

## TYPES OF SCIENTIFIC PAPER



# Crash course on Scientific Writing

- Contents needed for this course
- General guidelines on writing a good paper

Criteria	Expected content	Grade					
		1	2	3	4	5	6
Mission statement (weight = 10%)	Goal(s), Mission and Science Objectives	Goal, Mission and Objectives are not mentioned	Goal, Mission and Objectives are very vague or unclear	Goal, Mission and Objectives are mentioned but are not SMART	Goal, Mission and Objectives are SMART	Clearly flow down from one another. That is, the Goal includes the overall objective, the Mission details how those objectives will be met and the Mission and necessary Objectives show what should be done for the mission.	Goal, Mission and Objectives flow down clearly from overall requirements and then further details. Efforts have been made to show how the goal, mission and objectives compare to other similar missions.
	Stakeholders	No mention is made of stakeholders	A vague mention of stakeholders is made	Some stakeholders are mentioned, but not the most important ones, or not in an adequate way	The key stakeholders and actors are summarized and flow down into the requirements	The key stakeholders and actors are listed, and their needs are well distinguished from one another and flow down into the requirements	The students show a simple stakeholder value network (SVN) to indicate the interactions between stakeholders. This can be done through a small Risk & Stake Diagram or in a box format.
Mission design (weight = 10%)	CONOPS	CONOPS is not mentioned	CONOPS is unclear or vaguely discussed	Only some aspects of the CONOPS are mentioned	The CONOPS is discussed, with a list of key parameters or with a small vehicle, launch sequence etc.	The CONOPS is sufficiently detailed, showing that the mission is well designed and controlled	The CONOPS flows well from the Mission Statement. The different mission elements are well explained along with their main actions and driving/operational constraints.
	Project Timeline	The project timeline is not discussed	The project timeline is unclear or not well thought through	The project timeline is clear, but does not make the link with any of the system engineering phases (Phase A to E) discussed in class	A clear project timeline is given, from the actual design phase to the end of life	The project timeline is acceptable and realistic. Where needed, links are made with the risk assessment	The students make an effort to make the CONOPS clearly easy to understand, without overcomplicating the diagrams. The students make the link with the stakeholders and actors.
Systems engineering (weight = 15%)	End-of-Life (EOL) Strategy	No EOL considerations were made or discussed	The EOL is not clearly shown	The EOL considerations are included	The EOL strategy is logical and feasible	The EOL strategy follows from a tradeoff between technical considerations and sustainable practices	The students look beyond the current project limits and give an indication on extension or follow-up projects
	Functionality analysis	The functionality analysis is not mentioned	A vague functionality analysis is shown or mentioned	The functionality analysis of the space mission is not presented clearly	The discussed mission's functionality follows from the Mission Statement	The mission's functionality flows from an adequate functional breakdown	The students highlight what the technical implications, risks and sustainability advantages are of the EOL strategy
Mission engineering (weight = 15%)	Mission requirements	The requirements are not mentioned	A vague functionality analysis is shown or mentioned	Some key requirements are mentioned, but they are not clear on the correct way or clearly such a mission	The key requirements are given and are well defined. They are written in the correct way (i.e. using the verb "shall" and using an ID)	The key requirements are SMART. The link with the functional breakdown is clear. A good reasoning for them is shown	The students show a good reflection of the requirements. That is, the students highlight the requirements which show the design the most and their associated risks are discussed if relevant
	Mission constraints and limitations (environment)	Mission constraints and limitations are not discussed	A very vague discussion of mission constraints due to the spacecraft's environment is given	Any mission constraints and limitations are given and linked to the spacecraft's environment	Clear research on the spacecraft environment is presented in the table that has been shown. The overall mission constraints and limitations have been defined from them	The listed mission constraints and limitations flow into the requirements and the table	The students make it clear how the environmental constraints are addressed in the mission design
Mission Architecture (weight = 10%)	Mission success criteria and measures of success	No success criteria or measures of success are mentioned	Unclear what the mission success criteria are or how the system is to be measured	Mission success criteria are clearly mentioned and logical	Mission success criteria and measures of success are SMART and logical	The mission success criteria are clearly reflected in the requirements	The mission success criteria and measures of success are clearly linked to the CONOPS. Mission success criteria are given, in the secondary mission success criteria are given, in the primary system level
	Interface analysis	No interface analysis is done	A vague or rushed interface analysis is shown	The interface of few subsystems are analyzed	An analysis is done of the most important interfaces between subsystems. This is done in a list form or using block such as a design structure matrix (DSM)	The effect of the interface is discussed. Where relevant, risks associated with subsystems interfaces are discussed	It is clearly shown that requirements have been derived from the interface analysis and how they influenced the design
Risk assessment	Alternative conceptual solutions	No alternative conceptual solutions are mentioned	One or more alternative conceptual solutions are mentioned	One or more alternative conceptual designs are presented. No clear rationale is given on them or they are only applied retroactively	One or more alternative conceptual designs are presented. A clear rationale is given on them or they are only applied retroactively	It is clear that a trade-off was performed between both conceptual solutions, using at least one of the trade-off methods given in the lecture	A preliminary, yet more detailed, study of one of the most promising alternative conceptual solutions is shown. The tradeoff between the alternative conceptual and the chosen concept has also been clearly shown
	Budgets	No budgets have been shown or mentioned	Some budgets have been shown without further explanation	Budgets have been shown, but they are not quantified well	The most relevant budget has been shown and is well quantified	More than one relevant budget breakdowns are given, showing how the budget was composed. The breakdown is logical and based on research	The budgets are linked to the overall systems engineering process (requirements, etc). Some budget margins are shown and discussed. The technical implications of the most critical budgets are mentioned
Spacecraft configuration	Risk assessment	No risk assessment has been made	A vague risk assessment has been done	A clear risk assessment has been made	The risk assessment is well explained and uses systems engineering methodology with clear inputs for similar/unique values	The risk assessment methodology is chosen wisely, ensuring that the most relevant and high risk items are covered	Mitigation is proposed for the most critical risks
