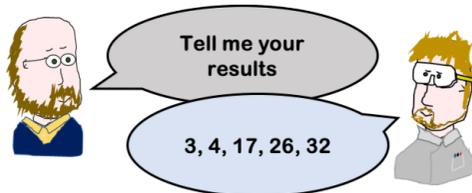


7.7 Results Sections

Describing your results effectively can maximise the impact of your findings and help to get your message across. The results will eventually become the easiest part of your manuscript to write, but, in my experience, it's an area that early career scientists need help. The usual problems are either that the results sections are incomplete or that they don't help the reader follow the story. Let's fix that.



Reporting your data without any context means your reader needs to do more work

Surely, it is just about writing down the results.

Yes, that is the basic premise. However, you can do more than that. You can use the results section to deliver the narrative of the whole story, making your paper more enjoyable or accessible for the reader. You can also write your results in a way that guides your reader thoughts about your data, to help them interpret your findings.

Hopefully, you have read lots of papers by this point, but you may not have noticed how those papers differed in the way their results section is constructed. Going forward, it can help your writing if you identify a few enjoyable papers, ones where you could follow the story easily and didn't have to re-read sections. Look carefully at the way that they have written their results and you will see some consistencies in the tone and rhythm of the writing. I have tried to pick those apart below.

Big Tip

Print your figures or have them open on the screen as you write your results.



What goes into your Results Subsections?

To be able to start writing you will need have made your figures and have an idea of the order in which you plan to deliver them. Hopefully you have thought about how the story will *flow* from one figure to the next. As you write, you might find that your initial plan doesn't connect as well as you hoped; do not be afraid to adjust the order to make the story easier to follow. The connection from one figure to the next should feel natural and should be easy to describe. With your figure order decided upon, you have your core structure.

If you write your results as one long list without any surrounding text it will be hard to absorb. The next step is, therefore, to break up the section into accessible pieces (we'll call these subsections). Each subsection should not try to do too much, it should be assembled to fully deliver one key point. Of course, too small a subsection is a problem

Subsection Elements

Subheading

- Why?
- How?
- What (text)?
- What (data figures)?
- Wrap?

too. If you break up your text into tiny pieces, it will be disruptive to the flow rather than beneficial. Therefore, you are looking for a happy medium with around three paragraphs on average, roughly 350-500 words each, which means describing one multi-panel figure or perhaps two less intricate figures.

As always, a caveat: not all journals allow your results section to be broken up into discrete units, some require one continuous section of prose. However, whether there are physical separations between subsections does not change the content you deliver very much.

Each subsection could contain up to six elements, although it will be very rare that you use all six in a single section.

Element	Usage	Purpose
Subsection title	Always (if allowed) *	Signpost, advance the story
Why clause	Infrequent	Establish the rationale for a change in direction
How clause	Usually	A very short overview of methods to make data easier to understand
Results	Always	Text description of findings including descriptive and inferential statistics
Figures and tables	Always**	Evidence to support your conclusions
Wrap / conclusion	Rarely	Concluding sentence to help clarify complicated or explain non-intuitive findings

*Although most journals allow your results section to be broken up into discrete units, some require one continuous section of prose without subheadings. All the other parts remain the same, but you are likely to use why and wrap elements more frequently.

**In old papers you might see “data not shown”, that is not allowed in modern science

The main part of **every** subsection is the text description of the results. All The other elements are there to provide context for those results. Which of the additional parts to include in each subsection depends on your story, the complexity of the data, the preferred style of your supervisor’s, and the standard style of your field. In the end, it is a balancing act where you are trying to help the reader “follow the story” but not to such an extent that you bore them with unnecessary repetition or with explanation of things that are obvious.

Subheadings

Most journals allow you to use subheadings to break up your prose. These can help you advance your narrative. You can use subheadings in three different ways:

Types of subheading

1. Simple signpost (very simple papers only).
2. Objective signpost (usually best for establishing your model system and validating analysis methods).
3. Results statement (usually best for reporting data, i.e. where you have answered a question).

