Rick Kahn's "system" for writing scientific papers

This is intended to give some concrete ideas as to one approach to begin the long and tortured process of writing a paper. Hopefully will it may also help you solidify your understanding of the roles that different sections play in a scientific paper and how they interact. Note that other faculty members have described alternatives so there certainly is no single "best" approach to writing. I suggest for those in early phases to sample different approaches and work out what works best for you. Also, sit down and discuss with your co-authors the approach that you plan to take as this can save a lot of time re-writing or re-ordering down the road.

Before writing, identify the target journal and go to their website to read their "Instructions to Authors". Pay attention to figure construction, file types accepted, formatting, etc., as doing things their way the first time can save substantial amounts of time overall.

I approach the writing of a paper with the following steps:

1. **Temporary title** -- I find it helps focus the thinking but title must evolve with the paper.
2. **Results** -- This is the hardest section to write and should take by far the most time because it requires both incredibly fine attention to details and a clear and logical flow of ideas from one experiment to the next. I often gain a better understanding of the experiments and their meaning while assembling them into a "story*". I find that the same data can often be presented in different ways, different orders, to relate variations on your story and that the impact can be quite different on the reader. And often in ways that may not be obvious to you because you are so steeped in the questions and the experiments. It can easily be the difference between quick acceptance or rejection of your ideas and conclusions. This is also why it is so important to get input from colleagues outside your lab after you write the first complete draft and as you proceed toward a final, submitted manuscript. It is also why it is so important to identify colleagues willing to read your work carefully and critically.

   I typically outline the Results I want to include in the manuscript, paying attention to the order of presentation and the logic that drives you from one to the next. Each point I want to make becomes a heading for a section that might be one or several experiments. I then fill in each section with a working title and the experiments to be described. After completing each section I ask what is the single most important result that supports the conclusion I want to make and try to build a figure around that. I know others will make figures first and then fill in the text based upon that. Perhaps some fields of study (structural biology comes to mind) might be more visually based. No single best answer here.

   I generally start the Results section with a brief description (one paragraph) of the broader questions being addressed and the experimental model being used. These were set up by the Introduction but many people don't read the Introduction before the Results and you want the reader to be clear what you are doing and have no concerns about your choice of experimental systems (organism, cell line, over-expression, co-IP, siRNA, etc). You want your reader to think you have thought these things through before you did your first experiment and that you made wise choices.

   Resist the temptation to describe your interpretations of your Results as those belong in the Discussion. That said, a little interpretation is important often to drive you to the next section. For example, "These results suggest that X is involved in Y. To more rigorously test this interpretation we performed a series of experiments doing Z." This is what I mean by being clear on the logic flow and how the sections fit together.

