

How to write a scientific paper/thesis – some hints

„A scientific experiment is not completed until the results are published“

General

A thesis or publication is a serious contribution to the scientific world. Writing it with limited effort or motivation or too much time pressure is never a good idea and will lead to rejection or a low grade in most cases.

Scientific papers constitute of the following chapters: Summary (=Abstract), Introduction, Materials & Methods, Results, Discussion, Acknowledgements, References, Tables, Figures. Bachelor, Master and PhD theses might be written in the same order as papers but with Tables and Figures included in the text body.

Most journals prefer to have a title page containing title, names of authors and affiliation (full postal address), corresponding author address and e-mail, short title, keywords etc. Bachelor, Master and PhD theses have a standard cover page format at BTU which needs to be strictly followed. They also need to have a page index and a declaration that the work has been created in an independent way. These formalities are mandatory!

All text bodies in thesis documents should be written in 11pt. Arial or Times New Roman with 1.5 lines line spacing and 2.5cm margins (top, left & right) and 2cm margins (bottom) including page numbers.

Only start a new text paragraph if a new topic is addressed (a single sentence or even 2-3 sentences cannot form a text paragraph). To help you write a section (e.g. Introduction) create subheaders for individual paragraphs indicating what these paragraphs should be about.

Use the spell checking function of word to identify errors.

As a rule of thumb, a BSc thesis should have 20-40 pages starting with the introduction ending with the conclusion depending on the number of figures and tables. A MSc thesis should have 40-60 pages starting with the introduction ending with the conclusion.

Do not plagiarize any content from other publications/sources. Do not copy and paste text, figures or tables from other documents into the thesis. Also avoid direct quotations from text sources.

Title (and headings)

„First impressions are strong impressions“

- Need to capture the major topics of the study. The title is the label of the study
- Need to be as short as possible
- Should not be narrow → avoid taxonomic focus
- Be specific; capture what you contribute to existing knowledge
- Do not use abbreviations or jargon

Summary

- Needs to be understood on its own → needs to contain in short Introduction, Materials & Methods, Results and Discussion
- State the hypotheses clearly early in the Summary
- Give major conclusions (“take home message”) as early as possible; give outlook/perspectives at the end if appropriate
→ Do not hide your major findings but state them right away
„Reading a scientific article, is not the same as reading a detective story. We want to know from the beginning that the butler did it“
- Many journals have restrictions for the length (and style) of Summaries

Typically, the Summary is written at the end of the writing process after it is absolutely clear what the major findings/implications of this study are.

Keywords: Usually are given following the Summary. Keywords supplement the terms of the title and are used for indexing the article → choose carefully general and specific (e.g. names of species) terms which describe the work, avoid terms used in the title

Introduction

- Guides to the major question/hypothesis of the study
→ needs to contain the major references of the topic of the study; in referring to previous work be selective, quote only what really is important; do not write a review
- Every aspect addressed in the thesis should have its own paragraph explaining what is known and what knowledge gaps exist. This needs to be supported by covering the

existing literature. It is crucial to read publications to learn about the subject and about writing style.

- To search for relevant literature use google scholar and relevant keywords. Look at publications with interesting titles and read the abstract to understand if the paper is relevant. Google scholar also allows you to search for related publications. If a paper is really important, go to the references that the paper used and look through them for more relevant publications.
- Ideally the Introduction ends with clearly stated hypotheses

The Introduction sells your study → include your topic in a wider possible frame/body of hypotheses, but do not introduce aspects that your study does not cover.

