Utrecht University

Scientific writing

Resource modules for MSc students in Earth Sciences
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Table of contents

1 Introduction 1

2 Scientific writing: definition and necessity 1

3 Structure of a scientific text 2

3.1 General structure of a scientific text: IMRAD 4

3.1.1 Structure of a research proposal 10

3.2 Using figures and tables in your text 11

3.3 Paragraph structure 12

4 Writing style and conventions 13

4.1 Syntax 13

4.1.1 Connecting sentences 13

4.1.2 Tips for increasing variation in your text 15

4.2 Language 16

4.3 Using tenses 18

4.4 Passive vs active voice 19

4.5 Spelling 20

5 How to tackle a writing assignment? 20

5.1 Planning 21

5.1.1 Purpose 21

5.1.2 Audience 22

5.1.3 Creating an outline 23

5.1.4 Time management 24

5.2 Drafting a text 25

5.2.1 Strategies to start writing 25

5.2.2 General tips for the writing stage 27

5.3 The revision process 28

5.3.1 Revising 28

5.3.2 Editing 29

5.3.3 Proofreading 30

5.3.4 General tips for revising, editing, and proofreading 30

5.3.5 Incorporating feedback 32

6 Formatting your text 32

6.1 Lay-out 32

7 References and other useful resources 36

1 Introduction

This resource module provides you with background information that may help you in your scientific writing process. It comprises a summary of resources from other universities and institutions, as well as adapted sections of our own BSc Earth Science writing manual that may offer a quick guide to get you started. Because scientific writing is one of the most common (and sometimes most challenging) methods of exchanging scientific ideas and knowledge, many articles and books have already been written about it over the last decades. At the end of this module you will find a bibliography consisting of the resources used in this module as well as other useful literature. We recommend you have a look at some of these resources to gain more detailed insight into the aspects of scientific writing that you struggle with most.

Before you get started, have a look at the table of contents above and try to assess which part of the writing process is most challenging to you and which parts you expect to be easier. Write down for yourself what you would like to gain from this module. Be critical of your skills and try to keep an open mind throughout. Next continue by working through the chapters that you feel could improve your skills the most. Do not attempt to work through this module from start to finish without making a self-assessment first. In that way, you risk losing focus on the parts you could improve most on.

Each chapter will start by listing the learning outcomes of that chapter. Do they correspond to those you set for yourself? Read through the chapters, check out the references of subjects you would like to learn more about, and review at the end of each chapter whether you have achieved the outcomes predicted at the beginning of the chapter. If not, go back to the parts you have not yet mastered and see what you can do to improve that.

2 Scientific writing: definition and necessity

Learning outcomes

At the end of this chapter you will be able to understand:

- What defines scientific writing
- Why scientific writing is important

Scientific writing is a tool to share the results, concepts, methods, and ideas of scientific research[1, 2]. It differs from other writing in that it targets a different audience, requires different language use, and in that it is structured and organized in a specific way[1]. Such organization and structure conventions are in some respects flexible and adaptable, but it is common to use a widely accepted framework to structure your work and communicate in an accessible, quick and easy manner. This chapter focuses on introducing the concept of scientific writing, its organization and structure, and it highlights some

important aspects to consider in your own writing. Becoming aware of the conventions of scientific writing is important to help develop confidence in your own writing and to improve your skills in the extensive process of planning, executing research, structuring, drafting, and revising that is the base of scientific writing[1].

The main goal of scientific writing is to communicate your research findings. It is however not sufficient to only write about the results of your research, but it is essential to integrate these with studied literature on previous research and a solid interpretation and synthesis of your data[3].

Good scientific writing is clear, concise, analytical, and precise. A clear structure is essential. Scientific writing also needs to be objective, cautious, and evidence-based[2, 4]. Scientific writing is all about informing and helping your audience to understand your research, rather than trying to impress them with complicated theory or words[3, 4]. Instead, scientific texts need to be highly readable and helpful in order to be understood and should be used and cited by other scientists[2]. Therefore, scientific writing is not complex: long sentences and complicated words only decrease the readability. Nevertheless, scientific writing is formal in language and style[4].

Scientific writing is one of the most common ways of communicating science. By communicating research outcomes in (peer reviewed journal) papers, scientists build upon the work and research of others. Scientific journal papers have high quality standards and therefore offer a source of valuable, lasting references for other scientists[2]. Besides communicating within the scientific community through journal papers and research proposals, written communication is also important to share your research with the general public[5], for example through essays, (popular) science communication ('sci-comm'), and newspaper articles. The following chapters will mainly focus on writing for the scientific community, but some advice will be offered for writing with a different audience and purpose in mind.

3 Structure of a scientific text

Learning outcomes

At the end of this chapter you will be able to:

- Correctly structure a scientific text according to the IMRAD method
- Know where and when to incorporate figures in your text
- Write figure captions
- Structure your paragraphs according to the conventions of scientific writing

(Scientific) texts generally consist of an introduction, main body of text (methods, results, and discussion in research papers) and conclusion[2]. This structure tends to follow the chronological order of the research process. However, the results and discussion sections often break with this, since it may be useful to mention the most important aspects there first[2].

Often, scientific texts are built up according to an hourglass structure. This structure is common, as it offers a clear narrative that will help readers to focus and to understand the importance of the research presented. The hourglass generally starts by setting a broad framework establishing the relevant knowledge already available in the field (1). Here, it is important to grab the attention of your audience by creating 'tension' and highlighting a controversy in published results, for example. The hourglass will continue to narrow down to the unknowns (2), the measures that can be taken to decrease this gap, and the value that such answers to open questions would have in your field (3). The text will focus on a specific research question (*e.g.*, a case-study) (4), and then start to build out again to explain the results found in this study (5). In the discussion, the results will be placed in a broad setting again (6), and their implications may be suggested in the conclusion (7).

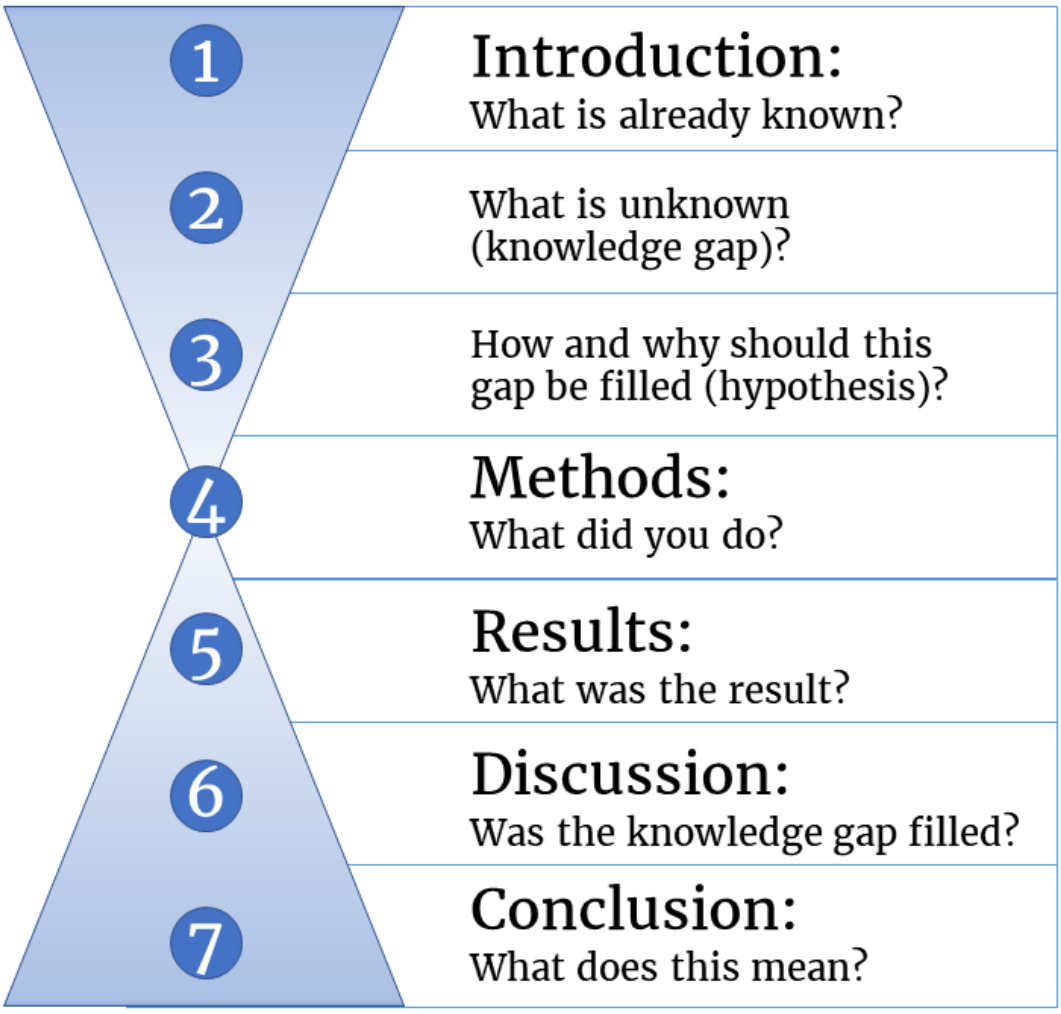

Figure 1. The anatomy of a scientific paper

Each specific research area, scientific journal or magazine, may have their own preferred structure for the articles they publish. The structures suggested in this chapter are general conventions, but remember to research the style and structure used in your specific field of interest. Likely, the authors of the literature you study for your own research will be the readers of your contribution, so try to understand the way they prefer to see things structured and adapt your own style to that (See Chapter 5.1.2 for more information on difference audiences to write for).

