How To Write Your First (Or Next) Paper

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a BitesizeBio.com eBook

Begin The Right Way

“If I had six hours to chop down a tree, I'd spend the first hour sharpening the axe.”

Abraham Lincoln

Section 01

Writing papers is an art that most of us learn on the job, and it is often a painful process. In this ebook, I'll run you through my step-by-step approach to writing papers and hopefully help make the process of writing your first, or next paper, a bit easier.

The vast majority of us don't actually start writing our papers by writing, but rather by creating a series of figures that illustrate the story that we are going to tell. With this in mind, my first piece of paper-writing advice to any student is this: learn to make a complete, compelling, professional-looking figure.

Think in figures

When you are at the bench, you can fall into a trap where you are performing experiments just to answer a particular question to your own satisfaction.

The problem with this is that you have a whole series of experiments preceding this one that you can start relying on as controls, and so you don't feel as compelled to add those controls to this experiment.

After all, you have been working with this reaction for months and you know that nothing happens to the substrate without Protein X. Since you are likely presenting a ton of experiments in your lab meetings, your labmates and mentor may not even call you out on 'trivial controls'.

The problem is revealed when you first decide to communicate your story to people outside of your lab, whether that communication comes in the form of a talk, poster, or a paper. You look through your lab notebook and realize that you don't have one experiment that has every element required to satisfy a critical viewer.

"Think in figures" is my advice to keep young scientists from falling into this trap. Instead of heading straight to the bench with your burning question, stop and ask yourself what elements (positive controls, negative controls, gel markers, etc.) would need to be in this experiment for it to be a figure in a paper.

Imagine your hypothesis is correct, and you're going to use the results of this experiment to convince a critical viewer – what lanes need to be on the gel to make your point? Would you convince (or at least frustrate) an opponent of your hypothesis?

Not only can thinking in figures help prevent you from having to re-do all of your experiments right at the moment that you should be focused on other matters (*i.e. writing your paper*), but it will tighten up your science. The first time your science should be critically reviewed is before you show it to somebody else.

Become a master of your techniques

By 'techniques' I'm talking about the manner in which you visualize your experiments: agarose gel electrophoresis, SDS-PAGE, western blotting, immunofluorescence, etc.

Some don't believe that pretty data is worth the effort, while others think that generating pretty pictures is something they'll do later, when they're ready to publish. Either way, they're wrong.

If you believe that how your data looks doesn't matter, crack open an issue of Cell and compare the figures to those from a low impact-factor journal in your field. While there are obviously many factors that determine where a paper will publish, I believe that 'prettiness' of the data can have a very real effect.

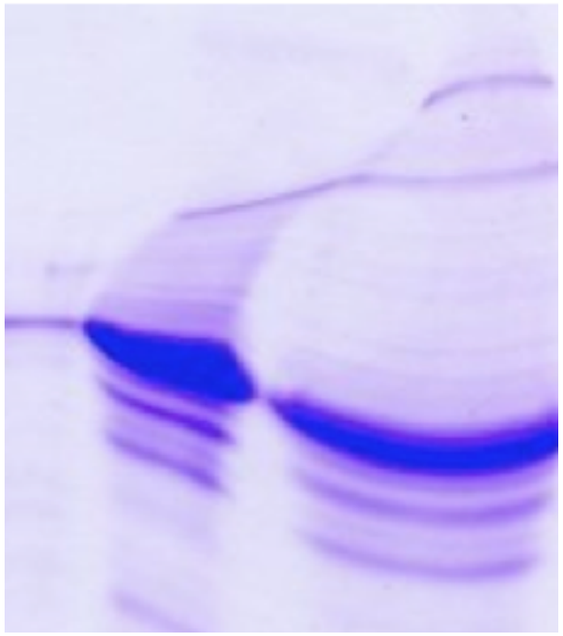
Clean, sharp gels and high signal-to-noise ratios in antibody-based techniques inspire confidence in the reviewers, influencing where the paper will publish.

It also creates an impression on the readers, influencing the actual impact your paper will have in your field.

As much as we might hate to admit it, a large part of science is trust in the authors of the papers we read, and you want people to trust the results you generate.

Becoming a master of a technique can take as long, and be as frustrating, as developing the story itself. Therefore I would always advise you to strive for this goal from the very beginning.

