

Mastering Academic Writing in the Sciences

A Step by Step Guide



Marialuisa Aliotta

Mastering
Academic Writing in
the Sciences

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Pre-Writing Step

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INFORMATION has never been so readily available as it is today. Gone are the times when scholars used to spend hours upon hours in a library searching for a paper relevant to their research. Today, most papers are available online, either through institutional subscriptions or via open access repositories for direct download.

Papers are not the only sources of information for a researcher, though. Others include books, theses, dissertations, conference proceedings, lecture notes, laboratory activity reports, collaboration reports, grant proposals, scientific magazines, outreach publications, and more. In fact, the risk is often to be in a status of constant information overload.

Becoming familiar with the amount of information available on any given topic can be a daunting prospect for many PhD students and early career researchers, especially when it comes to summarising previous studies into a literature review. Thus, it is important to be systematic in the way the information is sourced, stored and retrieved.

Even more important, however, is learning to *read* these sources and to extract valuable insight not just on content, but also on structure and style so that one is better prepared to write well.

2.1 GATHERING AND ORGANISING INFORMATION

Gathering and organising information should be one of the primary tasks of a conscientious student from the very early stages of their PhD project. It is also a key objective for any academic approaching and progressing through a new project.

Nowadays, many databases exist that can be easily accessed online for quick retrieval of papers in virtually any discipline. If you are unsure on how to use them, you may wish to contact local librarians who are normally very willing to help.

Once you have located sources of information potentially relevant for your project, you may want to store them in a way that makes it easy for you to retrieve them in the future. This can be done with any of the reference management software available, such as Endnote, Mendeley, Papers, Zotero¹. As you begin your PhD you may wish to spend some time familiarising yourself with the package that best suits your needs. However, I would advise you against spending too much time trying to work out their full potentialities or constantly looking for the latest new kit. What matters here is that you devise a personalised approach that works well for you.

When I was a PhD student, I used to download electronic papers and store them on my computer by the name of the first author and the year of publication (e.g., smith-1998). You can be more elaborate than that and add the journal name or use tag words that indicate the type of paper (whether it is theoretical, experimental or computational), or its key topic, or any relevant information that quickly reminds you about the content of the paper. Again, the aim here is to easily retrieve any information of interest even months or years after you first stored it.

As you build up your collection of papers (and other sources) it is also advisable to keep a record of every item in your 'library' by creating a file with all relevant bibliographic details. If you use LaTeX [5, 6] as your main editing tool (which I would strongly recommend for excellent production quality), you can create a BibTeX [7] file as a reference repository for any of your writing project, whether your PhD thesis or your research papers. Several books and online guides are available on the use of LaTeX and its associated packages, if you are not familiar with them.

Clearly, sourcing and storing papers and relevant articles is a process that continues throughout your research and you should get into the habit of staying abreast of the vast amount of literature produced as you progress with your project. However, storing your sources of information is only half the job. Now you need to read them and learn how to make the most of them!

¹Discussing them here goes beyond the scope of this book, but you can easily compare their features through a quick Google search (see for example: https://en.wikipedia.org/wiki/Comparison_of_reference_management_software).

2.2 THE THREE OBJECTIVES OF READING

When students ask me how to become better academic writers, my answer is always the same: by becoming a better reader first! Indeed, any writer is first and foremost a reader and there is so much that one can learn about writing by focussing not just on *content* but also, crucially, on *structure*, and *style*.

These are the three key objectives of reading: mastering each is essential to becoming a better reader and, in turn, a better writer.

2.2.1 Capturing content: Taking notes while reading

The first thing we focus on when reading a paper, a thesis, or a report, is typically *content*: is the information relevant to us? Do we get the answers we were looking for? Do we agree with the opinions expressed? Yet, we do not always capture content in a systematic way and we easily forget about what we have read, even a few months later.

One of the most effective ways of capturing content from the material we read is by taking notes. This is best done on paper rather than electronically. Annotating papers by hand (either at the margins of the paper itself, or on separate sheets) helps to crystallise information in our brains better than if we stored our notes on a computer. Of course, I would not argue you should print every paper you come across. But for those ones that are really important to your project, you should definitely consider printing them out and taking hand-written notes on them.

