Writing scientific (thesis) manuscripts

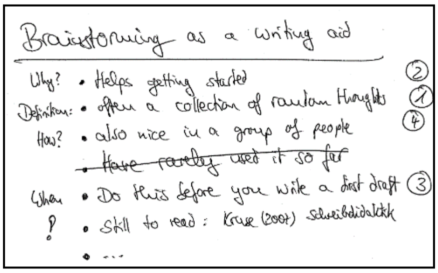
Guidelines at the Animal Evolutionary Ecology group, Univ. Tübingen

Continuously updated based on studend handouts contributed by students of the Scientific Writing *module 2014-2020 under supervision of Dr. Nils Anthes*

Initiating and organising scientific writing

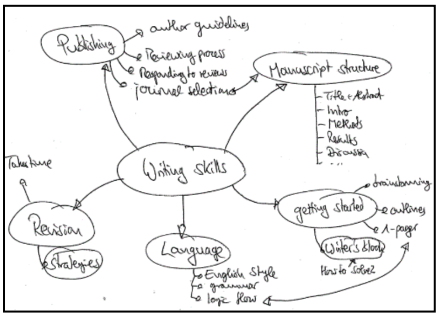
Writing a thesis or manuscript is a big task – "*too big an elephant to eat in a single bite*". Breaking this task into several more digestible pieces, each perhaps associated with a deadline, greatly helps to proceed in a well-organized manner. The following lists several 'pre-writing' techniques – any selection, combination or modification of these, given your personal preferences, can generate your optimal blend to initiate and keep momentum in scientific writing.

Brainstorming



- Pour your (unordered) thoughts, keywords, questions on a given topic / chapter on paper. No full sentences, no justification, no 'logic flow" needed (or even wanted)!
- Takes only few minutes – and is then the perfect start for subsequent sorting (→ *Clustering*).

Clustering and mind mapping: towards a concept map

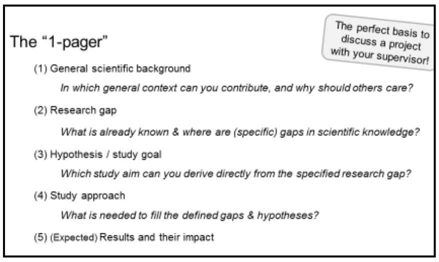


- Visually order the ideas that resulted from e.g. → *Brainstorming*
- Hierarchically order keywords in a concept map.
- Optimally done with pen and paper (or on blackboard, flipchart, …), but also software tools available (e.g. http://www.docear.org/)

Outlining

- Develop → *Concept map* into the "longitudinal" organization of topics and argumentation needed in writing.
- Make use of software tools (e.g. in MS Word, OpenOffice): Denote hierarchical headers to each topic you plan to treat in sequence. "Navigation maps" or "Document outlines" allow checking whether this sequence is (still) complete and consistent throughout manuscript preparation.

Developing a "1-pager"



- Simple technique to develop a first fully formulated version of a manuscript or thesis section.
- Develop along 4-5 key questions. Assure your argumentation consistently builds up along 300-500 words.
- Now, fill in gaps, expand on literature survey, explain underlying concepts in detail, … .

Freewriting

- Write without stopping for defined duration (e.g. 5 or 10').
- Follow the flow of your thoughts, without censoring.
- Usually takes the shape of formal sentences (⇔ *Brainstorming*).
- An efficient start into the writing process that is followed by ordering of ideas.

Journaling

- Keep a note on every thought you have on your writing project *whenever it strikes you*.

- Helps keeping track of ideas, frees space in your brain, avoids plagiarism … and makes it easier to continue writing, because some keywords are already on paper.

Get momentum – and keep it

Activate your 'writing momentum' by starting with topics / manuscript sections that you find particularly **easy** to write – this may carry over to the more difficult parts of your writing session. Hence, once you feel more positive and motivated about your writing progress, start to formulate your thoughts also on a more difficult part of your writing project. For example, finish every writing session by already making a few notes for the next = new writing part you wish to 'attack'.

Recognizing and solving Writer's Block

Many of us share difficulties in initiating and/or moving forward with writing tasks. We summarize these difficulties as 'Writer's Block'. The following describes typical such situations and suggestions potential solutions.

Mindset – the 'panic mode'

Situation	Reason	Solution
'My writing style is not good'	Perfectionism	Focus on content first (what you did, what you found, what it means). Keep improvemts to writing style for later revision.
'I'm scared of criticism'	Fear of being punished	Constructive feedback is a core component of science – it is there to help us improving texts.
'What happens if I fail?'	Fear of failure	Nobody will see your first draft – no matter how good or bad it is. Take small steps to then improve your draft. You will not fail!
'I can't decide which point should I focus on'	Lack of focus	Identify your one or two main research questions or hypotheses. They automatically determine the focus of all sections of your manuscript.

Doing the Writing

Situation	Reason	Solution
'Where should I start?'	Overwhelmed by the task	Use techniques to getting started and to organize your material (see above). Start writing with the section that seems most intuitive / simple to you.
'I can't think more'	Exhaustion	Assure you take rests. Have defined 'bursts of writing', possible no more than 20-30 minutes in one go. If you get stuck, it often helps to simply talk (rather than write) about your problematic section to some other person.
'I waste too much time for too little progress.'	Lack of efficiency	Avoid perfectionism on single sections, paragraphs, sentences or words (see above). Instead, focus o a rough, key-word style general outline of your study. Fill in gaps and detail later. Reconsider your writing environment. At which times, at what place, in which environment can you focus best, be distracted least?

Title

The title is the most prominent part of your paper. It makes people decide whether to read on. It is used in (online) library databases and is the reference to your work in talks, papers, and books. Good titles are short and attractive, also to non-specialists. They correctly emphasise the problem under investigation or even the main finding of the study, and limit taxonomic detail.

