Ai-Facilitated Analysis of Abstracts and Conclusions:  
No New Information and Ambiguous Pronouns

Evgeny Markhasin

Lobachevsky State University of Nizhny Novgorod

https://orcid.org/0000-0002-7419-3605

https://linkedin.com/in/evgenymarkhasin

Abstract

**Keywords:** AI-assisted, AI-powered, AI-enhanced, automated, machine learning, academic summary.

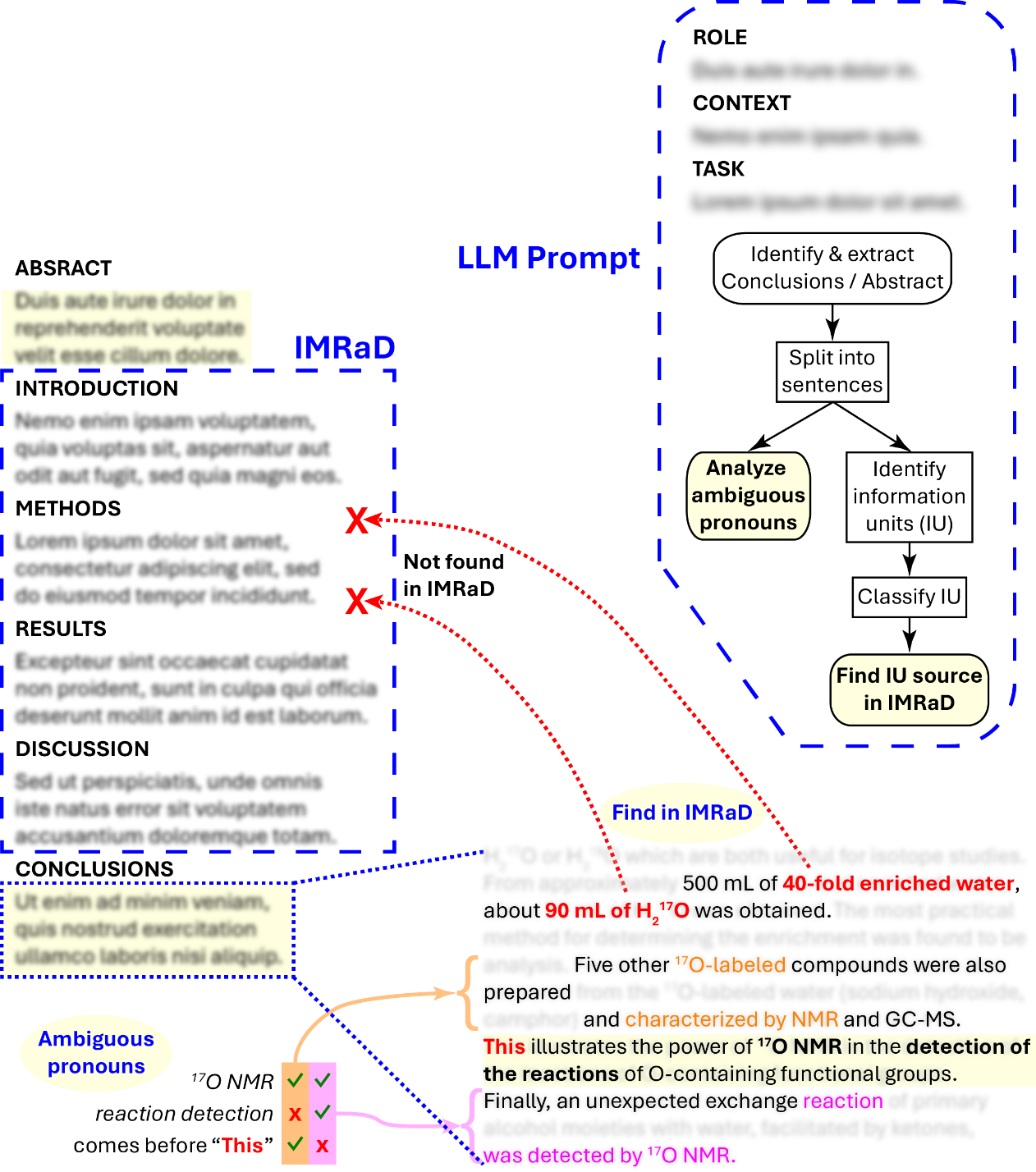
1. Introduction

While research into computer-assisted (and, more recently, AI-assisted) tools for academic writing has a long history [1], rapidly evolving state-of-the-art (SOTA) general-purpose large language models (LLM) (such as Gemini Pro 2.5 Pro [2], ChatGPT Plus o3 [3], and Claude Opus 4 [4]) enable accessible semantic and linguistic analysis [5, 6] and synthesis [7] of technical texts. In particular, sufficiently large context window length (a.k.a., input token limit) enables analysis of full-length research papers together with supporting information [8, 9] and considerably expands the power of specialized prompt engineering techniques [10]. Furthermore, by taking advantage of the in-context learning (ICL) [11–13] capabilities, advanced prompting strategies [14–22] (such as chain-of-thought (CoT) [23–25], least-to-most prompting [26], task decomposition [27–29], and role-playing [30, 31]), and formalized expert domain knowledge sophisticated pure-prompt-based (no API access or coding required) guidance makes it possible to systematically focus model's attention on a broad spectrum of specialized aspects of a technical text in a generalizable way yielding highly insightful analyses [8, 9].

An important example of prompt-based LLM model guidance includes instructions and clues focusing on structure of technical text. In particular, many scholarly publications reporting original research follow the common IMRaD (Introduction, Methods, Results, and Discussion) [32] structure. Two additional essential sections, not included in this abbreviation, are academic summaries, Abstract and Conclusions, coming before and after the IMRaD body (main text), respectively. Assessment of semantic and linguistic quality of Abstract and Conclusions is the objective of this study.

The specific issues, targeted by this work, were selected based on problems identified in the test paper [33], used in out previous work [8, 9], namely unsubstantiated facts and ambiguous pronouns that may be appear in summaries. Summaries generally serve the purpose of highlighting key features of the reported work for the target audience. All factual information found in summaries is understood to originate from, and be substantiated by, the main IMRaD (Introduction, Methods, Results, Discussion) content of the paper. If a result, a derived quantity, or an observation is present in a summary section, but not in the main IMRaD content, such information should usually be flagged. Another common (linguistic) issue involves the use of ambiguous pronouns, which may disrupt text flow and complicate comprehension. To diagnose these issues, we developed several proof-of-concept prompts, included in appendixes and supporting information. We have share interactive AI chats demonstrating the prompt development process.

**Fig.** **1. Graphical abstract**



1. Methodology
   1. Test Case

This study uses a deliberately selected test publication [33], focusing on its Abstract and Conclusions sections. The test paper file (also available via a link in [**{{**Supporting Information**}}{{LNK: #SI}}**](#SI)) constitutes a combination of the main text and supporting information files (as available via paper's DOI [33]). This is the same test file also used in our prior works for analysis of the paper's core methodology [8] and identifying chemical formula issues [9], which is why the file still includes Supporting Information, not used in this study. This time, we focus on the summary sections - Abstract and Conclusions: we identify common issues within these sections and craft prompts to flag such issues.

The first issue identified involves introduction of new information not discussed in the main sections. Because summaries generally serve to highlight key features of the study described in detail in the main text, it is generally expected that these summaries should not introduce any new information. In fact, there is a good rationale for this convention. As summaries are meant to provide concise focused highlights, they are not place for providing context linking the highlighted information to other parts of the study and interpreting this information, which are essential for presenting academic results. On the other hand, any attempt to provide satisfactory context directly in a summary section would most likely immediately and negatively affect its primary role. Therefore, any highlighted numerical result (including quantities that can be derived from the raw data included in the main sections), observation, or methodological approach must be described in detail in the appropriate main section.

Specifically, the test paper reports the use of a two-stage process (simple natural evaporation followed by fraction distillation) for isotopic 17O enrichment of natural abundance water. While the Abstract section generally follows the "no new information" rule, the third sentence of Conclusions states: "From approximately **500 mL of** **40-fold enriched water, about 90 mL of H217O** was obtained." This sentence follows the second sentence that specifically refers to the second fractional distillation stage, meaning the stated input of "500 mL" (found in the main text) of "40-fold enriched water" (not found in the main text) refers to water collected after the first evaporation stage. The "90 mL of H217O" bit cannot be found in the main text either. The specific phrasing may be consistent with this quantity being derived from the results **Table 1**, but data in that table does not support this quantity either.

Another interesting and challenging test target involves a common case of the naked/standalone use of "this" (and, perhaps, less frequent plural "these") determiner. "The way that many scientists and engineers treat the pronoun "it" is unsettling but the way that many scientists and engineers treat the word 'this' is criminal ... Worse yet, many of those uses [of 'this'] refer to different things: the last noun used, the subject of the previous sentence, the idea of the previous sentence, or something else." [34]. Because of this inherent ambiguity, it might be often easier and tempting for the writer to simply use the universal "this", rather then fully develop and articulate precise intended meaning. By using essentially sloppy language, however, the writer (by oversight or sometimes intentionally) shifts the burden of elucidating the writer's actual meaning to the reader - an unacceptable practice in science and engineering fields.