Deciding which paper is important can be done through some quick skim reading. The following focus box provides some useful tips on how to take notes while reading. Once you have familiarised yourself with the content and understood most of it, you can proceed to filling in the Paper Annotation Tool, as explained in the next section.

TIPS ON TAKING NOTES WHEN READING

When reading a paper or a thesis chapter, you are more likely to remember its content if you take notes as you read. Here are some useful tips for effective note-taking:

- Print out a copy of the source you are reading (a thesis chapter, a research paper, a collaboration report).
- Underline key concepts or results as you read.
- Highlight any factual information you are likely to need again (e.g., for your literature review). This can be a final numerical result; an outstanding issue; a key reference to some other source.
- Take explanatory notes as you read. Try to be concise and to the point. If possible, write at the margins of the paper. Alternatively, use a separate sheet of paper and make sure you keep it physically attached to the source it refers to.
- Whenever possible, take notes by hand NOT on the computer. Writing longhand will help you memorise better what you have read.

2.2.1.1 *The paper annotation tool*

Many PhD students (and indeed most of us) tend to forget the content of what they read, especially after having read several dozens of papers a few years into their doctorate.

A useful way to overcome this problem and to standardise the notes you take is to use what I call a *Paper Annotation Tool*, or PAT in short. It consists in a single double-sided A4 sheet containing a set of pre-defined and general questions with some space for answers. A copy of the PAT I normally use is reproduced here (you can download an electronic copy at <https://www.crcpress.com/9781498701471> or create your own). Just make sure you fill in the PAT only after having fully read and understood the paper.

The questions are largely self-explanatory and provide a versatile tool designed to help you extract and record key content and bibliographical details of any paper you read. If you work in a laboratory-based discipline, many of the papers you read will be of experimental nature and you can use the template provided as shown. If your discipline is more theoretical or computational you can re-phrase some of the questions on the sheet to better suit your needs.

PAPER ANNOTATION TOOL

TITLE:
 JOURNAL:
 AUTHOR(S):
 VOLUME:
 YEAR:
 PAGE(S):

What is the paper about?

What is the aim of the study?

Why is it important?

What is the approach/method used to acquire the data?

What is the approach/method used to analyse the data?

What are the key findings?

Is there any limitation?

What are the main conclusions and implications in the wider context?

Any other comments?

(feel free to modify any of the questions listed to fit your research area)

Whatever your discipline, the main purpose of using a PAT is to focus your mind on specific key aspects of the articles you read. Answering the questions in the PAT may take you longer than expected at first. However, the process is not meant to be tedious or overly time-consuming. In fact, with some practice you should be able to fill in the PAT sheet in just a few minutes.

As you keep using the PAT, you will gradually notice that the way in which you *approach reading* will change, as you will mentally remember the questions in the PAT and be in a better position to focus on what is important about the paper while you read it. In other words, you will start paying attention to things you might have previously overlooked, such as any limitations of the study or any flaw in the statistical significance of the results presented. With

time, filling in the PAT will turn you into a more critical reader and help you develop your own critical voice (Section 2.3.3).

In Section 2.3.6, we shall see how a systematic use of the Paper Annotation Tool can also prove extremely useful in planning and creating a matrix for your literature review.

2.2.2 Capturing structure: Developing a template

PhD theses and research papers in scientific disciplines follow a well-defined structure with key and clearly signposted chapters or sections. These are normally referred to as *Introduction*, *Methods*, *Data Analysis and Results*, *Discussion and Conclusions*, even though their titles, or indeed their order, may vary across disciplines or type of article (for example those appearing as a *Letter* or a *Rapid Communication*, rather than a *Regular Article*).

What is perhaps less obvious to many inexperienced writers is that even individual chapters, sections, and paragraphs obey to a standard (almost pre-defined) structure, where information is presented to the reader in a very specific sequence.