- Short = 8-12 words.
- Title types (it may depend on your study which works best):
  - *Question* → Can raise interest. Useful if your results allow more than a single conclusion. Otherwise often too vague.
  - *Descriptive / Neutral* → Describes main "goal" of your study without revealing finding.
  - *Declarative / Statement* → States your main finding (often the strongest possible title).
    Word order: independent variable – a verb – dependent variable – [organism].
    E.g. "Ocular sparks enhance prey capture success [in a benthic fish]"
- Raise interest, e.g. by adding a catchy summary. (For example as a hanging title: "*Active photolocation confirmed: Ocular sparks enhance prey capture success*"). Avoid when the first few words are uniformative or even distracting (e.g.: "*The early bird catches the worm: new technologies for the Caenorhabditis elegans toolkit*").
- Avoid humoristic titles (usually, native speakers will not LOL ;-)). Papers with such titles have been found to be less cited, on average.
- Use keywords: Be aware of the key search terms that researchers in your field will look for. Add one or two to your title – Search engines weight title words particularly heavily.
- Remove waste words, e.g. "*A study of …*", "*Characterisation of …*", "*Investigation of …*".
- Avoid ambiguity. Be especially aware of using correct syntax.
- Avoid subjective qualifiers (e.g. "important", "novel"). They rather weaken the relevance of your study.
- Avoid initials, formulae, acronyms, and abbreviations (unless well-known and expected in your discipline, e.g. DNA, X-ray).
- Avoid species names (they make your study appear of narrow relevance, result in lower citation rates, and have been found to increase rejection rates).
- Aovid series titles across mutliple chapters / publications.
- Draft your title early, but critically revise it as your study or writing reaches an end.

Abstract

The Abstract will often be the only section of your paper that readers read. Therefore, write it very consciously and check it multiple times before submission. Your abstract must work **independent of your article**: a sloppy reader just browsing your abstract should be left with an unbiased and complete understanding of your core approach and findings!

A good Abstract is concise (typical length ~250 words, 5-10 sentences, check target journal for details), precise, but not detailed, and easy to read. Essentially, it is a miniature version of your paper. A good abstract has each of the following components (1[-2] sentences each):

- **Importance**: Scientific / conceptual context, why is this interesting?
- **State-of-the-art**: 1 sentence summarizing current literature status …
- **However, …**: … that directly leads you to identify the research niche you intend to fill, combined with your hypotheses / study goal(s).
- **"We are unique"**: Methods or study approach taken to tackle this open question.
- **… and found that**: Key findings
- **So what?** Interpretation of these findings (→ Hypothesis confirmed / rejected? What does this mean for your field of research? What is the major novelty?)

Avoid technical terms or complicated reasoning. Instead, make (repeated) use of the most relevant terms that researchers in your field will watch out for when using web-based search engines. Abstracts have NO references and NO hints to Tables or Figures. You may include results in the form of numbers, such as averages, or amounts by which something increases, decreases, changes, etc. Some journals want to have an Abstract with subsections (check your target journal).

Introduction

A well-structured Introduction chapter typically develops along **4 main stages**:

(1) **Context**: The general field of research.
(2) **State-of-the-art**: A brief overview of the most relevant and recent work in this research area.
(3) **Gap**: Derivation of relevant gaps of knowledge in this field
(4) **Aims + Approach**: Specification of your study aims or research hypotheses, potentially coupled with a short outline of the study approach (sometimes a "stage 5").

Stage 1: Grab the reader's interest!

Typically a single, short paragraph that places your study in the **broadest adequate context** in which your study can still make a *direct* contribution. Make sure your first sentence captures attention, and starts at a level that "informed people" (NOT only specialists in your field) can connect to. Typically starts with "general concepts/problems" and gradually becomes "more specific".
To provide context for the remainder of the Introduction, it helps if the last sentence of stage 1

already reveals the ***general* goal** of your study (not yet the specific research gap, see stage 3). Use present tense or present perfect, indicating that you address “established knowledge”. Add references where applicable. Here and throughout, make sure to clearly define any specialized terms and abbreviations you may use.

Example (dispersal as context, explanation of its importance, short indication of the “general gap” in the last sentence, and embedded definition of ‘dispersal distance’):

“**Dispersal** *plays a fundamental* **role in** *xxx (references). For many marine species, dispersal occurs during a planktonic larval phase, but the duration of this larval period can range from minutes to months depending on the species (reviewed by xxx). How exactly larval duration affects dispersal distance (***i.e.** *the geographical distance moved from the natal area),* **however**, *remains a topic of considerable interest and debate*.” [Mod. from David et al. 2010, Mar. Bio.].

Stage 2: Review the state-of-the-art

Select literature to justify your study, but restrict yourself to the first and/or most relevant and/or most recent evidence (see section on Literature). Provide readers with a **concise** and meaningful overview of what has already been done in this field and/or how researchers argue about your topic of interest. Restrict yourself to topics that are **directly relevant** to your study.

Slowly move from the general research area (stage 1) to the specific problem you address in your study, thus preparing your argumentation for stage 3.

Stage 3: Identify a research gap

This section justifies why it was worthwhile doing this study. Logically derive the “space” that you are going to occupy – your research niche – from your literature review in stage (2). Be aware that research gaps can come in several, mutually non-exclusive, forms:

i. a “real” **knowledge gap** covering a currently unanswered research question,
ii. the **continuation** of previous studies that you will take a (little) step further e.g. by exploring new species / methodologies / samples / explanatory factors / causal relationships etc.,
iii. **counter-claiming** where you develop a different view-point onto a topic that seems “established” in its field.

