results to report;
2) Getting MS Word to keep the figures where you want them on the page.
The rest of the process is methodical and requires little creativity. If you are having difficulty with a particular sentence in Results, consider whether the sentence belongs in the Discussion! You have seen the following advice from the TC 231 web site.

> Anatomy of a Research Report: results and discussion
>
> **Results:** Everything before the Results section explains why you wanted data and how you got data. Everything after the Results section will explain what the data mean. Therefore, the data in the Results section are the core of the paper.
>
> - Only the facts—no interpretations.
> - Figures and tables—all appropriately labeled.
> - Calculations if necessary.
> - Point out the main idea in the results and in each figure or table—but don't interpret!
> - If you have more than one figure or table, then place informative text between the figures and/or tables as transitions.
>
> The results section shows the reader the data you collected in a format that is easy to read. Data are easy to read when they are grouped into succinct packets: each graph or table should convey only one or two sets of relationships among the dependent and independent variables.

Results papers and Techniques papers.
The guidance above is helpful for a scientific research paper, in which

- you are investigating an existing phenomenon or relationship
- most of the methods have been used before
- you have obtained quantifiable results (data).

The boundary between Methods and Results becomes blurred when we report the invention of a device or method. We have spent months or years developing a new technology, so our real method was our design process – but this method is seldom reported. Our *data* will consist of the output of our technology (e.g., pictures or sensitivity values), and a comparison to existing methods (on the same test subject, if possible). However, these test results may be meaningless outside the context of our device; our real result is the technique or method that we have developed. There are a few ways to handle this.

- According to TC 231, some journals include an Apparatus section. This would be the centerpiece of your paper, describing your novel design.
- If the journal does not have an Apparatus section, followed by Methods and Results, you may write procedural details into the Methods and put the device design into the Results. Some scientific journals do not accept this approach, making it more convenient to publish first in an engineering journal. You may then acquired data with a broader impact and submit a new paper to a basic-science journal.

Text in the Results section is similar to the verbal explanation that you would give if showing a Results slide during a presentation. Even though you try to make a table or figure that is self-explanatory, you would not show the slide and say, "Here, read this." to your audience. Write the paper as if your tables and figures will be included after the bibliography, as they often are in submitted manuscripts. The amount of detail that you provide in the text is often inversely proportional to the detail in the caption; this balance depends on the journal and your taste. Some results can be presented completely in text format. Such results are rare in research articles, but I do see them in conference abstracts, letters to the editor, and "Brief Communications." The authors are often reporting the progress of a developmental project or experiments with a negative results (e.g., "The proposed algorithm failed to recognize the target in any of the test settings.") Such results can be worth publishing because they help other researchers in the same field, but do not warrant peer review.

Tables and Figures.
TC 231 recommends selecting your presentation format based on the technical background of your audience. Your selection also depends on the type of data.
Tables are especially good if:

- The main purpose of the table is for reading values for computation
- You are confident in the accuracy of the results
- The independent variable is not part of a trend.

Tables work best with:

- two independent variables and one dependent variable (e.g., cell motility as a function of substrate coating and cell type, or
- one independent variable and multiple dependent variables (e.g., water properties as a function of temperature).

Figures are effective for showing trends and comparing data sets. A figure should have only one independent variable on the (horizontal) axis. A second independent variable maybe included by putting multiple traces on the same axes and labeling each one (e.g., temperature as $f(x,t)$, or patch clamp currents). Two dependent variables may be shown with different scales on the right and left sides of the plot.
The axis in each figure represents a variable; the numbers on the scale represent units. Therefore, in a plot of I(t), the horizontal axis is always time, or t, and the units label (hours, seconds, etc.) differs according to the numbers you choose. The axes should not be labeled simply 'amperes' and 'seconds'.
Try to plot your data in a way that emphasizes the signal and de-emphasizes the noise. Namely, do not let Excel connect the points unless the transition from one point to the next is important. Examples:

- A low-noise signal $f(t)$ would be connected (points are recorded consecutively).
- A high-noise signal $f(x)$ would not be connected (especially if the temporal order of collection does not coincide with x-axis). Each line between points does not represent a linear transition. In this case it is better to plot the individual points and draw a trend line through them.

Error bars can represent:

- Uncertainty, based on knowledge of your instrumentation
- Statistical information, based on multiple samples
- Total range of data collected

Discussion & **Conclusions**

The division of results, discussion, analysis, error analysis, and conclusions depends on the journal. The author guidelines will provide basic instructions, and reading some articles will provide examples.

Discussion

The primary purpose of the discussion is to help the reader understand and apply the results you obtained. I try to write as if the reader will not jump to any conclusions by himself, but that he will understand any relationships that I point out or describe mathematically.

The secondary purposes are

5) To demonstrate that your results match theory. If they don't, you should consider a) revising your experiments, or b) offering an alternative theory.
6) To demonstrate that your results match previous work
7) To find the positive aspects about the research (any time you learned something and can remember it, it is positive, *a la* Thomas Edison; any time that you learned something that no one else knew, it might be worth publishing)

Conclusions

Things to include in Conclusions:

☺ Suggestions for further research
☺ Your opinion of the success of the project

The last few sentences can be the hardest section to write, because you want to leave the reader impressed. >> If the reader is not impressed by now, don't force it into the last paragraph!

Personal opinions: Your opinion might be important, because you should be the most knowledgeable on your research (and you might be the most knowledgeable person on the topic). You should be able to justify your opinions ("The correlation was satisfactory because…").

Things to avoid in Conclusions:

☹ Overreaching statements (overly broad impact)
😐 Personal opinions when your opinion does not matter (sometimes it does!)
😐 Complete recapitulation of your results

Remember your acknowledgements for funding & advice!