Simple signpost:

The simple signpost helps the reader find the subsection they are looking for but nothing else. They can be as simple as the name of the technique used to generate a specific set of the findings. Example simple signposts: “RT-PCR data”, “Tensile testing”. Note that you see this heading most commonly in bioengineering or biophysics type journals.

These sorts of minimalist subheadings do not add much value beyond breaking up the text. Personally, I don’t like them. I think they are a wasted opportunity to do something better. However, there are times where they might be all that you need, the minimalist approaches are sometimes also the best. I recommend only using simple signposts when your story is linear with all the parts asking the same question without adding additional nuance.

As these types of signposts don’t tell the reader anything about the objective of your experiment or what the data means, if you use them then you are more likely to need to use “why” and/or “wrap” sentences (see below).

Objective signposts

These are slightly more informative signposts! Rather than just highlighting the technique, they let the reader know *why* you did a set of experiments. Example objective signposts: “Analysis of changes of Per2 mRNA abundance in response to serum shock”, “Determination of changes to material properties after plasma treatment.” Hopefully you can see how these examples would be more helpful for a reader than just “RT-PCR” or “tensile testing”; they let the reader immediately move on to finding the answer to the question. Objective signposts are widely used in engineering and medical papers, where much of the data is descriptive or direct measurements rather than requiring interpretation.

Even if you prefer to use the “results statement” type of subheading (next), objective



signposts will be what you need to describe a new experimental tool or to describe data that establish a model system; i.e. where the experiment is not testing a hypothesis. You also see effective use of objective signposts when the authors are describing multiple tests on a single thing, where the core hypothesis does not change direction as you progress through the paper.

As objective signposts sub-headings do not say what the outcome of your experiment was, the reader needs to get that information from the rest of the section. This means you are more likely to need a wrap or conclusion-type sentence in any subsections where you have used an objective signpost.

Result statement

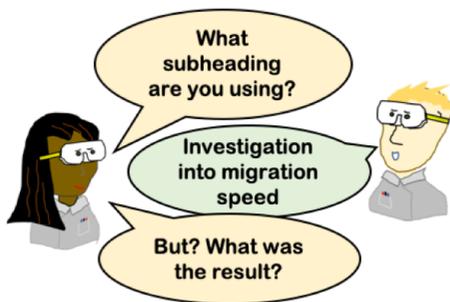
The most effective subheadings in terms of advancing your story is one which definitively states the results. Write the *answer* to the question your experiment asked, essentially as if each subsection were the title of a short paper.

Declarative statements might feel too bold, but subheadings are an opportunity for you to show the reader what your data mean before they reach the discussion. If you are writing a student paper or thesis, this is a chance to let your examiner know that you understand your study. Indeed, if I am marking a piece and a student has used an objective signpost when a result statement would have been better, then I worry that they haven't thought about or might not understand what their results mean, or that they aren't confident in their findings.

In case you haven't guessed, the results statement is my preferred style and is what I expect to see in most types of biological studies. Note your work doesn't have to be complex for you to use this approach, it works just as well in simple studies.

One extra point to note. If your experiment provides indirect measurements your description of the data should be limited to what you directly measured. However, to advance the narrative, you will likely need to make an inference. You can do that in two ways; firstly, in the subheading and secondly in the wrap. In the discussion of the paper you will need to cover the limitations of these interpretations.

While declarative statements are my preferred option, a manuscript will almost always contain a combination of the different styles. Objective signposts are used for tools development figures often early in the manuscript, while results statements used later in the paper for reporting and interpreting the data obtained.



Use subheadings to state your findings and advance the narrative

Big Tip

Don't try and force it. Use the sub-heading style that best suits each of your sub-sections.