As the structure provides the skeleton without which the whole document would fall apart, understanding how to structure individual parts of a research paper or thesis is vital to writing well and learning to capture this structure is another crucial aspect of reading.

The best approach I found about uncovering the structure of individual sections is the one suggested by Hilary Glasman-Deal in her excellent book *Science Research Writing for Non-Native Speakers of English* [8]. The approach consists in focussing not on the meaning (i.e., content) of each sentence, but rather on the *function* that each sentence accomplishes within a paragraph. In other words, understanding what the writer is trying to achieve with each sentence, and why these are presented in a given order, can allow us not only to recognise a distinct pattern in individual sections (*Introduction*, *Methodology*, *Discussion*, ...), but also – more importantly – can allow us to create section-specific templates to follow when we start writing.

The process outlined here will be fully presented in Chapter 9, together with a specific example on how to carry out a thorough analysis of the structure of an *Introduction*. Templates for the most common sections of a research paper or thesis are also presented in Chapter 9. Ideally, you should spend an adequate amount of time to familiarise yourself with the intended structure of each section of a typical paper in your own discipline before writing any content.

If you are reading this book while trying to write a paper or thesis, I would recommend that you begin with an individual paper section or thesis chapter first, using its corresponding template provided in Chapter 9. Focussing on the same section/chapter throughout, apply the step-by-step framework presented in this book and only move to a new section/chapter once you have completed all the steps. This will give you a good overview of the type of work (and time!)

required to produce a well-written final version. Hopefully, you should notice that writing new sections/chapters will prove easier and easier as you apply the approach presented here.

2.2.3 Capturing style: Learning from the masters

When I was an Alexander von Humboldt Fellow in Germany, I used to marvel at the manuscript drafts of my host, Professor Claus Rolfs, a world-leading figure in Nuclear Astrophysics and author of the book *Cauldrons in the Cosmos*, for many decades regarded as the *bible* in the field. I remember how his writing seemed to come out effortlessly and how everything was always concisely yet clearly expressed. I wish I had his talents! In an effort to improve my own writing style, I consciously started to pay attention to the *how* and not the *what* of his drafts. And to my great surprise, I started realising there was so much to learn by simply emulating what he had written.

Today, when I run my writing workshops I tell my students that an excellent way of improving on their own writing is by paying attention to the way of the masters. The easiest way of doing so is through... *copying!* Of course, I do not mean plagiarising material written by others. Rather, I mean using long-hand copying merely as an exercise to focus more closely on details that you may otherwise miss if simply reading or copying using a keyboard. When writing longhand, you are forced to slow down unless, of course, you are faster at writing by hand than you are at typing. Slowing down helps you notice the nuances of the text. And that is precisely where style hides in writing.

So, here is a simple task for you to start learning about style: find a paper (or indeed any text) that you regard as being very well written; focus on a specific excerpt (a paragraph, a sentence, a figure caption); and start copying it by hand. Incidentally, this exercise can be an excellent antidote to the writer's block ([Section 3.2](#)): by spending a couple of minutes copying someone else's text as a way to 'get going' you may soon realise that you have found that magical inspiration that sets you off to your own writing.

As you copy your targeted text, pay attention to the way sentences relate to one another: connectors such as *however*, *although*, and *therefore* are very powerful ways of alerting the reader to a change of direction (or indeed the reinforcement of one). However (!), more subtle links can be created by overlap (repeating something said in previous sentences); pronouns or relative clauses; or even the wise use of punctuation. Pay attention to the length of each sentence and how this can be used to provide emphasis: often a very short sentence after a rather long one acts like a punch in the stomach to attract the reader's attention! Notice how verb tenses are used. For example, reporting on research already carried out is typically done using past tenses. At times, however, the present tense is used instead. Ask yourself: why is that? Is the author trying to imply something without saying so explicitly? Try and pick up the subtleties of the language by reading between the lines.