Use signal words as appropriate, e.g. “yet unclear”, “however”, “rarely”, “although”, “nevertheless”, “but few”, “remains unknown”. Focus on a single gap, only. You can open multiple gaps, but always **restrict yourself** to those you are actually working on – long lists of open questions that are later only partially treated raise unfulfilled expectations in your readers. Multiple research gaps will usually need repeated cycles through stages (2) and (3)

Example (showing how stage 2 and 3 can be combined to sequentially build up your specific research niche):

“[literature review]. *These aforementioned studies* **have focused on** *the relationship between dispersal and larval duration across species;* **however***, larval duration can vary within species as well. For example, …* [more literature review]. *This* ***prediction is topical*** *given …,* ***but*** *there have been* ***few empirical tests*** *in natural populations.* [review of these few tests and their findings]. *To our knowledge, Kelly and Eernisse (2007) conducted* **the only study to date** *that has tested whether within-species differences in dispersal or genetic structure vary by temperature or latitude. In this study, we tested for …* [this is the transition to stage 4]… [Mod. from David et al. 2010, Mar. Bio.].

Stage 4: Occupy that gap!

From stage 3, derive a clear definition of your research aims, so that they cover exactly the gap(s) you outlined above. This stage defines the **readers' expectation** for the rest of the paper. Be clear and specific. Where applicable, explicitly state your working hypothesis.
Depending on journal style and research field, this section may include, or be followed by, a short justification of the general paradigm used to test your hypothesis. This should make clear why your study approach offers a **solid, critical test** of the posed research question.

Drafting an Introduction

- Begin with stage 4. Use it to reversely construct the argument that you need to guide readers to exactly your study topic.
- Draft stage 3 next: the gap or need for further work.
- Move to stage 1: the setting. Remember to grab the attention of the reader!
- Stage 2 in the end. Make sure you have found all the *relevant* work in the area.
- Check that the context for every topic / concept that appears in later sections of your manuscript has been developed in the Introduction.

Do NOT …

- … attempt to review **all** the literature. Focus on **relevance** (see section on literature work).
- … mention **exceptions** unless they are of direct relevance to your central scope.
- … talk about problems/topics that are **not directly related** to your data.
- … mention the **results** of your manuscript (unless specifically requested by journal).
- … set out to **prove** or 'demonstrate' or 'proof', rather set out to test, document, describe, scrutinize, investigate!

Methods

This section pursues two main purposes: (a) allow your study to be **<u>repeated</u>**, and (b) convey **<u>trust</u>** in your data collection and analysis.

Content and structure

1. <u>Study organism (or subjects, or sites)</u>, sampling and maintenance
   - Focus on details that are *directly relevant* to your study. No full account of taxonomy, biology, etc.
   - Sampling sites / Collection site(s) where applicable
   - Selection criteria for the sampled population(s) and the sampled individuals (Why a suitable population? Representative subset of population? Genetic diversity? …)
   - Culture & maintenance conditions (light, T, feeding, breeding regime etc.)
   - Ethical considerations: refer to ethics permit or animal experimentation permit as required.

2. Experimental design / data collection
   - ➢ Typically start with a short summary of your experimental “paradigm”, i.e. the overall design. This provides context for the details you report in the following paragraphs.
   - ➢ Provide full detail of experimental / observational procedure(s), and explain how each contributes to reach your key study goal.
     → assures repeatability
     → provides justification and raises trust in your study.
   - ➢ Pilot studies? Only mention when relevant, e.g. to justify a novel method.
3. Measurements and calculations
   - ➢ Which variables were measured, and why (i.e., to answer which question?)
   - ➢ Measurement instruments: include manufacturer and model, calibration procedures and how measurements were made
   - ➢ Calculations / derived measurements: explain in detail
   - ➢ New method? → Describe in all detail!
   - ➢ Established method? → Concise summary + references, describe deviations.
4. Statistical analyses
   - ➢ Which statistical tests were used on which data and to evaluate which specific hypotheses? Be specific about test assumptions. Explain statistical analyses in detail when going beyond simple standard statistics.
   - ➢ Significance level (when deviating from classical $\alpha = 0.05$)
   - ➢ Typical numerical display (e.g., all values are given as mean ± SE or SD or CI)

Writing style

- Past tense | precise wording | passive voice more frequent than in other sections.
- Subheadings help structuring the information in studies with more complex designs, e.g. multiple experiments or extensive laboratory protocols.
- Consciously decide on the best possible order – not necessarily chronological!
- **Be detailed enough** so that a third person could repeat the experiment. Rule: ALL components that could potentially affect your measurements need to be mentioned:
  - o The type of pen you used to individually mark shells of your study organism? YES!
  - o The type of pen you used to note down your measurements? NO!
- Only include the Methods needed to obtain the data **relevant** to your main topic.
- **Explain** why you collected different data sets, or why you used a certain method. At all times, it must be clear how your methods connect to the central hypotheses outlined in the Introduction.
- Supplementary data that do not contribute to the main topic of the manuscript but that are needed to show what material was available for the “main” analysis can be added to the Methods.

Results

This is usually the **shortest** of all sections, in particular in experimental studies (exceptions in morphological / descriptive studies).

- Be **concise** and focus on the **key findings** that are needed to **solidly evaluate** the questions / hypotheses raised in the Introduction
- Objectively **describe** and briefly (!) **interpret** your data in the context of your questions / hypotheses. Do not draw conclusions or speculate (→ Discussion).
- Reporting **statistical** analyses:
  - Name (i) the test used, (ii) the statistic-value (e.g. *F* or *t* value), (iii) the degrees of freedom, and (iv) the *P*-value. When "P = 0.000", write P < 0.001.
  - Integrate statistics into tables or figure captions where possible to minimize numbers reported in the main text.
  - Round numbers to 2-3 relevant digits. Be consistent!
- (Chrono)logical order according to methods part, OR order from the most to the least important result.
- Typical elements of a Results section (in particular when reporting on multiple or more complex experiments or data collections):
  - *Brief* reminder of experiment: background | goal | approach
  - The actual Results (longest part).
  - *Brief* conclusion (usage is journal depending! Not every element has to be included).
  - Example: *"Experiment 3 applied a sequential choice test in order to assess whether this and that is true. We found that animals were more likely to do this and that under condition y (Fig. 3a, 1-way ANOVA $F_{1,17}$ = xx, P = xx), but no difference between treatment groups was visible under condition z (Fig. 3b, statistical results).* [maybe more results]. *In summary, the findings of experiment 3 are consistent with our hypothesis that […], but also highlight this and that divergence."*
- Writing style: **past tense**, simple and short sentences, avoid verbiage.
- Tables & Figures (general):
  - Avoid when content can be easily described in short text
    → No overly simplistic displays.
  - Don't make displays too complex and cluttered → consider splitting.
  - Displays + their caption must be completely understandable without the text.
- **Avoid** …
  - … describing novel experimental procedures here (→ Methods section).
  - …**redundancy**! Data presented in tables <u>or</u> graphs are <u>not repeated</u> in the text. Instead, the text should briefly draw the reader's attention to **overall** effects and patterns visible in your displays.
  - …references to literature.