“Why” (or Link) Sentences

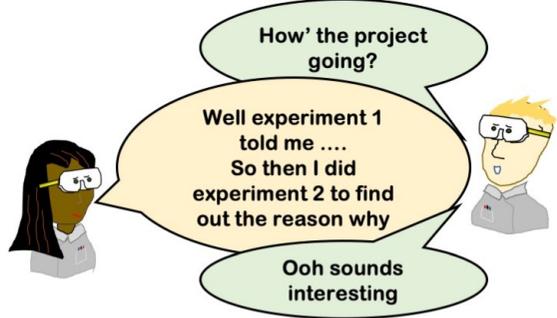
Although you will have established the overarching aim or hypothesis in your introduction, the data you obtained might have led you away from that starting point. Therefore, sometimes, including a “why” or “link” sentence help the reader follow the story. These short phrases (1-2 sentences maximum) can help the flow of the narrative and are also a way to flag relevant literature that isn’t relevant in the introduction but is needed as the story evolved.

Example “why” sentences might be as simple as: “Next we tested the hypothesis that...”, this sort of phrasing gives you a chance to be explicit about the goal of an experiment. But you can also go deeper, connecting the next of data to either previous studies or to earlier data in your manuscript; “Our data raised the possibility that... and previously it has been demonstrated that ... (ref), therefore to test this we...”

“Why” sentences are most effective when your story evolves through the course of your paper for example when your first set of observations raised new questions. In your manuscript, you can use why sentences to make sure that the new questions are clear to the reader before you describe the next set of data.

Don’t use why sentences in every subsection. You should only include them when they serve a useful purpose, where it helps the story. Some authors *never* use why sentences, so do not be surprised if your supervisor removes them from your draft. Similarly, you should not make the results longer than they need to be. Also, if you have used an objective subheading, you will not need “why” sentences very often, as you will already be telling the reader what you are trying to test in the heading.

Finally, importantly, you shouldn’t need a “why” sentence for your first couple of subsections as you really should have established your main aims and hypotheses in your introduction.



If you were talking about your work, you would connect the different parts together to help your listeners understand the progression. Your writing should do the same.

Example “Why” sentences

Simple

“Our next goal was to assess the integrin matrix receptor expression profile of BEP2D and NHBE cells...”

Connected to the literature

“Preliminary visual analyses suggested that the eyelid regions were missed with a higher frequency compared with the rest of the fact. As the eyelid are particularly prone to skin cancer development (refs), we...”

Change in direction: connect to past literature and to your data*

“Human keratinocytes migrate on a LM332-rich matrix (refs). In contrast, the fibronectin in the matrix of mouse keratinocytes appears to inhibit LM332-mediated cell motility (refs). The presence of both fibronectin and LM332 in the matrix deposited by alveolar and bronchial epithelial cells led us to next compare the migration behaviour of both cell types on a variety of substrates.”

*This final version is quite long; use something like this very sparingly.

“How” sentences

“How” sentences or sub-clauses are much more common than “why”. The “how” sentence tells the reader, *in very simple terms*, the approach used to generate the data. They serve as a little flag to the reader identifying which section of the methods they should refer to if they want more details.

At this point you might be thinking that including a “how” sentence in your results will make your work repetitive. That is a danger if you write too much, but let’s consider your readers. When your paper is published many of your readers will read the results sections before they read the methods. Unless it is specifically a methods paper, the results are the whole reason the person is interested in the paper. Adding a brief overview of the methods in the results can help the reader follow the flow of the experiments. The “how” sentence can act as a reminder of the overarching model or can be used to remove ambiguity when multiple approaches ask different parts of the same question. In simple terms, the “how” sentences will mean that your readers can get straight into the action, absorb the information more rapidly and generally enjoy reading your paper more. Everything about paper writing is about keeping the reader happy!

If you are writing a thesis or dissertation, you should think about your examiners. In longer-format writing, your methods and your results are likely to be further apart and there are likely to be many more methods used throughout the body of work. A “how” sentence therefore will help your examiner what you are doing and stop them from having to flip back through 50 pages to find the relevant section of your methods.

