HOW TO READ A SCIENTIFIC PAPER IN BIOMEDICAL SCIENCES

Jinane EL-Hage · Emilio Alarcón

LET'S GO!

How to Read a Scientific Paper in Biomedical Sciences

Author:
Jinane EL-Hage, MSc(c), BSc
Emilio I. Alarcón, PhD

Editor:
Irene Guzman Soto, PhD

Graphic Designer & Illustrator:
Dania El Khatib

Collaborators:
Bryan Liu, BSc (Candidate)
Ryan Tu, BSc (Candidate)

Sponsors:
University of Ottawa
University of Ottawa Heart Institute

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Land Acknowledgment

This book was written at the University of Ottawa Heart Institute, situated in the ancestral, unceded, and unsurrendered lands of the Algonquin Anishinaabe people, who are the guardians of these lands.

The authors and everyone involved in the writing and design of this book acknowledge the Algonquin Anishinaabe People's governance of this land and their enduring stewardship since time immemorial.

The authors also recognize the need to accept and address the harms and mistakes of the past and present inflicted by the systems of oppression on Indigenous people in Turtle Island and around the globe.

This book was created as an open-access educational tool as a humble way to honor the Indigenous people in Turtle Island who have shared, and continue to share, their knowledge with settlers.

"Otter and Fish" by Jared Tait

This painting shows references to the water and stars.
These spirits hold a strong connection to Anishinaabe beliefs and our land.

Jinane EL-Hage

Jinane EL-Hage is a Master's student in the Division of Cardiac Surgery at the University of Ottawa Heart Institute, pursuing a MSc in Biochemistry at the Faculty of Medicine, University of Ottawa. Recognized for her commitment to research and progress in materials science and regenerative medicine, she has been awarded both the NSERC USRA and CIHR CGS-M awards. Jinane is also deeply passionate about science communication, which led her to partake in hosting and producing episodes on Beats Research Radio, where she interviews scientists across various fields sharing their discoveries in a way that is clear and engaging for the community. Beyond her academic pursuits, Jinane actively contributes to rural communities around Ottawa, teaching STEM to Indigenous and rural students. She brings a student-centered approach to these lessons, aiming to make STEM engaging, relevant, and accessible by hands-on activities and drawing real-life connections.

Dr. Emilio I. Alarcón

Dr. Emilio I. Alarcón is Scientist in the Division of Cardiac Surgery at the University of Ottawa Heart Institute and Associate Professor at the Faculty of Medicine at University of Ottawa (www.beatsresearch.com). He is also the Director of CREATE-INTBIOTECH (www.intbiotech.ca). Dr. Alarcón has received several awards including uOttawa's Biomedical Researcher of the Year; Nano-Ontario Outstanding Early Career Researcher in Nanotechnology, Ontario's Early Researcher Award, the Canadian Biomaterials Society's Early Career Researcher Award, and recently accepted into the Royal Society of Canada's College of New Scholars. Dr. Alarcón has published over 100 peer-reviewed articles, trained +100 students in his laboratory, and taught +5,000 as a university professor. At University of Ottawa, Dr. Alarcón teaches Science Communication and podcasting (www.beatsresearch.com/Radio.php).

Dedication

Jinane EL-Hage dedicates this book first and foremost to the loving memory of her grandmother, Hikmat EL-Hage, whose brilliance and compassion continue to light her path. In a time when few women pursued education in Lebanon, she stood as one of just three women in a class of forty pursuing medicine. As a pediatrician, she not only dedicated her practice to healing but offered care without bounds and often at no charge. She was her greatest inspiration and dearest friend.

Jinane EL-Hage also dedicates this book to her parents, Samir and Rowaida, whose unwavering support has been the foundation upon which all her dreams stand. Your belief in her has been her greatest gift, and for that, she is eternally grateful.

Dr. Alarcón would like to dedicate this book to his wife, Madleen, for showing him that love is the best teaching tool an educator can use. Dr. Alarcón humbly dedicates this book to the loving memory of his mentor Dr. Eduardo Lissi Gervaso, who devoted his life to science, education, and social justice. His legacy will forever live in those who believe there is no social justice without equal access to education.

Above all, the authors dedicate this book to every student with a curious mind, striving for knowledge in challenging environments, often unseen by a world that turns a blind eye. You are the driving force behind this book. It is for you that the authors commit to creating open resources, hoping that this book serves as a step toward bridging the gap and ensuring equal access for all. Your hunger for learning will not be overshadowed by the barriers of circumstance!

PROLOGUE

Navigating scientific literature can be an overwhelming experience, especially for students encountering research papers for the first time. Many find themselves lost in unfamiliar technical terms, inevitable science jargon, dense information, and the complex structure of scientific papers. Amid the twists and turns of this challenging process, students are often unsure how to distill and extract core messages or even connect findings to broader scientific discussions. Beyond the built-in complexity of the papers themselves, the field of science often fails to consider other important challenges. These include excessive jargon, language limitations, cultural variations in cognition, and other factors related to readability (how clear and simple to read a text is) that might further impede comprehension.

We live in an age where information is readily available at the click of a button, yet it remains mostly inaccessible due to a lack of formal instruction in reading and interpreting scientific literature from our educational institutions. The ability to effectively read, interpret, and communicate scientific knowledge is more important than ever in today's world. While resources that combine case-study training with foundational content extraction and summarizing techniques are crucial for improving reading comprehension, there is not a one-size-fits-all pedagogical approach to tackle this issue. This book was created to help address these needs, providing a clear and structured guide for students in fields requiring critical engagement with scientific literature.

The tools presented in this book have been piloted in a mandatory science communication course for undergraduate students of the Faculty of Medicine at the University of Ottawa. As the goal of this is to equip students with valuable tools to effectively convey scientific concepts to non-experts and the public, an integral part of the course is that students need to face the challenges of critically analyzing multiple scientific papers. Even though other activities of this course, such as interviewing an expert scientist

and producing a podcast in lay language, are key for sharpening their scientific communication skills, the reading process is the most critical part of this learning exercise. Students must understand each study's strengths and limitations to accurately craft thoughtful interviews and structure an engaging podcast (some examples are presented at: https://www.buzzsprout.com/591520).

With an interdisciplinary approach, the present Open Educational Resource (OER) builds on case studies and open-access peer-reviewed publications from our team to guide students through key strategies for accurately identifying critical sections of research papers, preparing meaningful summaries, and articulating insightful questions for further discussion. Unlike other resources that focus solely on medical journals, this book provides strategies applicable across disciplines, reflecting on the interdisciplinary nature of today's scientific inquiries.

Additionally, this book compares ChatGPT-generated summaries with student examples generated using our guide. This comparison offers a learning opportunity for students to recognize the limitations of generative artificial intelligence in summarizing scientific papers and understand the importance of human insight in scientific interpretation.

CONTENTS

INTRODUCTION

Have you ever wondered about what happens in our **BRAINS** when we **READ**? How do we **PROCESS** and **ENCODE** information? More importantly, how do we **TRULY UNDERSTAND** what we read?

How often have you found yourself LOST in a complex scientific paper, rereading the same paragraph for several minutes to comprehend it?

Students in fields of Science, Technology, Engineering, and Mathematics (STEM) and biomedical sciences usually need to read hundreds of papers annually.

We have all experienced the frustration of repeatedly reading scientific text without understanding it. Not only individuals in STEM face this challenge; it can also affect the general public whenever they are interested in reading scientific papers.

Most scientific or clinical peer-review papers are exclusively intended for experts and not the general public!

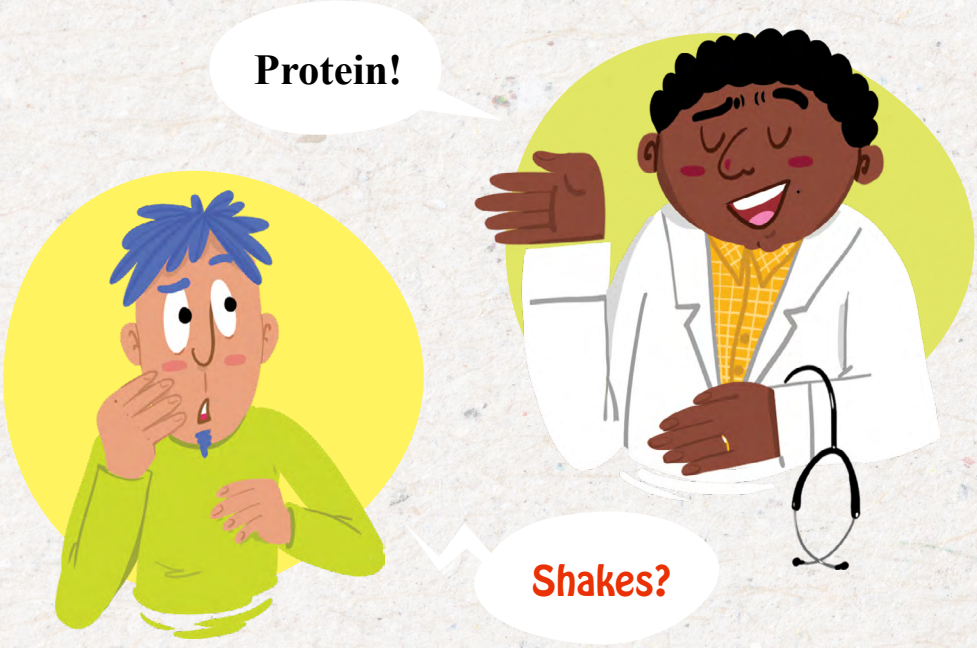
Peer review is
a feature that distinguishes research papers that are written in academic language by experts in a particular field and which undergo a review process by teams of experts to evaluate correctness and adherence to standards before publication.

It is estimated that students spend between **7 and 14 hours a week** reading academic material, which is a substantial portion of their academic workload and training[1–3].