3.1 General structure of a scientific text: IMRAD

During the UU Earth Sciences master programs, you will have to communicate results or findings in a research report. This can for example be in the format of a fieldwork report, a lab report, your guided research report, or your BSc or MSc thesis. Research reports have a formal structure[4]. For most reports you will write during your studies, you will mainly be expected to report according to the IMRAD structure.

Background of the IMRAD structure

Since the first half of the 20th century, the IMRAD (Introduction, Methods, Results, and Discussion) structure has become the dominant structure for scientific reports on original research (*i.e.* most journal articles, congress papers, bachelor and master theses, etc.). The four elements that make up this structure are the main ingredients for a scientific report and are preceded by an abstract and followed by conclusions. They also usually form the main headings for the successive sections of a scientific report or paper.

In a way, the IMRAD structure reflects the process of scientific discovery through the empirical cycle. Although the empirical cycle is often complex and involves many iterative feedback loops, the IMRAD structure seems to reduce it to an oversimplified, linear, and stepwise process. This is also why the IMRAD structure has been criticized in the past for being too rigid and too simplistic (*e.g.* Medawar, 1964). Nevertheless, the IMRAD method has been adopted by the majority of journals across a wide range of disciplines because it provides a clear and logical structure that helps the reader to browse through articles more quickly to find relevant information. Furthermore, papers and reports written according to the IMRAD method contain all required information to evaluate the quality of the research without unnecessary details.

In contrast to other scientific texts, Earth Science specific texts often contain a separate, additional chapter in between Introduction and Methods: the Background chapter. This chapter (or sub-section of the introduction, depending on the preferred style of the field or research journal) generally includes relevant background information, for example in terms of the geological or tectonic setting of the study area, that is relevant for readers to understand the context of the research presented in the text.

In the following paragraphs, you will find information on the specific sections that are incorporated in this structure. Note that the sections are ordered similarly to how you encounter them in a scientific report. This, however, is not automatically the order in which you will write them. For tips on the writing process and the order therein, see Chapter 5.

Title

The title of a paper or report reflects the content of the report and is informative and short (approximately 15 words at maximum). Omit any redundant phrases, such as "*a study of…*" or "*a report of…*". For reports, a subtitle may be added. An example of an appropriate title is "*Assessment of soil erosion in Africa using remote sensing*", because it informs the reader about 1) the subject (assessment of soil erosion), 2) the location (Africa), and 3) the research method (remote sensing). In a paper, the title is placed on top of the first page, followed by a list of authors. In reports, the title is on the cover page. The cover page also includes the names of the authors (and student number, if applicable), date and location of publication, name and code of the course, and the name of the supervisor(s) (if applicable).

Abstract

In the abstract you concisely summarize the context, purpose, methods, main findings, and major conclusions of the research, in this particular order[6]. It should inform the reader about the highlights of your work. Be aware that the abstract needs to announce the content of the report/paper or study, *i.e.* your findings, and not what the text contains[7]. The summary or abstract is not a chapter, so it is not numbered. For both research reports and papers, include a list of 5 key words that are related to your study. These key words should be mentioned at the end of the abstract.

Table of contents

Some research reports will contain a table of contents that consists of a list of all chapters, sections, and subsections. This is often the case for long texts, such as theses, but less common for scientific publications. Make sure you know what the preferences are for the editor/lecturer you are writing for.

The chapter and section titles in the table of contents should be short and each title should cover the contents of the section concerned. The table of contents reflects the logical order of the chapters and sections and refers to the respective page in the report where this section starts. Furthermore, extensive reports (*i.e.* theses) often include a complete list of figures and tables and a list of appendices with reference to the pages they appear on. Both tables and figures are numbered consecutively (do not use Roman numerals), but in research reports it is also allowed to number the tables and figures consecutively per chapter (*e.g.* Figure 1.1, 1.2 or Table 3.1, 3.2, .3.3, 3.4).

Introduction

In the introduction section or chapter, you indicate what has been studied, why it has been studied, and, in general terms, how it has been studied. The introduction comprises the top half of the hourglass format, starting broadly with the largest scale of impact of the study and the problem that exists at that scale. This is followed by an explanation of why that problem (still) exists, and it ends with the novel attempt you take at solving this problem, forming the aim of the study, or hypothesis related to a certain research question. The introduction then briefly indicates the methods you use to solve it in an outline of the approach taken, and briefly summarizes in what direction the results will be developed *without* indicating what the results or conclusions will be.

Ideally you already know the relevance of your research topic before collecting your data, and you should be aware of the relevant scientific background before processing and analysing your data. This should provide you with enough information to start a rough draft of your introduction in the initial phase of your study, when you are gathering and reading literature. Nonetheless, many research projects yield unexpected results, so you need to check at the end whether you have provided all relevant information (if not, add), or whether all information you provided is indeed relevant (if not, delete). Keep in mind that you can only write the final version of your introduction after you have finished at least a complete draft of the discussion[7]. Only then will you know the findings of your research.

If the problem you present in the introduction relates to a certain study area, it can be valuable to shortly introduce the geological setting to place your problem in that context. In that case, be concise and do not include details that your audience does not (yet) need to understand your problem statement. In-depth information may follow in the Background/Geological setting chapter.

Background

The background introduces the reader to the relevant context that is required to understand your specific study. This includes background information on your research setting (*i.e.* regional geology/geography etc.), as well as the relevant 'history of thought' (*i.e.* results found and conclusions drawn by previous researchers). For this reason, the title of the background chapter can also vary depending on its context (*e.g.* it may be called Geological setting). As you write the background chapter, think about its purpose for your audience: build up the chapter in a way that its relevance for your problem statement is clear to an audience that has no or little understanding of your field of interest.

Keep in mind that the background chapter describes the setting objectively. It does not, in contrast to the introduction, contain any arguments for the relevance or value of your work. Despite the many references to previous, relevant research in this chapter, it should not be seen as a full literature review and it should not summarize everything that is somehow

related to your topic. Remember, all relevant background information (and thus, most sources) that you want to discuss in your discussion need to be covered in either your introduction or background.

Methods

The methods section or chapter, sometimes called "*Materials and Methods*", describes how the study was conducted. It describes the procedures that you have taken, which materials you used to find an answer to your research question, and contains all necessary information to repeat the study. In the methods section, you show that the data were collected in a consistent, accurate, and accountable manner. This provides important information under which conditions your research outcomes have been established and, thus, in which context they can be interpreted. Although the methods section is primarily descriptive, it is also recommended to give reasons why you have chosen the methods and materials used. The methods section may contain the following subsections (if relevant):

- Field methods: description of the type of data (*e.g.* distance, height, thickness, direction, electrical conductivity) or samples (*e.g.* rock, soil, sediment, water samples) you collected in the field, how they were collected (*e.g.* corings), and used measurement devices (*e.g.* GPS, ruler, compass, EC meter; for these, provide manufacturer and device type if relevant). In the case of mapping, also describe which parameters were mapped and which system was used (*e.g.* classification system). Details of the sampling or observation strategy (*e.g.* transect sampling, observations of outcrops, random sampling, stratified sampling) should also be given here.
- Laboratory methods: description of the laboratory procedures or experiments: which parameters were measured using which method?
- Data processing: description of the statistical methods you used to analyze the measurement data.
- If available, also include information about the accuracy and precision of the acquired data, *i.e.* if it is based on independent, existing information (*e.g.* literature, device manuals etc.). If you have examined the accuracy and precision of the data yourself as part of your study (for example as part of a quality control), you should report only the methods here. The results of this examination should then be reported in the results section.

Results

In the results section or chapter you describe the main outcomes of your study obtained according to the methods section in a neutral (*i.e.* without interpretations that may be subject to discussion) and accessible manner. Limit yourself to only those results that are relevant to answer your research question. Generally, you do not use many citations in this section as you focus on your own data, and are not yet interpreting it[7].

Structure the description of the results by, for example, describing the primary features first, and then the secondary and tertiary features, etc. You may also order the description of your results geographically (*e.g.* from north to south), or chronologically (*e.g.* from old to young).

Present the relevant results in the form figures, tables, photographs, and maps. In the accompanying text, you elucidate the general patterns in the outcomes and give relevant quantitative information (*e.g.*, "*The upper layer is usually 2 m thicker than the approximately 30 cm thick lower layer*" or "*The grain size increases with depth from 2 mm near the surface to 5 cm at 1 m depth*"). Be as concise and to the point as possible when you describe your data[7] , quantify as much as possible, and avoid vague descriptions.