If you feel that the description of your data would benefit from a diagram of the experimental setup, then the “how” sentence is a way for you to include that figure reference in the right place in your story rather than in the methods section. Putting the experimental set-up diagram beside the data that the set-up generated is usually the most effective; it’s the easiest for the reader to interpret.

Most results sections will benefit from a “how” sentence but, as usual, we need some caveats; you are unlikely to need a “how” sentence if the methods are explicit in the

subsection title, or if you are using the same technique throughout the manuscript, or perhaps in a very short format, simple paper using a very limited repertoire of approaches.

Example “How” sentences

Single clause

... Fluorescence-activated cell sorting analyses indicated...

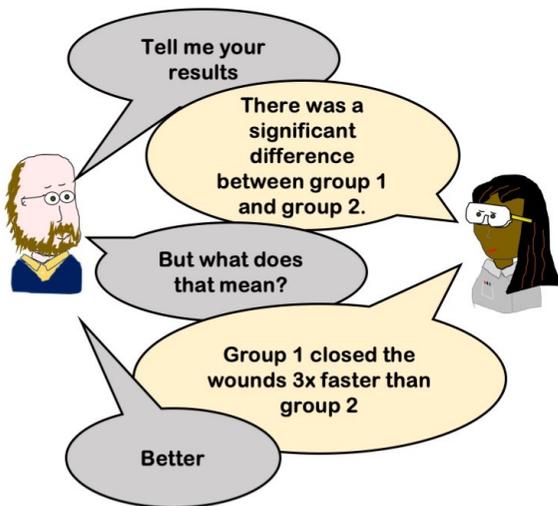
Full sentence

... To do so, we plated BEP2D cells on the matrix deposited by iHEK cells supplemented with fibronectin at 1, 2, or 5 $\mu\text{g/ml}$...

Referencing a diagram

... We next wanted to determine what happens to LaNt $\alpha 31$ expression and distribution in a more physiologically relevant porcine *ex vivo* three-dimensional (3D) alkali wound model (Fig. 4A) ...

Data description



Focus your sentences on what the data mean.

Use clear, understandable statements to deliver the *direction* and *magnitude* of the effect, then report the descriptive stats, results from any stats tests, and provide the figure location in parenthesis.

threshold means that they forget that P values are confidence measures and not measures of importance. The best single piece of advice in data reporting is to organise your sentences so they focus upon the *biological* or other real-world importance of the data rather than emphasising the statistical significance. Tell them the *direction* and *magnitude* of the differences (X was 3x bigger than Y) and provide the *actual numbers* (descriptive statistics) from each population, in addition to reporting the P values. A related problem that I have encountered frequently is writing two sentences; one about the differences or

This is it. This part is why the person has come to read your work. The data description is where you tell the reader all the results in clear, definitive terms.

The challenge is that a dry statement of just the numbers is hard to read and even harder to absorb. Therefore, you should aim to lead the reader through the data in a way that is easy to read, easy to follow. You guessed it; you should wrap the data into a narrative. Your goal is that no sentence should need to be read more than once.

One of the traps that new writers can fall into is that the focus on achieving P values below a target

correlations and then another about the statistics. You don't need to do this, one sentence is all you need, just report the outcome from your inferential statistics tests in the brackets at the end of the sentence).



Big Tip

Refer to every figure panel in order. Usually at the end of the sentence describing the data (Figure 1A).

The results numbers are best delivered in brackets at the end of the sentence (see example box) so that the reader can focus on the story of the data. Use the appropriate descriptions of the populations; means and SDs or CI for symmetrical data or median and ranges or CIs if non-symmetrical. Make

sure you use the appropriate number of significant figures. Look at the error and variability within your population, don't use more significant figures than the spread. Note that if you have presented data in graphs, you will need to write the summary data in text form, but you do not need to repeat any of the data presented in a table.