I'm not talking about taking a month off from project-advancing experiments to perfect your electrophoresis skills; even generating the first real figure of your



Ugly data won't inspire confidence in editors, reviewers or readers

story (paper) could take a notebook worth of work, you will have plenty of chances to practice while advancing your project.

After collecting the data from any particular experiment, analyze the execution of the technique as well as the scientific data that the experiment generated. If you think the data could be 'prettier', then when you plan the next experiment also think about what you might be able to do to improve your technique.

You can shorten this learning curve by keeping an eye out for others inside or outside of your lab that have already perfected the technique in question, and soliciting their advice and help.

Learn to use a vector-based graphic design program

We've all heard the cliché "a picture is worth a thousand words". In science, often a picture is irreplaceable with words, and a good illustration is worth 200-800 words. (Yes, I actually tried quantifying it a couple of times.)

With the restrictive word counts of some journals, a handful of good illustrations can buy you several more paragraphs of analysis and pontification in your manuscript.

Many scientists use PowerPoint to make their illustrations and, depending on your project, you can get by with it.

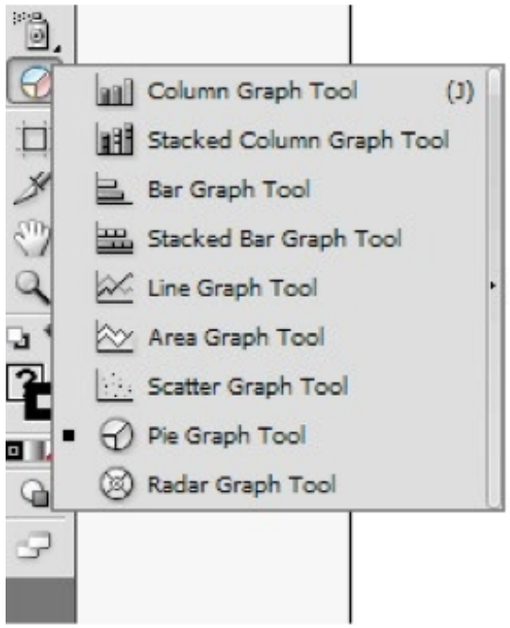
Considering that it is a presentation program and not a graphic design program, it does a pretty good job.

But I have never met anybody that regretted the time that they spent learning to use a true vector-based graphic design program like Adobe Illustrator or CorelDRAW, among others.

These programs offer more options and more control. This of course brings a dizzying array of buttons and commands that can be intimidating but I would advise any scientist to spend the time it takes to become proficient with one of these programs.

Some of the features in these programs are intuitive, but for most of us there will be a significant learning curve for the more advanced features. Therefore you want to learn to use this program when you have the time, and not when the pressure is on to publish your paper.

The good news is that there are several options for learning these programs. The most basic is the 'Google method', where you plug away at it, searching the internet for information about features you encounter or methods for accomplishing the task you have at hand.



Adobe illustrator and other similar tools can be tricky to learn but help you create slick-looking figures

A better option would be to buy a tutorial book that shows you the features by stepping you through a set of lessons.

The best option is to take a class. If you are a graduate student, you may be able to take undergraduate courses at your University for free.

Alternatively, Community Colleges also often offer courses on popular programs. Also, once you have the basics down, if you learn of others that are proficient with your program, don't be shy about asking for help – I can often show somebody the solution to their problem in minutes after they have spent hours searching for the answer.

Generating compelling, polished figures is the first step in communicating your results to the world. They will not only become the basis of your paper, but will be the starting point for any posters and talks that you give on this project. The next step – writing the first draft.

Writing The First Draft

“Start with the end in mind”

Stephen R. Covey

Section 02

You have been pounding away at your project, probably for a year... or two... or three... Anyhow, you now have a collection of figures that seem to tell quite a nice story, and now it's time to write the first draft.

There has been a lot written on the mechanics of scientific writing, and even if you haven't read that material, you have read a lot of papers.

So rather than giving you a section-by-section breakdown on paper writing, I'm going to outline my process for generating the first draft of my manuscripts.

Create an outline

Opinions differ on this point, but I personally like starting things off with an outline. This allows me to map out the order in which I introduce material, describe the experiments, and list the key points that I want to make about each without getting wrapped up in phrasing and transitions.

I do the whole thing – Introduction through Discussion including the Experimental Procedures. Usually at this stage I can see problems that might arise in the presentation and fix them without deleting sentences I spent hours crafting. It also serves as my 'map' while writing to keep me focused and aware of where I'm going in the narrative.