There is a significant gap between what scientists assume the public knows and the public's actual knowledge, and this gap grows larger, ultimately disengaging meaningful ties between the scientific community and the public.

For instance, a neuroscientist might use ***"synapse, action potential, and neurons"*** just like any ordinary word, while the public may have to do their own research to understand these terms.

Additionally, various words have differing meanings in scientific literature versus everyday life.



Reading primary scientific literature
is undeniably valuable for undergraduate students.

It refines their
SKILLS
in

- interpreting data
- critiquing flawed science
- generating ideas for future research[4]

It also
BOOSTS
their

- cognitive abilities
- knowledge of scientific processes
- self-confidence in science[4]

THUS,

students gain a deeper understanding of the scientific method, enabling them to formulate research questions, develop hypotheses, and draw conclusions from data.

It is then essential for students to cultivate

SCIENTIFIC LITERACY,

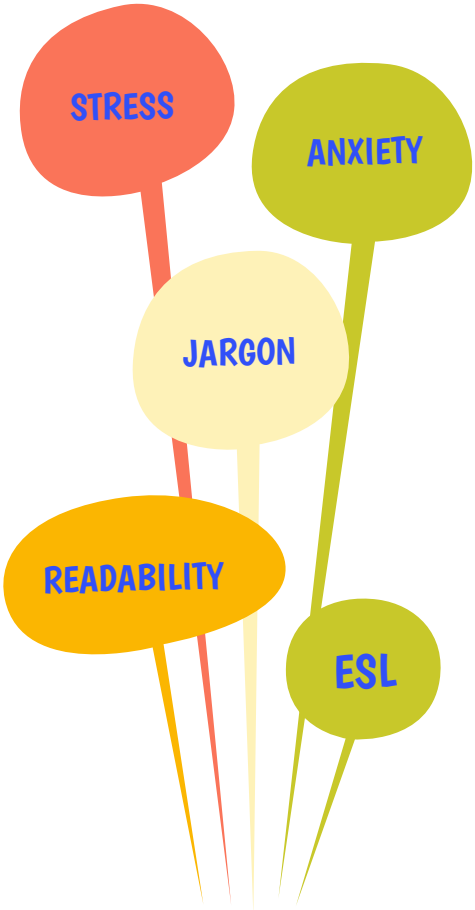
defined by the United States National Center for Education Statistics as-

“The knowledge and understanding of scientific concepts and processes-”[5]

Despite this importance, reading scientific papers remains a daunting task for most students, as they report **feelings of overwhelm** while facing unfamiliar terminology, technical details, and complicated diagrams[6].

With this overwhelm comes **anxiety and stress**, further hindering students' learning[7].

Furthermore, readers often encounter other difficulties while attempting to read scientific papers, including jargon, text readability, language barriers (English as a second language), and other factors.



BUT, WORRY NOT! WE'VE GOT YOU!

This book introduces practical methods and techniques to make your reading process more structured and efficient.

In Part 1, we highlighted some common challenges you may face when reading a scientific paper. By understanding these hurdles, you will be better equipped to expect and address them.

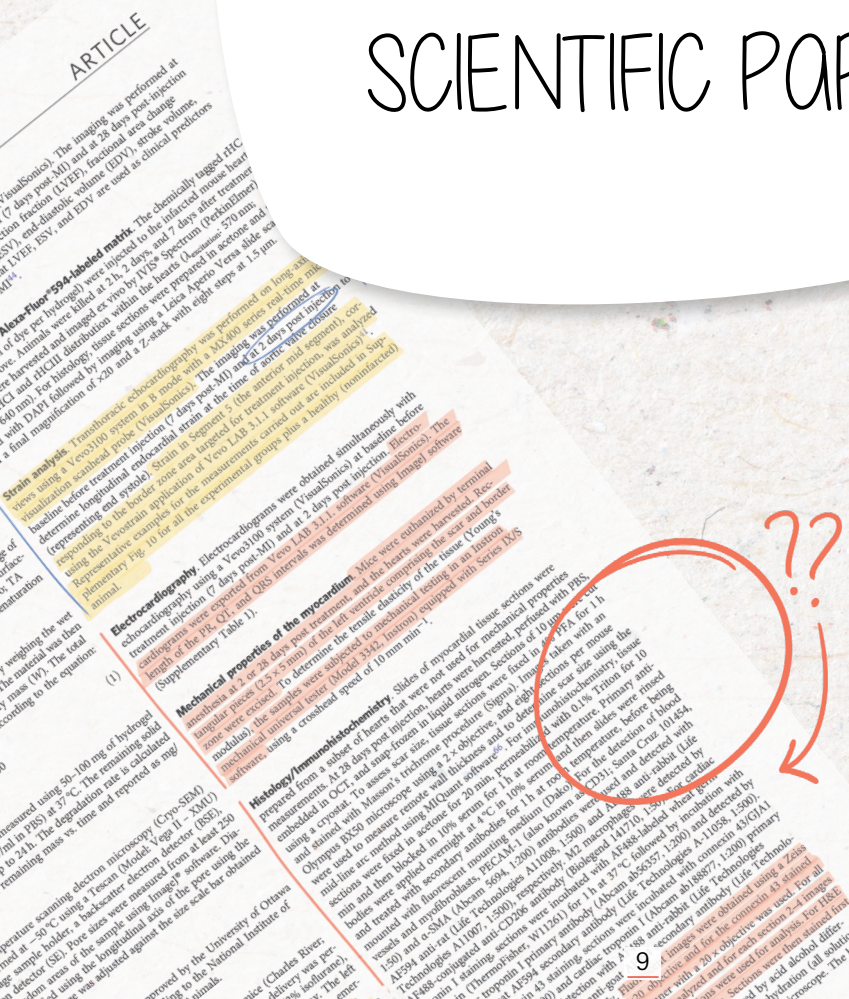
In Part 2, we present a step-by-step approach to effectively read and comprehend scientific papers. You will also find tools and templates to help you create your own summaries without spending endless hours revisiting the same content.

By the end of this book and upon completing the activities described, you will feel **confident** and prepared to analyze and dissect papers in STEM and biomedical sciences with clarity and ease!

PART I

CHALLENGES

WHEN READING A SCIENTIFIC PAPER



NEVER USE A JARGON WORD if you can think of an everyday **ENGLISH EQUIVALENT** [8].

1. Jargon in Scientific Text

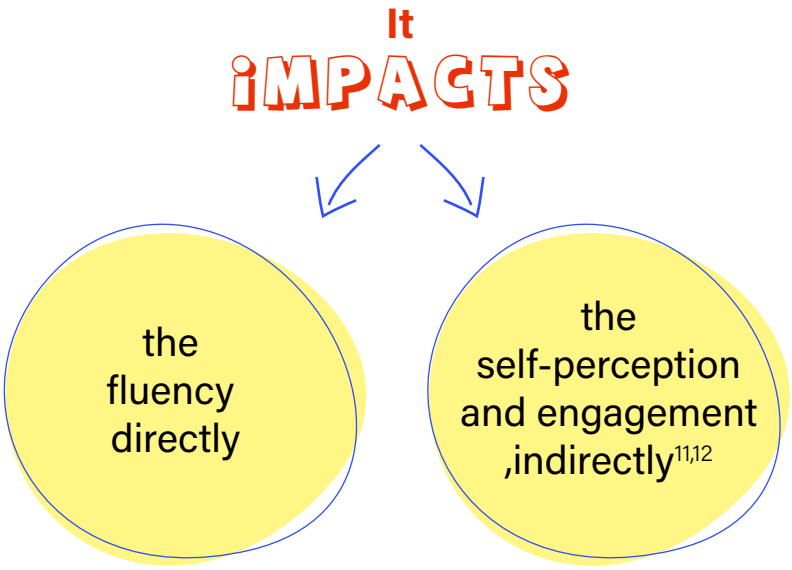
Jargon could be defined as an insider language with specialized technical vocabulary terms that prevents people from easily connecting with the intended message.

It limits understanding of complex concepts to only those sharing a common background, such as scientists, lawyers, or medical professionals while excluding others lacking that specialized knowledge[9].

To experts, scientific jargon quickly becomes second nature, and as they become more advanced within their field, the harder it is for them to recognize when they are using terms that non-specialists will find difficult to understand[10].

Research on the negative effects of jargon suggests that **non-experts struggle to fully understand information with large amounts of it** due to the barriers of unfamiliarity with such terms, the difficulty of the language, and a lack of prior knowledge[9-11].

Jargon not only hampers comprehension but also makes information harder to process.