The 'copying-by-hand' exercise works just as well for a poorly written

excerpt. In fact, you may exploit this technique to discover precisely *where* the problems lie in a text that you regard unclear or inelegant. You may realise, for example, that sentences are too long or too convoluted; that the subject is fifteen words away from its verb; that some pronouns are left hanging in the air without being clearly related to any other element of the sentence. Once you become aware of such pitfalls, just ensure that you do not make the same mistakes in your writing.

We often tend to forget that any piece of good text we read may have taken its author a considerable amount of time and effort. For example, a well-written paper in a peer-refereed journal may have undergone several iterations before appearing in its final form. Emulating to the way in which other writers render specific facets of scientific academic writing (accuracy, impartiality, objectivity, rationality) is especially helpful to develop your own style and hone your skill set. After all, good academic writing is an art and like any other form of art it takes time to master.

2.3 THE LITERATURE REVIEW

For most PhD students, writing a Literature Review is one of the earliest tasks they face when it comes to writing. Often, this is also one of the most daunting prospects for many scholars.

2.3.1 What it is and why it matters

The phrase ‘literature review’ is used to indicate both a *process* and its *outcome*. The process of carrying out a literature review consists in searching all papers relevant to your study. The search starts at a very early stage and shapes up the research question(s) that you plan to address in your project. It also helps identifying the key authors and journals relevant to your research.

Searching the literature and keeping up to date with the latest developments in our fields typically continues throughout the lifetime of a project and eventually culminates in the production of a literature review, a key component of any thesis or research paper. Intended as the outcome, the literature review thus provides a comprehensive overview of past and recent knowledge on a given topic and illustrates the context within which your own research is located.

Both the process and the product of a literature review are crucially important aspects of any research and it is imperative to do both well. Yet, it is not unusual for many to start reading papers upon papers only to realise that they have no clue as to *how* to condense in a few pages all the information they have unveiled.

The following sections offer a few key pointers to help you with both the process of performing a literature review and the process of *writing* one. For more in-depth overviews of all aspects related to literature reviews, you may wish to consult *The Literature Review. A Step-by-Step Guide for Students*

by Ridley [9], or *The Literature Review: Six Steps to Success* by Machi and McEvoy [10].

2.3.2 The literature review as a process

Searching the existing literature is greatly facilitated these days by the availability of powerful tools such as Google Scholar and extensive databases such as Web of Knowledge, Scopus, inSPIRE, MEDLINE, and EThOS. These should quickly help you locate *review articles* in your discipline. Review articles offer an excellent starting point for a literature search as they provide an exhaustive reference list and guide you through the latest developments, ideas or trends in your field. Other sources include *grey literature* (theses, laboratory reports, conference proceedings and posters) as well as field-specific webpages and professional organisations.

Once you have located a number of sources that may potentially be relevant to your research, you need to decide *what* to read and *why*. In particular, it is important that you establish the scope of your search early on so as to avoid becoming overwhelmed by the huge amount of information available.

Not all papers will be equally important to you. Start by simply scanning the content to find sections or keywords that provide the information you are seeking. Then proceed with skimming, namely reading through parts of text that give you an overview on content. And finally, move to in-depth reading from beginning to end. Just make sure this latter activity is only devoted to the papers that really matter to your project. These should ideally be printed out and stored with their respective Paper Annotation Tool sheets (Section 2.2.1.1).

2.3.3 Critical voice

A key aspect of carrying out a literature review consists in critically assessing the work of other scholars. For this purpose, you need develop your own critical voice which implies: looking for evidence that supports a claim; checking that the authors' conclusions follow from sound, logical arguments; assessing what implicit or explicit assumptions have been made, if any; verifying whether the authors' claims match those of other scholars or indeed your own evidence or knowledge.

In my experience, one of the best ways to improve personal critical skills consists in joining a Journal Club, namely an informal gathering of scholars who meet to discuss and critique a selected paper. If no journal club is available in your department, consider creating your own. All you need is just a couple of colleagues (other PhD students, young researchers, or more senior academics) with research interests similar to yours and the agreement to meet regularly (ideally once a week) for an hour or so.