Tables

- Preferential type of display if the focus is on **exact numbers**.
  - Your focus is on a trend/pattern? → use a Figure!
- The caption (placed above the Table) provides all detail to completely understand Table.
- Data are organized vertically (i.e., each **column** presents a single **type of data**), not horizontally (where a column may present different types of data).
- Text columns are aligned left, number columns right (or centred on the decimal point).
- Clear, open layout. Most journals only use (three) horizontal lines in tables. No vertical lines are used to separate columns.

Figures

- Preferential type of display if the focus is on **trends** or **patterns**.
  - Your focus is on exact numbers? → use a Table!
- Informative caption (see tables) placed below the figure. Add figure legend (describing colours, lines, symbols, etc.) if necessary.
- Axis-titles have to be brief, but complete. Look for the briefest (meaningful) expression you can think of. Always mention units (between brackets).
- Figure design:
  - The default figure design of a given software (e.g. Excel, JMP, R) is rarely particularly good for your specific purpose. Hence, some optimization of these graphics is almost always needed.
  - Prefer **vector** graphics over **bitmaps** given their higher quality and flexibility. This is often expected from the publishing journals and enhances quality of the printed version.
  - Figures are often reduced in size for printing. Hence, select large fonts for labels and titles or make the graph small. Avoid thin hairlines: they may become invisible in print.
  - Select axis-ranges as to avoid too much empty space.
  - Bar chart? Your y-axis must start at zero, or a broken axis makes restricted axis range clear to the reader.
  - Select distinct patterns, grey levels, or colours to distinguish between groups in the graph. Patterns (hatched or cross-hatched) are better than shades. The latter may become difficult to distinguish after photocopying.
  - Be prudent with colours. If used, they should be meaningful in terms of content!
  - Choose large and clearly distinct markers to differentiate groups.
  - Avoid 3D-graphics (unless there is a very good reason).
  - Be consistent in terms of pattern or colour throughout the text (e.g. white for females, black for males).

When showing mean values, always give the magnitude of variability, too (e.g. standard deviation, SE, CI)

Discussion

The Discussion serves to interpret your findings. It is crucial that this section follows a 'natural' logic along a transparent and clear scientific argumentation, as to convincingly reveal the relevance and implications of your findings. Note: Discussion sections can be quite short.

Discussions come in many different formats and orders. As a general rule, maintain an organisation **from specific to general**. Typical sections along this gradient are detailed below.

Note that a well-structured Discussion section essentially represents a **mirror-image** of your Introduction section (Fig. 1). This idea can greatly help to intitally **organize** the thoughts that you wish to address in your Discussion. It also illustrates that Discussion sections should typically NOT introduce novel concepts and ideas (expect perhaps towards the end), but rather **stick to the conceptual framework**, key words and terminology outlined in the Introduction.

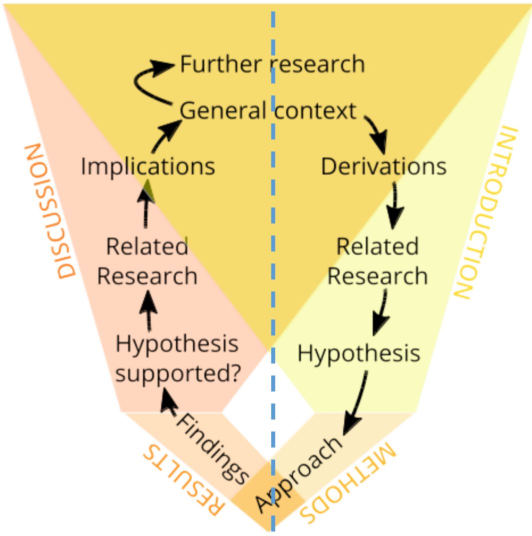


***Figure 1**: Schematic overview of a scientific publication (S. Yun-Christmann, mod. from R. Fritsch)*

Typical sections of a Discussion

- **Recap your CORE outcome**
  - Typically a single paragraph providing context for the Discussion:

    (a) Statement of **core** findings (very condensed, 1 to 3 sentences),
    NO repetition of results section, just "main patterns".
    Can include a very brief reminder of your experimental design.

    (b) Assessment of your core **research hypotheses** / questions in the light of these core findings (data consistent / inconsistent with predicted pattern?).
    Again: very short!

- **Interpret your findings**
  - Typically (by far) the longest section. Organize either by research hypotheses/questions, or along specific findings. You may repeatedly cycle through the following components if appropriate.
  - Classical components (applicability may vary with type of study, and components may be integrated in a single paragraph):

    (a) More detailed evaluation of research **hypotheses** in the light of your data:
    Which aspects are consistent / inconsistent / surprising / inconclusive?
    How do you evaluate alternative / competing hypotheses?
    Always clearly explain your logic.

    (b) **Biological** interpretation: What can you infer for your study system?

(c) **Methodological** interpretation: Identify components of your study design that may have introduced unwanted biases in your data. Make sure this is not just a "list of limitations", but you evaluate clearly why, and in which way, each one may, or may not, have had unwanted effects (= **systematic biases**!) on your conclusions.