You can start to write the results section as soon as you have a good overview of your data and have made a selection of what you want/need to include in your report. Be aware that any data you want to discuss in the discussion needs to be mentioned in the results section.

Discussion

In the discussion section or chapter, you give interpretations of your results and use these to answer the questions you phrased in your introduction. You are not allowed to present newly acquired data or published data that you haven't mentioned before in your setting or introduction. This means that everything you want to discuss needs to be mentioned in the introduction, setting, methods, or result section. Also be aware that you need to back up your interpretations with a clear, scientific reasoning: don't try to convince the reader, but simply explain your line of reasoning. It is important that the reader can follow your reasoning pathway and has the freedom to develop their own.

A persistent misconception is that the discussion section is meant to provide an overview of all flaws and uncertainties related to your observations and findings: this only diminished the impact of the research. The uncertainties of the research are given in the results. In the discussion, you identify and discuss what can be inferred from your outcomes bearing in mind the flaws and uncertainties that you honestly identified before.

Generally, the structure of the discussion follows the lower half of the hourglass format: you start small by relating and comparing your results to each other (*e.g.* Do they support or contradict each other?) and then put them in a broader context of the literature (*e.g.* what did others find that relate to your subject?). Alternative interpretations may also be given (*e.g.* "*The results suggest …, but could also imply …*"). You should also discuss the consequences of your findings for the aim/research question/hypothesis (*e.g.*, do the outcomes support or oppose the hypothesis? should you revise your assumptions? what information is still missing to definitely answer your research question?). Make sure you answer or at least discuss all the questions you posed in your introduction[7] . If it is not possible to solve a question yet, or if there are multiple explanations that are all equally

likely, you do not need to give a solution. However, you then must explain this to the reader[7].

Broadening further, you identify and discuss the implications for your field of science (*e.g.* what new questions arose from your work) and society (*e.g.* how can the new findings be used to solve societal issues or to develop new technology?). Remember to link back to the research questions and common thread you introduced in your first chapter(s) (see '*Introduction*'). If you have come across discussion points that do not relate to them, consider leaving them out to create a more focused discussion chapter. Alternatively, if your results do not answer your initial research question, consider changing or rephrasing the research questions you set earlier on.

Conclusion

In the conclusions section you summarize the main findings and provide answers to your research question. The conclusions should logically follow from your results and discussion. Do not present new facts or results that have not been discussed in a previous section. Finally, draw wider conclusions regarding the implications for new questions that arose from your study and the implications of the results for 'the greater picture'. This is also the main difference between the conclusion and the abstract, as the latter focuses more on the study itself, although some overlap cannot be avoided. Follow the bottom half of the hour glass and do not forget to list the 'small' conclusions.

Acknowledgements

It is common to include an acknowledgements section at the end of a larger research report, such as your thesis. Here, you can thank and refer to persons and institutes who have contributed to your research (*e.g.* by assisting fieldwork or laboratory analyses, for providing data, funding, or for feedback on an earlier draft of your report or paper). If you have been funded by a specific agency and have been assigned a grant number, this would be the place to mention that.

It is up to you who you want to include in this section but remember to acknowledge all who contributed to your research outcomes. For a thesis, it is common to acknowledge your supervisors, support staff, and funding bodies. You may also mention your research group, other students, friends and family, and other people/institutions you feel have contributed to your project. When you decide to include a personal thank you note, keep it as professional as possible. Do not make jokes and do not add frivolous acknowledgements (to your dog or stuffed unicorn).

References

At the end of the report or paper (after the conclusions section or chapter), you include a reference list, in which you list all literature to which you have referred in your main text.

Conversely, all references in the reference list should appear in the main text. The reference list is not a chapter, so it is not numbered. Just as the summary, the reference list is ordered in alphabetical order.

Make sure you keep track of your citations during the complete writing process. Document every source you read and cite from the first literature study to avoid any missing sources, which could eventually result in plagiarism. We highly recommend you to use a reference management tool during the writing process. If you add all your references to it, you can make the reference list after you have finished the complete draft version of your report. In the case you are not using one, update the reference list throughout the writing process to avoid a high workload at the end. See the *Reading scientific literature* for more information on reference management.

Appendices

An appendix contains materials that would obscure the structure and message of the text if it is included in the main text. Examples include tables of all quantitative research results, examples of field observation forms, or computer code. All appendices should be given an appropriate title and numbered consecutively.

3.1.1 Structure of a research proposal

Another genre you will likely encounter during your studies is the research proposal. In contrast to scientific reports, research proposals do not have a fixed format such as the IMRAD structure[6], so writing and structuring them may be a bit more challenging. Every funding organization has their own required format. When you are writing a research proposal for a course, the format will be stated in the assignment.

A research proposal is different from a scientific report of your own research in that you do not have (m)any results yet. It focuses on the framing of your subject rather than the results and their implications, and the purpose and audience that you are writing for may be different. In terms of purpose, you may have to convince your audience why your research should be funded. Doing so will require a clear problem statement including a description of the relevance and impact of your work, a convincing methodological strategy, and a presentation of previous (literature) or initial results. If applying for funding, you may also need to submit a timetable with your research plan and an indication of budget allocation. Make sure you know the requirements for your research proposal prior to starting, and ask others for example proposals if possible. In general: explain the problem without cosmetic fancy language. Do not exaggerate ("*The biggest challenge ever faced by science is the age of the sandstone in my backyard*"), and do not understate.

3.2 Using figures and tables in your text

Figures and tables are an essential part of scientific texts, especially in geoscience. They serve to visualize results, concepts, models, and field settings, and readers often skip to look at figures and tables as soon as they have an idea what the text is about and what it wants to achieve. Figures and tables therefore comprise one of the most important parts of your scientific text and it is worthwhile to spend time to visualize, annotate, and caption your work as comprehensibly and appealing as possible[7].

Preferably, you make all the figures you use yourself. This way, you can specifically adapt your figures to your research and data, and your figures will not show any irrelevant information. If you want to use figures from other sources, make sure to obey copyright restrictions and reference properly to the source. Sometimes, it is also necessary to ask permission when you want to use somebody else's figures. Only use high quality copies, and never include low quality scans or photographs. For more information and theory on using figures in science, see the *Visualisation* module.

Integration of figures in texts

Figures should be integrated into your main body of text as much as possible. Only add figures to your appendices when they are much too big to add to the main text (*e.g.* geological maps), or when they are part of supplementary materials that do not display your main results[7]. Incorporate figures in chronological order, only after referring to them in your text. Make sure to refer to all figures as soon as it is appropriate, so that readers can then continue on reading with the results shown in your figure in mind. There should not be too much overlap between the results shown in the figures and those discussed in the text; they should be stand-alone components that contribute to each other's value. There is no need to explain in your text in detail what is shown in the figures you refer to: all relevant information should be given in the figure captions.

Figure captions

Figure captions should be concise yet complete, including a description of the subject that is visualized, the location of the map/photograph in relation to an earlier figure, or explanations of abbreviations. Sometimes, figure captions may include a minor interpretation of the observations visualized. Generally, figure captions are presented below the figure, and tables consist of a heading above the table as well as a technical description below[7]. If you use or base your figure on somebody else's work, reference them accordingly and mention your adaptations, if applicable.

Photographs

(Field) photographs often need to be annotated for the reader to understand the features visualized[7]. In fact, a figure in a scientific text is often a combination of a photograph and

your field sketch. If the scale on your photographs is not clear, you can digitally add a scale bar as you would in any other figure.

Things to remember

- Keep a consistent formatting for your figures where possible.
- Include a legend for each figure, as well as spatial references such as coordinates, a north arrow, and a scale.
- Think about the scale that your figure will be presented at (*e.g.* A4 print, A0 poster) and adapt your annotations and font sizes accordingly.
- Reference and acknowledge other's contributions (adaptations from figures, photographers, etc.).
- State clearly when you have made photographs/figures yourself.
- Describe in your captions what maps you used as base layers, *e.g.*, and the coordinate system applied.
- Include explanations of abbreviations and measurement units in both tables and figures.

3.3 Paragraph structure

Paragraphs are the smaller units of a text. For clarity, it is essential that each paragraph treats only one topic. As a rule of thumb, paragraphs should not be longer than approximately half a page as this makes the text more difficult to read. On the other hand, paragraphs consisting of only one or two sentences are too short and make your text look messy[8]. Structuring your paragraphs and connecting them in a 'natural flow' will increase the readability of your work[1]. Structuring your paragraphs may be difficult when you are working with complex ideas, which often is the case when you are writing a scientific article/paper/report. You can follow the model below to build your paragraphs and to incorporate evidence in your writing.

- In the first sentence of the paragraph you state the topic or main idea of the paragraph, which is the **topic sentence**
- In the 'body of the paragraph' you can insert evidence or examples to your topic sentence. Note that every sentence needs to be connected to the topic sentence by explaining it, referring to it, or building upon it[1]. To establish coherence within a paragraph, make sure that each sentence is related to the topic sentence. This can be achieved by repeating key words or phrases or using parallel structures or linking words. You can find more information on this in Chapter 4.2.
- In the last sentence(s) of a longer paragraph you can refer back to the topic sentence[1]. You can also use the last sentence to connect this paragraph to the next by leading into the next paragraph.