The focus boxes that follow offer some tips on how to start a journal club and what items should typically be discussed. Briefly, people within the club

take charge in turn to select a target paper and circulate it to the other members some time before the meeting. During the meeting, one person presents the paper and leads the discussion, soliciting opinions from the other members. Questions that may be worth addressing include the validity of the approach(es) used, the novelty of the contribution, any potential limitation of the study, and so on. You may decide to circulate a set of common questions before the meeting or leave it to individual participants to bring their own.

In addition to improving your ability to evaluate the work of others, being part of a journal club can also foster your confidence, improve your argumentation skills, and promote a greater sense of belonging to your academic community. Last but not least, it will also teach you how to anticipate the expectations and potential objections that your readers may have: an outstanding vantage point when it comes to your own writing!

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TIPS ON STARTING A JOURNAL CLUB

Even if journal clubs are most effective with at least 4-5 members, one other person is all you need to make a start. This can be a fellow PhD student or a post-doctoral fellow. They do not have to be from within your research group, but ideally you want someone from the same discipline as yours.

Once you have found a willing partner, here is what to do:

Before and during the meeting:

1. Agree on a date and time for the meeting to take place. Ideally, once a week for one hour at most.
2. Identify a facilitator for the meeting. This is a role that can rotate amongst the members of the Journal Club.
3. Select a paper for discussion. This is normally done by the facilitator, but anyone can make suggestions.
4. The facilitator circulates the paper at least two days in advance of the meeting, possibly with a list of questions that will form the basis for the discussion.
5. Each member commits to reading the paper before the meeting.
6. At the meeting, the facilitator provides a brief oral presentation of the paper under discussion. There is no need to prepare slides or anything; a piece of chalk and a blackboard should be enough to write down key points if needed.
7. Everyone contributes to discussing and critiquing the paper (see the next focus box for possible questions to address).
8. Before the meeting ends, participants agree to a new date/time and identify the facilitator for the following meeting.
9. Meetings should take place regularly and start and finish at the agreed times.

ITEMS FOR DISCUSSION AT A JOURNAL CLUB

When discussing a paper, you can choose to focus on all or some of the following aspects (feel free to add your own):

Description of the Study

1. What was the purpose of the research?
2. Why is the research important in the wider context?
3. What was the nature of the study (experimental, theoretical, computational)?
4. Were its key objectives clearly stated?

Literature Evaluation

1. Was the literature review well presented and sufficiently up to date?
2. Was any major recent study left out?
3. Is the paper clear and well written?

Approach and Analysis

1. What was the method used in the study? Can you clearly identify it?
2. How were data obtained and analysed?
3. Is/was there any fault in the approach used?
4. Is the statistical analysis of the data appropriate and sound?

Results and Conclusions

1. What were the key findings of the study?
2. Were results well presented and properly discussed?
3. Did the author(s) provide an interpretation of the results?
4. Did the author(s) discuss any potential limitations of the study?
5. Could the study be replicated?
6. Was the study successful in solving the research gap(s) identified?
7. What additional questions does the study raise?

2.3.4 The literature review as a product

The outcome of an extensive literature search culminates in a compendium of the latest advances in your topic known as the *Literature Review*. Whether part of a PhD thesis, a research proposal, or a research paper, the literature review fulfils several key functions, namely:

- it brings the reader up to date with current knowledge on a topic;
- it locates a *gap* in research;
- it provides a *justification* for undertaking the study (this is especially important in applications for funds, given that the mere existence of a research gap does not necessarily imply it is important to address it);
- it demonstrates your knowledge on the current status of a field;
- it provides evidence (through citations) to support your claims, thus affording you a greater credibility.

Your research does not exist in isolation. Rather, it represents a tile in a much bigger jigsaw puzzle put together by what other scholars have done before you. Thus, the literature review provides the context for your research project and summarises previous studies as the foundations on which your own research builds. Depending on your specific field or topic, your literature review will take up one of four possible forms: traditional, systematic, meta-analysis, or meta-synthesis.