	Payload components	No payload has been mentioned	Some payload has been mentioned in a very vague and unclear way	The types of payloads needed for the mission and how they will fit the mission's function are mentioned	The types of payloads needed and specific on some of the payload types is given (e.g. a wide comparison with existing payloads, some requirements, etc)	Budgets for key payloads are given. Where possible, some comparative payloads are used as a point of reference	Details are given on the operations and configuration of the spacecraft's subsystems, during the most critical mission phases. This is also done from the requirements
Baseline Design (weight = 35%)	Thermal subsystem	No information on the spacecraft's thermal subsystem is given	Only some information on the spacecraft's thermal subsystem is given	The information provided on the thermal subsystem is vague or is missing key elements	All relevant information on the thermal subsystem is discussed. Most are detailed	The thermal subsystem is sized and the relevant characteristics are highlighted following a more detailed analysis. The subsystem is compliant to the high-level requirements	It is clear that the thermal subsystem was sized and the relevant characteristics are highlighted following a more detailed analysis. The subsystem is compliant to the high-level requirements
	Propulsion and ACS	No information on the spacecraft's propulsion and ACS is given	Only some information on the spacecraft's propulsion and ACS is given	The information provided on the propulsion and ACS is vague or is missing key elements	All relevant information on the propulsion and ACS is discussed. Most are detailed	The propulsion and ACS subsystems are sized and the relevant characteristics are highlighted following a more detailed analysis. The subsystem is compliant to the high-level requirements	It is clear that the propulsion and ACS subsystems were sized and the relevant characteristics are highlighted following a more detailed analysis. The subsystem is compliant to the high-level requirements
Scientific Writing skills (weight = 20%)	CDH (Command and Data Handling)	No information on the spacecraft's CDH subsystem is given	Only some information on the spacecraft's CDH subsystem is given	The information provided on the CDH subsystem is vague or is missing key elements	All relevant information on the CDH is discussed. Most are detailed	The CDH subsystem is sized and the relevant characteristics are highlighted following a more detailed analysis. The subsystem is compliant to the high-level requirements	It is clear that the CDH subsystem was sized and the relevant characteristics are highlighted following a more detailed analysis. The subsystem is compliant to the high-level requirements
	Structural and mechanical	No effort is made to show the structure or mechanical characteristics	The students only provide a vague description of the structure and mechanisms	Some aspects of the structure and mechanisms are detailed	The key aspects of the structural components are mentioned, including single points of failure, where logical, students highlight risks and risk mitigation	The key aspects of the structural components are mentioned, including single points of failure, where logical, students highlight risks and risk mitigation	The students go in depth on some relevant aspects of the spacecraft's structure and mechanisms, including single points of failure, where logical, students highlight risks and risk mitigation
Telecom and Ground Segment	Launch Segment	No effort is made to discuss the launch segment	The students only provide a vague description of the launch segment	Some aspects of the launch segment are detailed	The launch segment is discussed in sufficient detail	The key requirements for the launch segment are discussed, along with the requirements for the spacecraft due to the launch system (launcher and ground station)	The students go in depth on the effect of the launch segment on the spacecraft. Some details of the launch segment are discussed and it is shown how they relate to the spacecraft's design and/or the development (testing & validation requirements)
	Telecom and Ground Segment	No effort is made to discuss the ground segment	The students only provide a vague description of the ground segment	Some aspects of the ground segment are detailed	The ground segment is discussed in sufficient detail	The key design drivers for the ground segment are discussed and linked with requirements	The students go in depth on the link budget and ground station requirements based on calculations and literature. It is clear that some trade-offs were performed
Scientific Writing skills (weight = 20%)	Structure and content	The paper is not subdivided in any sections, according to relevant to the field	All the basic elements of a typical academic paper are provided. Depending on the topic of the paper, these are: introduction, literature review, discussion, conclusion and future work	Only the abstract, introduction and conclusion are clearly indicated. There is no structure given in the content of the text (e.g. the methodology and results or discussion on future work)	The aim, importance and novelty of the research topic is clear and the conclusions are logical. The content is structured logically, with all the necessary evidence and including sub-sections to discuss. The paper clearly goes from a broad perspective at the beginning, to a more narrow discussion on the topic of the research, followed by a breakdown of the discussion again at the end	Particular attention is put into the figures and tables and their captions. They are readable without needing pointing to or using lengthy phrases (e.g., a link to the figure's text area). The captions enable an understanding of the figures and tables on their own. The students make sure to cite the title, list of authors and provide their names and titles. The list of authors should be complete, with the corresponding author(s) indicated and the affiliation mentioned	The students put effort in making their figures accessible and clear. This includes, where possible, using graphic columns or columns of different heights, use of symbols (with associated legends/abbreviations). Equations are used, all symbols are explained and the formulas are presented clearly
	Respect of scientific paper guidelines	The paper does not follow any scientific writing guidelines	All paper guidelines are respected	Most guidelines are respected, but they are applied inconsistently throughout the paper	The general guidelines for the paper are respected throughout the paper. The paper is well structured	Some sources are used. Some articles cited are peer-reviewed. Some websites cited are credible (e.g. IEEE, NASA documents are authoritative). Only credible evidence is used for data points, where relevant, where necessary of the original source is given when paraphrasing. In such case, the source is provided	Most sources are recent (within the last 10 years) and so on. Where IEEE and NASA documents are used, the date of access is mentioned. Only credible evidence is used for data points, where relevant, where necessary of the original source is given when paraphrasing. In such case, the source is provided
Scientific Writing skills (weight = 20%)	Citations and quality of sources	The paper does not include any sources	Sources are included, but some do not support the statements for which they are cited	Sources are included but their formatting is not consistent or it is not clear how to find the original source material	Sufficient sources are included to support the statements in the paper. The reliability of the bibliography is consistent across sources	Most sources are recent (within the last 10 years) and so on. Where IEEE and NASA documents are used, the date of access is mentioned. Only credible evidence is used for data points, where relevant, where necessary of the original source is given when paraphrasing. In such case, the source is provided	Most sources are recent (within the last 10 years) and so on. Where IEEE and NASA documents are used, the date of access is mentioned. Only credible evidence is used for data points, where relevant, where necessary of the original source is given when paraphrasing. In such case, the source is provided