After finishing a reasonably detailed outline, it would be a good idea to give it to your mentor along with the figures (complete with legends) to look over.

Hopefully, your mentor can give this some serious consideration, and afterward meet with you and discuss it. If there are large, sweeping changes to the order of the experiments, or if he or she envisioned a different focus of the work than the one you've put forward, then the changes can be made here where the time investment in the prose is still minimal.

Determine the destination

You may have discussed this with your mentor before now, but if you haven't, then the meeting where you discuss the outline would be the best time to talk about what journal you will be sending it to.

This becomes most critical at the top of the pile – the manuscript you write for Nature will be radically different from the one you write for Cell. Other journals may not have such extremes in the structure, but may have other content requirements that should be kept in mind.

For example, a primarily biochemical paper intended for The Journal of Biological Chemistry will likely have to have more emphasis on biological relevance than if the same manuscript were being sent to Biochemistry.

Just spit it out

Now you have the outline with your mentor's tentative stamp of approval and a solid idea about where it should go, it's time to start fleshing it all out into a paper.

My next piece of advice is to be careful how much time you spend getting the wording just perfect on any particular section. If you are having a tough time

saying something just right, then take your best stab at it and leave behind an e-note saying “I’m not certain I’m happy with this yet.”

On one occasion I spent three days writing and re-writing just one paragraph that I thought was essential to the paper. In the first round of edits, my mentor eliminated the whole thing.

That was three wasted days, and in the end the paragraph wasn’t as necessary as I was convinced it was at the time.

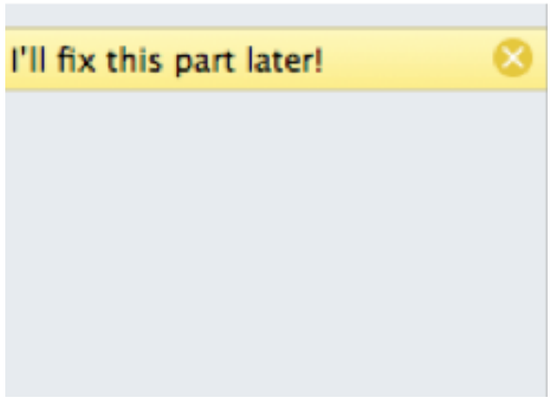
When you find yourself at a loss for just the right words, do your best in a reasonable period of time, mark it, and move on. The statement may not be as necessary as you think or your mentor may have just the right turn of phrase needed to make the point.

Let it rest

You just finished writing the first draft! You even referenced it! Now, if time allows, close the file and don’t open it again for a week.

You need time for your mind to ‘reset’ on the subject so you can read what you wrote again with fresh eyes. Besides, you probably should re-read the papers you referenced again, just to make sure they said everything you thought they said when you cited them. If you haven’t written the Experimental Procedures yet, this is also a good time for that.

Once you have let the manuscript rest, come back to it and read it again, slowly. Does it ‘sound’ like the published papers you’ve been reading? (In other words, did you get the tone right?) Make sure the narrative flows, fix the typos, and correct any wrong words (there, they’re, and their...). Of course, if you find any larger issues with the science, fix those as well.