A *traditional* (or *narrative*) review is probably the most common type. It provides a summary of a selected body of literature as a comprehensive background on a current research topic. A *systematic* review, by contrast, provides a rigorous and well-defined approach to review *all* literature in a given subject area. A *meta-analysis* review represents a statistical analysis on a large body of quantitative finding; whereas a *meta-synthesis* consists in a non-statistical analysis to integrate, evaluate, and interpret findings from qualitative studies. Typically, reviews in scientific subjects will be of the first type, with the others being more often used in social sciences and policy making. It is important that you identify the type of review you are going to write, as this will also frame the extent of your searching. If you are unsure, discuss things with your supervisor(s) or find out what is typical in your own discipline.

Unlike other sections or chapters of your thesis (or research paper), the literature review does not have a standardised format. In fact, even its location within the main body of your work may vary depending on the nature of your study and/or your discipline. Often the Literature Review may appear as a separate chapter in your thesis (sometimes referred to as *Scientific Background*). In some cases it is outlined in general terms in the *Introduction* chapter and revised in greater detail at the beginning of subsequent chapters; or it may appear interspersed throughout the whole thesis. There is no right

or wrong approach, but the right location may depend on the nature and purpose of your study. So, it is important that you find the format that best fulfils your needs.

Regardless of where it appears in your document, a well-written literature review will contribute to earn you authority, validate your choice of approach, and argue the case for the research statement or research gap that your study intends to address. While there is no pre-defined format for a literature review, it helps to arrange the material in a way that makes it easy for your readers to follow.

In science, recent and latest advances are typically mentioned first. However, depending on your project, you may need to trace the development or progression to current thinking and a more chronological order may be needed. Other common approaches in structuring your review include moving from the general to the specific, and comparing and contrasting. Other possible structures are discussed in [Section 4.3](#).

2.3.5 How to write a literature review

So far we have discussed the many facets of a literature review and its importance. But how do you actually write one? Given the extent of the undertaking, the best way to approach the task is to organise your work around the following successive steps:

1. Identify the research question your study aims to address (and hopefully answer). If different questions are addressed, elaborate a research statement that encompasses them all under a common overarching theme that provides a focus for your writing.
2. If applicable, break down individual components of your research question. For example, consider all the necessary aspects required to demonstrate a thesis (research statement). Hence, organise your material (and relevant papers) around them.
3. Consider the order in which you need to present the information to your readers based on the knowledge they already possess ([Section 3.1](#)).
4. Map out the main point of each paragraph and support each with relevant references. Keep revising the order of ideas until everything flows in a logical way. Remember that each step builds upon previous knowledge.
5. Keep a clear writing direction: whenever you struggle to write, take that as an indication that you may have to do some more work to create a detailed plan of action.

In the next chapter, we will explore a couple of techniques to help you organise your thoughts in preparation for your writing.

For extended reviews, decide whether you should organise your material by topic or theme and also make sure you include an introduction and a conclusion section (or paragraph) to summarise the key points you want your reader to remember. Where appropriate, use section headings to indicate a shift in topic and to provide a visual break to your text (see more on the structure of paragraphs in [Chapter 4](#)).

Citing other people's work. When citing other people's work, use paraphrasing rather than direct quotations and always provide a reference on any results, graphs, theory, or ideas sourced from someone else. In general, any claim or statement must be backed up by sufficient evidence, except if it forms 'common knowledge' in the field. So for example, you may write: nuclear reaction cross sections drop by orders of magnitude at sub-Coulomb energies without any specific reference because this is common knowledge in nuclear physics², but you would have to add a reference to a statement such as: the cross section was $0.3 \mu\text{barn}$ as it refers to a specific measurement.

On the other hand, if you are writing a report as part of your academic assessment, you may want to cite references also for aspects of common knowledge of your readership as a way of showing to your assessors your familiarity with the topic and your ability to locate textbook information and other sources.

The format you use to reference other people's work will largely depend on your discipline. The two most commonly used formatting styles in science are discussed in [Chapter 6](#).