The grade is calculated by rounding to the nearest quarter the outcome of the following formula:  
 Final Grade = 10% \* AVERAGE(Mission Statement expected content grade) + 10% \* AVERAGE(Mission Design expected content grade) + 10% \* AVERAGE(Mission Architecture expected content grade) + 35% \* AVERAGE(Baseline Design expected content grade) + 20% \* AVERAGE(Scientific Writing Skills expected content grade)

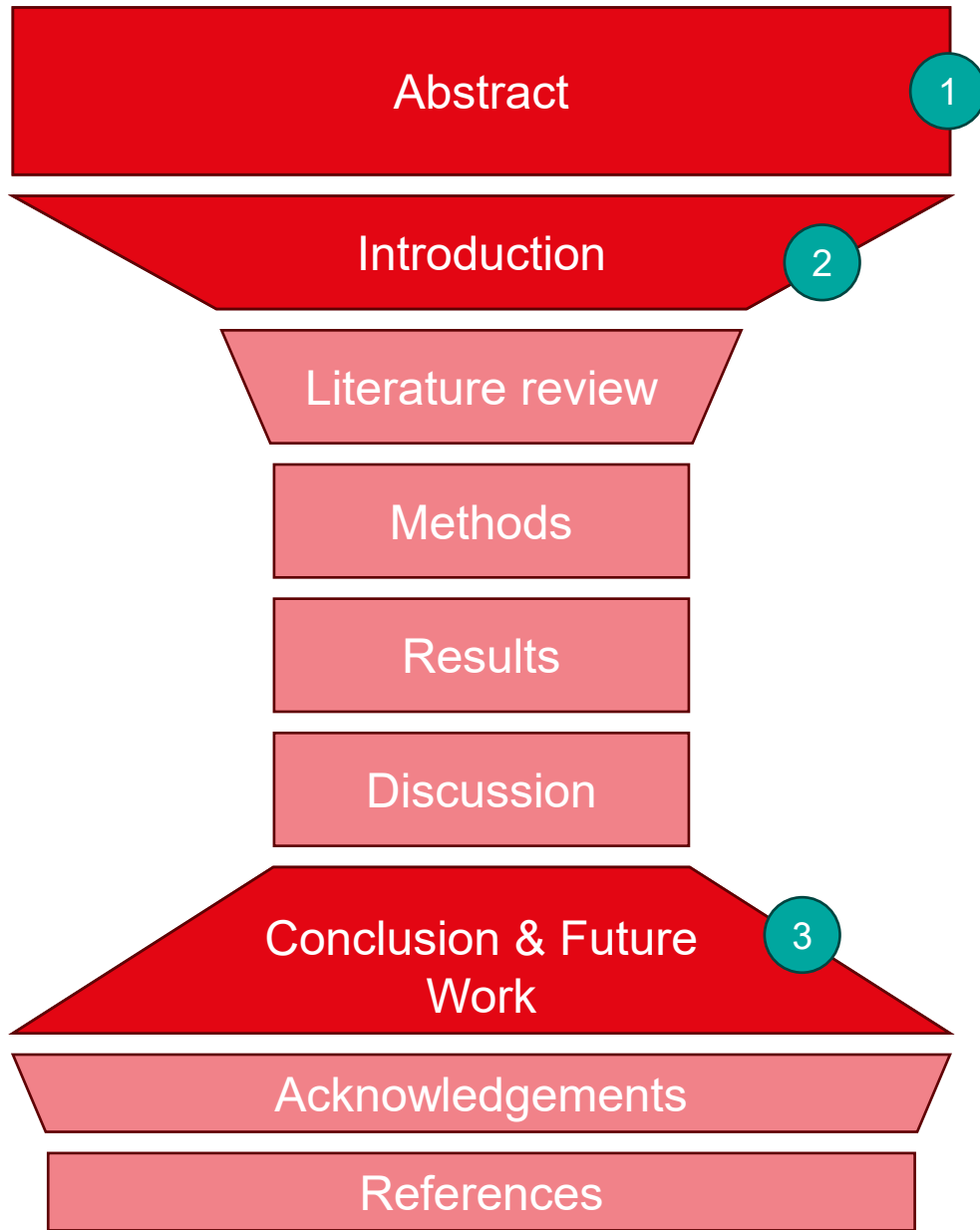
All the content items should be in the paper

But, if written in this exact order, you are writing a report.

Scientific paper is structured differently...

It is difficult to get a grade of 6/6 for each item. They are ment to indicate exceptional work