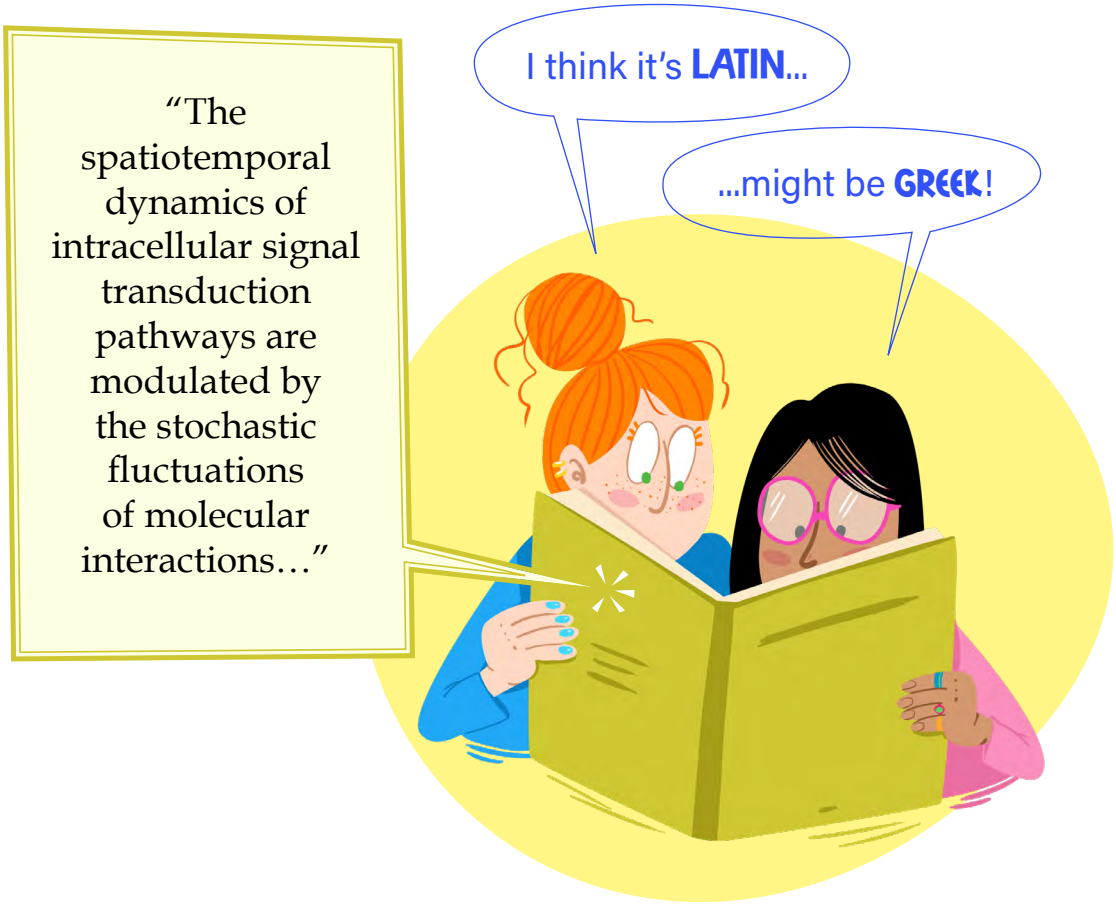
Often, understanding technical jargon in papers depends on a person's overall familiarity with the subject[13].

However, biases toward non-experts often arise when they try to explore unfamiliar topics. This applies equally to students studying diverse scientific disciplines. These specialized terms make the information less accessible and limit comprehension for non-expert readers[12].

One way to determine whether a text is laden with jargon is its impact on impairing readers' attempt to recall information from memory about the topic they read[12].

Another issue related to stumbling upon jargon in scientific text is the wide range of field-specific language used across various scientific disciplines, to which novice students are exposed and challenged. As expected, this situation becomes even more difficult for the general public.

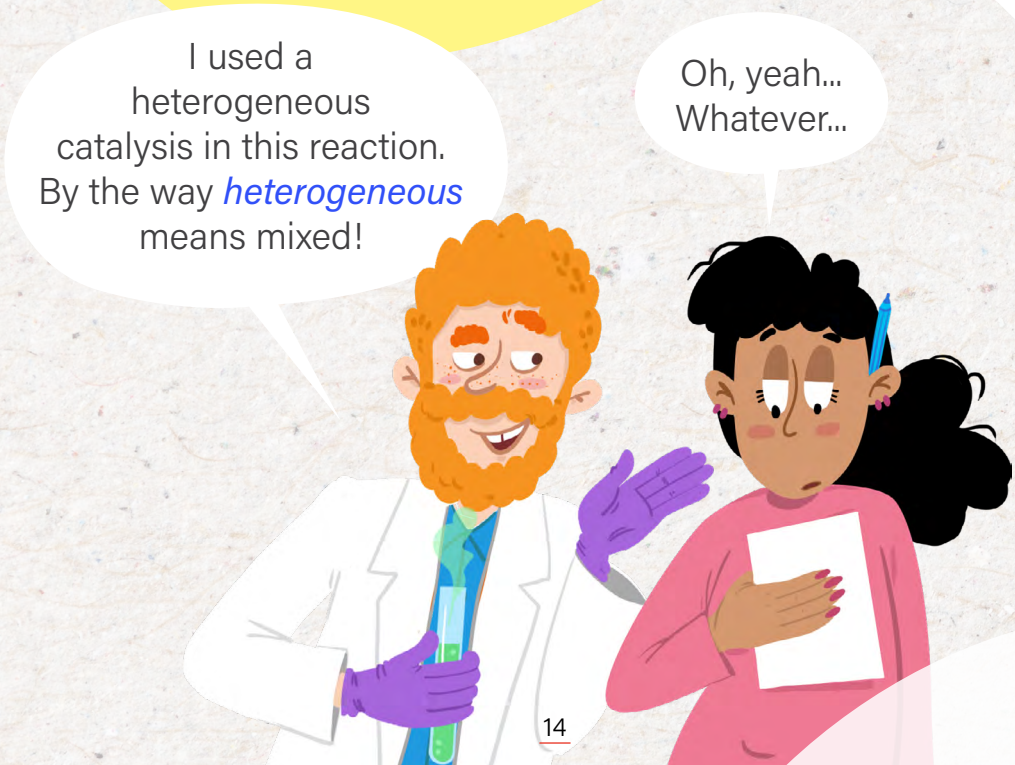
It is almost equivalent to trying to speak **70 different languages!** Being capable of comprehending such a multitude of languages is nearly impossible!



While jargon may serve a minor role, its drawbacks, such as making individuals feel uninformed or alienated from scientific literature, significantly outweigh its benefits, to the point where some researchers have found it causes people to lose faith in science[12, 14].

Therefore, its excessive use is generally unjustified. Those who read texts with jargon are less likely to perceive themselves as good at science, feel less knowledgeable about scientific matters, and feel less confident to engage in discussions related to science topics[12, 14].

The use of difficult, specialized words is a signal that tells people that they don't belong. You can tell them what the terms mean, but it doesn't matter. They already feel like that this message isn't for them[12, 14].



The problem of extensive use of jargon in literature is not going away!

In fact, Plavén-Sigrayand colleagues recently analysed over **700,000** abstracts from **12** sub-disciplines of life and medical sciences, reporting a steady rise in jargon use that has reduced the readability of texts overtime[15].

If this trend persists, the difficulty and frustration reported by many students when reading such scientific papers could:

1. Discourage faculty from teaching high quality scientific literature.
2. Keep assigning "difficult" papers that student cannot handle with their current reading strategies.
3. Do the complete opposite and give students simpler, less challenging papers that do not provide a full learning experience[4].

Remember: Jargon is Exclusion

Have you heard of Microsoft Office Word? Yes, it can provide **READABILITY STATISTICS** based on the average number of syllables per word and words per sentence. **HOWEVER ...**

2. Readability indices

A TRICKY THING !!

Clear reporting in scientific journals is essential for the scientific process[15].

One way that writers have been using to check the readability of their work is using readability formulas to quantify text clarity and predict how likely their target reader is to understand their text[16].

Different readability formulas use different metrics to evaluate text difficulty, but common parameters include word and sentence length and the percentage of multi-syllable words. The calculated readability level is then matched to the reader's expected educational level and age[17].

Limitations of Readability Indices

A detailed examination of such resources has revealed several disparities in their analysis, making the results nonrepresentative and for the most part unreliable[19].

These formulas are both

PRAISED & CRITICIZED

They are cost effective.

They are timesaving.

They reasonably measure text difficulty[20].

They lack a basis in comprehension theories.

They evaluate text purely on surface features while ignoring deeper aspects which affect understanding such as context, reader characteristics, and text cohesion[21].

They often miss important readability factors like the complexity of ideas, reader's familiarity with certain terminology, visual aids, text structure, and coherence[22, 23].

These tools can also easily be misused, as writers may focus too much on attaining a certain reading score while failing to acknowledge that **improving readability scores alone does not automatically make a text more understandable**[23].

ADDITIONALLY,

these formulas assume shorter words are always better, which is not necessarily true. Plain language requires you to write for your audience's needs, using familiar words rather than simply shorter ones.

For example:

Operation vs. **Stent**

'Operation' in the context of heart health may seem complex due to its syllable count; but is more commonly understood than a simpler word like 'stent.'

Remember what we discussed about jargon and the use of clear vocabulary in scientific writing? Well, readability measures do not often account for the average vocabulary of the intended audience. Hence, is it possible to measure readability without considering this key element?

This suggests that current indices may be oversimplifying the concept by primarily focusing on lengthy words and sentences, correlating these with readability, but failing to consider the challenges caused by word selection, such as the use of jargon[24].

We could all agree that
life would have been
SO MUCH EASIER
if there was
ONE UNIVERSAL LANGUAGE!

3. ESL : English as a Second Language

A DISADVANTAGE ?

One of the most difficult challenges that science students face is deciphering the complex language used[25].

While the many different languages spoken around the world are beautiful, they certainly add another layer of difficulty to research activities such as reading scientific texts.

For many students and researchers around the world, navigating scientific literature in English, a language that may not be their first, presents a significant challenge.

The global scientific community uses English as its primary language for communication, but this linguistic uniformity also disadvantages speakers whose first language is not English.

Research indicates the significant time barrier for non-native English speakers trying to read English scientific papers, as they require more time compared to their native English-speaking peers[26].

This issue even persists among mid- and late-career researchers, indicating that the challenge of reading in English does not necessarily diminish with experience.

Interestingly, when reading papers written in their first language, non-native English speakers have been found to need less time than native English speakers, highlighting that the primary challenge is not the complexity of the content itself but rather the additional brain load of processing complex science in a second language[26].

For non-native English speakers, the task of reading scientific literature involves

A DOUBLE BURDEN:

1. understanding complex scientific concepts
2. translating and decoding the language itself[27]

I don't know about you, but this would definitely lead me towards frustration and fatigue, making it harder for me to stay engaged and motivated.