Remember you must to reference and describe *every single figure panel* including supplemental figures, and the rules are that you must reference figure panels in order they appear; figure 1B has to be referred before 1C. If this may mean you need to change the figure to suit the flow of the story, then do not be afraid to do that.

Example data description sentences

...limbal-derived epithelial cells expressing LaNt α 31 GFP 2D area was approximately twice that of GFP- expressing cells and non-transduced pCEC (2D area + LaNt α 31 $2720 \pm 720 \mu\text{m}^2$, pCEC $1230 \pm 380 \mu\text{m}^2$ and +GFP $1280 \pm 280 \mu\text{m}^2$, $P < 0.05$, Figs. 5A, 5B).

We next assessed single cell motility by plating the transduced cells at low density on uncoated dishes and then tracking motility over 2 hours (Fig. 5C). These analyses revealed the LaNt α 31 GFP-expressing cells display approximately 50% reduced cell migration rates compared with controls (+LaNt α 31 $0.46 \pm 0.14 \mu\text{m}/\text{min}$ versus pCEC $0.91 \pm 0.14 \mu\text{m}/\text{min}$ and +GFP $0.77 \pm 0.04 \mu\text{m}/\text{min}$, mean values for all donors, $P < 0.05$, Fig. 5D).

Note: the text is assembled to focus on the story rather than the details, but also that the actual data, SD, P values and figure locations are all provided in parenthesis.

Data Figures

The data figures contain *evidence* to support your conclusions. The results in their text form should be fully understandable without having to look at the figures at all. I know it sounds odd to imagine your readers ignoring your lovingly crafted figures but appreciating that the figures aren't strictly necessary means you can change the way you

write sentences. Instead of saying “As shown in Figure 1C ...”, it is usually better to write your results as “the data revealed ... (Figure 1C)”. Compare those options and you will see that the first version emphasises the data *location* whereas the second places much more emphasis on the interesting stuff, the *results*.

Which figures go in the main text, which go in the supplemental figures?

We touched a little on this in the figure preparation section of the book, but I have come back to it here as it is when you are assembling the manuscript that you are in a better position to decide whether a figure panel is integral to the story or if it should be included only as a supplemental figure. This decision will not dramatically affect how you write about the data in the text of your results section, only where it is located.

Big Tip

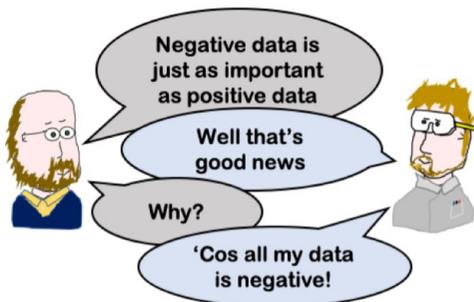
Most journals now allow unlimited supplemental figures. There is no reason for “data not shown”



The temptation is to include everything as main body figures. That’s fine if you have unlimited room such as in a thesis or have relatively small amounts of data that you want to deliver. However, most journals have restrictions on the number of figures you are allowed and sometimes the impact of a figure can be improved by removing some non-essential elements and thereby placing greater emphasis on the parts that matter. Using supplemental figures well can help to deliver your messages. Supplemental figures still get read and reviewed, the decision about which elements go where is just about impact. Some situations where it might be better to move a figure to the supplements:

- **Reagent validation.** Things like antibodies specificity tests, primer melt and efficiency curves, cell line validation, or other tests of your experimental system should always be included. However, these data probably don’t directly contribute directly to the narrative so they can be moved to the supplemental figures if desired.
- **Repetition of an experiment in a parallel population.** If you are reporting on findings in one cell type, you might use the supplemental figures to contain the data from the same experiment in other similar cell types. These extra data points are valuable for validation and generalisation of your findings, but they might not add anything new to the central story.