2.3.6 Literature review matrix

As we have seen, one of the key purposes of a literature review is to present a critical overview on the current state of knowledge on a given topic or research area. Sometimes, this can be a difficult task especially when previous work has been extensive. In such cases, preparing a *literature review matrix*³ can prove invaluable. The matrix is merely a table that lists a series of specific research questions or aspects of interest and their corresponding "results" as obtained in previous studies.

An example of a matrix I prepared for the literature review section of a research paper I was drafting is shown in [Figure 2.1](#). The paper was about the study of a nuclear reaction important in various astrophysical sites. Even though the reaction had already been studied by different groups and with different approaches (including some theoretical calculations), the overall agreement remained poor and the reasons for discrepancies unclear.

In order to facilitate the task of critically comparing and contrasting different results, I prepared the matrix shown in [Figure 2.1](#). Once I had all previous

²Unless of course, your readership is from a broader background than nuclear physics.

³I first came across this term on the excellent blog *The Thesis Whisperer* (<http://thesiswhisperer.com>), but many other similar phrases exist.

| | Direct Capture contribution | Method | Energy range [keV] | Resonance strength (183 keV) |
|----------------------------------|---|---------------------------------|--------------------|-----------------------------------|
| Rolfs (1973) | constant S-factor | prompt gamma-ray detection | 280-425 | not measured |
| Fox <i>et al.</i> (2004) | not measured | prompt gamma-ray detection | resonance | $(1.2 \pm 0.2) \times 10^{-6}$ eV |
| Fox <i>et al.</i> (2005) | questions Rolfs' data: may have been affected by contributions from two broad resonance tails. $S_{DC} \sim 2.5$ x less than in Rolfs | realistic Woods Saxon potential | resonance | $(1.2 \pm 0.2) \times 10^{-6}$ eV |
| Chafa <i>et al.</i> (2005, 2006) | not measured | activation | resonance | $(2.2 \pm 0.4) \times 10^{-6}$ eV |
| Newton <i>et al.</i> (2010) | S_{DC} in agreement with Fox's predictions. $S_{DC} \sim 2$ x less than in Rolfs | prompt gamma-ray detection | 257-470 | not measured |
| Hager <i>et al.</i> (2012) | S-factor in good agreement with Newton, but higher than Fox | DRAGON recoil separator | 260-470 | not measured |

Figure 2.1 Example of a literature matrix showing key research aspects (columns) and their corresponding outcomes (rows) as reported in various papers. A literature matrix can simplify the task of critically comparing and contrasting existing literature.

values and outcomes at a glance before my eyes, writing a literature review paragraph for the paper became very easy. It also highlighted how the different systematic uncertainties involved in the use of different experimental approaches (in this example, **activation measurement** and **prompt gamma-ray detection**) might have been the reason for the discrepancy (about a factor of 2) between the **resonance strength** values reported by Chafa *et al.* and by Fox *et al.*, respectively. An example of a possible literature section based on this matrix is shown in the following box.

The beauty of a literature review matrix is that it can be done at different levels of sophistication and for any topic. If the extent of your literature review is too broad, consider using different matrices, possibly arranged by theme. Of course, if you have filled in a Paper Annotation Tool (see [Section 2.2.1.1](#)) for each of the papers that you wish to include in your review, you should be able to quickly summarise all key information in your matrix and critically assess the current state of affairs in your review.

EXAMPLE OF A LITERATURE REVIEW SECTION

Early investigations of the $^{17}\text{O}(p,\gamma)^{18}\text{F}$ reaction cross section had reported a constant direct capture (DC) contribution to the S-factor (S_{DC}) in agreement with the four lowest data points measured by Rolfs (1973) at energies $E = 280 - 425$ keV by prompt γ -ray detection.

Fox *et al.* (2005) later questioned whether these data points were dominated by the DC process or rather affected by the presence of the two broad resonance tails. They thus calculated the S_{DC} using measured spectroscopic factors and a realistic Woods-Saxon potential, obtaining an S_{DC} value up to a factor of ~ 2.5 lower than that reported in (Rolfs, 1973). This result was later confirmed by Newton *et al.* (2010) through prompt γ -ray measurements in the energy range $E \simeq 257 - 470$ keV.