In fact, various studies suggest that international students with lower English proficiency often struggle and can develop feelings of depression and anxiety possibly correlating with being bombarded by jargon-heavy readings and assignments in a language that was not their own[27-30].

Finally, the true essence of mastering a foreign language goes beyond simply understanding its vocabulary and grammar rules. It is rather embracing what is often called the **'spirit of the language'**—which is much harder for non-native speakers to grasp than simply learning words and sentence structures[31].

Therefore, processing scientific text is a skill, demanding even more effort and focus to engage and manipulate the appropriate dialogue.

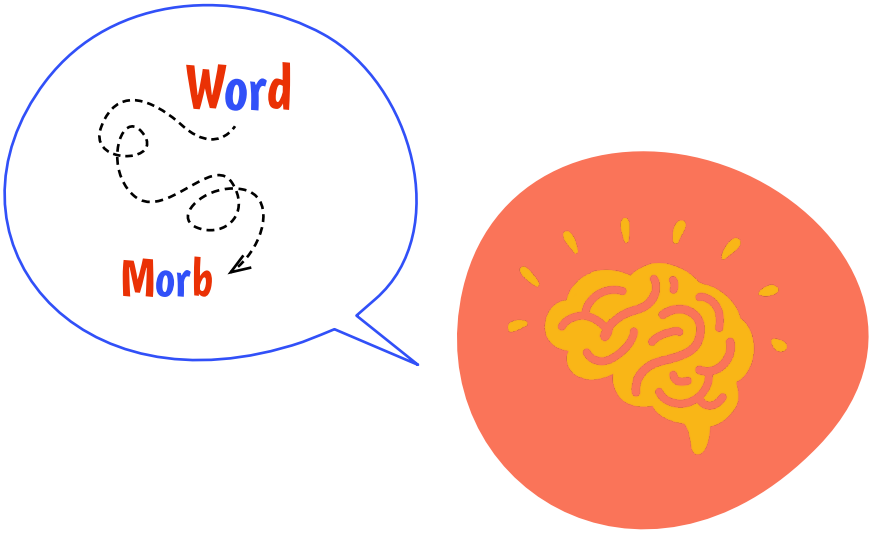
Reading
SCIENTIFIC RESEARCH PAPERS
can sometimes feel like
DECIPHERING A CODE.
But what happens when
THE MIND FACES CHALLENGES
that cause it to process
this code differently?
Or maybe not at all?

4. Neurodivergences and Scientific Paper Reading

A CHALLENGE !

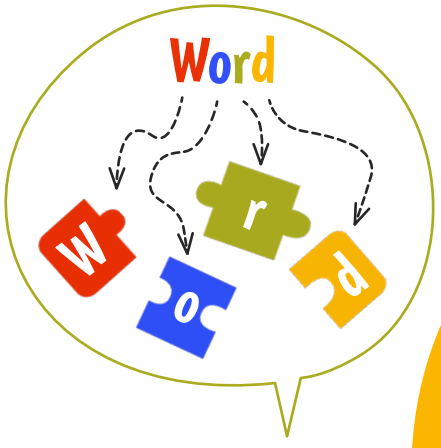
About 15% of the world's population live with some form of physical, sensory, or cognitive disability[32, 33]. For neurodivergent persons, the challenge is sometimes not even about understanding the science; it is mostly about unlocking the text itself.

Dyslexia is just one of many neurodivergences characterized by a struggle in accurately recognizing and decoding words, which can secondarily hinder comprehension and reduce the reading experience, further limiting the general knowledge base and vocabulary for the individual[34].



For individuals with **autism spectrum disorder (ASD)**, a study found that 60% of children with autism showed lower than expected performance in spelling, reading, and math. This is related to aspects of autism such as : Differences in social interaction, language, and communication, which can further hinder reading comprehension or even inferring meaning from conversations or texts.

Up to **65%** of children with autism struggle with understanding what they read, despite having good and intact decoding skills, often focusing on basic details and word for word, and unintentionally missing the broader context and meaning[35].



Unfortunately, this is the type of accessibility that we are missing in the creation and publishing of scientific text and interactive multimedia assistive technology.

What complicates the matter even more is the heterogeneity of language processing in autism because processing text is different in each case.

Attention Deficit and Hyperactivity Disorder (ADHD) is another type of neurodivergence that poses challenges on comprehending scientific text.

COMMON ADHD READING CHALLENGES:

Typical lengthy scientific texts
requiring long attention spans, which is particularly difficult for individuals with ADHD.

The third person writing style (instead of I or you),
commonly used in scientific text that lacks direct engagement, makes it easier for those with ADHD to lose focus.

The frequent use of complex jargon
is even more distressing for people with ADHD as neuropsychological studies have found that adults with ADHD exhibit reduced performance on complicated or time-consuming tasks[36]. Other recent studies also suggested impaired reading comprehension abilities in ADHD with difficulties finding main ideas from reading material[36].

A lot of this ties into the idea of accessibility in scientific papers.

For instance, creating documents without considering accessibility criteria is likely to cause difficulties for individuals with reading disabilities.

If documents are not adequately prepared to work at the interface with assistive reading technologies, it will not be possible to fully access their contents and doing so in the proper reading order[37].

5. Facing the complexity of the contents within a scientific research paper

Usually, several months or even years of work culminate in the publication of a peer-reviewed scientific research paper, which summarizes and condenses the results from multiple experiments conducted by diverse individuals over that time into only a few pages.

The process of preparing this document is not straightforward nor simple; it requires the input of numerous scientists, reviewers, and editors, resulting in numerous iterations until a continuous and extensive back-and-forth process culminates in the desired final version of the research paper, ready for publication.

Diving into the highly condensed information within a research paper represents **one of the most complicated tasks for undergraduate students and young scientists.**

Reading and fully understanding a research paper in a quick and single reading **is truly challenging, even for the most experienced scientists**.

COMMON CONCERNS & QUESTIONS

when reading a scientific research paper for the first time

Feeling of being lost within the large amount of information!

- Where should I focus? Background, research question, multiple graphs and figures, comparisons between groups and against diverse techniques and results, authors' claims,...?
- What am I exactly looking for?
- How and where to identify the key information?

There is so much that I need to know to be able to understand a research paper!

- Foundational concepts from a specific science field.
- Jargon and technical terms.
- Common experimental designs for specific objectives.
- Key methods and techniques.
- Alternate methods and techniques to validate certain results.
- Advantages and limitations of the methodologies chosen by the authors.
- How to really know what the actual novelty of the article is if I am not an expert?

I do not have clarity on what depth everything should be analyzed and understood!

- Am I also supposed to revise the supplementary materials?!
- I truly struggle to have a defined view of the potential implications and applications!

It is quite challenging to keep a clear picture of all the results and authors' claims to get an overall understanding of the study!

How am I supposed to evaluate and criticize a research article if I am just starting my journey in science?

- How can the overall 'quality' of a paper be defined?
- Is this merely based on the paper contents, or are there other factors to be considered? What about the number of citations, the impact factor of the journal, and the h-index of the authors? Are these also considered? Is any more important than the other?
- Are there clear metrics to define a paper's quality?
- How can I objectively evaluate a paper without letting my personal impressions dominate my judgement?
- I do not have a clear understanding on how to identify the limitations or flaws of the study!

What if I get the impression that the title, abstract, and/or even the keywords seem to be misleading? Where's the error?

- Am I not properly understanding the key message?
- Or is it possible that the authors are wrong in their claiming?
- What if there are contradictory or not-so-great results included?

How to not get lost all over again when the research papers have different content structures depending on the journal or editorial house?!

As it happens with mostly everything we do, the more we practice, the better we feel doing it, and the easier it becomes as we go! The same applies to getting used to reading scientific literature and feeling more confident while doing it.

Sooner than you may think, you will be able to answer all these questions based on your experience.

IN THE MEANTIME, WE SUGGEST:

1. To clearly identify the purpose of your reading and the particular needs considering your previous and current education and career stage.

2. To follow **the roadmap** we propose in the second Part of the book.

In summary, this is just a glimpse into the wide range of challenges experienced by most individuals when reading scientific text, alongside the various other difficulties previously mentioned.