Materials & Methods

- Gives in very detail how the study was undertaken; reading this chapter others should be able to repeat the work and get identical results!
- Start with the general things, e.g. the study site, and come to specific topics later, e.g. how many samples were taken
- If you refer to equipment give name of the apparatus, company and location of company incl. Town and country
- Use only SI units
- Needs to contain in detail the experimental design and the way the data were analysed. This usually is given as separate subchapter at the end of the Introduction

A note on numbers:

- In text numbers ≤ 12 are written in letters, those > 12 in numbers
- Numbers before units are generally given in numbers
- Do not start sentences with numbers; if unavoidable give in words

A note on species names

- Should generally be given in italics
- When mentioning a species first give genus and species name in full; if not uniformly used in the current literature include the name who described the species

- Later in text abbreviate the genus by its initial; if there are more than one species with the same initial use two letters for abbreviation
- Note that the Summary is a separate unit and should be treated as standing on its own → First mentioning of a species in the Summary does not count for the text body
- If you start a sentence in the text body with a genus name give it in full, do not abbreviate

A note on statistical analyses

- Be as concise as possible; do not go into detail of standard methods but refer to some standard text (if appropriate)
- In experimental studies give the factors studied explicitly; you may introduce standard terms for the factors studied; use these then uniformly throughout the paper. Experimental designs are best described by factors and factor levels, e.g. “The experiment was set up in a full factorial 2 x 2 design with the factors Temperature (10 and 20°C) and Moisture (50 and 80% of the water holding capacity). Five replicates were set up per treatment”.
- Give the software package used, include name, version, company, town and country (as in describing an apparatus).
- If using ANOVA state the type of ANOVA, e.g. “Data were analysed by fixed factor ANOVA”. Mention how you proved that the data are conform to preconditions for doing an ANOVA (normality, heteroscedasticity), e.g. “Homogeneity of variances were inspected using Levene test; if necessary data were $\log(x+1)$ transformed to improve homogeneity of variances”
- If using comparisons of means state these explicitly, if appropriate explain why the particular one was chosen, e.g. “Tukey’s honestly significant difference test was used for comparison of means”
- More complex statistics need to be explained in some detail but try to refer to references wherever possible, e.g. Scheiner & Gurevich (2001)

Results

‘If you are out to describe the truth, leave elegance to the tailor’ (Einstein)

- First do your statistics and use the statistical results to structure your findings; forget about non-significant findings, they are none; only include marginally significant

results ($P < 0.1$) if they fit to other findings and support these (or the findings of others, and you think this is really interesting)

- Prepare a Table with all the statistical analyses, start phrasing the results by translating the statistical findings into sentences (see note below)
- Start as set out in the Materials & Methods
- Be as plain and short as possible; use the simplest style possible; use short sentences
- Start sentences with the subject, use verbal style and direct formulations (see below)
- Use consistent terminology; use the same term for the same thing throughout, do not vary irrespective if it sounds boring; it does not have to sound interesting but clear
- Avoid too many data in text; give them in Tables and Figures
- When referring to data given in Tables or Figures do not state that such and such data are to be found in Table X or Figure X; rather explain what these data tell and then refer to the respective Table/Figure (usually given at the end of the sentence in brackets)

A note on how to get statistical results into words

- If only main factors are significant it's easy
"Earthworms significantly increased plant growth by 30% (Table X, Fig. Y)"
- If there are significant interactions, it is getting more complicated. The phrasing depends on the type of interaction, ordinal, hybrid or disordinal (see Bortz 1989, p. 364).

Generally, if there are significant interactions these have to be considered first.

Think of a 2 x 2 design investigating the effect of earthworms and Collembola on plant growth:

Ordinal interaction: "Earthworms significantly increased plant growth with the increase being more/less pronounced when Collembola were also present"

Hybrid interaction: "Earthworms significantly increased plant growth but only if Collembola were also present" (to make sure this sentence is correct you may need comparisons of means)

Disordinal interaction: "Plant growth depended on both earthworms and Collembola; without Collembola earthworms significantly increased plant growth whereas in absence of Collembola they decreased it"