3. **Figures** -- these are outlined early, during the outlining, and solidified as the Results are written. Some figures get quite complex and having to re-do them repeatedly can kill lots of time. This is why I prefer to wait until the Results are crystallizing from the writing before spending too much time on them.
4. **Figure Legends** -- best written while assembling the "final" figure. Different PIs and journals have different ideas about what to put into legends so do some checking before investing too much time here. Some want titles that tell you the point of the figure others specifically don't. Every figure should contain some indication of statistics used, number of times the experiment was repeated, cell line, assay, what the symbols and (error) bars mean, etc. Don't repeat protocols, just refer to Methods section but include enough details to understand the results shown.
5. **Discussion** -- I think Discussions are perhaps the easiest section to write but need the most attention to things outside your work and lab. Call me old fashioned but I believe that the authors have a responsibility to put their work into context of the literature and what precedes their contribution and it is not a place to self-aggrandize. I find it easy because I use a simple formula. Go through the Results section making a list of bullet points that you think you want the readers to take away as interesting new observations. Then prioritize your list from most to least important. The first paragraph of your Discussion will then consist of one (or perhaps two) sentence(s), e.g., "In this study we investigated the roles of X in Y, using Z cells/organism as a model system and to test the hypothesis that A. We found that.." Then list your observations from most important/interesting to least with each getting one sentence in this first paragraph. Each of those points/sentences then becomes a paragraph of your Discussion. In each of those paragraphs present a critical assessment of the strengths and weaknesses of your observations, your interpretation and how it relates to previously published work, citing them extensively to assist the readers in assessing your interpretations of those other studies and to distribute credit appropriately. It is your responsibility to know and accurately cite the literature and to be exhaustive in doing so. You cannot/should not fail to cite a paper because it disagrees with your results. Better to face the conflict head on, try to explain any discrepancies or acknowledge the differences in results/interpretation that will require additional experimentation to resolve. Finally, one paragraph to summarize your results and perhaps future studies required may be appropriate but is sometimes discouraged.
6. **Methods** -- I write Methods sections when I sit down to work on Results/Discussion and find I have writer's block. Methods are so cut and dried that it helps me to get things going and words on the page so after writing a few methods I find I am better able to make progress with the harder sections.
7. **Bibliography** -- basically treated like Methods and inserted as they occur to me. Note that in writing other sections I often have to look up the source of information and when I do so I insert the citation at that time to improve accuracy and save the time of looking it again later. Thus, most references are inserted (use Endnote or its equivalent!) as the manuscript is written and I don't need to do this as a separate activity.
8. **Introduction** -- I find that the writing of the other sections really crystallizes in my mind what the paper is about, the nuances, as well as the larger view. This is helpful to write the introduction as I agree with the idea that it should be an inverted pyramid. That is, write from general to more specific. I write a first paragraph about the field in general, highlighting importance to cells, to humans, relevance to any diseases, etc. From there I move to the next lower level, perhaps models of how the thing you are writing about work. Then onto limitations or gaps in the current understanding, all of course leading the reader to the inescapable conclusion that your work will fill this critical gap. So three paragraphs can be enough and form the basic introduction. However, often I find it is

important to include background information on either the method you will use, or some of the key reagents. For example, we just submitted a paper on use of cytoplasmic tail fusion proteins including amyloid precursor protein, furin, and mannose 6-phosphate receptor tails. So we included a paragraph on what those proteins do in cells and the signal sequences in the cytoplasmic tails that we were focusing on. I think a key to remember in writing the introduction is that the reviewers, and likely any and all readers, will be experts in one aspect but not all of your work. Thus, you want to highlight important aspects of the work and don't assume that because they got the paper to review that they get all its subtleties and nuances, or even the larger aspects.

9. **Final title** -- This is the last thing I write in the paper. You should now be very clear on the contents of the paper and what you think is the single most important take home message. Avoid the use of squishy or ambiguous terms. I have found that a weak or misleading title can be the primary cause of a paper being rejected. This was because the reviewer formed an opinion, based solely on the title, of what they expected to find in the paper and when they didn't, they felt the authors were being misleading. Once that happens, you will have a struggle on your hands getting the paper accepted.
10. **Critical input** -- Once you have a near final draft of your manuscript you will want to send it to colleagues for their comments. By "critical input" I mean both that it will be very important to the final manuscript and that you want to find someone (or several someones) who will try to pick it apart for weaknesses in writing, in research design, in interpretations, in scholarship (failure to cite important work or incorrectly doing so), or other things. This can save you an incredible amount of time and is certain to improve the quality overall. Once your paper is published it will be out there for all to read forever. You really want to minimize the number of mistakes or omissions.
11. **Cover letter** -- Perhaps the most fun to write because it means you have made it to submission. I have survived my career despite paying almost no attention to cover letters and basically have written just a couple sentences to the effect, "here is our paper, please accept it". But science is more complicated now and one is likely better off directing the manuscript to the optimal audience by including in your cover letter some key aspects of the work and thus the best reviewer(s). Not by name but by world view. For example, "In this manuscript we test central hypotheses regarding the mechanisms of membrane traffic using S. cerevisiae as a model system. Thus, expertise in yeast biology and an understanding of but not being wed to current models of membrane traffic would facilitate the review process and ensure fairness."