Don’t worry about the wording when writing your first draft

Phone a friend

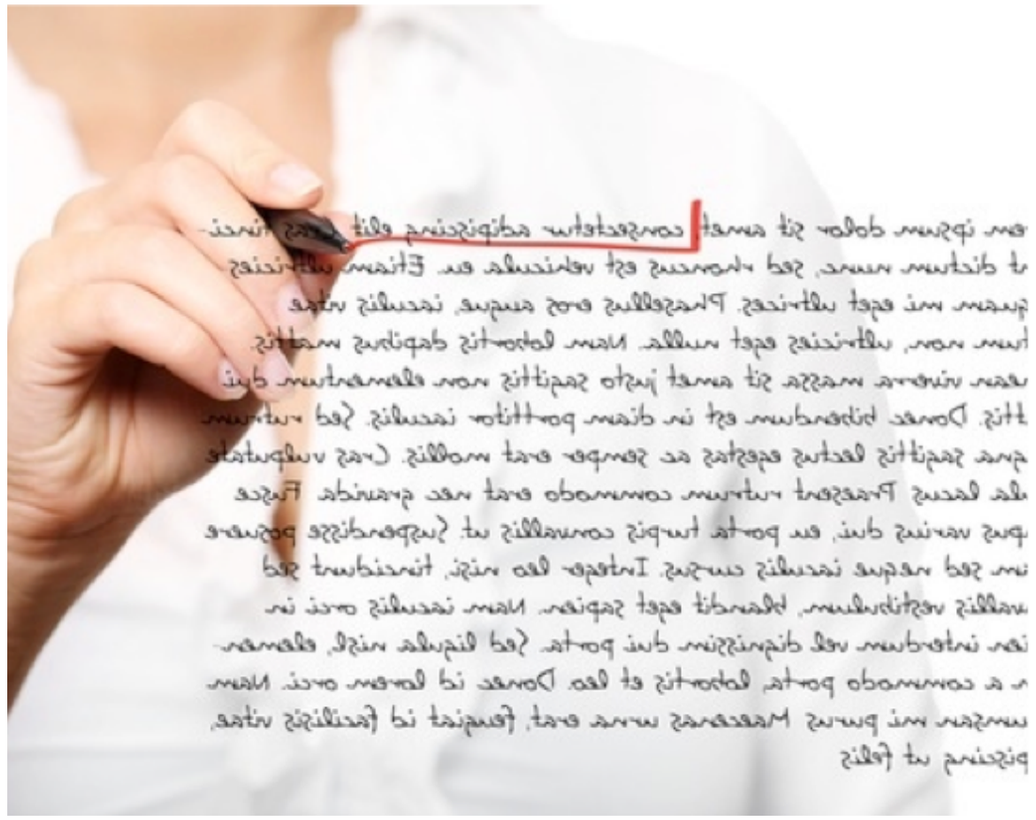
If you have a senior labmate with some publication experience that can be bribed with either cookies or beer, then have him or her read the manuscript over quickly and get some feedback.

Now is not the time for multiple opinions – ask just one person that you trust and respect.

Stress that you aren’t looking for line-editing, just general impressions of your writing style and the storyline. Once you get their feedback, try to incorporate it.

Now you have your first draft. It’s time to give it to your mentor. The next step – surviving the editing process.

Surviving The Editing Process



“No passion in the world is equal to the passion to alter someone else's draft.”

H. G. Wells

Section 03

Once you have written the first draft and handed it off to your mentor, the editing process begins. Depending on the personalities involved, this could be a very difficult time in the relationship between you and your mentor.

Here are the perspectives (perhaps mantras?) that I try to maintain during the process.

It isn't just your paper

After spending a lot of time working on the experiments, presenting lab meetings, and maybe even presenting a poster or giving a talk, you have come to think of the project as yours. It's understandable, and perhaps even necessary to maintain the level of dedication required to bring many projects to fruition.

With the edits of the first draft can come a hard truth – it isn't just your paper. Your mentor thinks it is also, or even primarily, his or her paper.

This isn't an entirely unreasonable perspective, since in all likelihood the rest of your field will actually refer to the paper as "the new one out of Dr. Bigshot's lab," and your mentor will be held far more accountable for what is said and how it's said than you will. Therefore, your mentor may have some very strong opinions on the exact wording of the manuscript.

Don't take it personally

Everybody has their own way of saying something, and if your mentor has crossed your way out and written his or her way in, don't take it as a personal criticism.

It may well be that your phrasing was just fine, and they aren't necessarily correcting what you wrote, but rather putting their own stamp on the manuscript. In this process you will discover that they have words they love to use, and words they hate to use. Over time, you'll likely discover that you have similar lists of words.

In the previous section, I warned against spending a large amount of time and effort to fine tune a difficult passage in the first draft of a manuscript.

Not only should you not do this because of time and effort considerations, but because spending that amount of time and effort makes you more invested in those areas of the manuscript. This makes changes or deletions of these sections much more frustrating to deal with.

In terms of a learning experience, one of the most difficult aspects of the editing process can be separating the changes due to stylistic differences from the changes made in the name of a more universal truth.

Stylistic differences are just a matter of personal choice, and shouldn't be taken too seriously, while the later changes are things you can learn from and use in the future.

The easiest way to tell the difference is to go over the edits with your mentor.

They will have a definitive reasons for the changes that you should probably learn something from while you'll hear things like "I thought this sounded better" or "I just

don't care for that word" for the edits that come down to stylistic issues.