- **Negative data.** Negative data is just as important as positive data and should always be reported. However, where you have tested many outcome measures or treatments and some have no effects, but others reveal interesting findings, then you will want to focus your story upon the interesting parts. All the negative or “no effect” data should still be included, and you still write about them, but the focus of the story is likely to be the parts where there is an affect.



Embedding Figures (probably no need!)

When you upload a manuscript to a journal the figure files are uploaded separately as .tiff, .pdf or .eps type files. This means that you *don't need* to embed the figures in your text. Keep them as separate files throughout the writing and editing process.

In contrast, if you are writing a student manuscript, including a dissertation or thesis you probably have some options. If you are using Microsoft Word or Apple Pages programs, you could choose to embed your figure in with the text. If you do that, be very careful:

- Make sure that you are not compromising quality. Check that in the final output you haven't dropped the resolution of your images, and that images and labels present properly.
- Make sure you are still following the figure rules. Be especially careful if you need to resize your figures when you are embedding them as things like the font and line sizes may have changed.
- Don't annoy your co-authors/supervisor. When you embed figures, use page breaks and anchors or other mechanisms to make ensure that the figure stays in the appropriate place within the page. Figures jumping around the page as you are editing is annoying!

My advice: make figures independently of your text with each figure on a separate page (with the figure legend if desired, though these usually go at the end of the manuscript text). Only combine the figures with the text at the very end of the writing process after you have converted your text to a pdf.

Big Tip

Don't embed your figures unless your instructions demand it!



Wrap Sentences

“These data demonstrate...” or equivalent summation sentences can be included at the end of a result subsection to round off the paragraph. However, if you use a “results statement” style of subheading they are usually not necessary. Occasional use of wrap sentences can help to reinforce a specific part of your message or can be used to clarify a complex set of disparate data. Including one can be an opportunity to hammer home your interpretation of the data.

Putting Results Sections Together

To re-emphasise, you should not use *every* component in *every* results subsection; only use what you need to advance your story. Below is an example of how the different parts could come together to tell a complete story.

<p>Figure 1: Establishes model System or new research tool</p>	<p>Objective Signpost How clause Data description</p>		
<p>Figure 2: First set of observations. (set up in the introduction)</p>	<p>Result title How clause Data description</p>	<p>Figure 5: Additional tool development</p>	<p>Objective Signpost Why clause How clause Data description</p>
<p>Figure 3: Second set of observations. (follow on from fig 2)</p>	<p>Result title How clause Data description</p>	<p>Figure 6: Fourth set of observations. Two experiment types addressing the same question</p>	<p>Result title How clause 1 Data description 2 How clause 2 Data description 2 Wrap</p>
<p>Figure 4: Third set of observations. Experiments designed based on data in Fig 2 and 3</p>	<p>Result title Why clause (segue) How clause Data description</p>		

What to check when editing

Simple things first: make sure you have written about every panel of every figure and have presented them in appearance order. Make sure you have included the magnitude of the effects, summary statistics and *P* values for your different populations.

Flow

Once you have checked that everything has been written about, it is time to edit at the sub-section level checking that each part is as clear and succinct as possible. The biggest thing to look for is the progression through the story, does it transition logically from beginning to end? Will the reader be able to understand the reason why you did the experiments and what they mean? Getting this overall “flow” to work well is more important than any individual sentence being perfect.

Significance

In my experience, many new writers tend to write, “statistically significant” (or not) in every sentence. However, this makes for harder to absorb sentences, and, importantly, it

is usually unnecessary if you are also reporting the P values. Therefore, at this stage, I recommend looking at every time you have used the word “significant” in the text and carefully analyse whether it makes the sentence better or not. Ask yourself why you have chosen to doubly emphasise the *confidence* you have in your findings rather than allowing just the P value to tell the reader that part of the story? If you use significant very occasionally and just to highlight some specific difference or lack thereof for impact then it is probably effective, but if you find that are saying “significant” in every sentence, then you are in a situation where editing at least some of those sentences will improve your work. Always make sure the primary focus of the results sentence is on what the data mean.