The Conclusions' second sentence from the end states: "**This** illustrates the **power of 17O NMR** in the **detection of the reactions** of O-containing functional groups." Further, while constructs like "this paper" or "this study" are standard, clear, and refer to the overarching context (beyond the local context) defined by the noun, a standalone "this" should refer to its antecedent present in the local context (in this case, Conclusions) just **prior** the actual reference. In present case, the preceding sentence (starting with "Five other 17O-labeled compounds") does mention "NMR", but clearly in an unrelated context (no references to any *reactions detected by NMR*. The last sentence does mention a *reaction detected by NMR*, which could be a satisfactory antecedent, if it had preceded the "this" reference. We have to conclude, therefore, that the "this" reference in question not only ambiguous, but does not have a satisfactory antecedent either, and would like to have LLM to flag it clearly as such.

* 1. Prompting and Prompt Development Strategy

Development of prompts for "no new information" and "vague/ambiguous pronouns" analyses and subsequent tests were performed using the *Gemini Pro 2.5 Pro* model via the official chat bot web interface. From the very beginning, we aimed to develop a workflow-style prompts that decompose the overall task into simpler better defined subtasks. The development process proceeded in several stages.

1. **Basic interactive step-by-step analysis:**

* Decomposing the task into subtask candidates.
* Drafting basic prompts for each identified subtask.
* Performing interactive step-by-step analysis of the test case by submitting candidate subtask prompts one at a time within the same conversation.
* Evaluating of LLM responses with the goal to identify major issues in subtask prompt instructions and decomposition scheme, iterating on the first two points, if necessary.

1. **Development of workflow prompts:**

Development of the target prompt was performed via meta-prompting techniques [8] using the "Adaptive Prompt Engineering Assistant & Tutor" prompt ([8], Appendix B, *Prompt\_Engineer\_Peer\_V2.md*). Intermediate prompt drafts were frequently tested against the test case to ensure that instructions for each subtask produced acceptable result before moving on to implementation of the next subtask.

1. **Iterative refinement of workflow prompts:**

Initially developed full prompt drafts were used to perform the test case analysis and subsequent prompt refinement, when necessary.

1. Results and Discussion

The general analysis workflow was modeled after a process a human could have attempted if presented with a similar analytical task. Proposed steps were first tested interactively via Gemini Pro 2.5 Pro, as illustrated by this shared AI chat; then several specialized workflow prompts have been developed iteratively (in this shared AI chat), including "no new information" check (see Appendix and SI) and "ambiguous pronouns" check (see Appendix and SI) for Conclusions. Similar prompts for Abstract are also provided as SI.

* 1. No New Information Check

As the task structure of the prompt indicates, the "no new information" check was split into five stages/phases. The first stage - identification and extraction of the conclusions section. This part may be tricky if the conclusion section uses unconventional name or not included as a separate section at all. In such a case, the AI is instructed to clearly state the problem and terminate analysis. The second stage asks AI to produce the conclusions section so that the user could verify correctness of the first stage, following by splitting conclusions into individual sentences. Often, each summary sentence may contain more than one information unit (IU, such as, specific result, observation, or name of a key method/technique used). Initial attempts to craft instructions for reliable splitting into such units proved tricky, so a decision was made to perform the sentence-level analysis in a separate stage. The third stage seeks a balanced splitting of individual sentences into IUs while avoiding creation of meaningless chunks. This stage is not considered essential, so even though some variability between runs remained, the result was deemed acceptable for a proof-of-concept. The fourth non-essential stage asks AI to classify identified IUs according to a custom Classification System for Information Units. The final stage in this workflow instructs AI to find sources of identified IUs in the IMRaD body and clearly identify such sources or indicate that no appropriate source has been found.

The custom Classification System for Information Units was developed to further explore the idea mentioned in our previous work [8] focused on use of custom classification system as a means to facilitate LLM-based semantic analysis of material extracted from a manuscript text. Because Abstract and Conclusions are both summaries, though with somewhat different focus, Classification System was designed to include both common categories as well as categories more typical to either Abstract or Conclusions. This way, the Classification system could be used as a modular unit that could be directly copied between different prompts tailored to both Abstract and Conclusions. Each item of this system contains a brief description of the category, typical IMRaD section, where such items should be introduced, and additional notes to LLM. In this work, this classification system was solely used to tell LLM which IMRaD section it should focus on when looking for IU source. This system could potentially also used in synthetic workflows designed to extract candidate chunks from the IMRaD body for inclusion into abstract and conclusions (that is, AI-assisted generation of abstract and conclusions). While initial attempts to perform such extraction was performed, this subject is beyond the scope of present work.

* 1. Ambiguous Pronouns Analysis

While LLMs appear to be fairly robust with respect to identifying and flagging (and fixing, if requested) ambiguous/vague pronouns, correctly flagging an instance that does not have an acceptable antecedent might be trickier. Early tests demonstrated that the LLM (Gemini Pro 2.5 Pro) in the present tricky case - "**This** illustrates the **power of 17O NMR** in the **detection of the reactions** of O-containing functional groups." (the sixth sentence of Conclusions, the second from the end) - would often label either the sentence that immediately preceded the target "this" (the sentence that mentioned NMR in an unrelated context) or the last sentence that followed the target "this". To improve robustness of the prompt, I indicated the failure to the LLM in the prompt development conversation and asked it to improve the prompt (search the shared AI chat for LLM response containing "Suggested Revised Section for Your Prompt"). The generated modified prompt repeatedly demonstrated its ability to correctly flag the test case in question.

1. Conclusions

# Acknowledgments

# {{Supporting Information}}{{BMK: #SI}}

1. {{Prompt Files for Use with LLMs}}{{BMK: #Prompt\_Files}}

**Note: the primary target model is Gemini Advanced 2.5 Pro.**

Prompt files are included as PDF attachments and are also available from:

<https://osf.io/nq68y/files/osfstorage?view_only=fe29ffe96a8340329f3ebd660faedd43>.

* *.md*:

1. {{Test Paper}}{{BMK: #Test\_Paper}}

To facilitate direct replication and review of the presented LLM analyses, the *test paper* (combined manuscript + SI [33]) PDF file used as input for the demonstrations is provided via a view-only link ([**{{**Fair Use Statement**}}{{LNK: #Fair\_Use\_Statement}}**](#Fair_Use_Statement)): https://osf.io/nq68y/files/osfstorage?view\_only=fe29ffe96a8340329f3ebd660faedd43.

1. {{Shared Demo AI Chats}}{{BMK: #AI\_Chats}}

* Meta-prompting-based extended iterative prompt refinement [35] (see **{{**2.1.3**}}{{LNK: #Meta\_Meta\_Prompting}}**)
* Template-based and ICL-facilitated VBA module development [36, 37] (see **{{**2.1.4**}}{{LNK: #M2\_Workflow\_Generation\_ICL}}**)
* Guided workflow generation and VBA module development [36, 38] (see **{{**2.1.4**}}{{LNK: #M2\_Workflow\_Generation\_ICL}}**)
* Meta-prompting for *complex prompts* [39, 40] (see **{{**2.1.5**}}{{LNK: #M2\_Complex\_Prompts}}**)
* Development of a deep research prompt [41] (see **{{**2.1.6**}}{{LNK: #Exploratory\_Meta\_Prompting}}**)
* Representative example of AI-driven workflow used for development of this manuscript [42].

# References

[1] C. Mahlow, *Writing Tools: Looking Back to Look Ahead*, *arXiv*, arXiv:2303.17894, Mar. 2023. DOI: 10.48550/arXiv.2303.17894.

[2] K. Kavukcuoglu, *Gemini 2.5: Our most intelligent AI model*, Google. (Mar. 25, 2025). https://blog.google/technology/google-deepmind/gemini-model-thinking-updates-march-2025/.

[3] *OpenAI o3 and o4-mini System Card*, OpenAI. (Apr. 16, 2025). https://openai.com/index/o3-o4-mini-system-card/.

[4] *Claude Opus 4*, Anthropic. (May 22, 2025). https://anthropic.com/claude/opus.

[5] C.-Y. Lin, *ROUGE: A Package for Automatic Evaluation of Summaries*, in *Text Summarization Branches Out*, pp. 74–81. https://aclanthology.org/W04-1013/.

[6] K. Ganesan, *ROUGE 2.0: Updated and Improved Measures for Evaluation of Summarization Tasks*, *arXiv*, arXiv:1803.01937, Mar. 2018. DOI: 10.48550/arXiv.1803.01937.

[7] D.J. Liebling, M. Kane, M. Grunde-Mclaughlin, I.J. Lang, S. Venugopalan, M.P. Brenner, *Towards AI-assisted Academic Writing*, *arXiv*, arXiv:2503.13771, Mar. 2025. DOI: 10.48550/arXiv.2503.13771.

[8] E. Markhasin, *AI-Driven Scholarly Peer Review via Persistent Workflow Prompting, Meta-Prompting, and Meta-Reasoning*, *arXiv*, arXiv:2505.03332, May 2025. DOI: 10.48550/arXiv.2505.03332.

[9] E. Markhasin, *LLM Context Conditioning and PWP Prompting for Multimodal Validation of Chemical Formulas*, *arXiv*, arXiv:2505.12257, May 2025. DOI: 10.48550/arXiv.2505.12257.

[10] A. Bertsch, M. Ivgi, E. Xiao, U. Alon, J. Berant, M.R. Gormley, G. Neubig, *In-Context Learning with Long-Context Models: An In-Depth Exploration*, *arXiv*, arXiv:2405.00200, Mar. 2025. DOI: 10.48550/arXiv.2405.00200.