- If you want to check whether your paragraphs are well built, read only the opening and closing sentences of the paragraph: they should connect and be logical.

4 Writing style and conventions

Learning outcomes

At the end of this chapter you will be able to:

- Use a scientific writing style
- Use academic language
- Write a clear, coherent and attractive text
- Use appropriate words according to the conventions of scientific writing
- Use correct tenses

Keep in mind that there is a certain language style and syntax associated with scientific writing. Your text should be easy to read and comprehensible, not over complicated jargon and terminology. This chapter provides a number of useful tips and considerations with respect to scientific conventions in writing style.

In the degree programs of Earth Science, we generally follow the style manual by the American Society of Agronomy (ASA). We refer to this document to find general information about the use of abbreviations, punctuation, and units in your text. For further information about the correct use of punctuation, see this website. Please note that if you have trouble writing in English, there are various courses available through the UU language school.

4.1 Syntax

The readability of your written texts relies heavily on a clear, attractive, and coherent structure of the sentences. The readability of your text is enhanced by connecting your sentences and varying the structure and length of sentences. The next sections discuss some hints and suggestions how to achieve this. Note, however, that some recommendations should be used sparingly and with care to preserve their impact.

4.1.1 Connecting sentences

Linking words and - sentences

Linking words or phrases mostly consist of conjunctive adverbs and are used to link ideas from one sentence or paragraph to the next. They are also called **sentence connectors** if they are placed at the beginning of a sentence or **transition words** if they connect paragraphs. Linking words emphasize the connection between ideas, so they help readers

follow your line of reasoning or see relations that might otherwise be misunderstood or missed. Useful linking words (organized by their goal) are:

- Illustration: as shown by, *e.g.*, especially, for example, for instance, in particular, namely, particularly, specifically, such as, that is, to illustrate.
- Addition: again, and, also, besides, equally important, first (second, etc.), further, furthermore, in addition, in the first place, moreover, next.
- Comparison: also, in the same manner, likewise, similarly.
- Contrast: although, and yet, at the same time, but, despite, even though, except, however, in contrast, in spite of, nevertheless, on the contrary, on the other hand, regardless, still, though, unlike, whereas, yet.
- Logical relation: accordingly, as a result, because, consequently, for this reason, hence, if, otherwise, since, so, then, therefore, thus.
- Temporal relation: after, afterward, as, as long as, as soon as, at last, before, during, earlier, finally, formerly, immediately, later, meanwhile, next, since, shortly, subsequently, then, thereafter, until, when, while.
- Spatial relation: adjacent to, above, below, beyond, close, elsewhere, here, nearby, opposite, to the right, left, north, east, south, west, etc.
- To summarize or conclude: in conclusion, in summary, on the whole, that is, therefore, to conclude, to sum up.

If you use the linking words at the beginning of a clause, they should be followed by a comma. In the middle of a clause, a comma is usually placed both before and after the linking word. It is recommended to vary linking words such as the ones suggested above to increase the attractiveness and readability of your work. However, always be consistent in sequence style, such as sticking to first, second, third… (or firstly, secondly, thirdly…).

A **linking sentence** coherently connects the preceding sentence with the next sentence, for example: "*This has four consequences. First, …*" Or "*This can be illustrated by the following example*".

<u>Pronouns</u>

Pronouns (*e.g.* it, they, these, which, who etc.) are used to refer to a noun or one or more persons (the pronoun's antecedent). The use of pronouns may help to increase the relation between sentences if the antecedent is in the preceding sentence. The pronoun should however refer unambiguously to its noun. For example:

Ambiguous: "*We applied the method in an experiment. <u>It</u> consisted of three steps.*"
Unambiguous: "*We applied the method in an experiment that consisted of three steps.*"

Parallel structures

Parallel structures involve the repetition of sentences or phrases that conspicuously have the same grammatical pattern. The repeating pattern in a series of consecutive sentences helps the reader to see the connections between ideas. Parallel structures can be applied to the word, phrase, or clause level and are usually joined by the use of coordinating conjunctions such as "and" or "or." For example: "*A slope failure results in transport of debris downhill by slumping, sliding, rolling, or falling*"

Note that the sentence elements should be in the same grammatical form so that they are parallel. So, avoid faulty parallelisms, such as: "*A slope failure results in transport of debris downhill by slumping, sliding, rolling, or by rockfall*"

4.1.2 Tips for increasing variation in your text

Vary sentence length

Avoid long sentences and vary the length of consecutive sentences. An example of a faulty, long sentence is: "*Numerical models describe reality in terms of mathematical equations, usually at least partly based on laws of natural sciences, which allows the modeller full control over specified boundary conditions and laws, so that the physics-based model may be used to test whether a hypothesis does not conflict with the laws of physics.*"

This sentence can be broken up into: "*Numerical models describe reality in terms of mathematical equations, usually at least partly based on laws of natural sciences. Modelling allows full control over specified boundary conditions and laws. Thus, a physics-based model may be used to test whether a hypothesis does not conflict with the laws of physics.*"

Vary order of clauses

To increase the attractiveness of your text, vary the order of clauses in consecutive sentences. If a repetitive grammatical pattern has no function to connect ideas, a sequence of sentences with a similar pattern becomes boring. For example: "*Karst landscapes result to a significant degree from the dissolution of bedrock. They are most commonly underlain by limestone and dolostone bedrock. They contain surface karst landforms, such as sinkholes, caves, and large flow springs. Karst landscapes are characterised underground drainage networks that commonly bypass surface drainage divides.*"

This sentence can be rephrased into: "*Karst landscapes result to a significant degree from the dissolution of bedrock. They are most commonly underlain by limestone and dolostone bedrock. Sinkholes, caves, and large flow springs are typical landforms that can be found in these landscapes. Another characteristic feature of these landscapes is the occurrence of underground drainage networks that commonly bypass surface drainage divides.*"

4.2 Language

A scientific text is written in complete sentences, but it is not prose. Scientific language is a concise description of facts. Besides the use of a proper syntax, the use of lively, precise, clear, and simple words makes your text more comprehensible and readable. The following tips will help you with this:

Use key words consistently

Particularly in paragraphs in which you define or identify an important idea or theory, be consistent in how you refer to it. This consistency and repetition help the reader to understand your definition or description. Thus, avoid the use of synonyms for key words throughout your text. On the other hand, avoid the overuse of single expressions other than key words by using synonyms to represent equivalent meanings. To find appropriate synonyms, you can use a thesaurus.

Use formal words

Avoid informal or spoken language in scientific texts. Avoid contractions such as "*don't*", instead write "*do not*". Also use formal alternatives for informal words. Examples of informal words and their formal alternatives are:

Informal (wrong)	Formal (correct)
a lot of	much, many
do (verb)	perform, carry out, conduct
big	large
like	such as
think	consider
talk	discuss
look at	examine
get	obtain
keep	retain, preserve
climb	ascend
really	… (leave out)
things	… (be precise)

Be concise

Avoid wordy or empty words and phrases in your report or paper. Instead use concise alternatives:

Wordy	Concise
In order to	To
As a matter of fact	In fact
At the present time	Now, currently
Due to the fact that	Because, since
In spite of the fact that	Although, though
Are dependent on	Depend on

Furthermore, avoid phrases that do not add meaning or information such as "*It is interesting to note that*", "*It can be remarked that*" or "*… are observed*". These will make your texts unnecessary long and difficult to read.

Use precise and concrete words

You can enhance the clarity of your writing by using concrete, specific words rather than abstract, general ones.

- Avoid vague words and phrases for quantifications, such as "*a lot, many, large amounts*". For example "*The layers are different in thickness*". Instead, use concrete descriptions and quantify numerically whenever possible, for example "*The thickness of the lower layer is 2 m, whereas the upper layer is only 0.3 m thick*".
- Use specialist terms accurately, but avoid using technical terms that the readers will not understand. If you need to use such unfamiliar technical terms anyway, provide a definition.
- Avoid ambiguous words and phrases.

Use neutral and objective words

Scientific writing strives to be as objective as possible. To accomplish this in your text:

- Use words that express exaggerated certainty ("*undoubtedly*", "*obviously*") sparingly, and relativizing words ("*sometimes*", "*possibly*", "*somewhat*") similarly with care. Using these too often will make your text look less trustworthy or convincing.
- Avoid clichés ("*this site is excellent for…*" instead of "*this site is the cream of the crop for*")
- Avoid subjective words, such as "*gigantic*", "*beautiful*", "*nice*", "*fantastic*", or "*enormous*". These imply a value judgement.
- Do not present anything as a fact if you do not support it with evidence. Thus, be careful with words like "*indicate*" or "*prove*". Instead, if you are giving interpretations or assumptions, use words like "*suggest*" or "*may be related to*".

4.3 Using tenses

In scientific writing, there are conventions about the correct use of verb tense. Beside the time frame (past, present, future), the verb tenses you use in your report or paper also reveal whose idea is presented (yours or someone else's) and how general or specific your description is. In brief, the following tenses are commonly used in scientific texts:

Simple present

In general, the simple present tense is used to describe an action that that occurs now or on a regular basis. In scientific reports or papers, this tense is used to describe a generally accepted scientific fact or a personal statement. Therefore, it is typically applied in the introduction section, in which you give a literature review or statements of main ideas.

