Publications

How to Write a Biophysics Article Worthy of Publication:

Part 1- From Lab Notebook to First Draft

William O. Hancock
Pennsylvania State University

This is the first part of a three-part series, How to Write a Biophysics Article. Although the suggestions herein are geared toward a *Biophysical Journal* paper and are targeted for graduate students and postdocs, they apply generally to all scientific writing and all levels of scientists and engineers. In this first paper, I will discuss the hardest part of writing a manuscript — writing the first full draft. The important tasks of polishing your writing and figures to achieve publication quality will be tackled in the second paper, and the third paper will cover navigating peer review and getting your manuscript published.

Although many students and postdocs put off writing until they absolutely have to, there are important reasons why you should tackle the first draft of your manuscript earlier rather than later. The most important is that writing up your work in manuscript form is the best way to clarify which experiments are essential and which are less essential or even superfluous. Although it may seem that you are losing productivity by stepping away from the bench to write, in the end you will save a lot of time by avoiding unnecessary experiments, and you will have an added focus for those experiments that you realize are needed to complete your story. The second reason for starting early is the unavoidable truth that good writing requires extensive revising, and revising takes time. So, do not wait, start writing now!

Telling your story

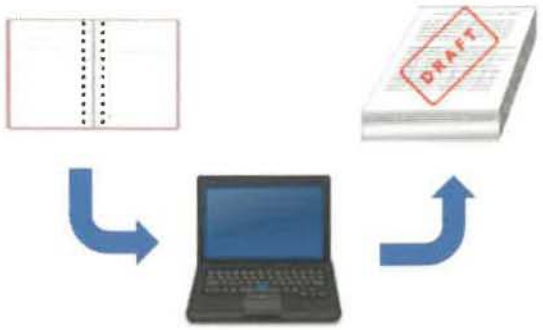
A good paper is one that addresses an important question and changes the way that the reader thinks about a problem. When you write a manuscript, it is important that you remember that you are writing for an audience. For this reason, it is often helpful to think of your paper as a story that you are telling the reader. The story is broken down into four sections: Introduction, Methods, Results, and Discussion. In writing your story you should aim to fulfill four goals:

- Explain why the question you have chosen to work on is important — guide your reader's thinking and get them excited about your work;
- Explain how you did the experiments — help your reader evaluate whether the methods are appropriate for the problem at hand;
- Clearly describe the results you obtained and the control experiments you did to substantiate your conclusions;
- Discuss how these results change the way in which we should think about the question at hand — educate your readers and convince them of the impact of your findings.

No bones about it, writing is hard. To minimize writers' block and the intimidation of a blank page, I lay out a series of steps here to help you build a first draft. It is assumed that you have a collection of data in your notebook, and you may even have an important breakthrough to report, which motivated you to write up your work. But writing is a very different activity from carrying out experiments or doing theoretical work, so having a clear game plan is vital.

Step 1: Define your story

What is the point you are trying to get across to your reader? This story is in the context of specific questions in your field, and you have a set of data that you want to present to try to tell this story. Defining the story early on is important because it will help you decide how you want to organize the presentation of your results. Defining the story is also important because it streamlines the Introduction and defines the specific background points you'll need to get the reader up to speed. Finally, the Discussion will hammer home the narrative of the story you presented in the Results — reiterating it, extending it, putting



it in the context of what has been done before, and pointing to where the story will go in the future. You should be able to summarize this story in a sentence or two and, in fact, it is a good idea to write these sentences at the top of your document that will grow into the first draft of your manuscript.

It is important to point out here that the narrative you present in your manuscript need not follow the historical sequence of your actual experiments. In fact, because research often takes a circuitous path, the ordering of the results in the manuscript generally should not follow the timeline of your experiments (and no, this is not cheating). Remember that you are writing a science story and not a science diary; hence, the trials and tribulations you encountered along the way (even though they took up a lot of your time) are not important to the reader. A related point is that you should avoid the urge to include all of your experimental data in your paper. The more threads you try to weave into the story, the more risk there is that you'll detract from the main storyline. To sum up: Think about how to create the best narrative that presents the work in a logical and memorable manner.

Step 2: Organize your figures

Your figures are the most important part of your manuscript. A good rule of thumb is that a reader should be able to look through your figures and the associated figure legends and get the gist of your story.

Hence, deciding how you organize the various plots, images, and diagrams into discrete multipanel figures is a key task. The Results section will be written around these figures, so a helpful approach is to "divide and conquer." Many journals (like the *Biophysical Journal*) allow the Results section to be broken into subsections, each with its own subhead, which makes your job much easier. Just as you wrote down the main point of your story above, write down a series of active statements that describe the data you are presenting, and use these statements to organize your figures. Then you can think of your Results as a series of chunks, each of which has an actively worded subhead that states a result (e.g., "Protein X activates complex Y"), has a figure and legend that present the data, and has one or more paragraphs that describe the data presented in the figure. These are the bullets that make up the key points of your paper.

This step is key, so here are a few pointers: (1) A good way to build your manuscript over time is to assemble your notes and data into a PowerPoint presentation that you can present at lab meetings and easily modify and reorganize. (2) For the first draft, don't worry too much about finalizing formatting of the panels in your figures, you can do this later; if some data are missing at this point, that's okay, put in a mock figure and keep pushing forward. (3) For journals that don't allow section headings, this type of organization is still helpful; just delete the headings.

Step 3. Write the Results section

Now that you have your figures together and have divided your Results into subsections, it is time to write. Each subsection should describe: (1) the specific question being addressed, (2) the methods employed, and (3) the results obtained. Each section should logically connect to and set up the next section. One good way to achieve a logical flow and a compelling narrative is to organize the sections of the Results as a series of questions. Another useful approach is to organize each section around a specific hypothesis that is being tested.