Think wisely where you put in most effort



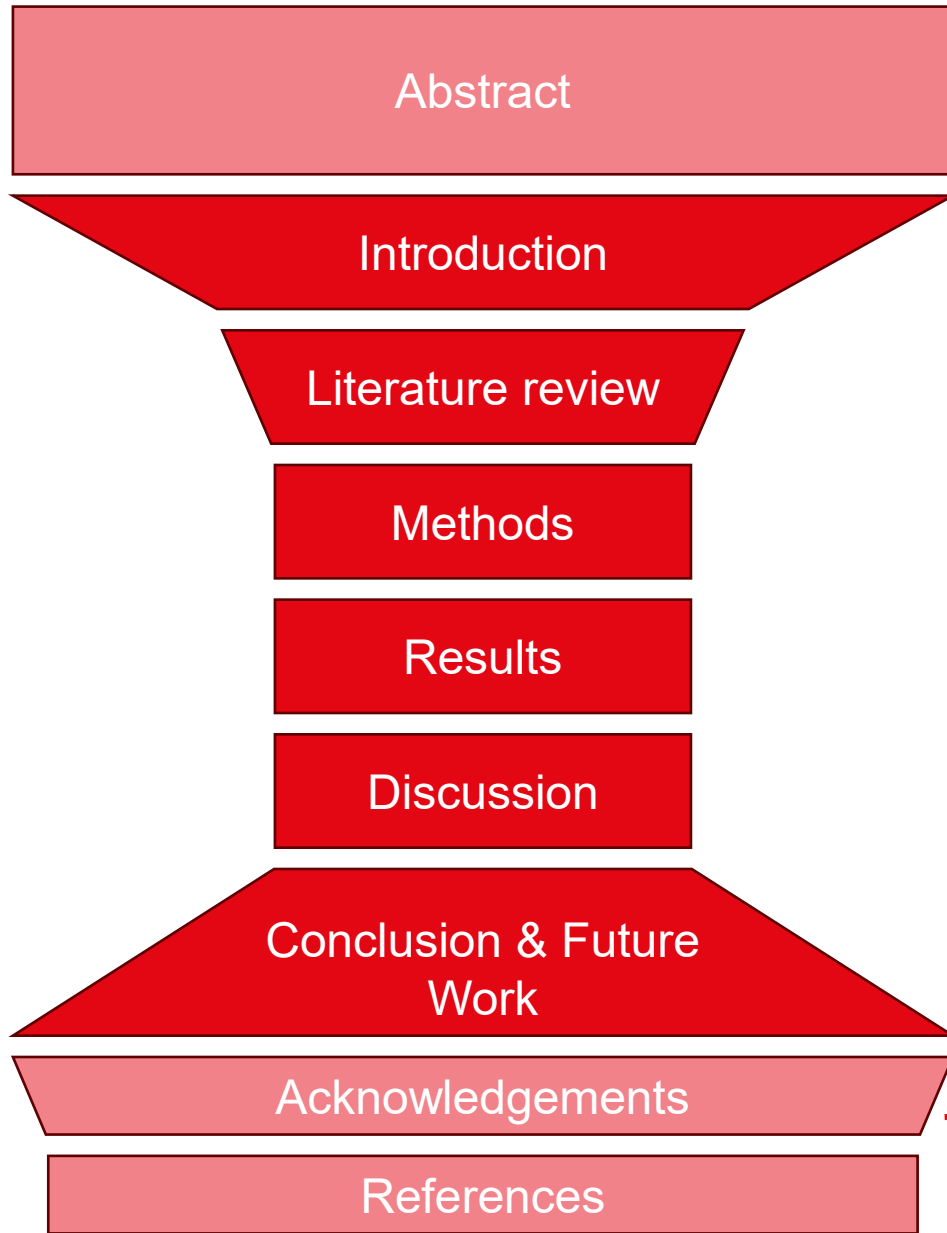
# Typical paper structure

How do you read a paper when you have little time?

Think about what this means for your paper!

- The abstract should be stand-alone and to-the-point
- The introduction should be clear
- The conclusion should enable you to understand the contents.

# Typical paper structure

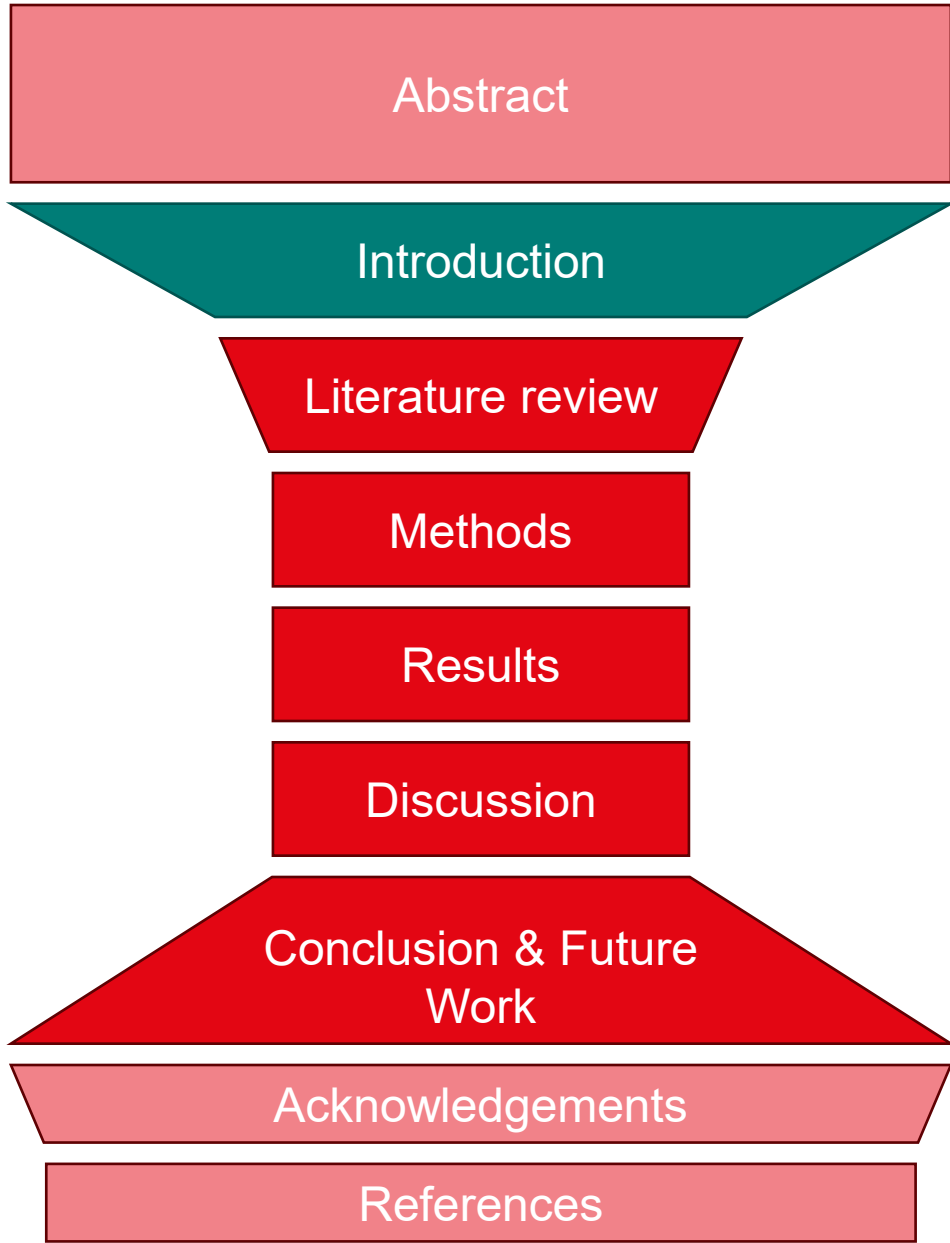


- Goal: Explain what the paper is about and show important results
- Content: All sections (more or less) very concisely and precisely (with numbers if possible)
- Should be understandable on its own

Core of the paper.

Let's discuss this in more detail...