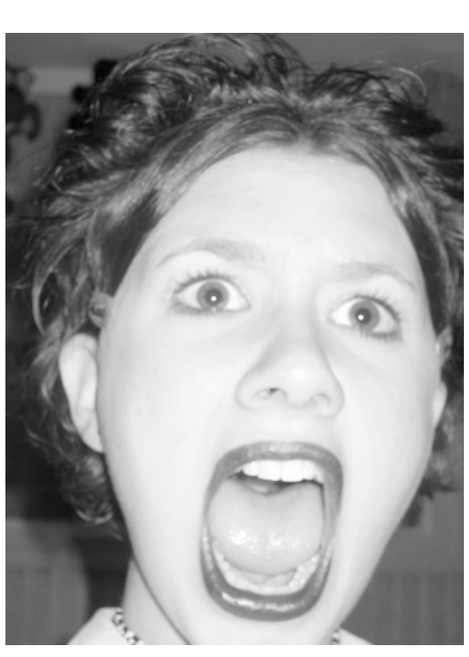
Be Prepared: Sometimes things change

The line-editing isn't necessarily the most frustrating element in the editing cycles. A number of times I've seen mentors get a manuscript full of experiments that they've seen over and over again, incorporated into a narrative that the student has discussed with them (and hopefully they approved of at the outline stage), and it wasn't until they saw the whole package put together that they realized that they didn't like the story.

This can results in a major restructuring of the manuscript, changing everything from the title on down. Sometimes it also means re-doing experiments to address subtly different questions than the original experiments addressed or including totally new experiments.

This can leave you with the feeling that a contract has been broken, and is usually expressed with sentences that begin "But you said that..." It undermines your confidence that the next version of the manuscript will be acceptable, as though you are trying to hit a moving target.

I mean, you did everything they said to do with the first draft, and that wasn't good enough, so why should you believe that doing what they say now will be acceptable either?



Cynthia's mentor decided her paper needed re-focussing, after the 5th draft

Now, I believe that this particular scenario happens less often with good mentors, who are engaged with their students and actively thinking about their projects long before it's time to write the paper.

But even with really good mentors, you have to realize that sometimes things change.

Sometimes when everything is packaged together, you realize that you need one more experiment to prove the model you've put at the end of the paper.

Or, after talking to a colleague at a meeting, your mentor thinks that the field would be more receptive to a closely related, but slightly different focus of the paper. There never was a contract between you and your mentor that said "I will do these ten experiments, and you must publish them without asking for any more."

Try to keep an open mind and see how the new requests will make the manuscript better.

You and your mentor are on the same side

In these situations, it's critical to try to maintain a healthy perspective, like the one above. My own rule is to look at each change that's made and ask "Is the new version incorrect or misleading in any way?" If the answer is no, then accept it. If it's yes, then set it aside and discuss your concern with your mentor. Take big deep breaths when you need to, and set time aside in your schedule to do relaxing activities if things start getting under your skin.

Look for the humor in the fact that in the second round of editing, your mentor is quite likely to re-edit their own work from the first round.

And remember each round of edits gets you closer to publishing your paper.

Getting Published

“It wouldn't happen... There hasn't been one publication by a monkey”

Karl Pilkington

Section 04

After what has potentially (likely?) been years of data collection and a month or two of writing, rewriting, wailing and gnashing of teeth, your first paper has been hammered into shape.

Hopefully the process has yielded something metaphorically closer to Michelangelo's David than Mr. Potato Head. Either way, it's time to send your creation out into the word and see your hard work in print. Here is a brief description of the publication process

The cover letter

In the old days, manuscripts were submitted by mail, and one wrote a cover letter so that the person who opened the package didn't have to figure out the contents on their own.

Nowadays, manuscripts are submitted electronically, but cover letters are still part of the package in one form or an other. For some journals it still looks like a letter, and for others the various elements are entered into fields on a web page.

The purpose of the cover letter is threefold:

• To explain to the editor the significance of the work (i.e. – why their journal should publish your work),

• To suggest other experts in your field to review the work,

• To exclude other scientists that may have competing projects or other conflicting interests. (There are some other legalities that are taken care of here, but they aren't all that interesting.)

The latter two areas are strictly between you and the editors at the journal, but know that these are only suggestions – if the editor feels that you have "stacked the deck" by excluding all of the most qualified scientists, they have the right to send it out to those that you have requested not review the work.