(d) **Literature** context: If other studies provide findings in a similar context, identify consistent, but also the conflicting findings. Provide informed and founded arguments as to why different datasets may disagree (e.g., differences in the biological setting? Differences in methodology?).

- **Limitations**
  - If not integrated in (2c), a separate section can treat exceptions, unsettled points, unexpected findings, and potential weaknesses in your study design. Explicitly addressing such aspects is an important component of good scientific practice. It enhances trust in your scientific approach.
  - As in (2c) consciously assess and argue to what extent any limitation may have adversely affected (= systematically biased) your findings.
  - Avoid apologetic tone
  - Trust your results if your study design has been carefully developed

- **Implications and Relevance**
  - Many Discussions end with a "Conclusion", even though the paragraph is often not explicitly labelled.
  - Explain how your study contributes to the **general research context** that you outlined in the Introduction section. Your contribution can, for example, be conceptual, methodological, in terms of scientific knowledge, or applied.
  - Which are the next logical steps following your discoveries? (Optional. If so: very short! Don't add a long list of tiny bits and pieces, rather one or two major next steps or remaining knowledge gaps).

Acknowledgements

Your choice. Usually all the people who commented on the ms are acknowledged, as well as the technical assistance etc. who cooperated. Do not forget to mention funding agencies (e.g. the DFG plus the relevant funding ID) when your project was supported by external sources.

Citations & References

- **When** to cite? Scientific texts are essentially a sequence of "statements". EACH statement needs support. This support usually comes from the literature, so cite the relevant source(s). *Exceptions* (= no literature reference needed):
  - statement reflects YOUR original idea, OR
  - statement is supported by YOUR data (then refer to e.g. Fig./Table), OR

- statement reflects “common knowledge”. Note: almost *nothing* is common enough knowledge to need no reference – so avoid!

- **Avoid plagiarism**: Read papers carefully, take notes, and <u>always</u> keep track of the connection between your thoughts and their original source. To avoid “sentence copying”, (i) <u>paraphrase</u> statements <u>without</u> looking at the original source and then (ii) return to the original paper and assure your statement correctly reflects the message intended in its source.
- Focus on the **most relevant** references. Sources are relevant, for example, when …
    - they develop and idea / concept for the *first time*, OR
    - they provide the first, or *particularly compelling*, evidence, OR
    - they represent the *most recent* development or status in the field.
- Avoid long lists of “minor” papers that *also* confirm established findings, unless this concerns the very core of your study topic (where you may want to be “complete” and briefly review “everything” that has been done so far).
- Prefer **primary** literature!
    - ***Secondary literature*** (= review articles) is OK for the general context of your study or smaller “side-kicks” – here you cite the overarching pattern as derived in the cited review paper. Do <u>not</u> use review articles to extract specific results from studies listed there – instead, trace the original paper.
    - ***Tertiary literature*** (e.g. unpublished reports, theses, websites, …) does not represent a valid scientific source. Exceptions are acceptable when this is truly the only place where a certain idea or finding is described (often the case when you refer to prior knowledge on your study system that has been established by recent BSc/MSc-students in your research group).
- **Consistency 1:** Text ⬄ Bibliography
  ALL references mentioned in the text are contained in the bibliography.
  ALL references listed in the bibliography are referred to in the text.
  This is facilitated by using standard ***bibliography software*** (e.g., EndNote). Even then, though, check your references carefully, in particular their formatting style.
- **Consistency 2**: in-text format
  In-text citations follow a single <u>consistent</u> format. Check with your supervisor or the target journal regarding formatting rules.
    - Life Sciences almost universally use the ***Author-year format***, e.g.
        - … blabla … (Baur & Chen 1990, 1992, Aronsen 1994).
        - … blabla … (Baur and Chen, 1990,1992; Aronsen *et al.*, 1994).
    - AVOID ***number formats***. (… blabla[1,2-5]). This style of some top-ranking journals is usually not acceptable for theses.
    - “*et al.*“ is typically used for references with more than 2 authors and replaces all authors but the first.
    - Multiple citations (***citation lists***) are typically ordered by publication year (oldest first), not alphabetically.
- **Consistency 3**: Bibliography format
  There is no universal rule how to format bibliography entries (preference varies with journal or supervisor). Always, however, adhere to the following two rules:
    - Be <u>consistent</u> with the format you chose.
    - Make sure all references contain <u>full information</u> that others need to trace exactly this publication. For example, journal references require (i) all authors, (ii) publication year, (iii) Title, (iv) Journal name, (v) Journal volume, (vi) pages [sometimes replaced by paper number, or digital object identifier *doi*]

- **Text flow** and references: Prefer ***information prominent*** style (Text tells a "biological story" and references are added in brackets, often at the end of a sentence) over ***author prominent*** style (Text tells a "story of what authors believe and find", sentences typically start with mentioning the reference). Use the latter wisely, for example to sketch the historical development of an idea, or an ongoing debate in your field.
- **Copying sources.** It is a general requirement that you have personally read all sources that you cite. Sometimes, you may fail to access a specific, often old, but particularly relevant source (e.g. Müller 1962). If so, you can cite its relevant findings as reported in other papers (e.g. in Mayer 2007). This source copying must become transparent, e.g.: "blabla (Müller 1962, as cited in Mayer 2007)". Only Mayer 2007 is added to your list of references.
- **Internet sources**: Avoid! If necessary, locate and provide
    - an author/responsible institution,
    - a website title,
    - the URL (even better: a permalink, if available – e.g. in Wikipedia),
    - your date of access.
    - To infer the "date of last update" for the information you look at, consider using Website Carbon Dating (http://cd.cs.odu.edu/).