- To indicate any financial supports (to show that it does (not) influence the research conclusions)
- To thank stakeholders or co-researchers



# WHY?

- Reason for the research

- Background information
- Problem
- Importance

- Aim of the research

- Main question
- Procedure

- Description of the paper's structure

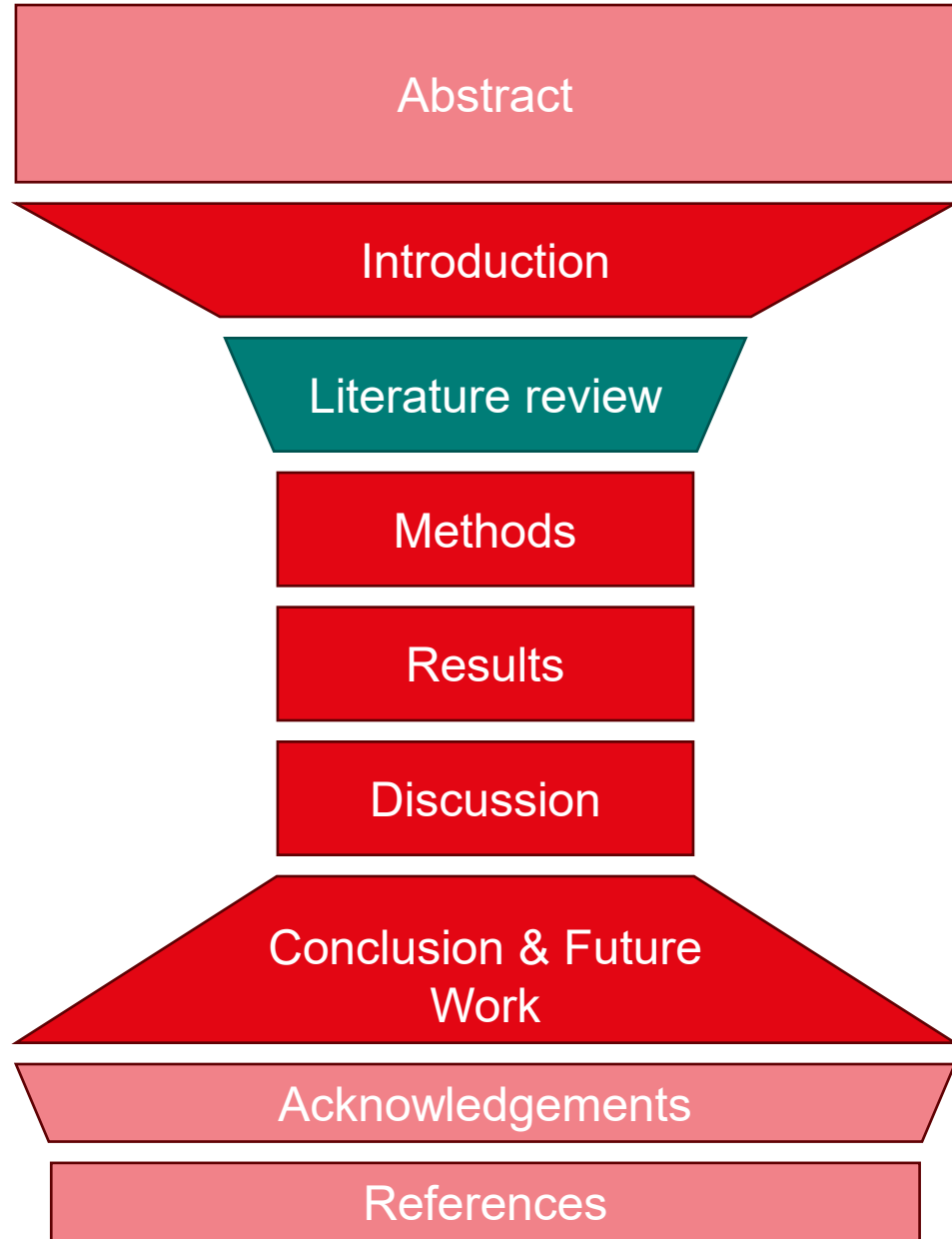
*"In the past decade, much research was focused on [...]"*

*"It remains unclear why [...]"*

*"The purpose of this study is to [...]"*

*"To do this, a preliminary system engineering approach was followed, focusing on [...]"*

*"This paper discusses [...] in the first section, followed by [...] in the second section"*



# WHY?

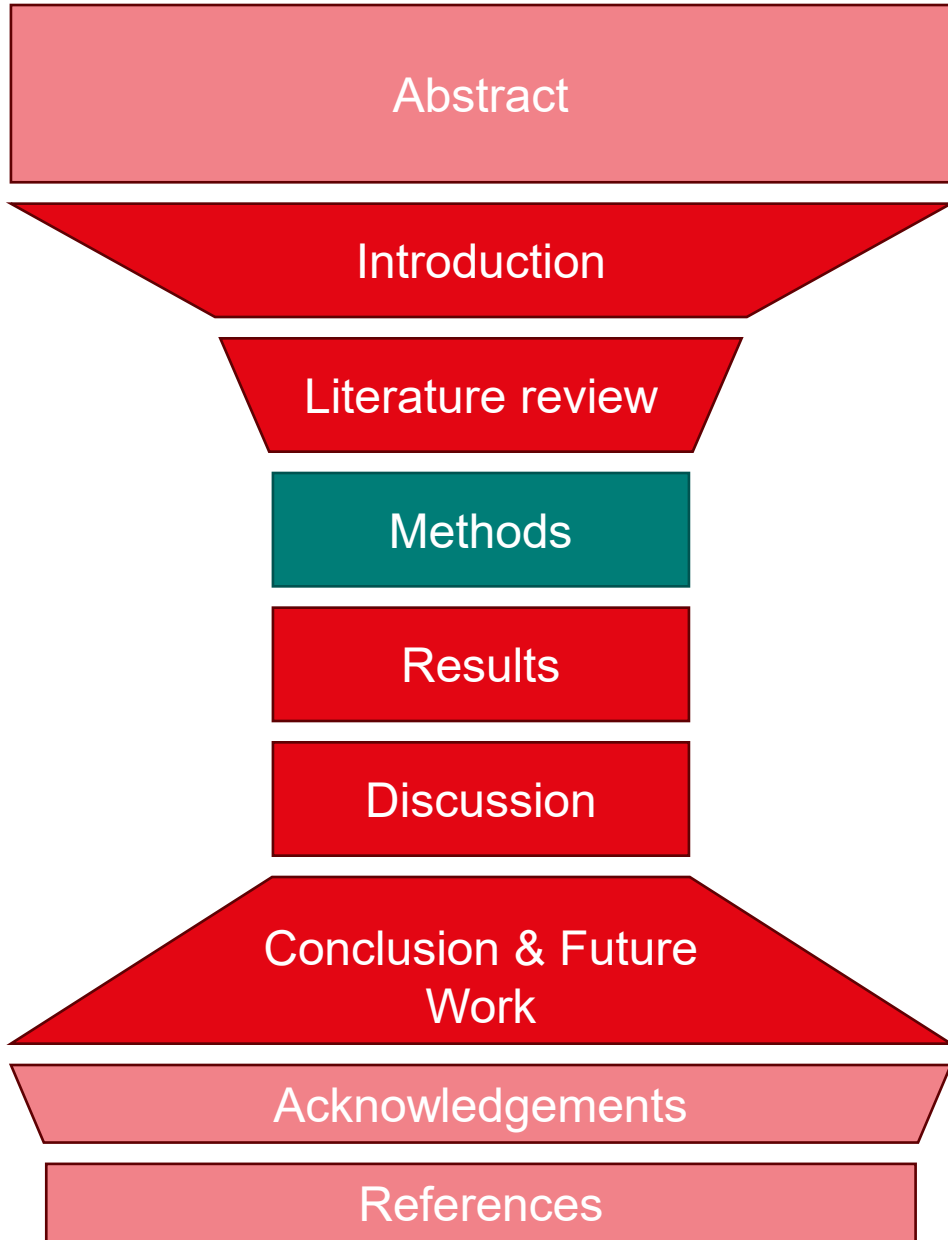
- Highlight the past work on the subject
- Inform the reader on what is already known and (more importantly) what knowledge gaps still exist
- Opportunity to further make the case for your paper