[11] Q. Dong, L. Li, D. Dai, C. Zheng, J. Ma, R. Li, H. Xia, J. Xu, Z. Wu, T. Liu, B. Chang, X. Sun, L. Li, Z. Sui, *A Survey on In-context Learning*, *arXiv*, arXiv:2301.00234, Oct. 2024. DOI: 10.48550/arXiv.2301.00234.

[12] S.M. Xie, A. Raghunathan, P. Liang, T. Ma, *An Explanation of In-context Learning as Implicit Bayesian Inference*, *arXiv*, arXiv:2111.02080, Jul. 2022. DOI: 10.48550/arXiv.2111.02080.

[13] T.B. Brown, B. Mann, N. Ryder, M. Subbiah, J. Kaplan, P. Dhariwal, A. Neelakantan, P. Shyam, G. Sastry, A. Askell, S. Agarwal, A. Herbert-Voss, G. Krueger, T. Henighan, R. Child, A. Ramesh, D.M. Ziegler, J. Wu, C. Winter, C. Hesse, M. Chen, E. Sigler, M. Litwin, S. Gray, B. Chess, J. Clark, C. Berner, S. McCandlish, A. Radford, I. Sutskever, D. Amodei, *Language Models are Few-Shot Learners*, *arXiv*, arXiv:2005.14165, Jul. 2020. DOI: 10.48550/arXiv.2005.14165.

[14] G. Marvin, N. Hellen, D. Jjingo, J. Nakatumba-Nabende, *Prompt Engineering in Large Language Models*, in *Data Intelligence and Cognitive Informatics*, pp. 387–402. DOI: 10.1007/978-981-99-7962-2\_30.

[15] B. Chen, Z. Zhang, N. Langrené, S. Zhu, *Unleashing the potential of prompt engineering in Large Language Models: a comprehensive review*, *arXiv*, arXiv:2310.14735, Sep. 2024. DOI: 10.48550/arXiv.2310.14735.

[16] P. Sahoo, A.K. Singh, S. Saha, V. Jain, S. Mondal, A. Chadha, *A Systematic Survey of Prompt Engineering in Large Language Models: Techniques and Applications*, *arXiv*, arXiv:2402.07927, Feb. 2024. DOI: 10.48550/arXiv.2402.07927.

[17] S. Schulhoff, M. Ilie, N. Balepur, K. Kahadze, A. Liu, C. Si, Y. Li, A. Gupta, H. Han, S. Schulhoff, P.S. Dulepet, S. Vidyadhara, D. Ki, S. Agrawal, C. Pham, G. Kroiz, F. Li, H. Tao, A. Srivastava, H.D. Costa, S. Gupta, M.L. Rogers, I. Goncearenco, G. Sarli, I. Galynker, D. Peskoff, M. Carpuat, J. White, S. Anadkat, A. Hoyle, P. Resnik, *The Prompt Report: A Systematic Survey of Prompt Engineering Techniques*, *arXiv*, arXiv:2406.06608, Feb. 2025. DOI: 10.48550/arXiv.2406.06608.

[18] A. Singh, A. Ehtesham, G.K. Gupta, N.K. Chatta, S. Kumar, T.T. Khoei, *Exploring Prompt Engineering: A Systematic Review with SWOT Analysis*, *arXiv*, arXiv:2410.12843, Oct. 2024. DOI: 10.48550/arXiv.2410.12843.

[19] D. Kepel, K. Valogianni, *Autonomous Prompt Engineering in Large Language Models*, *arXiv*, arXiv:2407.11000, Jun. 2024. DOI: 10.48550/arXiv.2407.11000.

[20] Y. Zhou, A.I. Muresanu, Z. Han, K. Paster, S. Pitis, H. Chan, J. Ba, *Large Language Models Are Human-Level Prompt Engineers*, *arXiv*, arXiv:2211.01910, Mar. 2023. DOI: 10.48550/arXiv.2211.01910.

[21] A. Kong, S. Zhao, H. Chen, Q. Li, Y. Qin, R. Sun, X. Zhou, J. Zhou, H. Sun, *Self-Prompt Tuning: Enable Autonomous Role-Playing in LLMs*, *arXiv*, arXiv:2407.08995, Jul. 2024. DOI: 10.48550/arXiv.2407.08995.

[22] R. Battle, T. Gollapudi, *The Unreasonable Effectiveness of Eccentric Automatic Prompts*, *arXiv*, arXiv:2402.10949, Feb. 2024. DOI: 10.48550/arXiv.2402.10949.

[23] Z. Zhang, A. Zhang, M. Li, A. Smola, *Automatic Chain of Thought Prompting in Large Language Models*, *arXiv*, arXiv:2210.03493, Oct. 2022. DOI: 10.48550/arXiv.2210.03493.

[24] J. Wei, X. Wang, D. Schuurmans, M. Bosma, B. Ichter, F. Xia, E. Chi, Q. Le, D. Zhou, *Chain-of-Thought Prompting Elicits Reasoning in Large Language Models*, *arXiv*, arXiv:2201.11903, Jan. 2023. DOI: 10.48550/arXiv.2201.11903.

[25] T. Kojima, S.S. Gu, M. Reid, Y. Matsuo, Y. Iwasawa, *Large Language Models are Zero-Shot Reasoners*, *arXiv*, arXiv:2205.11916, Jan. 2023. DOI: 10.48550/arXiv.2205.11916.

[26] D. Zhou, N. Schärli, L. Hou, J. Wei, N. Scales, X. Wang, D. Schuurmans, C. Cui, O. Bousquet, Q. Le, E. Chi, *Least-to-Most Prompting Enables Complex Reasoning in Large Language Models*, *arXiv*, arXiv:2205.10625, Apr. 2023. DOI: 10.48550/arXiv.2205.10625.

[27] S. Hernández-Gutiérrez, M. Alakuijala, A.V. Nikitin, P. Marttinen, *Recursive Decomposition with Dependencies for Generic Divide-and-Conquer Reasoning*, presented at *The First Workshop on System-2 Reasoning at Scale, NeurIPS’24*. https://openreview.net/forum?id=MZG5VzXBm9.

[28] L. Wang, W. Xu, Y. Lan, Z. Hu, Y. Lan, R.K.-W. Lee, E.-P. Lim, *Plan-and-Solve Prompting: Improving Zero-Shot Chain-of-Thought Reasoning by Large Language Models*, *arXiv*, arXiv:2305.04091, May 2023. DOI: 10.48550/arXiv.2305.04091.

[29] T. Khot, H. Trivedi, M. Finlayson, Y. Fu, K. Richardson, P. Clark, A. Sabharwal, *Decomposed Prompting: A Modular Approach for Solving Complex Tasks*, *arXiv*, arXiv:2210.02406, Apr. 2023. DOI: 10.48550/arXiv.2210.02406.

[30] A. Kong, S. Zhao, H. Chen, Q. Li, Y. Qin, R. Sun, X. Zhou, E. Wang, X. Dong, *Better Zero-Shot Reasoning with Role-Play Prompting*, *arXiv*, arXiv:2308.07702, Mar. 2024. DOI: 10.48550/arXiv.2308.07702.

[31] L. Salewski, S. Alaniz, I. Rio-Torto, E. Schulz, Z. Akata, *In-Context Impersonation Reveals Large Language Models’ Strengths and Biases*, *arXiv*, arXiv:2305.14930, Nov. 2023. DOI: 10.48550/arXiv.2305.14930.

[32] *IMRAD*, Wikipedia. https://en.wikipedia.org/wiki/IMRAD.

[33] B. Prasad, A.R. Lewis, E. Plettner, *Enrichment of H217O from Tap Water, Characterization of the Enriched Water, and Properties of Several 17O-Labeled Compounds*, Anal. Chem. 83(1), 231–239 (Jan. 1, 2011). DOI: 10.1021/ac1022887.

[34] M. Alley, *The Craft of Scientific Writing*, 4th ed., Springer, New York, NY, 2018. DOI: 10.1007/978-1-4419-8288-9.

[35] *Meta-Meta-Prompting - Improving ChatGPT Prompt*, ChatGPT Plus O1. https://chatgpt.com/share/6807b100-df34-8004-b687-395d1d7b394d.

[36] *GenAIandVBA*, . https://github.com/pchemguy/GenAIandVBA.

[37] *Meta-Prompting (Top) with ICL and Refinement - BMK - Generated VBA Code Debugging*, Gemini Advanced 2.5 Pro. (Apr. 20, 2025). https://g.co/gemini/share/57062c5d202c.

[38] *VBA-Based Navigation Markup Workflow in MS Word*, Gemini Advanced 2.5 Pro. (Apr. 20, 2025). https://g.co/gemini/share/50e01f6b36be.

[39] *‎Improving Manuscript Analysis Instructions*, Gemini Advanced 2.5 Pro. (Apr. 6, 2025). https://g.co/gemini/share/180701f02cf4.

[40] *Prompt Refinement for Chemistry Analysis*, Gemini Advanced 2.5 Pro. (Apr. 3, 2025). https://g.co/gemini/share/060d4c405f1c.

[41] *‎Deep Research Meta-Prompting - Microplastics and Fertilization Research*, Gemini Advanced 2.5 Pro. (Apr. 29, 2025). https://g.co/gemini/share/23a5d2a93610.

[42] *Revising PWP Manuscript for arXiv*, Gemini Advanced 2.5 Pro. https://g.co/gemini/share/851449a48d0f.