For the methods, be brief because full details are in the Materials and Methods section, but give suf-

(Continued on next page.)

ficient information for a reader to understand the essentials of what you did. And for the results, as you proceed logically from one figure panel to the next, you should describe the key result contained in each panel, perhaps provide additional details that are not in the plot or legend, and summarize the "take-home point" before moving on to the next result. For your initial draft, include all details (err on the side of verbosity) and distill down to essentials in later drafts.

Writing the Methods in parallel with the Results makes sense because you can progress through the same sequence (for each Results section you write, write the corresponding Methods section).

A note on verb tense. It is generally accepted that your narrative should be in the past tense when you are discussing what you did and what you found. In contrast, when discussing data that are in the literature, we typically use the present tense — which may seem surprising. But most importantly try not to mix past and present tense in your manuscript.

Step 4. Write the Discussion

For writing the Discussion you need to step back a bit. Whereas the Results section is very specific and detailed, the Discussion needs to put your work into a larger context. It is good to start the Discussion with a paragraph that reiterates the question set up in the Introduction and then reiterates the key results in a concise way. An added benefit of summing things up here is that it provides a running start for your Discussion. You then need to relate your work to previous work that has been done and put it in the context of the field overall. You should also critically evaluate your methods and results — what are the strengths and limitations of your approach, and how do they compare to previous or related work? You should extract as much meaning from your results as possible (without going overboard). What results amplify and confirm others? What subtleties in the data suggest other phenomena beyond what you're looking at specifically?

Step 5. Write the Introduction

Now that you've written most of the manuscript, it's time to write the Introduction. Return to the story you defined at the start (maybe you need to revise it somewhat after laying out all of the results?), and think about the points you've made in the Discussion. In the Introduction you want to lay out the basic logic and motivation for your study — build a framework that makes the reader excited and hungry to see your results. To achieve this, you need to provide the key background material that enables the reader to understand the state of knowledge in the field. Avoid a comprehensive review of the field, and instead focus on the important open questions and why they are important. Build a convincing argument for why you did what you did.

In setting up the background, you should write with the literature that you reference close at hand, and be checking that what you think is in the papers is actually written in the papers. Beware of boldly stating what you assume to be true — provide evidence and references when stating any "fact." Also, avoid referencing review articles whenever possible, and instead reference the original papers where key observations were made — if you make an important discovery wouldn't you rather have people reference your hard work rather than a review article written by someone else?

The last paragraph of the Introduction is key. It should briefly describe what you did and what you found, and it should set up the Results section. In this way, the Introduction creates tension and intrigue, and this last paragraph gives a sneak preview of what is to come. Ideally this last paragraph of the Introduction should also link to the first paragraph of the Discussion, providing two bookends of the Results.

Step 6. Write the Abstract, Title, and Reference List

Now that you have your complete text, you should write the Abstract. Be brief and to the point (check word limit for the journal). Minimize background, clearly state your results and include any methodological details you need.

Finish with the implications of the work. You will hone your abstract later.

If you haven't settled on your title yet, this is the time. Be specific and be precise. Also, finishing your first complete draft means that you have a complete reference list with proper formatting. Bibliographic software is essential. Suitable packages include EndNote, Mendeley, and Zotero; use whatever works best for you. One consideration in choosing software is that editing subsequent drafts is much easier if you and your coauthors use the same package.

Final notes

The key task to remember here is to get all of your results and all of your thoughts down on paper — the honing and polishing will come later. Remember: it is better to start writing earlier rather than later. Your next step is to refine your writing. It has been said that the last 10 percent of the work takes 90 percent of the time, which is a bit extreme but not too far from the truth where writing is concerned.

Revising your draft will be the subject of Part 2, which will appear in the June issue of the Newsletter.

On the Move

Jean Chin, a member of the Society since 1996, has retired after 23 years of service as a program official at the National Institute of General Medical Sciences (NIGMS), National Institutes of Health. Chin managed research grants in membrane biochemistry and biophysics, transport and lipid metabolism, and served as the NIGMS contact for Academic Research Enhancement Awards (R15).

Steve Goldstein, a member of the Society since 1990, has been appointed dean of the Stritch School of Medicine, Loyola University Chicago, effective May 1, 2017. He has most recently been a professor of biochemistry at Brandeis University and prior to that provost and senior vice president for academic affairs.

Grants and Opportunities

Science and SciLifeLab Prize for Young Scientists

Objective: The prize is to incent the best and brightest to continue in their chosen fields of research. Four total winners will be selected, one from each of the following categories: Cell and Molecular Biology, Ecology and Environment, Genomics and Proteomics, and Translational Medicine. Each year the grand prize winner will receive US $30,000; each of the three other category winners will receive US $10,000. The grand prize winning essay will be published in *Science*. The winners will also be honored in Stockholm, Sweden, during Nobel week.

Deadline: July 15, 2017

Website: http://www.sciencemag.org/prizes/scilifelab?et_rid=49219874&et_cid=1213128

Discovery of In Vivo Chemical Probes (R01)

Objective: To support investigators who have interest and capability to join efforts for the discovery of in vivo chemical probes. It is expected that applicants will have in hand the starting compounds ("validated hits") for chemical optimization and bioassays for testing new analog compounds. Emphasis will be placed on projects that provide new insight into important disease targets and processes.

Deadline: June 5, 2017

Website: https://grants.nih.gov/grants/guide/pa-files/PAR-14-279.html

Members in the News

Padmini Rangamani, University of California, San Diego, and Society member since 2011, was recently named an Office of Naval Research Young Investigator for 2017.