For example: "*This thesis examines the first approach*"

Simple present is also used to refer to figures and tables in your text, for example:

"*Figure 3 shows that…"*

Past tense

The past tense emphasises the completed nature of a past activity or event. This tense is used to describe such past activities or events, for example:

"*The drawdown of the Mediterranean water level caused erosion and deposition of nonmarine sediments*"

More importantly, past tense is used to describe the methods, results, or conclusions of past research, including your own study that you are reporting on. For example:

"*Vissers et al. (2013) found that the maximum extension in the eastern end of the Piemonte Ligurian Ocean was ~315 km*"
or
"*The measured piezometric levels were interpolated to a groundwater table for the entire study area*"
or
"*We demonstrated that nitrate concentrations differ strongly between the major flow routes*"

Note however that you descriptions of rocks and structures always need to be in the present tense.

Present perfect tense

Present perfect tense is used to describe unfinished actions that started in the past and continue to the present. In scientific texts, the use of this tense is usually limited to the introduction section (literature review) to indicate that research in the area is still continuing or still has immediate relevance. For example:

"*Recently, there has been a strong debate about the melt rate of Himalayan glaciers*"
or
"*This method has been effectively used in snow cover mapping*"

4.4 Passive vs active voice

The use of either passive or active voice in scientific writing often depends on the style and goal of the text. Passive voice generally focuses more on the action (*i.e.* the verb) of an object rather than the subject in a sentence. Active voice is defined by a subject taking action upon an object. For example, one might choose to say, passively: *"The orientation of slickensides was measured in three locations",* in which the emphasis lies on the object (the slickensides) and the action (was measured). In active voice, the sentence would be: "*We measured the orientation of slickensides in three locations*", *i.e.* highlighting the subject (we) simultaneously to the action and object.

Traditionally, scientific texts relied on the use of passive voice; however, there has been a more recent shift towards active voice use in scientific publications. Sometimes, passive voice is conceived as more objective, but sentences using passive voice are also lengthier, impersonal, and may be perceived as boring. In texts where you present your own results next to cited results from other scientists, passive voice may confuse your audience as it could be unclear whose results you are actually discussing. In contrast, active voice is more concise and unambiguous; it appropriately describes science, which is actively performed by scientists. Because the purpose of scientific texts is to transfer knowledge and ideas to an audience, it is valuable to write it down in such a way that it cannot be interpreted incorrectly, or out of context. The unambiguity of active voice is a useful tool to do so. Despite this, the focus on subject (we, I) in active voice both is still not always preferred by readers and reviewers. In some (research) cultures and countries, a fully active text is therefore not always applied. An example of the focus on subject:

"*We measured the metal concentrations in the water samples by ICP-OES*"; *i.e.* active voice: emphasis lies on subject (we) as well as action and object.
or
"*The metal concentrations in the water samples were measured by ICP-OES*"; *i.e.* passive voice: emphasis lies on action (measure) applied to object (metal concentrations in samples).

The debate over the use of either active or passive voice in scientific writing is also ongoing amongst the instructors of the Earth Science programmes at Utrecht University. Therefore, make sure to check the requirements of your assignment, thesis, or journal paper and ask supervisors/editorial boards for their preferences if you are unsure what voice to use.

Most importantly, **remain consistent** in your voice use, and remember to clarify which results were obtained by what research group (*i.e.* separate your own results from those of others and correctly apply references). Also, keep in mind that in Earth Science we often describe actions (*e.g.* deposition of sediments, deformation etc.) to which the subject is unclear or unimportant. In such cases, passive voice is preferred, and such contexts allow for a deviation from a generally active narrative in the rest of your text. For example:

"*During the early Malm (Oxfordien) thick layers of dark marl were deposited. We analysed samples from this deposit using XRF.*";
In the first sentence the subject is unclear (and unimportant) and the action (deposition) and object (marl) are emphasized. In the second sentence active voice is used as it refers to the action taken by the authors.

4.5 Spelling

Despite the fact that British English and American English are generally similar in many respects, there are a number of more or less well-known spelling differences you should be aware of. The main differences and examples of American English and British English can be found on the Oxfords dictionaries website[9]. For your report or paper, choose either American English or British English and remain consistent in spelling throughout your text. Note that citations should always be cited exactly in the original spelling.

5 How to tackle a writing assignment?

When writing a research report, keep in mind that the writing process already starts prior to data collection and analysis and continues throughout the complete research process[3]. Although each writer may have different preferences throughout the process, writing is often subdivided into three different stages that take place more or less subsequently: planning, drafting, and

Learning outcomes

At the end of this chapter you will:

- Know how you can best approach a writing assignment
- Be able to plan and design a research project (incl. research question)
- Know different ways to start drafting your text
- Be able to revise your text
- Know how to incorporate information from literature

revising[10]. Inexperienced writers often skip the planning and revising steps because they feel this saves them time[8]. However, going through all stages of the writing process is essential for a focused text and a good readability[3]. In the next subchapters, you will find more in-depth information on the different stages, and how to tackle them.

5.1 Planning

Planning and designing a research project is a valuable first step in the writing process. This stage entails[3, 4, 7, 8]:

- Defining the purpose of your writing product;
- Phrasing your (preliminary) research question;
- Understanding the audience you are writing for;
- Designing your preliminary outline;
- Time management

Investing time in the planning phase will prevent you from losing sight of your goals throughout the writing process, it will improve the readability of your text[7] and you will save time restructuring and ordering your thoughts during the actual writing process[8].
Keep in mind that the planning phase is only the first step in the writing process. It is common to come back to your initial plans to *e.g.*, reassess and adapt your research question or outline later on.

5.1.1 Purpose

Often, the purpose of scientific writing is to share your research findings, to make people aware of the value of your research, and to build upon the existing literature[6]. However, scientific writing can also serve other purposes, such as to teach or instruct, communicate or to apply for a grant[6].

Different genres in scientific writing serve different primary purposes. For example, the main purpose of a grant proposal is to convince someone to fund your research. Journal papers may be used to fill a gap in already existing research, and you will need to honestly present your results while also aiming to convince your audience of their importance. For a table with a good overview of the purposes of different scientific genres, take a look at the Middlesbury website section about 'Addressing your purpose'.

During your master's degree, a course assignment often helps you to determine the purpose of your work. You can look at the question and other information in the assignment to determine your purpose, and to decide how to approach it[4]. If the assignment is more open, start defining the purpose of your text by asking yourself the basic why, what, how, and when questions: Why are you writing? What do you want to achieve by writing it? How can you be most effective? When will you have achieved your purpose?[6]. Once this is clear,

move on to defining your research question, determining your audience, and start building your text in the form of an outline[4].

Phrasing a research question

Phrasing a good research question will help you align your text to your purpose and to keep it clear and focused. For a shorter texts, such as essays or research reports, you usually formulate one question. For a longer text, such as a thesis, you can formulate multiple questions. However, all questions should be clearly connected to one main question or problem[11].

To formulate a good question requires consideration of the following:

- The question is important, relevant, and interesting: this should become apparent by a clear relation between the information provided in the background and your research objectives.
- The question is simple and sufficiently specific to be answered in your study: narrow down your question as much as possible so that it is entirely clear which exact topic you will be studying.
- The question is measurable: the answer can be found by measurement. Usually that measurement is performed relative to something else (*e.g.* 'larger than') in the context of existing literature.
- The question is feasible: you can find an answer within the given time frame and with the resources and facilities offered.

5.1.2 Audience

It is essential to consider the reader of your scientific text prior to writing and to tailor your text accordingly, as scientific texts can be written for many different audiences with different levels of expertise on the subject[6]. Potential audiences include (from least to most specialized): the general public, customers or clients, fellow students, general scientists, *e.g.*, staff members of other research groups, experts in your field of research, *e.g.*, thesis supervisors, or sometimes a combination of the above[4, 6]. These audiences need to be targeted differently by providing varying levels of background knowledge[4] or by adapting the language and tone you use[6, 12]. Writing for a mixed audience can therefore be challenging, since you may not be able to target your complete audience with one text[2].

Most of the time when you are scientifically writing your audience will consist of specialists, general scientists, and/or other students[6]. Often, you will be writing for a specific course assignment where the audience consists of an academic assessor who might be a general scientist or a specialist in the field, as well as your peers. The assignment itself may further specify your target audience[4]. If possible, try to get hold of the (peer) assessment sheet or rubric, this may help you target your audience even better. The rubric used to assess Earth Science master theses at Utrecht University is accessible through Blackboard.

To determine your target audience and how to align your text accordingly, you can ask yourself what your audience already knows, what knowledge they need to understand your message[4], and what questions or doubts they may already have about your research subject[12]. Answering these questions for yourself ahead of time will help you keep their attention and convey your message successfully.

5.1.3 Creating an outline

Creating an outline will help you to organize your thoughts and ideas and to structure and keep track of large amounts of data and information[10]. Additionally, it will help you to show relationships between your ideas, and it will make your text more structured, clear, and logical, thus making it more readable for your audience.