## Tips:

- Cite recent work (at most 10 years old) to stay relevant
- Paraphrase and combine sources where possible

## Important:

- Do not copy-paste words, findings, figures, tables!
- This is plagiarism
- If paraphrasing or modification if not possible: indicate where you got it from (quotation marks, mention from which source a figure was modified, etc)



# HOW?

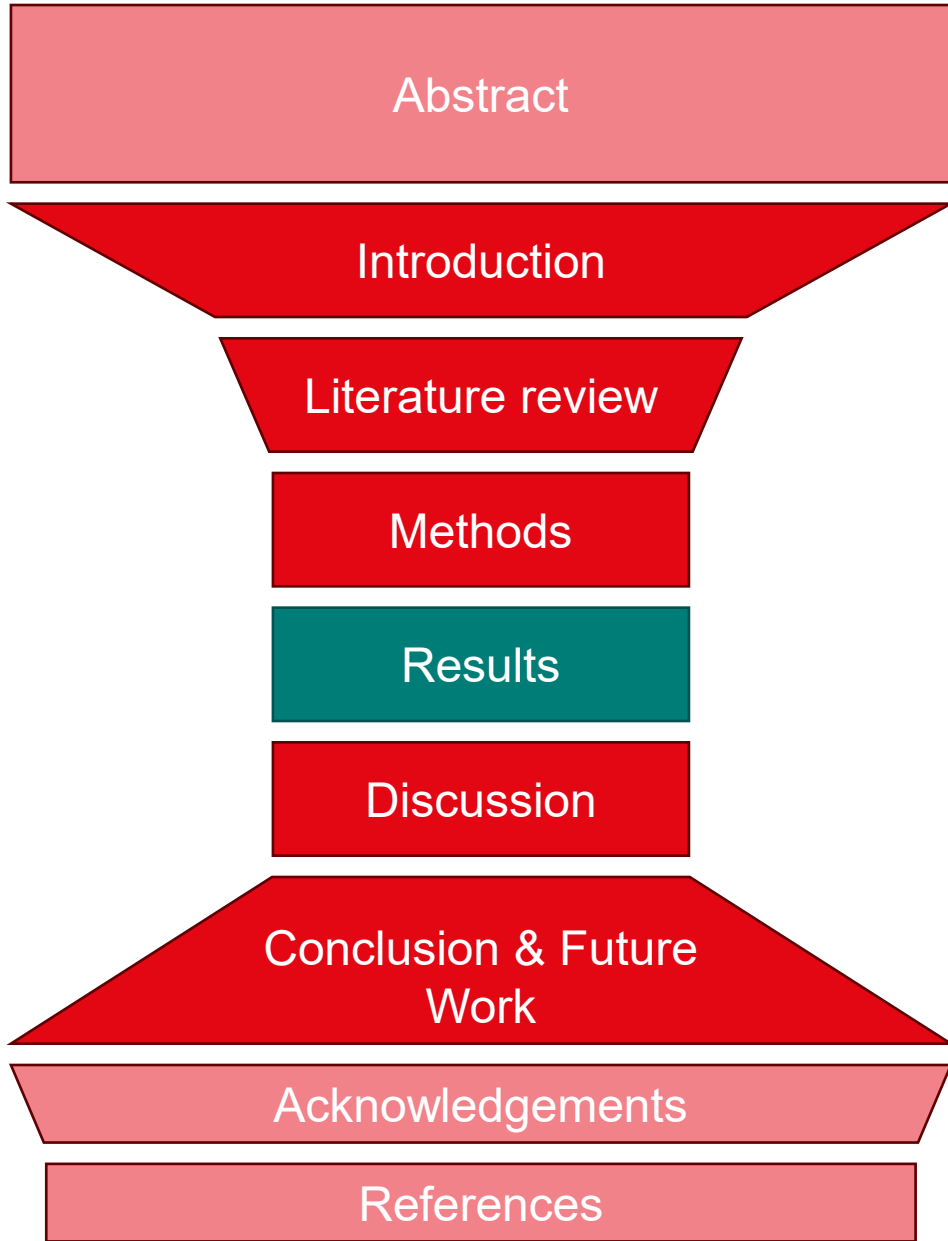
- Discuss the process of data collection and calculations
- Inform on how the data analysis or any calculation was done
- If any stakeholders are involved (for data collection etc), mention them

*“The data used for this study were collected from [...]”*

*“Following the initial calculation methodology by [...], it was found that iterations were needed for [...]”*

## Tips:

- Do not show any results here already
- You may mention any iterations you needed to do after your first calculations