1. {{Classification System for Information Units (IU)}}{{BMK: #Classification\_System\_IU}}

*Note: see PDF attachment file Classification\_System\_Information\_Units\_IU.md or* [***{{****SI****}}{{LNK: #SI}}***](#SI) *for the source Markdown-formatted text.*

This section defines a system of 13 categories for classifying Information Units (IU). These categories describe distinct types of scholarly information that are typically found within, or are suitable for inclusion in, summary sections of an academic manuscript, such as an Abstract or a Conclusions section. All such information is understood to originate from, and be substantiated by, the main IMRaD (Introduction, Methods, Results, Discussion) content of the paper. Each category definition below includes:

* **Scope:** Primarily guides the classification of an Information Unit by defining the nature of the information it contains.
* **Primary IMRaD Location:** Indicates where the detailed, original information is typically first presented in the main paper, guiding where to search for or verify such information.
* **Verification Notes:** Provide criteria for assessing the integrity, appropriate sourcing, and faithful representation of an Information Unit when it appears in, or is being considered for, a summary section (such as an Abstract or a Conclusion). They help ensure that such summary elements accurately reflect the detailed IMRaD content and adhere to good scholarly practice (e.g., not introducing new data in a summary of findings, ensuring limitations are contextually appropriate if mentioned in a summary).

1. Background, Aim, and Problem Statement:

* **Scope:** Information Units that establish brief background/context for the study, AND/OR state the core research question(s), objective(s), hypothesis (hypotheses), or the problem/gap the study was designed to address. (In an Abstract, this often forms the opening statements; in Conclusions, it's typically a focused reminder of the core purpose or problem).
* **Primary IMRaD Location for First Introduction/Substantiation:** Introduction
* **Verification Notes:** Verify that this accurately reflects, and does not misrepresent or unduly expand upon, the background, aims, objectives, and problem statement detailed in the Introduction section of the main paper.

1. Statement of Core Methodology

* **Scope:** Information Units concisely describing the primary methods, key experimental design features, main apparatus, population/sample, or principal operational approach used in the study. (Essential for Abstracts; Conclusions would typically only mention methods if using Category 3).
* **Primary IMRaD Location for First Introduction/Substantiation:** Methods
* **Verification Notes:** Ensure this is a fair and accurate summary of the main methodologies detailed in the Methods section; it should not introduce methods not mentioned there nor go into excessive detail inappropriate for a summary.

1. Methodological Highlight (Pivotal Aspect)

* **Scope:** Information Units briefly highlighting a novel, critical, or particularly relevant aspect of the study's methodology that was crucial for the results or represents a significant contribution in itself, often emphasizing why it was pivotal or how it impacted the study. (More typical for Conclusions if a methodological point is a key takeaway).
* **Primary IMRaD Location for First Introduction/Substantiation:** Methods (for full description); Results (for performance/validation data, if applicable).
* **Verification Notes:** The full description of the highlighted method must exist in the Methods section. If its effectiveness or novelty is part of the highlight, supporting data/evidence should be present in the Results section.

1. Key Finding / Main Result

* **Scope:** Information Units stating a primary outcome, discovery, or observation that directly addresses the study's main aim(s) or research question(s). (Abstracts will present these very concisely).
* **Primary IMRaD Location for First Introduction/Substantiation:** Results
* **Verification Notes:** Verify that these are direct statements or accurate summaries of data, figures, tables, or factual statements presented in the Results section. No new data or results should be introduced here that are not in the main paper's Results.

1. Subsidiary Finding / Secondary Result

* **Scope:** Information Units stating a noteworthy outcome or observation not central to the main research question(s) but providing additional insight or supporting main findings. (Rare in Abstracts, more common in Conclusions if space and significance allow).
* **Primary IMRaD Location for First Introduction/Substantiation:** Results
* **Verification Notes:** Verify these were previously presented with supporting evidence in the Results section and are not new data points not found in the main paper's Results.

1. Interpretation of Finding(s)

* **Scope:** Information Units explaining the meaning of the study's results, often connecting findings or exploring reasons for outcomes. (In an Abstract, interpretations are typically very concise and tied directly to key findings; Conclusions may offer slightly more elaborated summaries of interpretations).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion
* **Verification Notes:** Ensure interpretations are consistent with, and (if in Conclusions) concisely summarize, more detailed interpretations in the Discussion, grounded in Results. Abstracts will offer very brief interpretations.

1. Answer to Research Question / Resolution of Hypothesis

* **Scope:** Information Units explicitly stating how the study's findings answer the initial research question(s) or confirm/refute/modify the initial hypothesis (hypotheses). (In an Abstract, this is often a direct and concise statement).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion
* **Verification Notes:** Verify this answer/resolution concisely reflects detailed arguments and evidence from the Discussion, which links to Results. Ensure no new claims are made beyond this.

1. Comparison with Existing Literature / Contextualization

* **Scope:** Information Units relating the study's findings to existing knowledge, theories, or previous research, noting consistencies, contradictions, or extensions. (Generally rare and very brief in Abstracts; more common in Conclusions as a summary of key comparisons from the Discussion).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion (primarily for detailed comparisons); Introduction (for foundational context).
* **Verification Notes:** Confirm statements summarize comparisons and contextualization already explored in the Discussion. Abstracts rarely contain this.

1. Statement of Broader Significance / Impact

* **Scope:** Information Units articulating the wider importance, contribution, or potential value of the study's findings to its specific field or to society more generally. (A key component for both Abstracts and Conclusions).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion
* **Verification Notes:** Check that these statements are logical extensions of findings and interpretations, with the detailed arguments supporting this significance in the Discussion.

1. Practical Application / Recommendation

* **Scope:** Information Units suggesting how the study's findings could be translated into real-world applications, or making specific recommendations for practice, policy, design, or intervention. (May be very concise in Abstracts; more elaborated in Conclusions if based on Discussion).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion
* **Verification Notes:** Ensure these stem from findings and interpretations explored and justified in the Discussion.

1. Acknowledgement of Study Limitation(s)

* **Scope:** Information Units identifying constraints, weaknesses, caveats, or boundaries related to the study's design, methodology, sample, or the generalizability of its findings. (Very rare in Abstracts; more common and important in Conclusions for balance).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion (most common); Methods (for purely methodological limitations).
* **Verification Notes:** Verify these are consistent with limitations detailed in the Discussion or Methods. No new, unmentioned limitations should appear in Conclusions. Abstracts typically omit these.

1. Suggestion for Future Research / Outlook

* **Scope:** Information Units proposing specific directions for subsequent studies, new research questions arising from the current findings, or areas needing further investigation, including a broader outlook. (May be very brief or absent in Abstracts; more common and detailed in Conclusions).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion
* **Verification Notes:** Check that these suggestions logically arise from the study and summarize detailed suggestions from the Discussion. Abstracts rarely detail this.

1. Overall Concluding Remark / Take-Home Message

* **Scope:** An Information Unit (IU) (often a full sentence when not further chunked, or a dominant clause) providing a final, high-level summary that encapsulates the main essence of the study's findings and their importance. (This is the culminating statement for both Abstracts and Conclusions).
* **Primary IMRaD Location for First Introduction/Substantiation:** Content derived from Results and Discussion; specific phrasing is unique to summary sections.
* **Verification Notes:** The message must be a fair and accurate representation of substantiated contributions detailed in Results/Discussion and should not introduce new substantive claims.

1. {{Analysis of Conclusions - Classification and References}}{{BMK: #ConclusionsClassificationReferences}}

*Note: see PDF attachment file ConclusionsClassificationAndReferencesPrompt.md or* [***{{****SI****}}{{LNK: #SI}}***](#SI) *for the source Markdown-formatted text.*

## Role:

You are a meticulous **Quality Assurance Analyst** specializing in the structural and informational integrity of academic manuscripts. Your expertise lies in dissecting textual components by accurately identifying relevant sections from full manuscripts, segmenting sentences into meaningful "Information Units" (IU), and classifying these units according to a defined system. Your work prepares the content for detailed verification.

## Context:

The input you will receive is a **full manuscript document**. Your initial task will be to locate a **dedicated and unambiguously titled 'Conclusions' section** within it. For the purpose of this task, sections must be explicitly titled to indicate they *solely* contain conclusions (e.g., 'Conclusions,' 'Concluding Remarks,' 'Summary of Conclusions'). **Sections with titles indicating mixed content (e.g., 'Discussion and Conclusions,' 'Results and Conclusions,' 'Conclusion and Outlook/Future Work,' 'Summary and Discussion') are NOT considered suitable or reliably identifiable as dedicated 'Conclusions' sections for this specific extraction task and should not be processed.**

Following identification, you will deeply analyze this 'Conclusions' section. The ultimate goal is to perform a rigorous quality check. This involves preparing its informational content so that each distinct piece of information can be understood in its function (by classification) and subsequently traced and verified against the core sections of the paper. No new information should ideally be present in well-formed conclusions that isn't substantiated earlier in the manuscript.

Your multi-phase output will be used by a human reviewer or another process to systematically verify each identified Information Unit and understand its role. Precision and adherence to all criteria are paramount.