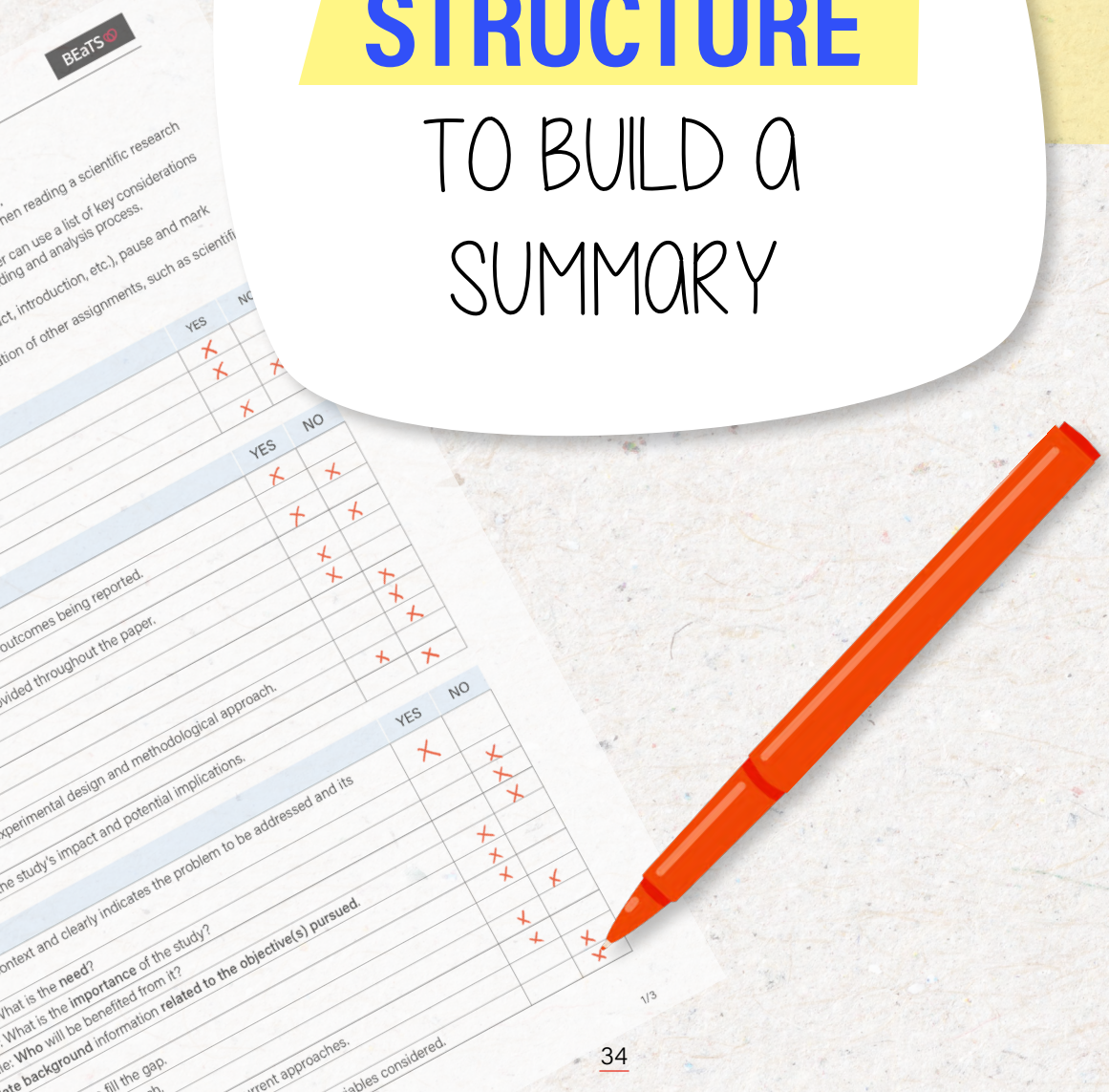
Our goal was to highlight these challenges and barriers in a way that resonates with readers, making them more relatable and understood, so they know **they are not alone in their struggle and that challenges are not a reflection of their abilities.**

Do not let these challenges and barriers discourage you!

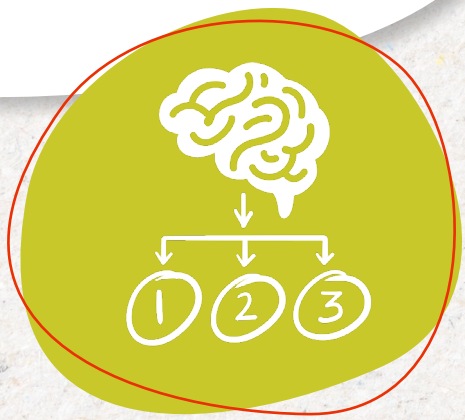
Next, you will find our proposed strategy for a more efficient reading.

PART II

OUR PROPOSED STRUCTURE TO BUILD A SUMMARY



STRUCTURE IS PRESENT IN EVERYTHING,
from the vastness of the universe to subatomic particles.
OUR BRAIN ALSO ANALYZES AND PROCESSES INFORMATION IN A STRUCTURED WAY,
which allows us to perceive and interact with the world around us.



1. The Processing of Information

A BRAINY AFFAIR !

Do not be afraid not to know something!

Many of us fear not knowing something, partly because the educational system that we grew up in, taught us to strive for expertise in everything we learn instead of encouraging a love for exploration and curiosity.

Curiosity is the driving force of science, and this is genuinely the umbilical cord that connects all the areas of human knowledge and has fueled technological advancements in the last 100 years.

By making it a **habit** to highlight concepts or words you need to become more familiar with and by understanding these scientific terms you will empower yourself, boost your confidence and improve your scientific literacy.

Learning and Memory have been a matter of intensive study during the last century[38]. While the brain's role in learning is outside the immediate scope of this book, we must understand that learning and memory, although deeply interconnected, are not the same.

You might recall information; let us say, from your high school biology class. You might remember that cells divide, but you might not understand each step involved in cell replication and proliferation.

LEARNING vs. MEMORY

is

"the acquisition of skill or knowledge"[39].

- a long process as it depends on the complexity of the task or set of skills being learned.

is

"the expression of what you have acquired"[39].

- an almost instant process.

For example:

Piloting a helicopter, is more difficult and takes much longer than learning to use a smartphone.

Learning and Structure have been linked in learning theories, including the **structural learning theory**. What is this theory you may ask?

Well, it suggests that learning happens by building and applying specific rules to solve problems and gain knowledge.

Each rule has three parts:

1. inputs (the starting information)
2. outputs (the results)
3. steps (the actions to transform inputs into outputs)

By mastering simple rules first, learners can combine simple and basic concepts to gradually form more complex rules, which are then used for solving challenging problems[40].

Structural learning theory can be employed to answer questions such as "How do learners use and acquire knowledge? And why can some people solve problems for which they apparently have all the required knowledge, whereas others cannot?"

Remember: Structure is your best friend!

Many universities overlooked the importance of teaching essential reading and comprehension skills early in students' academic journeys, instead focusing on assigning extensive reading lists without assessing students' readiness to engage with the material[41].

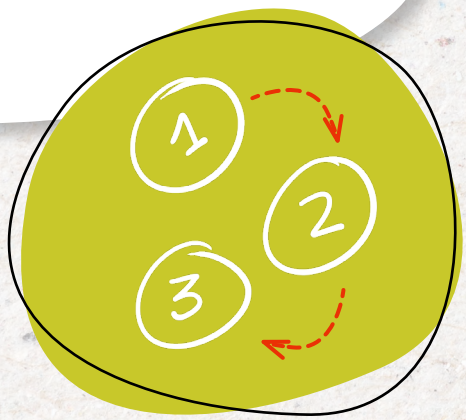
Therefore, many undergraduates or postgraduates have never been formally taught how to read scientific papers despite advancements in educational methods on reading techniques. The problem persists because many instructors pass on teaching methods as they have been taught without integrating crucial academic reading skills into the curriculum[42].

To establish a solid foundation
for reading scientific papers,
we need to start with a
structured approach.
This can make all the difference,
and this is where our

STRUCTURED SUMMARY PROCESS

comes in!

When you approach a new paper, instead of reading it start to finish, **TRY BREAKING IT DOWN INTO MANAGEABLE SECTIONS,** and focus on each section before moving on to the next one. Wouldn't that make things a bit **EASIER**?

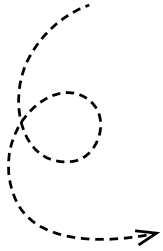


2. The Structured Summary Process

A ROADMAP !

We all process information differently; reading a text once might be enough to understand and produce a summary for some individuals. For others, the process can be more demanding, and it might take at least three to four reads before you can understand the content well.

In this book, inspired by the **structural learning theory**, we propose a system to help you create a summary that captures essential concepts clearly in a summarized yet structured text.



This system

simplifies complex information,

making it easier for the non-expert reader to understand. The reader could further apply this structured summary system to other tasks, such as presenting a journal club, and writing scientific articles or reports.

We have previously discussed various challenges readers face when engaging with scientific papers, including jargon, English as a second language, and factors like neurodivergence, all of which impact the readability of scientific papers and the difficulty of creating accessible texts for all readers.

The structured summary process proposed in this book acts as a **roadmap** that will help readers:

1. Navigate and overcome the various challenges affecting their reading and understanding of scientific text.
2. Learn to identify and extract critical information in a structured way and assemble it into the proposed summary sheet.
3. Learn the difference between learning and memorizing what is necessary from the paper.
4. Lead readers to use their filled summary sheet to create clear and accessible lay summaries that could be used for assignments, presentations, and reports without downplaying the scientific foundation.
5. Objectively and critically evaluate the contents of a research paper to identify areas of improvement by setting clear assessment metrics.

THE STRUCTURED SUMMARY PROCESS

includes the following sheets:

A. The Words/Concepts Definitions Template

B. The Reading Guidelines
- B.1 The Checklist
- B.2 The Score System

C. The Summary Report

IN ADDITION,
you will find
two papers
to practice on!

These sheets are not just tools for condensing information but can help you navigate the various sections of any paper by establishing a clear **roadmap** to follow.

1.THE WORDS/CONCEPTS DEFINITIONS TEMPLATE

As part of your first reading attempt of the entire research paper, write down all the words and concepts that are not familiar to you as you go through it and then search for their meaning once you are done reading.

In addition, having a definition using your "own" language will help you remember them and make it easier to create a summary that is clear and accessible for you to understand.

Consider going **back to re-read** specific sections if further clarification or context is needed after learning the vocabulary that was new to you.

Download the **Words/Concepts Definitions Template** in the link below:

http://hdl.handle.net/10393/50115

2.THE READING GUIDES

Think of this step as a guiding light designed to make you more aware of your reading process and set expectations as you begin reading the paper.

By quickly skimming and filling out either of the reading guides you instill an **intentional approach to reading**, ensuring that you engage with the paper purposefully from the first skim. This process allows readers to evaluate the quality and readability of the paper in a critical and engaging way during the initial reading.