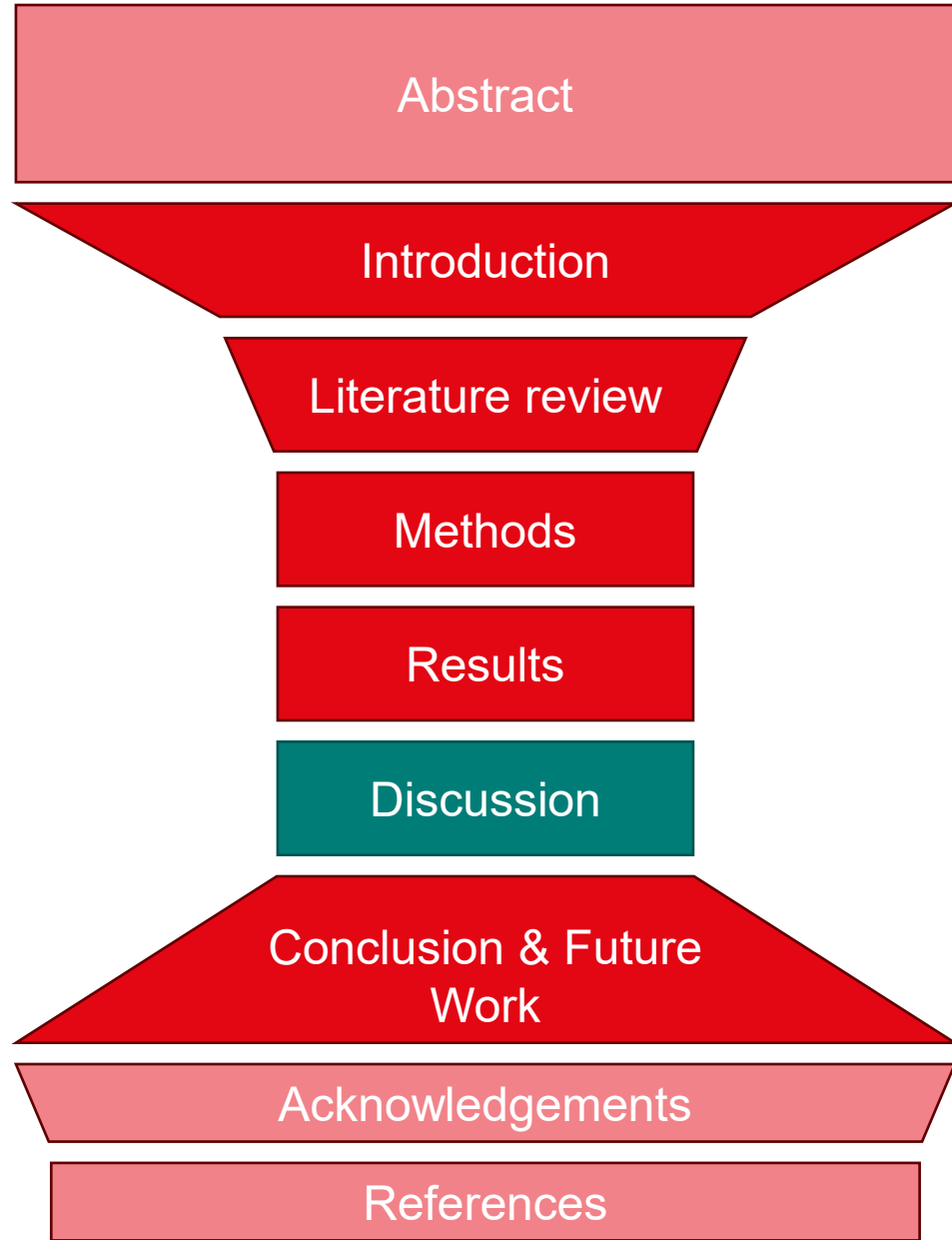


# WHAT?

- Show the results concisely and clearly
- Be as factual as possible
- Include figures or tables where useful.
- Describe your results

## Tips:

- The results should flow logically from the methodology discussed in the section above
- It is tempting to begin discussing the results in this section already, however: keep that as much as possible for the discussion! This helps with the reading experience (for a reader with little time)
- A figure often conveys more than a 1000 words ever could...
- Avoid repetitions: no need to re-explain the methodology for example.



# WHAT?

- This is the place to hone in on interesting results
- Highlight any unusual finding or underline the aspects you find most relevant
- Possibility to compare findings with that of other research (see literature review)
- Discuss any limitation of the research

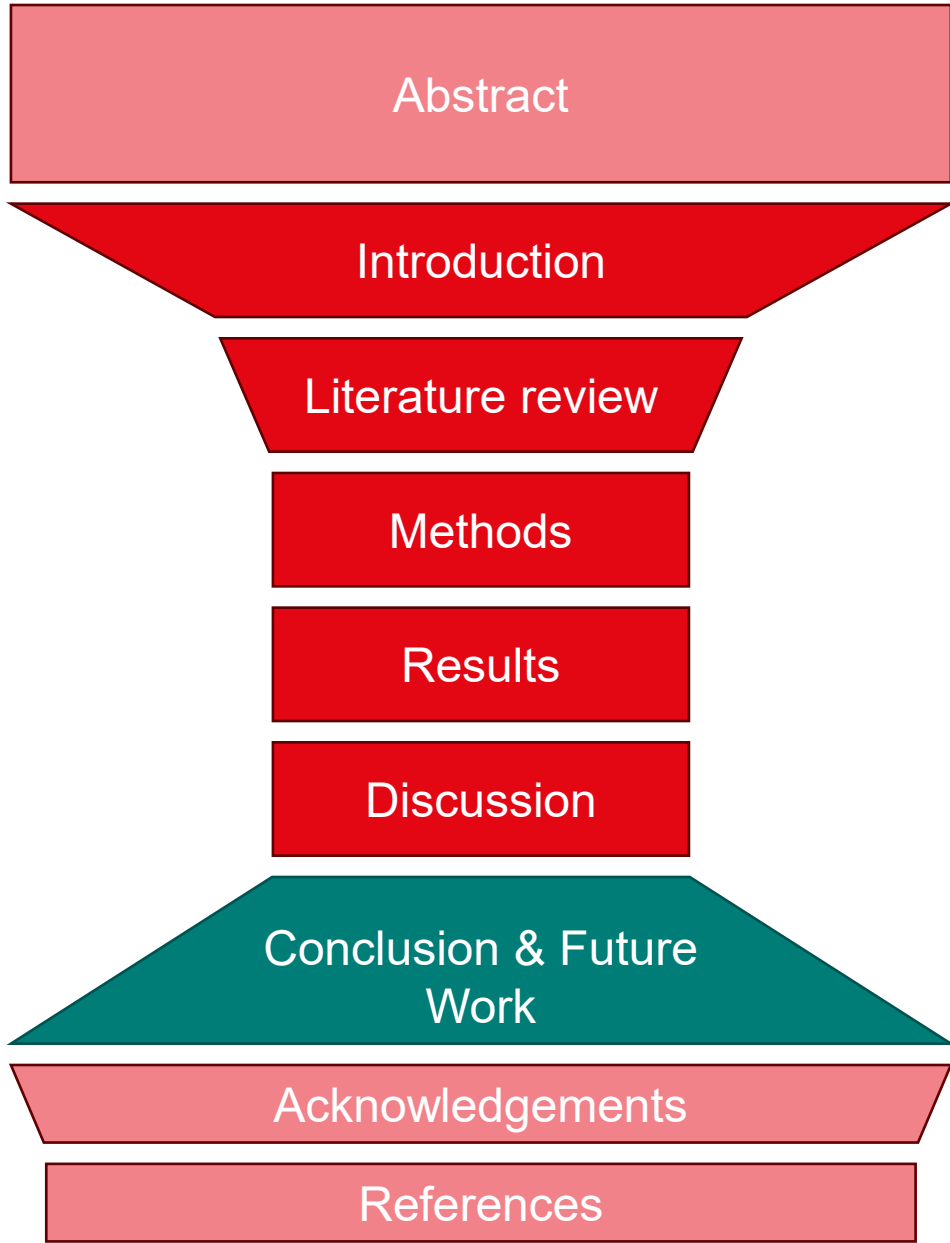
*“The results shown above are particularly relevant for [...] because [...]”*