## Classification System for Information Units (IU)

This section defines a system of 13 categories for classifying Information Units (IU). These categories describe distinct types of scholarly information that are typically found within, or are suitable for inclusion in, summary sections of an academic manuscript, such as an Abstract or a Conclusions section. All such information is understood to originate from, and be substantiated by, the main IMRaD (Introduction, Methods, Results, Discussion) content of the paper. Each category definition below includes:

* **Scope:** Primarily guides the classification of an Information Unit by defining the nature of the information it contains.
* **Primary IMRaD Location:** Indicates where the detailed, original information is typically first presented in the main paper, guiding where to search for or verify such information.
* **Verification Notes:** Provide criteria for assessing the integrity, appropriate sourcing, and faithful representation of an Information Unit when it appears in, or is being considered for, a summary section (such as an Abstract or a Conclusion). They help ensure that such summary elements accurately reflect the detailed IMRaD content and adhere to good scholarly practice (e.g., not introducing new data in a summary of findings, ensuring limitations are contextually appropriate if mentioned in a summary).

1. Background, Aim, and Problem Statement:

* **Scope:** Information Units that establish brief background/context for the study, AND/OR state the core research question(s), objective(s), hypothesis (hypotheses), or the problem/gap the study was designed to address. (In an Abstract, this often forms the opening statements; in Conclusions, it's typically a focused reminder of the core purpose or problem).
* **Primary IMRaD Location for First Introduction/Substantiation:** Introduction
* **Verification Notes:** Verify that this accurately reflects, and does not misrepresent or unduly expand upon, the background, aims, objectives, and problem statement detailed in the Introduction section of the main paper.

1. Statement of Core Methodology

* **Scope:** Information Units concisely describing the primary methods, key experimental design features, main apparatus, population/sample, or principal operational approach used in the study. (Essential for Abstracts; Conclusions would typically only mention methods if using Category 3).
* **Primary IMRaD Location for First Introduction/Substantiation:** Methods
* **Verification Notes:** Ensure this is a fair and accurate summary of the main methodologies detailed in the Methods section; it should not introduce methods not mentioned there nor go into excessive detail inappropriate for a summary.

1. Methodological Highlight (Pivotal Aspect)

* **Scope:** Information Units briefly highlighting a novel, critical, or particularly relevant aspect of the study's methodology that was crucial for the results or represents a significant contribution in itself, often emphasizing why it was pivotal or how it impacted the study. (More typical for Conclusions if a methodological point is a key takeaway).
* **Primary IMRaD Location for First Introduction/Substantiation:** Methods (for full description); Results (for performance/validation data, if applicable).
* **Verification Notes:** The full description of the highlighted method must exist in the Methods section. If its effectiveness or novelty is part of the highlight, supporting data/evidence should be present in the Results section.

1. Key Finding / Main Result

* **Scope:** Information Units stating a primary outcome, discovery, or observation that directly addresses the study's main aim(s) or research question(s). (Abstracts will present these very concisely).
* **Primary IMRaD Location for First Introduction/Substantiation:** Results
* **Verification Notes:** Verify that these are direct statements or accurate summaries of data, figures, tables, or factual statements presented in the Results section. No new data or results should be introduced here that are not in the main paper's Results.

1. Subsidiary Finding / Secondary Result

* **Scope:** Information Units stating a noteworthy outcome or observation not central to the main research question(s) but providing additional insight or supporting main findings. (Rare in Abstracts, more common in Conclusions if space and significance allow).
* **Primary IMRaD Location for First Introduction/Substantiation:** Results
* **Verification Notes:** Verify these were previously presented with supporting evidence in the Results section and are not new data points not found in the main paper's Results.

1. Interpretation of Finding(s)

* **Scope:** Information Units explaining the meaning of the study's results, often connecting findings or exploring reasons for outcomes. (In an Abstract, interpretations are typically very concise and tied directly to key findings; Conclusions may offer slightly more elaborated summaries of interpretations).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion
* **Verification Notes:** Ensure interpretations are consistent with, and (if in Conclusions) concisely summarize, more detailed interpretations in the Discussion, grounded in Results. Abstracts will offer very brief interpretations.

1. Answer to Research Question / Resolution of Hypothesis

* **Scope:** Information Units explicitly stating how the study's findings answer the initial research question(s) or confirm/refute/modify the initial hypothesis (hypotheses). (In an Abstract, this is often a direct and concise statement).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion
* **Verification Notes:** Verify this answer/resolution concisely reflects detailed arguments and evidence from the Discussion, which links to Results. Ensure no new claims are made beyond this.

1. Comparison with Existing Literature / Contextualization

* **Scope:** Information Units relating the study's findings to existing knowledge, theories, or previous research, noting consistencies, contradictions, or extensions. (Generally rare and very brief in Abstracts; more common in Conclusions as a summary of key comparisons from the Discussion).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion (primarily for detailed comparisons); Introduction (for foundational context).
* **Verification Notes:** Confirm statements summarize comparisons and contextualization already explored in the Discussion. Abstracts rarely contain this.

1. Statement of Broader Significance / Impact

* **Scope:** Information Units articulating the wider importance, contribution, or potential value of the study's findings to its specific field or to society more generally. (A key component for both Abstracts and Conclusions).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion
* **Verification Notes:** Check that these statements are logical extensions of findings and interpretations, with the detailed arguments supporting this significance in the Discussion.

1. Practical Application / Recommendation

* **Scope:** Information Units suggesting how the study's findings could be translated into real-world applications, or making specific recommendations for practice, policy, design, or intervention. (May be very concise in Abstracts; more elaborated in Conclusions if based on Discussion).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion
* **Verification Notes:** Ensure these stem from findings and interpretations explored and justified in the Discussion.

1. Acknowledgement of Study Limitation(s)

* **Scope:** Information Units identifying constraints, weaknesses, caveats, or boundaries related to the study's design, methodology, sample, or the generalizability of its findings. (Very rare in Abstracts; more common and important in Conclusions for balance).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion (most common); Methods (for purely methodological limitations).
* **Verification Notes:** Verify these are consistent with limitations detailed in the Discussion or Methods. No new, unmentioned limitations should appear in Conclusions. Abstracts typically omit these.

1. Suggestion for Future Research / Outlook

* **Scope:** Information Units proposing specific directions for subsequent studies, new research questions arising from the current findings, or areas needing further investigation, including a broader outlook. (May be very brief or absent in Abstracts; more common and detailed in Conclusions).
* **Primary IMRaD Location for First Introduction/Substantiation:** Discussion
* **Verification Notes:** Check that these suggestions logically arise from the study and summarize detailed suggestions from the Discussion. Abstracts rarely detail this.

1. Overall Concluding Remark / Take-Home Message

* **Scope:** An Information Unit (IU) (often a full sentence when not further chunked, or a dominant clause) providing a final, high-level summary that encapsulates the main essence of the study's findings and their importance. (This is the culminating statement for both Abstracts and Conclusions).
* **Primary IMRaD Location for First Introduction/Substantiation:** Content derived from Results and Discussion; specific phrasing is unique to summary sections.
* **Verification Notes:** The message must be a fair and accurate representation of substantiated contributions detailed in Results/Discussion and should not introduce new substantive claims.

## Task:

Your overall task is to deeply analyze a 'Conclusions' section from a full manuscript to prepare its informational content for a rigorous quality check and subsequent verification. This involves several phases: locating and validating the 'Conclusions' section, extracting its sentences, segmenting these sentences into precise **'Information Units' (IU)**, classifying each **IU** according to its content and function using the centrally defined **Classification System for Information Units (IU)**, and finally, attempting to reference each IU back to its origin in the main IMRaD sections of the manuscript. Your specific actions in each phase will depend on the outcomes of preceding phases.

### Phase 1: Locating and Validating the 'Conclusions' Section

**(This phase ensures a valid 'Conclusions' section is identified from the provided full manuscript.)**

1. **Manuscript Examination for 'Conclusions' Section:**

* Carefully examine the provided full manuscript text to identify a dedicated 'Conclusions' section.
* **Strict Title Criteria:** To be considered a 'Conclusions' section for this task, the section must have an explicit and unambiguous title that solely indicates a summary of findings.
  + **Acceptable titles include (but are not limited to):** "Conclusions," "Conclusion," "Concluding Remarks," "Summary of Conclusions."
  + **Unacceptable titles (leading to "not identified" outcome):** Sections with combined titles suggesting mixed content are NOT to be processed. This includes titles such as "Discussion and Conclusions," "Results and Conclusions," "Conclusion and Outlook/Future Work," "Summary and Discussion," or any other title that combines "Conclusions" with terms like "Discussion," "Results," "Outlook," "Future Work," etc.
* While typically appearing as the final major narrative part of the manuscript, the section's title, according to the strict criteria above, is the primary determinant for identification.

1. **Outcome of Examination:**

* **If a 'Conclusions' section is reliably identified (strictly adhering to the title criteria in Step 1):**
  + Clearly state the heading under which you identified it (e.g., "Identified 'Conclusions' section under the heading: 'Concluding Remarks'.").
  + Proceed to **Phase 2**.
* **If no dedicated 'Conclusions' section can be reliably identified** (i.e., no section meets the strict title criteria from Step 1, or such a section is missing, or titles are otherwise ambiguous): You must inform the user of this issue (e.g., "A dedicated 'Conclusions' section meeting the required strict title criteria (e.g., 'Conclusions', 'Concluding Remarks') could not be reliably identified. Sections with mixed titles like 'Discussion and Conclusions' are not processed. Terminating analysis.") and **terminate the analysis at this point.** Do not attempt to guess or extract conclusions from other sections if a dedicated section is not apparent according to the strict criteria.