The significance of the work may or may not be confidential – some journals now send this statement along with the abstract when asking potential referees if they are willing to review the work.

From what I have seen, however, the journal will explicitly state which sections are confidential and which will be shared with the referees.

The importance of the cover letter grows, generally speaking, as the impact factor of the journal rises.

At the top of the heap, journals like Cell, Science, and Nature are only interested in publishing novel, ground-breaking research and they receive far more manuscripts than they can publish.

The cover letter for these journals needs to convince the editors that your manuscript fits the bill, otherwise your manuscript may never even be read. Well, it will, but not by them...

The editors

Every journal is organized differently, but in general terms there are at least two levels of editors – ones at the top that have the final say on publications, and a second tier of editors that actually handle the review of the manuscripts, often called managing editors.

At the top journals these positions are all filled by full-time PhDs that work for the journal, while most journals have a much larger staff of academic lab heads (PIs) who volunteer a portion of their time to the journal as editors.

Once you and your mentor submit your manuscript to a journal, somebody takes a look at the cover letter, abstract, and key words and tries to decide which of the managing editors has the expertise to manage the review of the manuscript.

This editor doesn't need to have the level of expertise that the referees' posses, but he or she must be familiar enough with the field to know who to ask to be a referee, and to make educated decisions when there is a difference of opinion between two referees or between a referee and the authors.

Once the manuscript (with cover letter) has been sent to the managing editor and that editor has agreed to handle the paper (if the editor is a volunteer), then the first decision that he or she makes is whether or not the manuscript is suitable for the journal.

If this editor feels that your work isn't consistent with the journal's mission, then he or she can reject the paper without it even going out for review. This is called an editorial rejection, and there isn't much you can do about it. It could be because:

- They don't believe your topic is "sexy" enough for their journal

This is not a recommended cover letter approach for convincing the editor that your topic is "sexy"

- They don't think it constitutes a significant enough advance in the field even if the topic is sexy

- They think the discipline is wrong (trying to publish a biochemistry paper in The Journal of Cell Biology, for example),

- They feel that the work is derivative (it has already been published before).

The only good thing about an editorial rejection is that it generally happens quickly.

If the editor is undecided about a manuscript's suitability for their journal, he or she may send out "feelers" to lab heads, which consists of an e-mail containing the title, authors, abstract, and possibly a significance statement and solicit their opinion.

The referees

Well, you have just found out that your manuscript has been sent out to review. So what is actually happening?

Remember the “feelers” sent out above? If the lab head contacted feels that the work belongs in that journal, feels qualified to review the work, doesn’t have any conflicting interest, and has the time, then he or she will be asked to review the work.

Now what is supposed to happen is that this scientist receives the manuscript and reviews it, keeping the information in strict confidence.

Some lab heads do this, but some farm out the paper review to their senior graduate students and postdocs.

You should keep this in mind – once you send the work out the door, the question isn’t “Does anybody in my field know about my work?”, but rather “How many people in the field know about my work?”

Even if the lab head has farmed out some of the legwork of the review, almost all will read the manuscript themselves and come to their own conclusions.

When the referees submit their reviews, there are parts that are relayed back to the authors, and parts that only the editors see.

In addition to a field where you can enter editor-only comments and concerns, there are also a series of statements that the referee must choose from. They are some form of the following:

• Publish without revision

• Publish with minor revisions

• Consider for publishing upon major revisions

• Reject

As the author, you never actually see what the referee recommended – you receive the recommendation of the editor. The editor’s recommendation is influenced by the referee’s recommendations, but the editor has the freedom to come to his or her own conclusions.

It’s good to bear this in mind, because sometimes a referee will be held responsible for killing a manuscript, when he or she actually recommended publication (almost certainly with revisions) but the editor disagreed. (We’re not supposed to know who reviews our papers, of course, but speculation on referee identity is a favorite pastime of many scientists, and raised to the level of an art by some.)

Dealing with the reviews and writing your response

Your manuscript wasn’t rejected, but the referees did have some criticisms, though. Don’t worry about that – we all get them. I think criticisms are how scientists prove to others that they actually read something.

Referee comments can fall into one of several different categories:

The referee has no idea what is going on.

Sometimes the editor just picks a bad referee, and the referee either didn’t want to admit ignorance or truly believes they can review papers outside of their discipline. The best example of this that

I've heard was a friend that had a math-intensive paper reviewed by somebody that didn't know the basic mathematical symbols used in the paper, mistaking them for variables which were left undefined, to their great outrage.