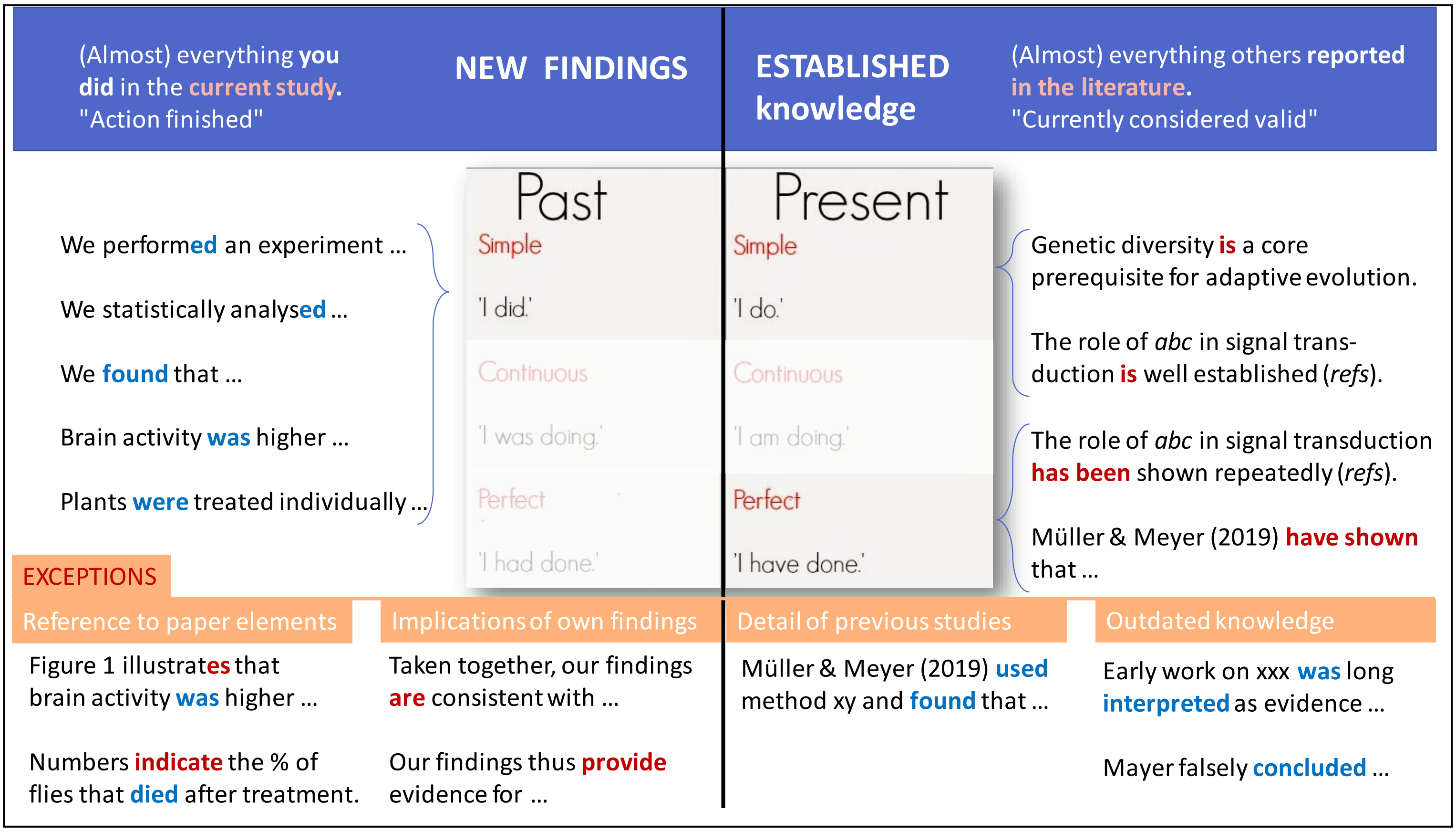
Style 1: Tense and voice

Why pay attention to tense and voice? They …

- … contribute to the impression you leave in terms of academic soundness and seriosity,
- … convey relevant information: tense → time + "scientific establishment", voice → focus.

Tense

Rule-of-thumb: Methods and results of your current study are (almost exclusively) presented in the *past tense*, while established (= published = "currently true") knowledge is typically reported in the *present (perfect) tense*. Exceptions apply, as briefly summarized in the graphical display below:



Voice

For English scientific texts, there is a clear preference for the **active voice**. Many journals explicitly ask for it. It increases clarity about the subject of a sentence. Moreover, active voice clearly highlights that the writer(s) take responsibility for their study. Passive voice can be used at appropriate places, but use it reluctantly.

Active: Subject (*doer*) + Verb + Direct Object
Passive: Subject (*receiver*) + Verb + Past Participle + by + Indirect Object (*doer*)

Advantages of Active Voice

- *Immediacy*: straightforward, explicit, nothing hidden, avoids ambiguous statements.
- *Conciseness*: fewer words for same content.
- *Responsibility*: Emphasises the "biological actor", or the "responsible authors".

Use passive voice when …

- … the actor is unknown or irrelevant.
- … you want to emphasize the object acted upon, or the action.
  (A story about bees? → "*Bees pollinate flowers*".
  A story about flowers? → "*Flowers are pollinated by bees*")
- You are talking about generally accepted knowledge.
- You want to avoid repeating "we" at the beginning of every sentence (Methods section!).

Style 2: Structure and flow

Good structure and flow is achieved when implicit **reader expectations** are fulfilled. This has direct consequences for a suitable sentence as well as paragraph structure.

Sentence structure

- Subject and verbs:
  - Have **verbs close to their subject** (no more than 10 words). Applies also to other modifiers (adverbs and adjectives), keep them close to the word they are modifiying.
  - Have your verb describe the action. (***What** did they do?*)
  - Have the subject be the actor. (***Who/What** is the sentence about?*)
- Sentences have a beginning (**topic position**) and an end (**stress position**).
  - *Topic position*: what the sentence is about. This should be "old information", i.e. common knowledge or information introduced before (typically in the previous sentence), links backwards and prepares for upcoming material.
  - *Stress position*: "exciting" information → material at this position is automatically emphasized. This is typically "new" information, representing *closure and fulfillment* of the sentence. Have only a single (maybe two) piece(s) of new information per sentence!
  - A sentence without old information probably lacks connection to the previous sentence, impeding flow and leaving a logic gap. Generate this connection, either by adding old information or by adding a sentence to provide the missing link.
- Before going through a list of topics, provide context so that the reader knows what the list is about. (E.g.: *Previous research has identified three mechanisms of active sensing. First,* [explain mechanism 1 in detail]. *Second,* [mech. 2]. *Third,* [mech. 3]).