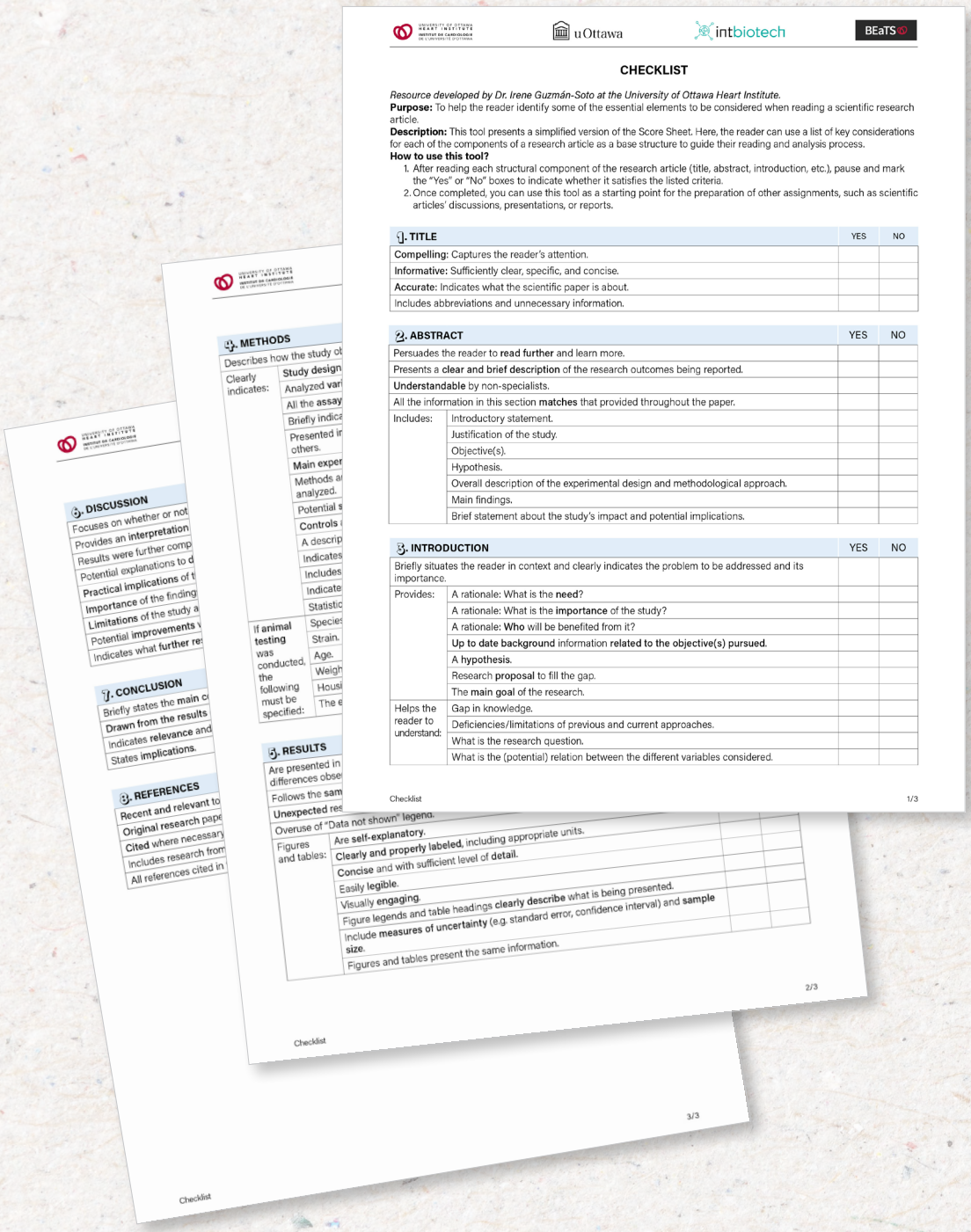
2A.THE CHECKLIST

Acting as an objective critic, the reader here can use the reading guide checklist to assess various aspects of the paper, such as:

- the quality of the paper title (is it compelling, informative, and accurate?)
- the clarity of the introduction
- the presence of visually engaging figures
- whether a general background knowledge is included or if further external research is required, just to name a few.

The reading guide checklist includes specific criteria for evaluating each section of the paper.

This initial evaluation creates a lasting first impression, helping readers **set expectations and identify key areas to focus on** before revising the paper a second time for a deeper analysis.



CHECKLIST

Resource developed by Dr. Irene Guzmán-Soto at the University of Ottawa Heart Institute.
Purpose: To help the reader identify some of the essential elements to be considered when reading a scientific research article.
Description: This tool presents a simplified version of the Score Sheet. Here, the reader can use a list of key considerations for each of the components of a research article as a base structure to guide their reading and analysis process.
How to use this tool?

1. After reading each structural component of the research article (title, abstract, introduction, etc.), pause and mark the "Yes" or "No" boxes to indicate whether it satisfies the listed criteria.
2. Once completed, you can use this tool as a starting point for the preparation of other assignments, such as scientific articles' discussions, presentations, or reports.

1. TITLE	YES	NO
Compelling: Captures the reader's attention.		
Informative: Sufficiently clear, specific, and concise.		
Accurate: Indicates what the scientific paper is about.		
Includes abbreviations and unnecessary information.		

2. ABSTRACT		YES	NO
Persuades the reader to **read further** and learn more.			
Presents a **clear and brief description** of the research outcomes being reported.			
Understandable by non-specialists.			
All the information in this section **matches** that provided throughout the paper.			
Includes:	Introductory statement.		
	Justification of the study.		
	Objective(s).		
	Hypothesis.		
	Overall description of the experimental design and methodological approach.		
	Main findings.		
	Brief statement about the study's impact and potential implications.		

3. INTRODUCTION		YES	NO
Briefly situates the reader in context and clearly indicates the problem to be addressed and its importance.			
Provides:	A rationale: What is the **need**?		
	A rationale: What is the **importance** of the study?		
	A rationale: **Who** will be benefited from it?		
	Up to date background information **related to the objective(s) pursued.**		
	A **hypothesis.**		
	Research **proposal** to fill the gap.		
	The **main goal** of the research.		
Helps the reader to understand:	Gap in knowledge.		
	Deficiencies/limitations of previous and current approaches.		
	What is the research question.		
	What is the (potential) relation between the different variables considered.		

Checklist 1/3

Download the **Checklist** in the link below:

http://hdl.handle.net/10393/50115

It is important to note that the Checklist is a fluid and flexible tool you can adapt to your needs.

It is proposed to use it as a checklist for guiding your reading to serve as an initial assessment to prepare you for fully immersing yourself in the paper after a first skim, or as an optional or complimentary post-reading evaluation.

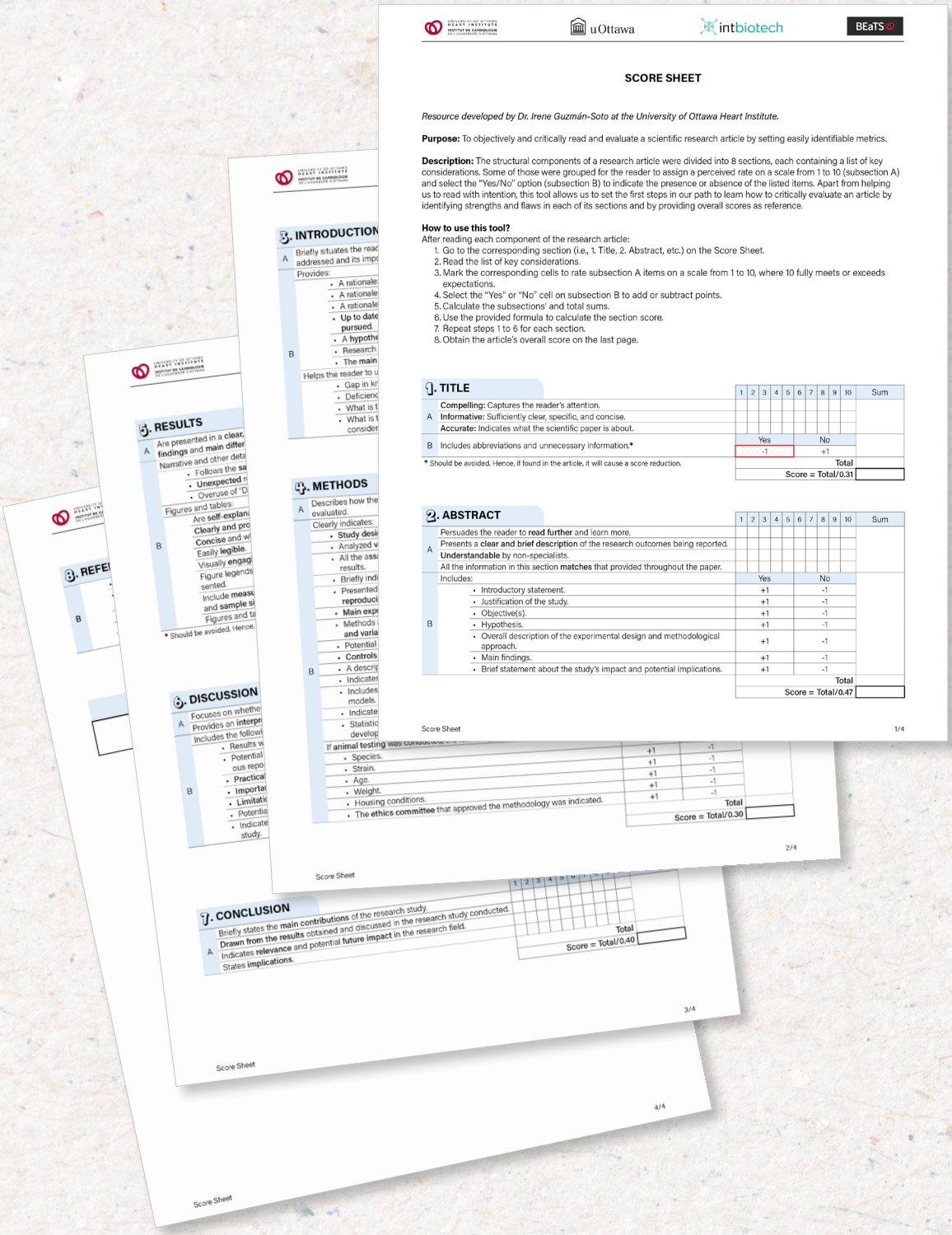
2B. THE SCORE SHEET

For novice readers, it can function as a straightforward guide, while for more advanced tasks, the score sheet reading guide can be used to objectively evaluate papers by assigning, scores to critical elements and important considerations part of the paper's structure.