To create an outline, you first need to determine the goal of your text, your audience, and your research question(s) (see Chapters 5.1.1 and 5.1.2). After this you can follow the next stepwise approach to help you to create the outline. Note that you can use this to make an outline for the complete text, but also to write an introduction with your research objectives before starting a bigger research project, or to write a specific chapter.

- Brainstorm. Write down everything you can think of. There is no need to pay attention to writing correctly; this phase is just to gather all your ideas[10].
- Evaluate your ideas[10]: which can stay and which need to go? Keep your reader in mind: what do they need to know[4]? Also keep your research questions in mind: are the ideas relevant to your questions?
- Organize your ideas: group related ideas[4, 10]. You can use conceptual maps to connect your ideas, concepts, and authors/papers[13].
- Order your grouped ideas into chapters and paragraphs[10]. Again keep your reader in mind: in what order do they need to read the information to understand everything?[4]
- Keep the paragraphs disconnected for a while, this also makes it easier to switch paragraphs around to improve the flow of your document once you start building your arguments (or have a rough draft of the full document)
- Create (sub)heading[10]

Alternatively, you can also make an outline by asking yourself questions that you will answer in your text, by making conceptual maps to connect ideas, concepts, and papers, or by listing topic sentences[13].

Be aware that you only select information that is relevant to your research question. This will make the end-product shorter, more focused, and easier to read. Do not try to include everything you know in your outline[7].

In the end, your outline should look like an annotated table of contents including chapter (paragraph) titles and some comments/explanations on the content of the chapter (paragraph) showing your line of thought. In summary, your outline already determines the content of your text before you start to write, making the writing process easier[8].

Processing existing literature

An essential part of outlining your text is to establish a research framework to inform your reader of the relevance of your work and to show your understanding of the state of the art of the field you are contributing to[1]. This framework will consist of scientific literature that you will need to read, assess in terms of relevance, and incorporate into your own text. This last step can be achieved by i) paraphrasing, ii) summarizing, iii) synthesizing, or iv) quoting the existing research. As it can be challenging to combine many different sources to determine your research framework, it is important to know which of the possibilities listed above is best applied in which situations. Note that more information on finding literature and reading scientific literature can be found in the *Reading scientific literature* module.

Summarizing or synthesizing scientific literature is usually performed by paraphrasing certain parts of journal papers. Paraphrasing entails expressing the findings of other researchers *in your own words*. This is common practice in Earth Science texts. Another less common way to include another's work in your text is by quoting their publications, *i.e.*, literally incorporating their published text or data in your contribution[1].This may be valuable for short pieces of text that are crucial to include, word for word, in your own work. **Remember that without citing or referencing the literature and data you use, you may be committing plagiarism or fraud.** To read up about the plagiarism rules at Utrecht University, see this link. Information on accepted ways to cite and reference others' work can be found on the website of the UU library.

You may experience some initial difficulty with rephrasing other people's work. Get started by determining what information you need to frame your research question or to achieve your purpose and look up literature accordingly. Then, copy-paste the most relevant parts of that literature into your writing document and try to combine the materials from each paper into a few cohesive sentences. Keep the goal of your paragraphs in mind and only incorporate literature that is necessary to communicate the intended message of your text. Summarize information from papers that say similar things, and if relevant, use words such as 'but' and 'in contrast to' to show your audience that there are disagreements between different authors in your field[12]. It may help to take some distance from your paraphrasing work and come back to the text with a fresh perspective later on.

5.1.4 Time management

Scientific writing can be a time-consuming process consisting of designing the project, reading and collating relevant literature, phrasing and visualizing your own results,

discussing them, and fitting them into the framework of pre-existing research. Start your project by making a time schedule to determine how much time you think you will need for your research (literature review/field work/lab analyses), and make an estimate of how much time you think you may need to structure, write, revise, restructure, and rewrite your text. Remember that adapting your time plan along the way is part of the process. You may find yourself 'writing to think'[12] in your first draft, so it will be necessary to revise that text and organize it in a more structured way later on. Start writing as soon as possible (don't leave it till the end![3]), and keep at it (see Chapter 5.2 for tips on this, and the *Self-regulated learning* module for further information).

5.2 Drafting a text

One of the most challenging aspects of scientific writing can be to start writing with a blank page in front of you. This chapter suggests some techniques that may help you to get started and keep writing. Before you read the following, try to evaluate for yourself what you struggle with most: Do you struggle with knowing where to start? Do you find it hard to stay focused? Are you unsure of what you want to write? Identify some key points for yourself and try out some solutions that are suggested in the following chapter for yourself. At the end of this chapter you will have gained an array of techniques to pick, choose, and apply the ones that work best for you.

If procrastination or time-management is something you struggle with generally, please take a look at the related chapter(s) in the *Self-regulated learning* module.

5.2.1 Strategies to start writing

The common structure of a research paper is not necessarily indicative of the order of drafting. Each writer will eventually develop a preference for the drafting order of the various components of their work. There is no right or wrong way to do so, but there are several common places to start.

<u>Create an outline</u>

One way to reduce the pressure of starting off with a project is to write down the structure and outline of your text and to slowly build up its content. Since the structure of a scientific text is generally fixed[8], there is a low threshold to note down your chapter and sub-chapter titles. You can then also make a set-up for your document layout by assigning headings to chapter titles, including page numbers, etc.. Once your blank page has turned into a neat-looking table of contents, you can continue outlining your text by adding content-specific bullet points to the different (sub-)chapters. Even if you feel more comfortable with the content of some chapters than you do with others, try to note down a few things under each heading and do not forget to repeat this process anytime something new comes to mind. Eventually, if you keep adding information to your bullet points, and when you expand the

short phrases into full sentences, you will find yourself developing paragraphs. Keep in mind that what you are working on is a first draft of your text. You will come back to revise it at a later stage (see Chapter 5.3): **what you write down now is not and does not need to be perfect**.

Visualize your results

Generally, visualizing your results is an efficient way of science communication (see *Visualisation* module). By developing your illustrations (figures, tables, etc.) first, and placing them in your previously defined outline, the story you want to tell your audience will become more apparent and it will be easier to write it up. Once you have drafted your figures, you can move on to write your methods, results, discussion, and conclusion chapters. Your introduction and abstract may be written after that, and you can finish off by writing a title, your acknowledgements, and formatting your references[14].

Write what you know

If you are not yet sure how to visualize your results, it might be useful to start by simply writing down the things you already know: your methods and results. Your methods chapter should generally be quite easy to write, and once you have your results your observations should be clear as well. From there, write up your discussion points, generate some figures, and continue with the conclusions, introduction, and abstract in an order that works for you.

Start with the abstract

You could also work in the opposite order and start by writing the abstract and introduction of your text first. Writing the abstract of your scientific text allows you to put your thoughts to paper, even before you finalize all the research necessary for your project. Since your abstract and introduction will include the aim of the research, these chapters serve to phrase your research question, and to set a framework for the rest of your text. Your abstract may include some early conclusions (that you can/should change later) that give you a goal to write towards. The clearer you define your goals and your research question, the easier it will be to write the rest of your scientific text[3]). While adding literature, objectives, and approach to the introduction chapter, try to develop the structure of your paper or thesis[13]. You can do this, for example, by outlining, ordering, and introducing your sub-questions in different paragraphs. Remember that this structure and even the research question(s) you set here may be subject to change once you continue your research and writing. You may have to revise this chapter thoroughly as you round up your work. This of course counts for all first drafts, regardless of the order you write them in.

Work from your research proposal

In your Earth Science MSc program at Utrecht University, you will likely be expected to write a research proposal prior to your MSc thesis research. This proposal may already consist of a thorough literature review and problem statement that will make up the first chapter(s) of

your final thesis. In that case, it will be useful to follow up your work on the introductory chapter(s) by drafting figures and writing the remaining chapters after that; *i.e.* a combination of the drafting orders presented above.

5.2.2 General tips for the writing stage

Sitting down to write can be easier for some than it is for others, and it may take some time to develop a strategy that works for you. Here are some common techniques that you can try out and cherry-pick parts from to develop your own ideal writing strategy:

- Many writers **assign a certain amount of time each day** to merely focus on writing. They set a certain time (*e.g.* from 9:00-11:00 am) and stick to that, so that writing becomes part of everyday life. This does not mean that they are writing full paragraphs or chapters each day, but it can help to allocate a specific time to write out ideas or to document your progress of that day. Documenting your entire research process (as when keeping a field book during fieldwork, for example) will prove to be a valuable time investment when you write up your text at the end of the project. When allocating a certain part of the day to write, keep in mind that your energy levels vary throughout the day. Experiment a little to determine when you have the best focus and energy to write and plan your day accordingly.
- If the blank page is too daunting, it may also help to **start by writing the separate sections** of your text in separate documents[13]. By splitting it up into sizeable chunks, you may reduce the frustration of a not yet neat-looking or well-reading document.
- **Include (early) conclusions in your text[13]**. Each time you write a sub-section of your Results chapter, try to immediately note down some implications of those results in your Discussion and/or Conclusion chapter(s). You may need to rewrite these later, but it will help you organize your thoughts, not forget about important implications your results may have, and keep seeing the light at the end of the tunnel.
- **Leave some clear-cut tasks for the next day**[13], but note down some key words so you don't forget your train of thought. It can also help to make a to-do list for the next day so that you know where to start/continue. This will keep you from spending valuable energy and time doing so when you make a fresh start.
- **Try working together with others who have similar tasks.** Having a writing buddy can motivate you to get started or keep going when you struggle with motivating yourself. Besides, you could help each other by having discussions during breaks, or by reviewing (parts of) each other's work.
- If you dread working on certain sections of your text and you find yourself procrastinating, **try working with the Pomodoro techniq**ue (see the *Self-regulated learning* module). Getting started is often the hardest part and working on something for a short, dedicated time with a break in sight, might help you get in the flow.
- Once you have progressed a bit further, **collect your small bits and pieces of writing into a larger file** so you keep an overview of your progress. Once most parts are nearly

finished, having everything together may help you see the finish line and motivate you to get it done[13].