Paragraph structure

1) Topic sentence → States the topic and connects to previous paragraph
2) 2-4 sentences about the stated topic → examples, more details, implications, arguments, discussions,...
3) Last sentence → Conclusion, connection to next paragraph

Paragraphs should typically treat just **a single** well defined **topic**. This topic should then consistently form your subject, and be mentioned in the topic position of (nearly all) sentences. Do not forcefully change the subject because you don´t want to use the same word again, it only confuses the reader.

Alternatively, you may build up a **logic** along a sequence of topics. Then make sure they follow a linear argumentation (A *implies* B. B *implies* C. C *implies* D. etc.), and "hand over" the sentence subjects accordingly. Connectives help, e.g. "therefore", "on the one hand … on the other hand ...", "however", "(al)though", "yet", "despite", "whereas", "consequently", "as a result ..." … but use them correctly!

Of course, these two types of paragrahps can also be mixed.

Further guidance (strongly recommended):

Gopen & Swan: The Science of Scientific Writing

Writing Paragraphs – Scientific Writing Center UNC college

Writing style 3: Clarity in Scientific Writing

Scientific writing aims at absolutely minimizing ambiguity, and thus any potential source for confusion or misunderstandings in the reader. English offers some particular pitfalls in which certain sentence constructions can easily generate (at least partially) misleading meanings. At best, this leaves your reader wondering for a moment, and he/she can then identify the true meaing from the context (still being a bit annoyed about imprecise language). At worst, this leads a reader to entirely misunderstand what you try to say.

The following four topics refer to grammatical issues that lead to such situations where the meaning of a sentence can drastically change if constructed in the wrong way.

- Refer to the lecture slides for more detail on each topic!

Pronoun referents

Example: "Light can penetrate the tissue and reach the optic nerve. **Here**, part of **it** can get trapped …"

The second sentence has 2 ambigous pronouns: "Here" can refer to either "the tissue" or "the optic nerve". "it" can refer to either "light" or "the tissue" or "the optic nerve".

Reforumlate such sentences to remove any ambiguity, e.g. be repeating the referent.

Solution: "Light can penetrate the tissue and reach the optic nerve. **Some of the light** can get trapped **in the optic nerve** …"

Dangling participles

Participle constructions should always be avoided in scientific writing. They often tend to generate confusion, because it is unclear which noun they are actually modifying (and usually they modify the wrong noun).

Example: "*After **doubling** nitrogen concentration, **plants** showed a 4-fold increase in growth.*"

Here, the participle refers to plants, which is wrong. Instead, it should refer to "the researchers".

Solution: "*After **we doubled** nitrogen concentration, plants showed a 4-fold increase in growth.*"

Generic and specific articles

See decision rules in lecture slides: When to use none, a generic ("a", "an"), or a specific ("the") article.

Which and that

- "… **, which** …" introduces non-restrictive clauses: They add **extra** information to a noun that **can** be omitted without changing the meanging of the sentence.

  Example: "*Treatment plants**, which** received extra nitrogen**,** grew larger than control plants.*"

- "… **that** …" introduces restrictive clauses: They add **specific** information to a noun that **cannot** be omitted.

Example: “Treatment plants **that** received extra nitrogen grew larger than control plants […, while treatment plants that received extra phosphorous did not]”

Things to avoid

An entirely incomplete and subjective list of this to avoid ;-)

Topic	“No go”	Better
• Colloquial language	We **got** 5 measures … Size **got** bigger … We **did** this experiment ...	We **obtained/received** … Size increased … We carried out/conducted
• Contractions	Plants **didn’t** …”	Plants **did not** …
• Impressive words	elucidate, utilize	show, use
• Imprecise words	very, quite , sort of, ….	specific numbers
• Wordiness	in a careful manner owning to the fact that the vast majority of	carefully, because most
• Superfluous words	Note that, so-called, basically, in terms of…	
• Personal judgment	hopefully, easily, obviously, luckily, unfortunately	
• Repetitions	the one and only	the only

- Incomplete sentences
- Incoherent orders, e.g. name hypotheses 1, 2, 3, but then explain them in sequence 2,1,3
- Words of unknown meaning: It may be tempting to use online dictionaries to find alternative or “more elegant” expressions for a given word. Avoid unless you know the term is used in a correct context.

Formalities

- Consistent punctuation, (. , ; : ? !), avoid semicolons.
- Consistent use of italics, underlining, roman or Arabic numerals, abbreviations, ….
- Space: NEVER a space before, but ALWAYS exactly ONE space after ; , . : ?) }]
- Avoid unwanted line breaks by using **non-breaking spaces** (*Ctrl* + *Shift* + *space*) or **non-breaking hyphens** (*Ctrl* + *Shift* + “-“), e.g. between values and their unit (“10 km”, “1.7 kg”)
- Single-digit numbers (0 - 9) typically in words, multi-digit numbers (10 and above) in numerals.
- Write years in full: 1994, not 94. 1990s, not 90s.
- Use appropriate (international) **date formats**:
  December 6, 1996 = US style.
  6 December 1996 = British style.
  Months often abbreviated to the first 3 characters (Jan / Feb / Mar …).
- Use appropriate (international) **time formats**:
  24 h standard HH:MM(:SS), with or without colon. Avoid a.m. and p.m.. E.g. “… at 9:00”, “… no later than 13:27”, “… until 2100”

- Time / date information is (almost) always placed at the end, not the beginning of a sentence.
- Restrict abbreviations / acronmys to very well-establihsed ones, e.g: days = d, hours = h, litres = l, molar = M, …
- Consciously (and critically) check the suggestions of your spell and grammar checker – and make sure it is consistently set to either US English or UK English.
- **Decimal point** (NOT comma) is consistent throughout your text, tables and figures. Most easily achieved by setting your computer to English date and time formats.