In some upper-level graduate courses, some assignments may involve identifying limitations in assigned research papers and suggesting ways to improve them.

How you use the score sheet depends entirely on your preferences and objectives.

Its primary value lies in training and assisting readers to approach papers with intention and critical engagement.



Download **the Score Sheet** in the link below:

http://hdl.handle.net/10393/50115

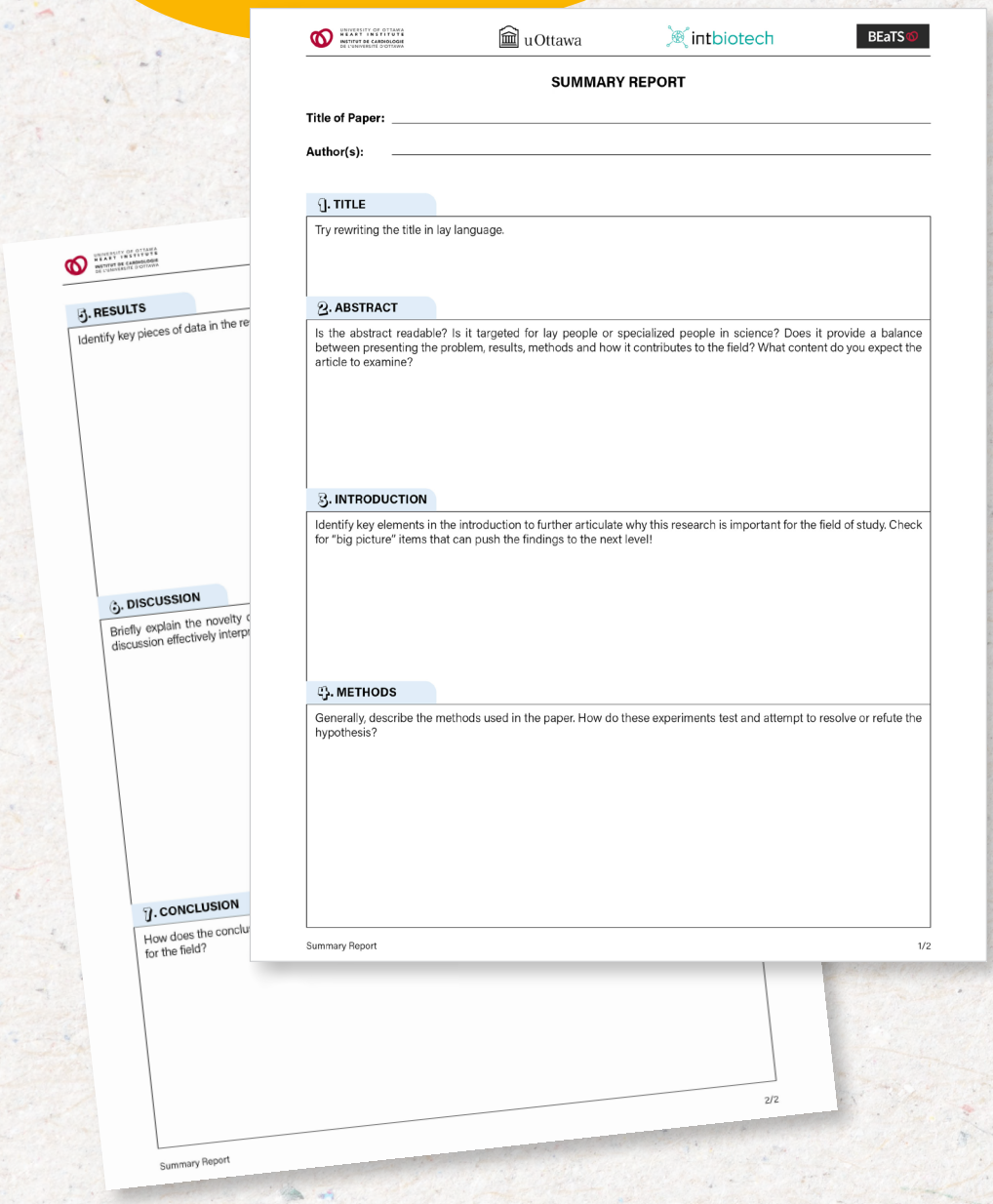
3.THE SUMMARY REPORT

This is the core of our structured summary process. We designed a summary report sheet which can guide the reader to create a sectioned summary using different questions relating to each section of the research paper.

All of the information collected in the previous sheets (the Words/Concepts Definitions Template, the Checklist and the Score Sheet) will now be used to create the **Structured Summary** by filling out the Summary Report.

Additionally, completing the summary report will solidify the main concepts, reducing the need to constantly go back and forth within the main article and will save time.

Complete each section on the summary sheet before moving onto the next section of the paper. Responses should be in point form and answering the prompts provided.



SUMMARY REPORT

Title of Paper: _____

Author(s): _____

1. TITLE

Try rewriting the title in lay language.

2. ABSTRACT

Is the abstract readable? Is it targeted for lay people or specialized people in science? Does it provide a balance between presenting the problem, results, methods and how it contributes to the field? What content do you expect the article to examine?

3. INTRODUCTION

Identify key elements in the introduction to further articulate why this research is important for the field of study. Check for "big picture" items that can push the findings to the next level!

4. METHODS

Generally, describe the methods used in the paper. How do these experiments test and attempt to resolve or refute the hypothesis?

Summary Report 1/2

5. RESULTS

Identify key pieces of data in the re

6. DISCUSSION

Briefly explain the novelty
discussion effectively interpr

7. CONCLUSION

How does the conclu
for the field?

2/2

Summary Report

Download **the Summary Report** in the link below:

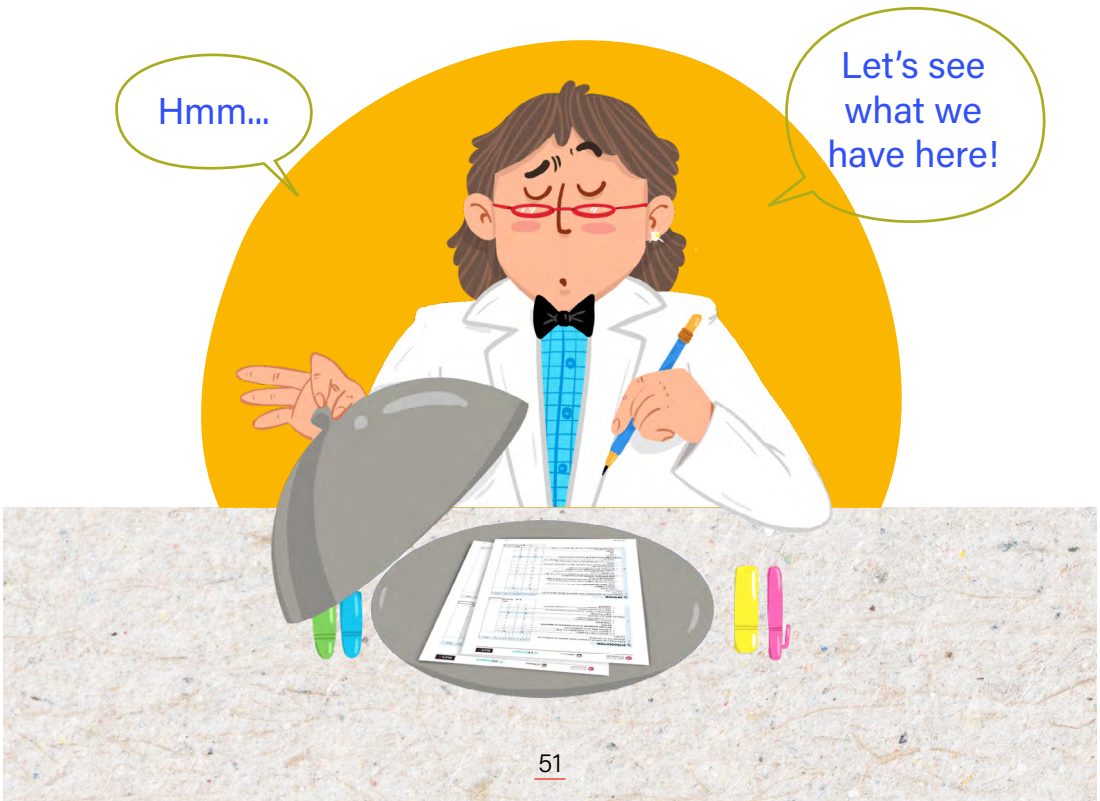
http://hdl.handle.net/10393/50115

YOUR TURN TO TRY!

This is an exercise for you to put everything we have talked about into practice.

1. Read the linked papers below.
2. Search for the meaning of the words and concepts unfamiliar to you. Use the Words/Concepts Definitions Template.
3. Use the Checklist to break down the paper's content and develop a deeper understanding.
4. Use the Summary Report as a guide to write a structured summary of the paper.

If you want to take it a step further, you can score the paper based on all the criteria we have on the Score Sheet and see how well you can pick up small and bigger details from these papers. You will feel like a food critic, but for scientific papers!