A note on Tables and Figures

- Tables contain data in a comprehensive way; data in Tables need not be the most important for the study but they may be important to document for the general understanding of the study; avoid reporting data which do not differ significantly from others
- Figures are to highlight major findings → only present the most important data in figures, never give non-significant findings in figures. Use a high resolution and avoid blurry figures.
- Tables and Figures always need to be referred to in text
- Tables have headings, Figures legends
- Table headings and Figure legends should be understood without consulting the text (Materials & Methods) → be comprehensive, explain any term/abbreviation used in the Table/Figure; give e.g. species names in full
- In manuscripts Tables are given with Table heading following the References, one Table is given per page; Figures are given one per page without legend, legends are given on a separate page titled “Legends of figures”
- Tables look like the following (note that P-values are provided with 3 digits, other test statistics are given with 2 digits):

Source	df	SS	MS	Pseudo-F	P(perm)
Country	1	30.83	30.83	19.31	<0.001
Date	2	144.59	72.30	45.29	<0.001
Roof	2	2.08	1.04	0.65	0.674
CountryxDate	2	73.41	36.70	23.00	<0.001
CountryxRoof	2	1.43	0.72	0.45	0.828
DatexRoof	4	1.74	0.43	0.27	0.992
CountryxDatexRoof	4	1.74	0.44	0.27	0.990
Res	72	114.93	1.60		
Total	89	370.74			

Discussion

This is the most difficult part of the study. Here you combine previous knowledge with your findings. Giving guidelines is more difficult too. Some general hints:

- You may well start with the most significant finding, don't hide and try to come to it after having discussed all the less important findings
- Combine your results; you may restate major data but generally avoid repeating what has been stated in the Results; if you repeat results do it in a more general way

- Generally, discuss the implications of your findings rather than stating what was found
- Separate findings and conclusions clearly by changing from past tense to present tense: “Reproduction of X was increased in presence of Y by a factor of about two suggesting that the fitness of X increases with prey quality” (Note: first part of sentence might be passive voice, the second and more important part needs to be active voice)
- Avoid phrasing conclusions using “seems to” or “appears to” (“Reproduction of X was increased in presence of Y by a factor of about two; it appears that the fitness of X increases with prey quality”). Avoid these phrases in general! State the facts/findings and draw conclusions using “suggesting that” or “indicating that” if this remains to be proven, or by “demonstrating that” or “proving that” if there is no doubt at all
- You may discuss contradictory findings but be short, avoid lamento and back and forth arguments. If you can’t state it clearly be silent!
- Avoid speculations, a maximum of 1-2 may be allowed in a paper (even these are likely to be cut by reviewers)
- Give the Discussion an aggravating tense coming to the major implications of the findings at the end. These might be highlighted in a separate subchapter “Conclusions” but only if substantial implications are to be highlighted or if the complex subjects of the Discussion need to be brought together
- Ideally the Discussion ends with an outlook/take home message once highlighting that this study substantially contributed to existing knowledge and that these new findings have major impact

References

Standardize the format of your references carefully so that all references are in the same format. For publications: consult instructions to authors of the respective journals for details

- Give only those references referred to in text; check carefully!! It is very boring for Editors and referees to see inadequacies of references
- It is boring but virtually every journal has a different style of how to print references. Again check carefully and be sure the style matches what is asked for in the instructions!!!
- Often journal titles need to be abbreviated; consult ISI webpage (journal titles) to check for correct abbreviations

A note on references in text:

- Any knowledge has an origin; if you can trace the one who invented this knowledge quote the work
- Do not give references for generally accepted knowledge available in standard textbooks
- Do not be comprehensive, give the one who first came up with the idea, potentially one who wrote a review on the subject and potentially one who recently worked on the subject → usually no more than three references should be given for one subject
- Usually give references at the end of the sentence in brackets; if you like to highlight a specific finding/author give the author(s) in text with the year of publication in brackets

Appendix

In papers Appendices should be avoided! In Bachelor, Master and PhD theses Appendices are essential for documenting the data to allow later publication (this, however, may also be done by an electronic appendix (CD)!).

When you think you have finished your thesis/paper you should check for: a) typing and formatting errors, b) too long sentences (can you split them up)?, c) Are there any superfluous words that can be omitted without changing the content of the sentence? (often words like However or Nevertheless do not make much sense) and d) Are there any empty or popular phrases, buzzwords or the like that came into the text, no matter in which way? Delete and write in scientific language!