More recently, the total (i.e., DC plus broad-resonance contributions) S factor was determined at $E = 260 - 470$ keV using the DRAGON recoil separator at TRIUMF (Hager *et al.*, 2012) and found to be in fairly good agreement with values by Newton *et al.* (2010), albeit consistently higher than the total S factor reported in Fox *et al.* (2005).

As for the $E = 183$ keV resonance strength, only two values exist to date: $\omega\gamma = (1.2 \pm 0.2) \times 10^{-6}$ eV, as determined by a prompt γ -ray measurement (Fox, 2004, 2005), and $\omega\gamma = (2.2 \pm 0.4) \times 10^{-6}$ eV, as determined by the activation technique (Chafa *et al.*, 2005, 2006). They disagree at the 95% confidence level. The origin of this discrepancy is not understood at present, but may be due in part to unobserved gamma transitions in Fox *et al.* (2004, 2005) and/or an inappropriate subtraction of the DC component in either Fox *et al.* (2004, 2005) or Chafa *et al.* (2005, 2006).

Unfortunately, the lack of experimental data at low energies and the largely unconstrained S_{DC} -factor have so far precluded the accurate determination of the thermonuclear rate for the $^{17}\text{O}(p,\gamma)^{18}\text{F}$ reaction. A renewed effort for the experimental investigation of this important reaction is thus required.

Chapter 2: The Pre-Writing Step
In a nutshell...

- Become a better reader by paying attention not just to *content*, but also to *structure* and *style*.
- Get in the habit of taking hand-written notes on the papers you read, especially the ones critically relevant for your project. For the latter, fill in a Paper Annotation Tool sheet. This will be useful for later retrieval of information and for creating a literature review matrix.
- Learn to develop your critical voice by joining a journal club. If none is available at your department, consider establishing one yourself. Guidance on how to do so is given in this chapter.
- Familiarise yourself with the most common type of literature review in your research field and discuss with your supervisor the extent and purpose of your search.
- Plan your literature review carefully by arranging key elements by theme if necessary. Use a literature matrix to gain a comprehensive overview of the current status of knowledge in your project area.

EXERCISES

- 2.1 **Take notes** [10 minutes]. Using the Paper Annotation Tool, take notes for every important paper that you read. Keep the PAT attached to the paper and store in a suitable folder for later retrieval.
- 2.2 **Unveil the structure** [30 minutes]. Following the outline presented in [Section 2.2.2](#), start paying attention to the underlying structure of different sections in the papers you read. In [Chapter 9](#) we will explore more thoroughly how to develop section-specific templates.
- 2.3 **“Copy” from the masters** [5 minutes]. Take an excerpt from a paper or thesis in your discipline and start copying it by hand while paying attention to the *way* in which things are written. Refer to [Section 2.2.3](#) for what you should pay attention to while copying.
- 2.4 **Prepare a literature matrix** [20-40 minutes]. Before you begin writing a literature review, consider preparing a matrix like the one in [Figure 2.1](#). Keep adding to it as you find new papers and other sources. For extended reviews, consider preparing a matrix for each theme or sub-topic if necessary.

- 2.5 **Putting things into practice.** If you decide to start writing while reading this book, focus on one section/chapter at a time and cover all the steps involved in the writing process (from Pre-Writing to Proof-reading) before moving to a new section/chapter.

FURTHER READING

Wallace, M. and Wray, A. (2011). *Critical Reading and Writing for Postgraduates*, SAGE Study Skills - SAGE Publications Inc. (second edition).

Researching for your Literature Review – Monash University

<http://www.lib.monash.edu>

<http://guides.lib.monash.edu/researching-for-your-literature-review/home>

Library & Learning Commons – Bow Valley College

<http://bowvalleycollege.libguides.com/literature-reviews>

On all matters around doing a PhD

The Thesis Whisperer

<http://thesiswhisperer.com>

And for some fun

PhD Comics

<http://phdcomics.com>