*“The reader should note that the above results are in stark contrast with literature, which can be explained by [...]”*

*“The findings shown in the section above highlight the necessity for more work because [...]”*

## Tips:

- This section is really for you to play with!
- Contents are highly dependent on the paper's subject and results.



# SO WHAT?

- Provide an answer to the research question
- Describe what next actions (if any) should be taken to further the research
- Open up the discussion and bring it back into the bigger context

*“This paper discussed [...] in order to fill the gap in knowledge on [...]”*

*“It was shown that [...]”*

*“Most notably, this aspect of the results stands out because [...]”*

*“This research adds to the ongoing work to [...]”*

*“More work must be done in the field of [...] to [...]”*

## Important:

- Conclusion should be understandable on its own
- It should follow directly from previous sections → NO NEW INFORMATION!
- Be as accurate as possible: add key numbers etc

Abstract

Introduction

Literature review

Methods

Results

Discussion

Conclusion & Future  
Work

Acknowledgements

References

## How to write it efficiently?

- Prepare everything (results, tables, figures etc)
- Start from the contents (methods, results, discussion)
- Then, move to the introduction and conclusions
- In the meantime: Abstract can be drafted
- Check your references at the end.

Key tip from former teacher of this course:

- Do not be a perfectionist! Just write, then edit.

Note: see this year's grading rubric for the final requirements for the Scientific Writing Skills

	GRADE	1	2	3	4	5	6
Scientific Writing skills (weight = 20%)	Structure and content	The paper is not subdivided in any sections, providing no structure to the text.	Not all elements of a typical structure of an academic paper are visible	Only the abstract, introduction and conclusion are clearly indicated. There is no structure given to the content of the work (e.g. the methodology and results) or discussion, or future work	All the basic elements of a typical academic paper are provided. Depending on the topic of the paper, these are: the abstract, introduction, content (structured as deemed logical in e.g. literature review, methodology and results), discussion, conclusion and future work. The paper clearly goes from a broad perspective at the beginning, to a more narrow discussion on the topic of the research, followed by a broadening of the discussion again at the end.	The aim, importance and novelty of the research is clear and the conclusions are logical. The content is structured logically, with all the necessary sections and including sub-sections for better readability. The structure of the paper is introduced concisely in the introduction and any substructure of a section is introduced briefly at the start of said section.	The text is split up logically in paragraphs. Efforts is put into clearly indicating the contents of the paragraph through its first sentence. The readers can thus know at a quick glance what to expect in each paragraph. Titles of subsections are chosen to speed up the clearly indicate the contents in order to speed up the reading. The Abstract can be read as a completely stand-alone text, including a brief summary of the introduction, the paper's content and conclusions. If relevant, the most essential paper's conclusions are quantified in the abstract. For readers with little time, the introduction and the conclusions should provide enough information to understand the paper.
	Respect of scientific paper guidelines	The paper does not follow any scientific writing guidelines	Not all paper guidelines are respected	Most guidelines are respected, but they are applied inconsistently throughout the paper	The general guidelines for the paper are respected throughout the paper. The page limit is respected.	Particular attention is put into the figures and tables and their captions. They are readable without needing zooming in or using reading glasses (e.i. a font size close to the paper's font size). The captions enable an understanding of the figures and tables on their own. The students have put care into the title, list of authors and possible headers and footers. The list of authors should be complete, with the corresponding author(s) indicated and the affiliated institutions.	The students put effort in making their figures accessible to all. This includes, where possible, to use grayscale colours or colours of different brightnesses, use of symbols (with associated legends) and annotations. If equations are used: all symbols are explained and the formulas are presented clearly.
	Citations and quality of sources	The paper does not include any sources	Sources are included, but some do not support the statements for which they are cited	Sources are included but their formatting is either inconsistent, or do not allow one to find the original source material	Sufficient sources are included to support the statements in the paper. The formatting of the bibliography is consistent across sources.	Some sources are recent. Some articles cited are peer-reviewed. Some websites cited are credible. It is clear when statements are paraphrased or directly quoted. Quotations marks are used for direct quotations, while rephrasing of the original quote is done when paraphrasing. In each case, the source is provided.	Most sources are recent (within the last 10 years) and up to date. When URL (not DOI links) are added, the date of last access is mentioned. All websites used as sources are authoritative. Any popular knowledge sources or general (less trustworthy) websites are acknowledged as such in the text. Most sources are peer-reviewed articles

# More info:



Info on figures, citations and more (also on presentations)!

See in Moodle

General > Course Resources > Scientific Writing help material > "2023.12.11 Moodle – Communication.pdf"



Info on requirements for each section, the quality of figures and writing paragraphs

Scans have been placed on Moodle

General > Course Resources > Scientific Writing help material > Writing for readers with little time