- **Try writing with an audience in mind** that you know will find your work interesting (*e.g.* a friend you study with/peers), and who does not have to grade your work.
- **Ask a peer, friend, or supervisor to review** (part) of your text and give constructive feedback[3]. You can do this at different stages, *e.g.* you could have someone review the structure of your work, the discussion chapter, your figures, etc. Be kind to those who help you and try to divide their work load: it could be useful to gain multiple perspectives from different (not too many!) people or on different parts of your text, and it will take your reviewers less time to consider short sections rather than your entire text. Remember to communicate clearly what you expect from your reviewers: Do you want them to revise, edit, or proofread (see Chapter 5.3), and do you want them to edit the text itself or merely make suggestions with a few comments?

5.3 The revision process

After you have finished the first draft of your text, you need to critically review your work to refine and improve it[4]. To make sure you have sufficient time to 'revise' your work, make sure you incorporate time for this in your planning. Note that it is better to revise and edit your text after you have finished writing your draft or a complete section. In the writing stage, your writing grows 'naturally' while you are thinking and exploring new ideas[4]. If you try to already revise your work during the initial writing phase, it will restrict your thinking and creativity, and it will slow you down[4].

The revision process can be separated into three parts. Ordered from largest to smallest in scale: revising, editing, and proof reading[4]. The different stages will be discussed in this chapter.

5.3.1 Revising

When you are revising, you deal with your text on the largest scale[11]: in this stage, you perfect the structure and logic of your text and arguments.

To make sure your text works as a whole, **start by reading your text from start to finish**[4]. When you are revising you focus mainly on reorganizing, rewriting, adding, or cutting content[4, 8]. First of all, check if all relevant sections are present in your text (see Chapter 3.1) for what needs to be included). **Look critically at the structure** (on a larger scale). Are your (sub)chapters ordered correctly to guide the reader through your arguments in a logical and clear way[4]? If not, you can reorder complete chapters or paragraphs if necessary.

Next, **make sure all paragraphs/sections contribute to your main argument or question**. Pay attention to repetitive, unclear or off-topic sections of your text[4]. Keep your main

question/subject/purpose in mind when you are revising, make sure every section is focused. Do not hesitate to delete content that is not fitting to your text. Even if it might feel difficult to do this at first, it will improve your end result by making your text more focused[8]. Also **check your word count** (if applicable) and decide what parts you can delete/shorten or extend if necessary[4].

On the paragraph level, you need to **check if every paragraph covers only one subject**. If a paragraph contains more than one subject, you need to split it up or remove the irrelevant section[15]. You also need to **check if the first sentence of the paragraph always is the topic sentence**. This will make it easier for the reader to follow your argument. If you would like to more on paragraph structure, you can take a look at Chapter 3.3.

Examples of questions to ask yourself when revising are:

- Do all parts of your text contribute to your research questions?[8]
- Is the information you give sufficient to understand your point? [8]
- Is the central argument of your text clearly introduced, developed and concluded?[4]
- Does the content cover everything you mentioned in the introduction?
- Does the content cover everything that was asked for in the introduction?
- Does your introduction align with the body and conclusion of your text?
- Do you answer all questions you have stated in your introduction?

5.3.2 Editing

After you have finished your revisions and you are confident about them[10], you can start editing your text. In this stage, you deal with your text on a smaller scale, *i.e.* on the sentence level[11]. You consider whether you convey your meaning accurately, clearly, and concisely. When you are editing you mainly focus on grammatical errors, spelling, and writing style[10] rather than reorganizing and rewriting your content[4, 8]. Editing works best if you read over your text multiple times and focus on a different issue every read.

On the sentence level, you generally need to check if you have followed all guidelines for writing style (Chapter 4). This means improving sentences that do not have a good flow[8]. You also need to check if the different sections of your text run over into each other smoothly[8]. If this is not the case yet, you can add linking words or phrases.

If you are struggling with how to correctly phrase your ideas in specific parts of the text, take a look at the Academic Phrasebank from the University of Manchester for example sentences. Check if certain words are repeated too often in a single paragraph for example, due to limitations in your vocabulary. You can use a thesaurus to search for synonyms to make your text more diverse. Also check if you are often using superlatives in your text (*e.g.* crucial, important, essential). This decreases their value and makes your text less trustworthy. Use these words sparsely so they stand out more, and always explain why

something is important/crucial/essential etc. For more information on writing style, syntax, word use, and grammar, take a look at Chapter 4.

5.3.3 Proofreading

Proofreading is the last step before you submit your paper[4]. Even when you have extensively revised and edited your text, you need to go over it one last time as errors might have come up during the editing process[4]. Proofreading is a final check where you deal with your text on the smallest scale: you look at your text line by line to spot any mistakes before submitting the assignment[4, 11].

When you are proofreading, you check your final text for[4, 10]:

- Accuracy: Are all the facts you presented correct?
- Inconsistencies: This counts for spelling (*e.g.* UK vs US English, or using hyphened vs spaced vs collated words), capitalizations, formatting, in-text citation of references, writing Latin words and abbreviations (*e.g./ i.e.)* in italics, (un)necessary spaces between words as well as between values and their units etc. Remember to also check whether you have explained your abbreviations prior to using them throughout your text (once you introduce them, continue to use them!).
- Language: Did you make any grammar or spelling errors? Did you use a correct scientific writing style?
- References: *e.g.* Are all sources you used referred to correctly? Is the reference list complete? Did you use the same reference style throughout the document?
- Layout: Is your layout clear and clean? Are all the paragraphs separated in a similar way?

Tips for proofreading

- Make a list of what to look for[10]. You can list mistakes you are aware you often make, also from previous assessments. You may also use the rubrics of the assignment.
- Use the search function in MS Word to check your document for errors you encounter that may occur more often[10].
- Start proofreading from the end of your text. This way, you focus on the sentences rather than the bigger ideas of the text[10].
- Ask a friend to read over your text when you have finished proofreading yourself. They may spot mistakes you overlooked.
- Temporarily change the font and font size of the document. This will often make it feel like you're reading your document for the first time, and errors you previously missed can be spotted more easily. Similarly, reading a printed version of your document can help with this (but printing repeatedly isn't exactly environmentally friendly).

5.3.4 General tips for revising, editing, and proofreading

- Build in time for revision in your planning!

- Leave your work to rest for a couple of days before you start revising or editing. This way, you take some distance from it, which makes it easier to spot mistakes[4, 8]. It is also easier to delete text when you have taken some distance from it[8].
- Work together with a peer and give feedback on each other's work. This will benefit you both as it is easier to spot and correct mistakes in someone else's text[8].
- Try to read your text from your audience's point of view[4].
- Read your text out loud to spot unclear sentences[15]. Additionally, reading out loud will slow you down a bit, which prevents you from missing errors/mistakes.

Use of track-changes

It is easy to lose track of changes you or others make to your text in the revision phase. To retain an overview, it can be extremely useful to use editing tools such as the track changes function in MS Word. For a step-by-step manual on how to use track-changes in MS Word, see this website.

Tips for using track changes and comments:

- Always use track changes and comments when you are revising and do not manually highlight/strikeout/underline/change text colour to indicate changes. Track changes and comments are easily searchable; manual changes, however, are not. You might miss manual changes when editing since you are familiar with the document and have read over it many times, making them invisible to you.
- Use the comment function for suggestions and explanations.
- Clean up your track changes and comments periodically, for example after each round of editing.
- Use Hide or Reveal Markup in MS Word to spot errors such as multiple spaces, missing or excess periods and commas in a heavily edited document.
- Track changes and reference management tools do not always go well together. Therefore, temporarily turn off track-changes when you are adding or changing references. Alternatively, you add the final references after you have finished editing.

Revision etiquette for group writing assignments:

- Use track-changes when making improvements on text written by someone else. This way, the original text is traceable as well as who made the suggestions.
- Use comments to explain why you made certain suggestions and to provide information to your co-authors.
- Appoint someone to accept all changes that are left after a round of editing. Often, people are reluctant to make ‘final’ changes. However, if the track changes are still there after a while, everyone should agree with them, and it should be okay to accept them.
- Make sure everyone is using a similar software. Although track changes in MS Word work well between MS Word versions for Mac and Windows, they do not with other software

such as Google Docs. You can for example all use the browser version of MS Word in online MS Office.