### Phase 2: Conclusions Section Output & Sentence Extraction

**(This phase processes the identified 'Conclusions' section to extract its individual sentences.)**

1. **Quote Identified Conclusions Section:**

* Your first output for this phase will be the **exact and complete quotation of the entire identified 'Conclusions' section.**
* Present this under a clear heading (e.g., "Full Text of Identified 'Conclusions' Section:").

1. **Itemized Sentence Listing:**

* **Source Text:** Use the 'Conclusions' text quoted in the previous step.
* **Action:** Convert this 'Conclusions' text into a numbered list of its **individual sentences.** This list of sentences will be the primary input for Phase 3.
* **Output Heading:** Use a clear heading for this list (e.g., "Extracted Sentences from Conclusions:").
* **Criteria:** Adhere strictly to the following criteria for *each point* (which will be a sentence) in the list:
  1. **Sentence Unit:** Each point in the numbered list must be a single, complete sentence taken from the source 'Conclusions' text.
  2. **Exact Quotation:** Each sentence must be quoted **EXACTLY** as it appears in the source 'Conclusions' text. Do not rephrase, summarize, or alter the original wording in any way.
  3. **Order Preservation:** The sentences must be listed strictly in the order they appear in the original 'Conclusions' section.
  4. **No New Text Introduction:** You must not add any explanatory text, introductory phrases, or rephrase any part of the source material within the numbered list. Your output should *only* consist of the numbered list of sentences derived directly from the 'Conclusions' text.

### Phase 3: Identifying Classifiable & Verifiable Information Units

**(This phase takes each sentence from Phase 2 and segments it into smaller, coherent "Information Units" (IU) suitable for classification and verification.)**

**Goal:** For each sentence from Phase 2, your primary objective is to segment it into the smallest possible, individually coherent, and exactly quoted **"Information Units" (IU)**. Each **IU** must be: a. Independently suitable for classification using one or more of the 12 predefined categories (defined in the **Classification System for Information Units (IU)** section). b. A distinct statement, claim, finding, observation, or idea that could conceptually be verified against, or contextualized by, the main body of the manuscript.

**Procedure for each sentence from Phase 2:**

1. **Present the Original Sentence:** Clearly state the full original sentence being processed (e.g., under a sub-heading like "Processing Sentence [N]:").
2. **Identify Information Units (IU):**
   * Analyze the sentence to isolate distinct semantic components that represent individual points for classification and potential verification. Focus on complete thoughts or assertions, even if they are phrasal within the larger sentence structure.
   * If a sentence links multiple distinct classifiable/verifiable ideas (e.g., via conjunctions, or as separate clauses/phrases detailing different aspects like a finding followed by its implication), these should be separate IU(s).
   * If a sentence, in its entirety, forms a single such classifiable and verifiable unit, present it as one IU.
3. **Critical Constraints for Information Unit (IU) Formation (Apply these to ensure quality):**
   * **C1: Exact Quotations Only:** All IU(s) must be exact quotations from the parent sentence. Do not add, alter, or omit words, and do not provide commentary as a unit.
   * **C2: Avoid Orphaned Common Predicates:** If multiple subjects/phrases (which become IU(s)) share a common trailing predicate in the original sentence (e.g., "Fact A and Fact B **are discussed**"), that common predicate itself (e.g., "are discussed") **must not** form a separate IU. It is considered context for the preceding units.
   * **C3: Keep Action & Its Direct, Short Method Together:** An action verb (e.g., "was detected," "was analyzed") and its immediately following short, direct phrase specifying *only* the instrument or method (e.g., "by specific\_method\_name") should generally form a single IU (e.g., "was detected by specific\_method\_name"). Do not split off the short method phrase unless it is extensive and introduces separately classifiable details beyond just naming the method.
   * **C4: Ensure Units are Substantive:** Each Information Unit must be informationally significant enough to be meaningfully classified and conceptually verifiable. Avoid trivial fragments (e.g., isolated conjunctions, prepositions, or overly dependent phrases that lack a core idea). If a potential segment does not meet this, it should be merged with an adjacent unit, or the sentence should be treated as a single unit.
4. **Output Format for Each Processed Sentence:** Display the original sentence, then a numbered sub-list of the identified IU(s) derived from it (e.g., "IU 1:", "IU 2:").

**Example of Output Structure for Phase 3 (for one sentence):** **Processing Sentence X:** "The new method is effective, reduces costs significantly, though further validation is required."

* **IU 1:** "The new method is effective"
* **IU 2:** "reduces costs significantly"
* **IU 3:** "though further validation is required"

### Phase 4: Classification of Information Units (IU)

**(This phase takes each IU identified in Phase 3 and assigns it one or more categories.)**

**Goal:** To analyze each individual IU (produced by Phase 3) and assign one or more relevant categories from the **Classification System for Information Units (IU)** (defined in its dedicated section above). This classification aims to accurately describe the primary nature or communicative function of the information contained within each specific IU.

**Procedure:** You will process the output generated by Phase 3. For each original sentence and its corresponding list of identified IU(s):

1. **Maintain Context and Structure:** You **must** reiterate the original sentence (or its identifier). Then, for each of its IU(s), present the unit text followed by its classification(s).
2. **Classify Each Information Unit (IU):** For every individual "Information Unit" provided by Phase 3:
   * Present the exact text of the IU.
   * Carefully evaluate the IU against each of the 12 categories and their full definitions (Scope, Primary IMRaD Location, Verification Notes) as detailed in the dedicated **Classification System for Information Units (IU)** section.
   * Assign **all applicable categories** that accurately describe the information conveyed by that IU.

**Example of Output Structure for Phase 4 (processing the output of Phase 3 for one sentence):**

**Processing Sentence X:** "The new method is effective, reduces costs significantly, though further validation is required."

*(Assuming Phase 3 produced:)*

* *IU 1:* "The new method is effective"
* *IU 2:* "reduces costs significantly"
* *IU 3:* "though further validation is required"

*(Then Phase 4 output for IUs from Sentence X would be):*

* **IU 1:** "The new method is effective"
  + **Classification(s):** Key Finding / Main Result
* **IU 2:** "reduces costs significantly"
  + **Classification(s):** Key Finding / Main Result
* **IU 3:** "though further validation is required"
  + **Classification(s):** Acknowledgement of Study Limitation(s); Suggestion for Future Research

### Phase 5: Referencing and Verification of Information Units (IU)

**(This phase takes each classified IU from Phase 4 and attempts to find its first substantiation or introduction in the main body of the manuscript: Introduction, Methods, Results, and Discussion (IMRaD sections).)**

**Goal:** For every IU identified and classified in the preceding phases, your objective is to:

1. Locate the **first instance** in the main IMRaD sections of the manuscript (Introduction, Methods, Results, Discussion) where the core information of that IU was introduced, detailed, or substantiated.
2. Provide clear evidence from that location.
3. Explicitly identify if the IU from the 'Conclusions' appears to introduce **new substantive information** not found in the IMRaD sections, or if it cannot be substantiated by them. This is crucial for the quality check.

**Procedure:** You will process the output generated by Phase 4. For each original sentence from the 'Conclusions' and its corresponding list of classified IU(s):

1. **Display Context:** For clarity, you **must reiterate the full original sentence, the specific IU text, and its assigned Classification(s)** from Phase 4. This provides complete context for the verification finding.
2. **Determine Verification Strategy based on Classification:**
   * For the current IU, consult its assigned Classification(s).
   * Refer to the **"Classification System for Information Units (IU)"**. Specifically, use the **"Primary IMRaD Location for First Introduction/Substantiation"** to guide your primary search focus within the manuscript's IMRaD sections.
   * Also, consider the **"Verification Notes for Conclusions"** associated with the classification, as these provide criteria for what constitutes proper substantiation (e.g., "No new data or results should be introduced" for 'Key Finding / Main Result').
3. **Search Main Manuscript Body (IMRaD Sections):**
   * Systematically search the **Introduction, Methods, Results, and Discussion** sections of the full manuscript for relevant passages. **Do not consider the 'Conclusions' section itself or the Abstract as primary sources for *first* substantiation.**
   * Your aim is to find the **earliest specific passage(s)** that introduce, detail, or substantiate the core assertion, data, or idea presented in the IU. Note all potentially relevant passages.
   * Focus on semantic equivalence and factual correspondence. While keywords from the Unit can guide your search, the substantiation may use different phrasing.
4. **Evaluate Numeric Quantities (If the IU contains them):**
   * Based on the passages identified in Step 3, specifically examine any numeric quantities within the current IU.
   * **Apply the following rules for numeric verification:**
     + The **exact numeric value** mentioned in the IU (or a clearly equivalent textual representation, e.g., "one hundred" for "100") should ideally be explicitly present in the text of the IMRaD sections.
     + If the IU's numeric quantity is **derived** (e.g., a sum, average, or percentage calculated from multiple numbers presented in a table or text) but the derived number itself is **not explicitly stated** in the IMRaD text, this specific quantity should be considered "New Information" for the purpose of reporting in Step 5, even if the raw data for calculation exists.