When you get these types of comments (and you will, eventually), the hardest thing to do is to write a polite response, but you should.

Remember, you don't know who the referee is, but they know who you are, and scientists have excellent memories.

"You didn't cite my favorite papers."

If you have the space to add a couple sentences and/or a couple references, add them. This person spent their valuable time helping you publish your paper, so do as they ask.

Chances are that you should have cited them in the first place, and citations are one criteria that is used to evaluate established scientists, so it isn't just an ego thing. Now if they ask you to rewrite your entire introduction, it may be a different story.

The "nitty-gritty details" question.

These are usually asked by the people right in your field, and they can go one of two ways.

Some are so specific and detailed that trying to incorporate the information that the reviewer requests into the manuscript itself is difficult to do while keeping the paper accessible to the average reader.

In this case, it may be sufficient to just answer the question in the response letter and the referee will be satisfied that the work is solid.

On the other hand, the issue may be a more important point than you originally thought, so if the information can be incorporated without confusing the average reader, incorporate it into the manuscript.

"This is nice, but I would rather have read your next paper."

This one is tough – you've put together ~6 figures (and a bunch more in supplemental), and all the referee wants are the next 6 figures, which you thought would be your second paper.

Re-read your title and conclusions – does your data solidly support these statements?

Sometimes referees ask for the next paper because the authors promised more with the title than they delivered with the data. If this isn't the case, then politely state in the response that you agree that the next 6 figures/experiments would be very interesting and exciting – so exciting that they will get their own paper.

"You did it all wrong."

This is the toughest. The referee doesn't like your reagents, your experimental design, your interpretation of the data, or all of the above.

I think the most important thing to do is try to detach yourself emotionally from the

situation and ask if there is any validity to what they are saying.

Keep an open mind and try doing the experiments their way and see what the results are. If the results are different, then they may have saved you from having to retract the paper in the future.

If the results are the same, then your work and the conclusions have only gotten tighter. If their requests are completely off-base or unfeasible (the experiment that costs millions of dollars or uses an instrument with specifications that hasn't been invented yet), then you need to communicate this politely in the response letter.

One thing that you should bear in mind when writing the response to the reviews is that the editor is obliged to communicate the referee's review to you, regardless of whether the editor agreed with it or not.

Your response may only be read the editor, or it may also be forwarded back to the referee for additional comment.

This is why I emphasized politeness so many times above. You also have to strike some balance between rebuttals to a referee's criticisms and changes to the manuscript.

If the editor requests additional comments from the referee and all you have done is argue the validity of the referee's comments without changing anything in the manuscript, then the referee isn't going to be very happy about the situation.

An elf in the publishing tree-house formatting your manuscript for publication

On the other hand, you should never weaken, diminish, or reduce the clarity of your manuscript just to appease every comment of a referee.

Page Proofs

You have survived the review gauntlet, and the journal has accepted your creation. You aren't quite done yet, but don't worry, the next step is pretty painless.

After accepting your manuscript, the journal ships it off... someplace... where they format it for publication. (I like to think it is a tree-house full of elves with laptops rather than the cubical farm that it likely is.)

These formatted files are called the page proofs, and these files will show up unannounced in you inbox with a ~48 hour deadline for you and your mentor to review and return them.

After you return them, that is it. That is what is published, warts and all. Fail to return them? They might publish the paper “as is”. So pay attention to your inbox and the details!

Remember that list of words that your mentor hates? Well the journal/line editor has their own list, and they have edited your text.

The best advice I was given is to read the paper backwards, one sentence at a time. This forces you to read what is written, and not to start reciting the manuscript you wrote in your head.

This can allow you to catch any typos that have snuck through, and to catch the edits that the line editor has made. If the edits that have been made don’t change the meaning or clarity of the statement, let them go – learn to pick your battles. Don’t forget to check the references, either. It may be a good idea to bribe a grammar/spelling gifted friend to help you out as well.

Scrutinize the figures, both printed and actual size, (preferably on several different printers) and enlarged on your computer screen. Has the resolution changed? Is the brightness and contrast acceptable? Are there any typos/ misspelled words in the figure itself? This is your last chance to fix it in the manuscript without the potentially embarrassing publication of a correction.

Congratulations! You have published your first paper! Now how far are you along on the next manuscript?

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