5.3.5 Incorporating feedback

Often you will receive feedback from peers or supervisors in the form of track changes and comments. Be aware that reviewers always make suggestions to your text, not final decisions. It is up to you to accept or reject them[16]. Moreover, you can learn a lot from track changes and comments, especially when they are made by someone with more research or writing experience than yourself. Therefore, always go over each suggested edit and check if you understand why it was made, and if you agree with it before accepting.

Sometimes, you will be expected to respond to reviewer's comments. Do so respectfully and constructively and explain with clear arguments what you have changed and, if applicable, why you disagree with them and chose not to follow their suggestions.

6 Formatting your text

Learning outcomes

At the end of this chapter you will:

- Understand what constitutes a good layout
- Know what aspects of your layout you need to look out for when formatting your text

Presenting your scientific writing in a neat and organized manner will help readers to focus and will improve conveying your message. Often, scientific readers will initially only selectively read your text, starting with the aims and objectives in your introduction, the figures in your results section, the discussion (including figures), and conclusions. If the reader's interest is piqued, they will continue reading other sections of your text or look into some of your references. Understanding your audience's reading patterns will help you structure your text in an accessible way: consistently refer to literature and other parts of your text and include all important information in your figures. This chapter will suggest some strategies to develop a consistent layout and will offer some guidelines on the use of figures, tables, and diagrams in your text. For more information on this, take a look at the *Visualisation* module.

6.1 Lay-out

Incorporating a consistent layout in your scientific text will help make your audience focus on the message you want to bring across. Your layout needs to be clean (not too many embellishments), and clear (your chapter headings and paragraph-separations need to stand out). Additionally, your figures should be incorporated into your text in an organized manner. Some tips and tricks:

General

- Read your writing assignment: Is a certain layout required? Do you need to use a certain line spacing or font and font size, for example? Is there a maximum word count you need to adhere to?

Page numbers

- Include page numbers when you first start working in a text document. A common placement is at the bottom of the page. You may choose to do so in the middle, on the right, or on alternating sides on odd and even pages.
- Use Arabic numerals for your main body of text. It is common to use a different number format, often Roman numerals, on pages prior to the main body of text (abstract, table of contents etc.) or in the Appendix
- Do not number your cover page unless it contains the abstract.

Formats and fonts

- Use preset (modified to your taste) styles to format the different types of text (headings, body text, figure, and table captions, etc.)
- Use a clear font and font size. If not indicated in the assignment, use a serif font (*i.e.* with decorative strokes, *e.g.*, Times New Roman, Garamond) for printed text, and sans serif font (*e.g.* Calibri, Segoe UI) for digital text.
- If you are using a coded writing program like LaTEX, the document class "*article*" regulates fonts and font sizes for you and keeps the format consistent. When working with Word or comparable apps, check that all of these features are the same throughout your document.

Table of contents

- It is recommended to make an automated table of contents in MS Word (or LaTEX if you prefer), specifically for larger reports and theses. You can find the "*Table of Contents*" function under "*References*". For more information and a tutorial, see this link.
- Remember to update your entire table of contents at the end of the writing process.
- The table of contents should contain a title ("*Table of Contents*" or "*Contents*"), clear headings, and the page numbers where the respective chapters and subchapters can be found[11].
- Include all level one (*e.g.* "*3. Methods*) and two ("*e.g.*, *3.1 Age model*") headings. Level three headings (*e.g.*, 3.1.1 …) are optional[11].
- Include all appendices[11].
- Do not include the table of contents itself[11].

Chapters

- It is common to start each new chapter on a new page. If you print your document double-sided, new chapters should start on a right page (odd page number). If necessary, add a blank page (even page number).
- Chapters and sections reflect the global structure of a text. They often have a standard title such as "*Introduction*" or "*Methods*", which allow readers to find information readily and quickly. All titles should have the same logical hierarchy. For example, if you describe the geological formations found in your study area, name the consecutive sections accordingly. Keep an eye out for mixing geological formations with chronostratigraphic units or geomorphologic units either in the titles or text. For example, if all chapter headings list ages of geological units, use Late Cretaceous, not Upper Cretaceous, which defines a stratigraphic position! Double check if necessary.
- The titles at the same hierarchical level should be formatted in the same manner (font type and size). These styles can be defined in your word processor (for example, in Word: in the Style ribbon in the Home tab, such as 'Heading1', 'Heading2', 'Heading3'), which results in a consistent numbering and lay-out.
- Titles do not end with a full stop.

Chapter numbering

- Chapters, sections, and subsections should be numbered using Arabic numerals (1, 2, 3.1, 3.2, 3.3, etc.).
- In Word, link your numbering to the styles you assigned to each heading. For more information, see: https://shaunakelly.com/word/numbering/numbering20072010.html
- Numbering of subsections with more than three numerals (*e.g.* section 4.2.3.4) is unclear and should be avoided. Alternatively, use font effects such as italics for subsection titles to further structure your text. Non-numbered subsections should not appear in the table of contents.
- The preface, summary, and list of references are not numbered

Paragraphs and line spacing

- To start a new paragraph, indent the first line of a paragraph by about 1 cm (and do not leave a blank line between the paragraphs), but do not do this to the first line of a chapter, section, or subsection. This method is common in most British-English texts. Alternatively, you could start a new paragraph by leaving a blank line between the paragraphs.
- If you opt for blank lines between paragraphs, beware that Word settings may comprise a large line spacing. Because of this, single line breaks may look like a blank line, but they are not and, when opened in another text editor, multiple paragraphs may be interpreted as a single paragraph, which reduces readability. Unless stated otherwise, use single spaced lines and set a small line spacing to avoid too much unused space in your documents.

Tables and figures

- All tables, figures, photographs, and maps should be numbered consecutively in the order as they appear and referred to in your report or paper. In papers and short reports, number them sequentially. In longer reports, include the chapter number in the table/figure number (*e.g.* Table 4-1, Table 4-2, Table 6-1; Figure 1.1, Figure 1.2, Figure 3. 1, etc.).
- Provide a caption to your table or figure. This caption should be sufficiently informative to understand the table or figure without reading the main text.
- Place the table caption above the table and the figure caption below the figure.
- Each table and figure should be referred to in the text. Refer explicitly to the table/figure number. In word processors, it is advised to insert cross references, which update the table or figure numbers automatically when a new table/figure is inserted, moved, or deleted. This tool is also useful for automatically generating lists of tables and figures.
- Place the table or figure closely and preferably after the reference to it.
- Explain the symbols used in the table/figure caption or figure legend.
- Give units to the symbols (in the caption, in the row and column headers of tables, in the figure legend, or in the axis titles of graphs).
- In tables, use the symbol '-' or "*n/a*" (not applicable) when a parameter was not determined
- If a table or figure is borrowed from the literature, provide appropriate references. For official publications, you may need permission from the publisher of the original table or figure.
- In tables, use only horizontal lines between the rows; do not use vertical lines to separate columns.
- In tables, align text and numbers to the right.
- Provide a scale bar and orientation to maps, cross sections, and field sketches.

Handing in

- When you hand in your report digitally, make sure you save it as a PDF file, unless stated otherwise in the assignment. This way, your figures, captions, and tables will remain in the style you envisioned for them.

7 References and other useful resources

The information in this module is largely based on the BSc earth sciences guide for scientific writing. Other resources that were used are:

[1] The University of Sheffield - Academic Skills Centre
[2] Nature education - English communication for scientists
[3] Academische vaardigheden voor de opleiding Natuurwetenschap en Innovatiemanagement – Department Sustainable Development, Utrecht University (not publicly available)
[4] University of Leeds - Academic writing
[5] Duke - Graduate school scientific writing resource
[6] Middlesbury - Write like a scientist
[7] Rhodes University - Scientific writing for geologists
[8] UvA - Academische Vaardigheden
[9] Oxford Dictionaries - British and American spelling
[10] Purdue online writing lab
[11] Scribbr - Dissertation structure or Scribbr - Proofreading
[12] University of Chicago - The craft of writing effectively
[13] Raul Pacheco-Vega - Academic Writing
[14] Elsevier - Reference formats
[15] Duke - Revising in 7 steps
[16] University of Arizona - Using Track Changes
[17] Wordvice - Hourglass structure
[18] Writing clear science - Target audience

Other useful references are:

A short guide on scientific writing
Craft of science writing
Eloquent Science: A practical guide to becoming a better writer, speaker, and atmospheric scientist
Guidelines for writing in the geosciences - Lindemann and Cartwright
Scientific Writing geology resources - Illinois library
Turabian, Kate L. 2018. A Manual for Writers of Research Papers, Theses, and Dissertations. 9th ed. Chicago: University of Chicago Press
Turbek et al. 2016 - Scientific writing made easy: A step-by-step guid to undergraduate writing in the biological sciences
Writing geoscience papers: A list of useful resources