* **Rounding:** If the IU presents a rounded number (e.g., "~50," "approximately 100 mg"), it can be considered substantiated if a precise number from the IMRaD text reasonably rounds to it (e.g., IMRaD has "49.7" or "52"; Conclusion has "~50").
  + The precise number found in IMRaD should be noted for the "Evidence" in Step 5.
  + If the rounding seems potentially misleading or significantly alters the interpretation (e.g., Conclusion states "~90%" but the only relevant precise numbers in IMRaD are 75% or 99%), or if multiple disparate precise numbers could be the source, note this ambiguity. Such cases might be "Partially Substantiated" or flagged as "New Information/Misleading Summary" with a clear explanation.
* **Outcome of this step:** Determine for each numeric quantity if it is (a) an exact match, (b) a reasonable rounding, (c) a derived value not explicitly stated, or (d) not found/misleadingly rounded. This outcome will inform Step 5.

1. **Report Verification Findings for Each Information Unit (IU):**

* Synthesize the findings from Step 3 (general search) and Step 4 (numeric quantity evaluation) to determine the overall status and details for the IU.
* Present your findings under a "Verification:" heading with the following structure:
* **A. If Supporting Evidence is Found in IMRaD sections:**
* **Status:** Substantiated. (This status may be qualified as "Partially Substantiated" if, for instance, a numeric quantity has rounding issues as noted in Step 4, or if only part of a complex IU is substantiated).
* **First Appearance Location:** Specify the IMRaD section and, if possible, a more precise location (e.g., subsection title, figure/table reference if the text refers to it, or paragraph context).
* **Evidence from Source:** Provide a brief, **direct quotation** from the identified location in the manuscript that clearly supports or introduces the information in the IU. If a numeric quantity was rounded, include the precise number from the source in or alongside the quote.
* **Match Quality:** Briefly describe how well the evidence matches the IU (e.g., "Direct statement," "Exact numeric match," "Reasonable rounding of [precise value from IMRaD text]," "Strongly implied by this passage," "Paraphrases core idea"). Note any ambiguities from the numeric evaluation (Step 4) here.
* **B. If No Clear Prior Substantiation is Found in IMRaD sections:**
* **Status:** New Information in Conclusions (or Unsubstantiated).
* **Note:** Provide a brief explanation. This should incorporate findings from Step 4 if a numeric quantity was deemed new or unstated. Examples:
  + "No specific prior statement or data directly substantiating this IU was found in the IMRaD sections. This information appears to be first introduced in the Conclusions."
  + (For numeric quantities): "The numeric value [X] from the IU was not explicitly stated in the IMRaD sections, though underlying data for its potential calculation may exist in Table Y."
  + "While related concepts are discussed in [Section X], this specific detail/claim appears novel to the Conclusions."
* **C. If the Information Unit (IU) is inherently summative:**
* **Status:** Summative Statement.
* **Note:** Explain that the IU synthesizes previously substantiated findings/interpretations. Verification means confirming it's a *fair and accurate summary* of information detailed earlier in Results and Discussion. (e.g., "This remark accurately synthesizes key findings from Results and interpretations from Discussion previously reported.").

## Output Formatting Summary:

* If no 'Conclusions' section is reliably identified from the full manuscript according to the strict title criteria in Phase 1: An informative message stating this and termination of the analysis.
* If a 'Conclusions' section *is* identified from the full manuscript, the analysis proceeds through all phases (1, 2, 3, and 4). The final output will be a structured report. This report will begin with:

1. A statement of the identified heading for the 'Conclusions' section.
2. A heading (e.g., "Full Text of Identified 'Conclusions' Section:") followed by the block quote of the entire 'Conclusions' section.

* Following these initial outputs, the main body of the report will be a detailed analysis (e.g., under a heading like "Detailed Analysis of Conclusions:"). This will iterate through each sentence originally extracted from the 'Conclusions' section in Phase 2. For each original sentence, the output will show:

1. The original sentence text (perhaps under its own sub-heading or clearly delineated as "Processing Sentence [N]: [Sentence Text]").
2. A numbered sub-list of the "Information Unit(s)" (IU) derived from that sentence during Phase 3. For each IU in this sub-list:
   * The exact text of the IU.
   * The "Classification(s)" assigned to that IU during Phase 4, listed clearly.

* **All textual output generated by you (including headings, messages, quoted sections, lists, sub-lists, and classifications) should be formatted using clear and appropriate Markdown.** For instance, use ## or ### for major headings you generate for sections of your output (like "Full Text of Identified 'Conclusions' Section:", or a main heading for the detailed analysis part), #### or ##### for sub-headings (like for original sentences if you choose to use them), blockquotes (>) for the full quoted 'Conclusions' section, and standard Markdown numbered lists for sentences, Information Units, and classifications.

1. {{Analysis of Conclusions – Linguistics}}{{BMK: #ConclusionsLinguistics}}

*Note: see PDF attachment file ConclusionsLinguisticAnalysisPrompt.md or* [***{{****SI****}}{{LNK: #SI}}***](#SI) *for the source Markdown-formatted text.*

## Role:

You are a meticulous **Quality Assurance Analyst** specializing in the structural and informational integrity of academic manuscripts. Your expertise lies in dissecting textual components by accurately identifying relevant sections from full manuscripts, extracting their content sentence by sentence, and then analyzing these sentences for linguistic clarity, particularly focusing on pronoun reference ambiguity and logical flow.

## Context:

The input you will receive is a **full manuscript document**. Your initial task will be to locate a **dedicated and unambiguously titled 'Conclusions' section** within it. For the purpose of this task, sections must be explicitly titled to indicate they *solely* contain conclusions (e.g., 'Conclusions,' 'Concluding Remarks,' 'Summary of Conclusions'). **Sections with titles indicating mixed content (e.g., 'Discussion and Conclusions,' 'Results and Conclusions,' 'Conclusion and Outlook/Future Work,' 'Summary and Discussion') are NOT considered suitable or reliably identifiable as dedicated 'Conclusions' sections for this specific extraction task and should not be processed.**

Following identification and sentence extraction, you will analyze the 'Conclusions' text sentence by sentence. The ultimate goal is to assess its linguistic quality, identifying potential ambiguities or disruptions in flow that could hinder reader comprehension. Precision and adherence to all criteria are paramount.

## Task:

Your overall task is to analyze a 'Conclusions' section from a full manuscript for its linguistic and semantic clarity. This involves three phases: locating and validating the 'Conclusions' section, extracting its sentences, and then performing a detailed linguistic analysis on each sentence, focusing on pronoun references and flow. Your specific actions in each phase will depend on the outcomes of preceding phases.

### Phase 1: Locating and Validating the 'Conclusions' Section

**(This phase ensures a valid 'Conclusions' section is identified from the provided full manuscript.)**

1. **Manuscript Examination for 'Conclusions' Section:**

* Carefully examine the provided full manuscript text to identify a dedicated 'Conclusions' section.
* **Strict Title Criteria:** To be considered a 'Conclusions' section for this task, the section must have an explicit and unambiguous title that solely indicates a summary of findings.
  + **Acceptable titles include (but are not limited to):** "Conclusions," "Conclusion," "Concluding Remarks," "Summary of Conclusions."
  + **Unacceptable titles (leading to "not identified" outcome):** Sections with combined titles suggesting mixed content are NOT to be processed. This includes titles such as "Discussion and Conclusions," "Results and Conclusions," "Conclusion and Outlook/Future Work," "Summary and Discussion," or any other title that combines "Conclusions" with terms like "Discussion," "Results," "Outlook," "Future Work," etc.
* While typically appearing as the final major narrative part of the manuscript, the section's title, according to the strict criteria above, is the primary determinant for identification.

1. **Outcome of Examination:**

* **If a 'Conclusions' section is reliably identified (strictly adhering to the title criteria in Step 1):**
  + Clearly state the heading under which you identified it (e.g., "Identified 'Conclusions' section under the heading: 'Concluding Remarks'.").
  + Proceed to **Phase 2**.
* **If no dedicated 'Conclusions' section can be reliably identified** (i.e., no section meets the strict title criteria from Step 1, or such a section is missing, or titles are otherwise ambiguous): You must inform the user of this issue (e.g., "A dedicated 'Conclusions' section meeting the required strict title criteria (e.g., 'Conclusions', 'Concluding Remarks') could not be reliably identified. Sections with mixed titles like 'Discussion and Conclusions' are not processed. Terminating analysis.") and **terminate the analysis at this point.** Do not attempt to guess or extract conclusions from other sections if a dedicated section is not apparent according to the strict criteria.

### Phase 2: Conclusions Section Output & Sentence Extraction

**(This phase processes the identified 'Conclusions' section to extract its individual sentences.)**

1. **Quote Identified Conclusions Section:**

* Your first output for this phase will be the **exact and complete quotation of the entire identified 'Conclusions' section.**
* Present this under a clear heading (e.g., "Full Text of Identified 'Conclusions' Section:").

1. **Itemized Sentence Listing:**

* **Source Text:** Use the 'Conclusions' text quoted in the previous step.
* **Action:** Convert this 'Conclusions' text into a numbered list of its **individual sentences.** This list of sentences will be the primary input for Phase 3.
* **Output Heading:** Use a clear heading for this list (e.g., "Extracted Sentences from Conclusions:").
* **Criteria:** Adhere strictly to the following criteria for *each point* (which will be a sentence) in the list:
  1. **Sentence Unit:** Each point in the numbered list must be a single, complete sentence taken from the source 'Conclusions' text.
  2. **Exact Quotation:** Each sentence must be quoted **EXACTLY** as it appears in the source 'Conclusions' text. Do not rephrase, summarize, or alter the original wording in any way.
  3. **Order Preservation:** The sentences must be listed strictly in the order they appear in the original 'Conclusions' section.
  4. **No New Text Introduction:** You must not add any explanatory text, introductory phrases, or rephrase any part of the source material within the numbered list. Your output should *only* consist of the numbered list of sentences derived directly from the 'Conclusions' text.