Six Golden Rules for Preparation

A good introduction is relatively short!

A good method's chapter is detailed!

A good result's chapter is boring!

A good discussion is exciting!

A good abstract is comprehensive! (max. 350 words)

A good list of references is accurate!

General hints on writing

The sentence

- Stick to the basic rules (at least in the Results).
Start with the subject, then tell what it does (→ verb) and come to the consequences (→ object).
"Earthworms increased plant growth"

Tense: past or present

- The rule: all you did, all your findings are presented in past tense, they have been done
→ Summary, Materials & Methods and Results are presented in past tense
Some exceptions:
"The study was conducted in a 120 y old beech forest, parent rock at the site is Rotliegend" (the forest will be different in near future, the soil, in contrast, is going to stay the same for the next thousands of years)
"Fig. X documents that ..." (but generally avoid such indirect phrasing, see below)
- All the knowledge that the study is based on is presented in present tense – knowledge is!
→ most of the Introduction is presented in present tense
"A large fraction of oribatid mite species reproduces by parthenogenesis (reference)"
- Discussion: Here you switch between past and present tense according to some principle rules
Knowledge of others is presented in present tense
Your findings are presented in past tense
If you draw conclusions out of your findings switch to present tense. In this way you clearly separate data/findings from conclusions based on them:
"The sex ratio varied between 40 and 60% suggesting that in the studied population the ratio between males and females is balanced".

Activ and passive voice

- Generally, the active voice is preferable, it is easier to understand and shorter
"The growth of X was inhibited by Y" better rephrase
"Y inhibited the growth of X" (six compared to eight words; message easier to get)
Exceptions: In Material & Methods the passive voice is most commonly used
"Ten ml of distilled water was added" (indeed "was" is correct if the amount was added in one portion!)

Direct vs indirect statements

- “It was shown that the size of X exceeded that of Y” rephrase to “X was bigger than Y”
- Get to notice and avoid phrases used in indirect statements, such as “was shown”, “was documented”, “was found to”, “was demonstrated”, “revealed” etc.

Nominal vs verbal style

- Avoid bureaucratic style (even if being German!)
“The growth of X exceeded that of Y” rephrase to “X grew faster/bigger than Y”
(this way you also start with the subject not the object!)
Get sensitive to nouns which can be rephrased into verbs; verbal style is always easier to follow and sounds more elegant

Singular vs plural

Some examples:

- „data are analysed”
- “The fauna is dominated by...”
- “To the vessels 10 ml of water was added”; “To the vessels 10 ml of water were added in portions of 3 and 7 ml”

Commas and more

- In German there are quite strict rules, English rules are less strict and follow more to clarify grammatical relationships
- Phrasing should try to minimize the use of commas “It, without being significant, increased with time” rephrase to “It did not significantly increase with time”
- Starting a sentence with “However”, “In addition”, “Generally” etc. is followed by a comma. Introductory statements longer than four words are followed by a comma
“Following an initial increase, the respiration of X reached a plateau of Y ml O₂ h⁻¹ g⁻¹ dry weight”
”In contrast to our expectations, the respiration decreased later in the experiment”
- Semicolons might help in tighten the text
”Respiration of X increased early in the experiment and then reached a plateau. Ten hours after reaching the plateau the respiration of X decreased again.” rephrase to

“Respiration of X increased early in the experiment and then reached a plateau; ten hours later it decreased again”.

Some final notes

- Read papers of distinguished authors in high impact journals several times and focus on style rather than content
- Start writing a paper by hand!!! It is easier to structure your ideas by handwriting than by typing them into a computer
- Get started in writing in the order Materials & Methods, Results, Discussion, Introduction and Summary
- Before writing the Discussion once again think about hypotheses and the major finding/focus of the paper (later compiled in the Introduction) → compile the story of the paper before writing the Discussion and Introduction
- Write as much as you can (based on data of course)!