Some useful sources with specific hints on do's and don'ts in scientific writing

- The Writing Center – Univ. North Carolina at Chapel Hill: https://writingcenter.unc.edu/tips-and-tools/
- Academic Phrasebank – Univ. of Manchester: http://www.phrasebank.manchester.ac.uk
- Tischler, M.E. (o.J.): The Scientific Writing Booklet. URL: https://cbc.arizona.edu/sites/cbc.arizona.edu/files/marc/Sci-Writing.pdf

Manuscript Submission

Authorship

- Authorship and its order should be jointly decided by all putative authors. Do this EARLY.
- Every listed author must have made substantial contributions.
- Each author takes full responsibility for the paper content.
- The first author is ideally responsible for the experiment, data collection and writing.
- Ph.D. students should be first authors on most papers they produce in their thesis. Supervisors will usually be senior authors.
- Most journals today require an author contribution statement!

Selecting the journal

- Aims and scope: good match with your study topic!
- Where others publish: assures you reach your target audience.
- Impact factor: May help to assess "reputation" within your field. But don't overemphasise. Journal impact factor is a poor predictor of paper quality and impact. When targeting a top journal, send a presubmission inquiry to assess their interest.

Submission

- Follow the journal guidelines as closely as possible, e.g. with respect to …
    - Text formatting rules and maximum word count.
    - Bibliography style
    - Expected file types (Main text as *.pdf, *.doc, *.tex, …?)

- Acceptable file formats, layout and resolution for (photo)graphs?)
    - Editorial board (who will likely evaluate your manuscript?)
    - The time frame of the reviewing and publishing process
- Always add page numbers **and** line numbers (reviewers hate missing line numbers!)

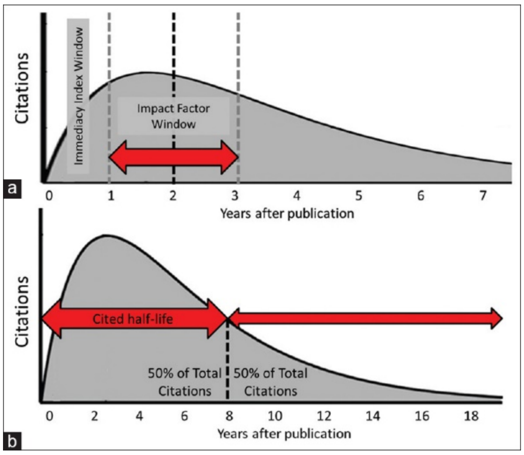
Journal and researcher metrics

Journal Impact Factor (JIF)

- Attempts to measure productivity and citation impact of a **journal** (not of authors!).
- Is calculated annually, using data from the last three years: JIF = C/A
  C = number of citations of articles (years X and Y) in year Z
  A = articles published in year X and Y
- Only compare journals from the same field because smaller fields naturally have smaller impact factors because of less citations.
- Differences among fields cannot logically depend on any aspect or research quality at all! Even within a singel discipline, it is difficult to make a generalization or comparison across different subjects!
- JIF favours journals with high review article percentage because those are often cited.
- Treat JIF with care, it can only give you a rough idea.

Journal Immediacy Index

- Number of citations to articles in the year with respect to the number of articles published in that year.
- Measure of how rapidly the average article in a journal is used.



Journal Cited Half-Life

- Number of publication years from the current year that account for 50% of citations received by the journal.
- Measure of longevity of use the average article.

Hirsch-Index (h-index)

- Attempts to measure the productivity and impact of an **author**.
- h = 6 → author has at least published 6 papers which were each cited at least 6 times.
- Producing many poor papers which are not often cited will not raise the h-index. Producing one paper that is cited often will also not raise the h-index. Only consistent output and citations can raise the factor. The h-index cannot sink, it takes into consideration all publications produced by the author.
- Since it cannot easily be skewed by a single well-cited paper or a large number of poorly cited papers, the h-factor is considered to be more stable.
- Only compare scientists who are at the same stage in their professional lives; “new” scientists who simply did not have the time to publish yet, cannot have high h-indices.
- Also treat with care.

Useful links

- Open Researcher and Contributor ID (***ORCiD***): https://orcid.org
  → Register of unique researcher identities
- ***ResearcherID***: http://www.researcherid.com
  → Identifier system for scientific authors (by Thomson Reuters)
- Directory of Open Access Journals (***DOAJ***): https://doaj.org
  → A community-curated online directory that indexes and provides access to high quality, open access, peer-reviewed journals
- **Open Access Publishing Fund of the University of Tübingen** (funded by the DFG): http://www.ub.uni-tuebingen.de/forschen-publizieren/open-access-publikationsfonds.html
- ***bioRxiv***: http://biorxiv.org
  → Pre-print server for manuscripts of biological scineces
- **Dryad**: http://datadryad.org
  → Currated general-purpose data respiratory. Required by an increasing number of jorunals

The manuscript reviewing process

Step I: Initial Editorial Evaluation

- After submission, the manuscript will be assigned to an editor who will handle it throughout the review process.
- Editor reads the manuscript and evaluates if it is ready for review.
- If mandatory requirements are followed, the paper will be sent out for review.
- If requirements are not followed (e. g. formatting is not in style of journal) the manuscript will be rejected and not sent out for review.

Step II: External Peer Review

- Editors invite reviewers to cover technical and conceptual aspects and screen for potential conflicts of interests.
- Editors insure that process is finished in a timely and constructive manner.
- Editors gather feedback from reviewers and send it out to authors.

Step III: The Decision

- Editors evaluate the reviews and make a decision on the manuscript.
- The decision (acceptance, invitation to revise, rejection) will be communicated with a letter stating how to proceed next.