Paper 1

Injectable human recombinant collagen matrices limit adverse remodeling and improve cardiac function after myocardial infarction

Sarah McLaughlin, Brian McNeill, James Podrebarac, Katsuhiro Hosoyama, Veronika Sedlakova, Gregory Cron, David Smyth, Richard Seymour, Keshav Goel, Wenbin Liang, Katey J. Rayner, Marc Ruel, Erik J. Suuronen & Emilio I. Alarcon.

https://www.nature.com/articles/s41467-019-12748-8

Paper 2

Low Energy Blue Pulsed Light-Activated Injectable Materials for Restoring Thinning Corneas

Aidan J. MacAdam, Marcelo Munoz, Jinane El Hage, Kevin Hu, Alex Ross, Astha Chandra, Jodi D. Edwards, Zian Shahid, Sophia Mourcos, Maxime E. Comtois-Bona, Alejandro Juarez, Marc Groleau, Delali Shana Dégué, Mohamed Djallali, Marilyse Piché, Mathieu Thériault, Michel Grenier, May Griffith, Isabelle Brunette & Emilio I. Alarcon.

https://advanced.onlinelibrary.wiley.com/doi/full/10.1002/adfm.202302721

Before we get
too comfortable with our
ARTIFICIAL INTELLIGENCE (AI)
ALLIES, it is crucial to
discuss the potential
PITFALLS AND DANGERS
of relying on these
powerful tools.

3. The Use of ChatGPT in Academia

The rise of AI, particularly large language models (LLMs) such as ChatGPT, has led us into a new era for academia and learning.

These tools have revolutionized the academic landscape by breaking students and scholars free from traditional constraints and is now serving as a powerful tool used for:

- proofreading written text
- simplifying lengthy scientific papers
- explaining complex concepts
- generating ideas for brainstorming

The main risks associated with the over dependence of ChatGPT in academia that have been explored by various studies include plagiarism and compromised originality, over-reliance on the technology, a decline in critical thinking capacity, and generally lower quality of the final product.

HOW CAN YOU INTEGRATE AI INTO YOUR ACADEMIC WORK FLOW WITHOUT LOSING THE DEEPER INSIGHTS THAT COME FROM HANDS-ON READING?

As you can imagine, there are numerous ways ChatGPT can be useful in academia while still upholding the integrity and originality of your work.

1. Instead of relying on it to write everything from scratch, which would compromise your academic integrity and can get labeled as a plagiarism case, it can be treated to tools like Grammarly for example. It's great for fixing your grammar, improving sentence structure, and polishing awkward or ungrammatical language.
2. When using this tool for brainstorming ideas, follow through with independent research, using academic sources to build upon those ideas.

It is important to make things clear, once again, using ChatGPT as an editing aid to make the information you wrote clearer and easier is acceptable, but the real issue arises when users generate large amounts of content without properly reviewing or understanding the cited or used literature.

ChatGPT often pulls from existing literature, and while we can only hope that it is not copying things identically, the risk of penalty for plagiarism is high, bringing substantial damage to one's career.

Just like **thumbprints**, writing styles differ significantly from one individual to another, which is why we can distinguish between novel writers. With ChatGPT however, the writing style is quite distinct and can be easily recognized, making it clear when someone has over-relied on AI generated content.

So, can you trust what **CHATGPT** gives you?

The short answer is

NO,

not entirely.

While ChatGPT can be helpful with tasks we previously outlined, it is also prone to lots of mistakes. It is very common for it to fabricate information or present details that are inaccurate, random or simply unfounded.

4. ChatGPT vs. Students

ON EXPERIMENT !

In the following section, we will examine the validity of all these claims, through the following experiment:

1. We gave our Summary Report sheet along with a new scientific paper, never read before, to students to assess whether the sheet could facilitate easier comprehension.
2. We gave the same Summary Report sheet and linked the scientific paper to ChatGPT to test its ability to summarize the content in a similar manner.

The goal here was to test the effectiveness of current AI and LLM tools, like ChatGPT, in comparison to independent student reading of these peer reviewed papers using our Summary Report sheet as a guide.

PROMPTS GIVEN TO CHATGPT TO FILL THE SUMMARY REPORT

What can I help you with?

- Provide the Paper link or as a pdf.
- I am trying to write a summary report on the attached article can you answer a few prompts?
- Try rewriting the title in lay language.
- Is the abstract readable? Is it targeted for lay people or specialized people in science? Does it provide a balance between presenting the problem, results, methods and how it contributes to the field? What content do you expect the article to examine?
- Identify key elements in the introduction to further articulate why this research is important for the field of study. Check for "big picture" items that can push the findings to the next level!
- Generally, describe the methods used in the paper. How do these experiments test and attempt to resolve or refute the hypothesis?
- Identify key pieces of data in the results that are instrumental to articulating the work's novelty and contribution to the field.
- Briefly explain the novelty of the study. How does the discussion relate to the objective of the article? How does the discussion effectively interpret key data?
- How does the conclusion capture the main findings of the work? Does it expand on or emphasize future work/implications for the field?

Create image | Surprise me | Summarize text | Code | Brainstorm | More

STUDENTS VS. CHATGPT
in critically summarizing a scientific paper

In this link, you will find the summary report sheets that were filled by each the student and ChatGPT for this experiment. This is what we used as a reference for our comparison between the two in the table below:

http://hdl.handle.net/10393/50115

Here is what we observed:

When asked to transform article title to lay title:	
original paper title: **Injectable human recombinant collagen matrices limit adverse remodeling and improve cardiac function after myocardial infarction**	
"Injectable Collagen Helps Repair the Heart after a Heart attack" **ChatGPT** simplifies the title and makes it lay but uses broad words such as "heal heart damage" instead of citing a specific usage such as tissue regeneration.	*"Injectable human collagen protein reduces improper tissue regeneration and improves heart function after heart attack"* **The students'** response is much longer and is still not in lay language even though it is more precise and scientifically specific.
When asked to organize a Summary:	
Chat GPT is more organized and uses headings and section titles to organize the summary.	**Students** uses simple bullet points to present their summary without any organizational approach.

ChatGPT adds redundant and unnecessary details that makes the summary very wordy. Example, ChatGPT repeats previously mentioned information under a different heading or section title.	**Students** remain concise and consistent in the amount of information provided for each section of the summary.
ChatGPT is not always able to detect and find certain sections of the paper. (Example: unable to detect the abstract).	**Students** did not have a problem answering the prompts of each section from the paper.
ChatGPT fell short on supplementing its claims with evidence from the paper and instead provided general conclusions that often overstate and distort the conclusions of the study.	**Students** focused on the general idea of each prompt and provided specific supporting examples relating to the prompt, with specific conclusions.
When asked to provide final conclusions and future applications of the study results	
ChatGPT generates very broad and insignificant conclusions. *Example:* The principles and techniques developed could be applied to other medical fields, potentially revolutionizing treatments for various tissue-related conditions.	**Students**' answers cite specific future applications. *Example:* The techniques developed could ease in manufacturing and potential applications for in situ cornea shape manipulation.
When asked to explain the methods used :	
ChatGPT says: Specific materials like hyaluronic acid glycidyl methacrylate and chondroitin glycidyl methacrylate were prepared through chemical reactions involving methacrylation," with no further details or context even though these types of advanced methods are often unfamiliar by students and require external background search.	**Students** conduct background search on the methods used and are better able to explain and summarize complex methods with simple terms.
ChatGPT missed some key results, when asked to summarize the study results.	**Students** were thorough and managed to summarize all key results.

Chat GPT did not simplify overly technical terms such as words like "revascularization" and "cytocompatibility" which were included in its generated answers without greater context.	**Students** wrote the results in simpler language with enough background definition for technical terms.
When asked to summarize discussion :	
ChatGPT misinterpreted the discussion on corneal crosslinking. It claimed that "Unlike corneal crosslinking, which only stabilizes thinning corneas, the new biomaterials have the potential to replace the lost collagenous extracellular matrix." However, the material discussed in this paper still relies on corneal crosslinking.	**Students** used critical thinking and background research to understand the scope of the study discussion.
Despite **ChatGPT**'s faults and inconsistencies, it enables for the rapid generation of enormous amounts of information and delivers a general summary of the material faster than human-written summaries.	**Students** not planning on using ChatGPT need to read the paper multiple times to understand and be able to summarize it correctly according to our summary report sheet.

THE KEY TAKEAWAYS FROM THIS COMPARISON

1. Upon initial skimming of the paper, by using the summary sheet prompts with ChatGPT, this can offer an introduction that can prepare you for your own reading and analysis of the paper.
2. Use your own words to summarize the paper and not AI language.
3. Use AI as a complementary tool, not a replacement. Your academic journey might need less ChatGPT and a bit more critical thinking!

CONCLUSION

If you have reached the end of this book and completed the proposed activities, know that you are taking your first step toward actively learning what should have been taught systemically on how to effectively read a scientific paper. You should be proud of your efforts, and now you can use them to practice and guide your next readings throughout your academic journey and career.

In this book we started by discussing the main barriers that many encounter, and then we moved on to suggesting a framework for efficiently summarizing papers in the shortest time possible.

Begin by skimming the paper, noting down and defining the main technical terms in your own language.

Next, you can use either of our reading guides, setting the stage for intentional reading and serving as a guide for where to focus your attention.

Note that the reading guide is reduced and framed around the summary report sheet, which is the final step.

This is the second most critical step, following intentional reading, where you carefully read specific sections of the paper and summarize each based on different questions we provide in the summary report sheet.
You can later use this summary sheet for other assignment, reports or objectives, minimizing the need

to revisit the paper and saving valuable time. Remember, the more you practice, the more expert you become at using this method, and it will automatically guide your future reading using this framework!

Believe in yourself- your mind is a valuable tool and training it with a structured process will empower you to tackle any paper you encounter.

Now, you can **confidently venture** into the vast landscape of scientific literature, believing that you have the skills to navigate even without being an expert on the topic.

Some recommended reading outside of the scope of this book :

Structure, John McPhee, The New Yorker, January 6, 2013,
https://www.newyorker.com/magazine/2013/01/14/structure

The Science Writers' Handbook series, National Association of Science Writers,
https://www.nasw.org/page/science-writers-handbook-series

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Thank you!

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