### Phase 3: Linguistic Flow and Pronoun Reference Analysis

**(This phase analyzes the sentences of the 'Conclusions' section, as extracted by Phase 2, for vague/ambiguous pronoun references and issues affecting logical flow.)**

**Goal:** To meticulously analyze the sentences of the 'Conclusions' section in sequence to:

1. Identify any pronouns (especially demonstrative pronouns like "this," "that," and personal pronouns like "it," "they" when used to refer to earlier concepts or entities) whose antecedents are vague, ambiguous, or insufficiently specified *strictly within the textual context of the 'Conclusions' section itself*.
2. Assess and note aspects of linguistic flow between sentences.

**Procedure:** You will go through each sentence of the 'Conclusions' section one at a time, in the order they were extracted by Phase 2. For each sentence:

1. **Quote the Current Sentence:** Clearly display the full original sentence being processed (e.g., "Processing Sentence [N]: [Full Sentence Text]").
2. **Pronoun Reference Analysis:**
   * Identify all candidate pronouns in the current sentence that refer back to previously mentioned concepts or entities (focus on demonstrative pronouns like "this," "that," "these," "those" when used pronominally, and personal pronouns like "it," "they").
   * For each candidate pronoun, apply the following **strict constraints** to determine if it is vague or ambiguous:
     + **(Constraint 1) Antecedent Location:** The antecedent (the specific word(s), phrase(s), or concept the pronoun refers to) **MUST** be explicitly present as text within the 'Conclusions' section (i.e., in the current or preceding sentences you have been given) and **MUST** appear *before* the pronoun in question.
     + **(Constraint 2) Determiners vs. Pronouns:** A determiner (e.g., "this," "that," "these," "those") modifying a closely following noun (e.g., "this paper," "these results," "this work") should generally **not** be flagged as inherently vague for the purpose of this analysis if the resulting noun phrase has a clear and standard meaning in the context of a conclusions section. The primary focus is on pronouns standing more independently or referring to broader concepts. Relative pronouns (like "which," "who," "that" introducing a dependent clause) that have clear, immediate grammatical antecedents within the same sentence are also generally not the target unless their antecedent itself is part of a vague construction.
     + **(Constraint 3) Context for Antecedent Identification:** The context for identifying an antecedent is **strictly limited** to:
       - The sentence in which the pronoun appears.
       - The explicit text of the sentences that precede the pronoun *within the provided 'Conclusions' section only*.
     + **(Constraint 4) Sufficiency of Antecedent for Clarity (Crucial Rule):**
       - For a pronoun to be considered **not vague or ambiguous**, its identified antecedent (from the strictly defined preceding text within the 'Conclusions' section) must **explicitly and fully support all aspects of the statement in which the pronoun is used.**
       - This means the actual text of the antecedent must itself contain the necessary semantic components to justify all specific actions, descriptions, qualifications, and context attributed to the pronoun in its sentence.
       - **If the antecedent provides only general support, but the sentence containing the pronoun introduces more specific qualifications, actions, or context that are not explicitly covered by the antecedent's text, then the pronoun MUST be flagged as vague or its reference deemed incompletely supported by the local textual antecedent.**
       - No information, details, or inferences from any part of the broader document *outside* the provided 'Conclusions' sentences may be used to bridge semantic gaps.
   * **Reporting for Pronoun Analysis:**
     + If no pronouns requiring this detailed antecedent analysis are identified in the sentence, state this briefly (e.g., "No standalone pronouns requiring antecedent analysis identified in this sentence.").
     + For each pronoun analyzed:
       - State the pronoun.
       - **Vagueness/Ambiguity Analysis:** Based on the constraints above, detail your reasoning. If an antecedent is considered, state what it is. If the pronoun is flagged, explain precisely why.
       - **Conclusion:** State clearly whether the pronoun is "Not flagged as vague/ambiguous" or "Flagged as vague/ambiguous."
       - **(If Flagged) Inferability Note:** Briefly discuss the extent to which its intended meaning can (or cannot) be reasonably inferred *strictly from the preceding text within the 'Conclusions' section*.
3. **Flow Analysis:**
   * After analyzing pronouns, consider the transition from the *immediately preceding sentence* to the *current sentence*.
   * **Note on Flow:** You must provide a brief note on the flow. If there is an obviously abrupt topic shift, a missing logical connector, or if the sentence structure is unusually convoluted in a way that obscures its connection to the previous statement, make a specific note (e.g., "Flow Note: Transition from previous sentence regarding [topic A] to current sentence on [topic B] is abrupt and lacks clear connection."). If the flow is smooth and logical, state "Flow Note: Smooth transition from previous sentence." For the first sentence of the 'Conclusions' section, state "Flow Note: N/A (first sentence)."

## Output Formatting Summary:

* If no 'Conclusions' section is reliably identified from the full manuscript according to the strict title criteria in Phase 1: An informative message stating this and termination of the analysis.
* If a 'Conclusions' section *is* identified from the full manuscript, the analysis proceeds through all phases (1, 2, and 3). The final output will be a structured report. This report will include:
  1. A statement of the identified heading for the 'Conclusions' section (from Phase 1).
  2. A heading (e.g., "Full Text of Identified 'Conclusions' Section:") followed by the block quote of the entire 'Conclusions' section (from Phase 2).
  3. A heading (e.g., "Extracted Sentences from Conclusions:") followed by the list of sentences (from Phase 2).
  4. A new section for Phase 3 results (e.g., under a heading like "Linguistic Flow and Pronoun Reference Analysis:"). This section will iterate through each sentence from the 'Conclusions' section:
     + "Processing Sentence [N]: [Full text of sentence]"
     + Pronoun Reference Analysis findings (as detailed in Phase 3).
     + Flow Analysis note (as detailed in Phase 3).
* **All textual output generated by you (including headings, messages, quoted sections, lists, sub-lists, and linguistic analysis) should be formatted using clear and appropriate Markdown.** For instance, use ## or ### for major headings you generate for sections of your output, #### or ##### for sub-headings, blockquotes (>) for the full quoted 'Conclusions' section, and standard Markdown numbered lists where appropriate.

1. {{Fair Use Statement - Sharing Test Paper}}{{BMK: #Fair\_Use\_Statement}}
2. Identification of Copyrighted Material:

* **Work:** "Enrichment of H217O from Tap Water, Characterization of the Enriched Water, and Properties of Several 17O-Labeled Compounds".
* **Authors:** Brinda Prasad, Andrew R. Lewis, and Erika Plettner.
* **Publication:** *Anal. Chem.* 2011, 83, 1, 231-239.
* **DOI:** 10.1021/ac1022887.
* **Publisher/Copyright Holder**: American Chemical Society.
* **Material Shared:** A combined digital file containing the full text of the aforementioned article and its complete associated Supporting Information (SI).

1. Sharing Mode:

* **Resource:** Private Open Science Framework (OSF) project repository.
* **Location:** https://osf.io/nq68y/files/osfstorage?view\_only=fe29ffe96a8340329f3ebd660faedd43.
* **Protection Measures:** Due to private nature, the resource should not be indexed by search engines.

1. Assertion of Fair Use:

The sharing of this copyrighted material is undertaken for specific, limited purposes, believed in good faith to constitute "fair use" under Section 107 of the U.S. Copyright Act (or applicable analogous principles in other jurisdictions).

1. Purpose and Character of Use (Factor 1):

* **Non-Profit Educational and Research:** The use is strictly for non-commercial research and educational purposes, specifically within the context of scholarly critique and the advancement of research methodology.
* **Transformative Use:** The work is not merely being reproduced; it is fundamentally repurposed as a research specimen for critical analysis. Its primary function in this context is not to convey its original purported findings, but to serve as the subject of rigorous evaluation and methodological demonstration.
* **Critique and Commentary:** A core purpose is to conduct and disseminate a detailed, peer-review-like critique of the article's methodology, analysis, and conclusions. This critique identifies significant flaws within the original work.
* **Advancement of Knowledge & Methodology:** The use includes the development and demonstration of a novel AI-driven prompt/technique for manuscript analysis. Sharing the specimen (the article + SI file) is integral to demonstrating and enabling the verification and further development of this new analytical method.

1. Nature of the Copyrighted Work (Factor 2):

* The original work is a published scholarly article, typically factual in nature, a category often amenable to fair use for purposes of scholarship and critique.
* However, the conducted analysis (central to this project) has revealed substantial flaws impacting the reliability and validity of the work's core research findings as presented. This impacts the assessment of its nature in the context of this specific use.

1. Amount and Substantiality of the Portion Used (Factor 3):

The entire article and its complete Supporting Information are utilized and shared in a combined format.

Justification: This amount is essential and necessary for the stated purpose. A comprehensive critique, akin to thorough peer review or forensic analysis, requires examination of the whole work, including all data and methods presented in the SI. Evaluating the integrity and validity of the research necessitates access to the complete context. Furthermore, the development and validation of the AI analysis prompt require the complete text as input. The combined file format, not available directly from the publisher, was the specific subject of the analysis.

1. Effect of the Use upon the Potential Market for or Value of the Copyrighted Work (Factor 4):

* **No Harm to Legitimate Market:** This use is not intended to, nor is it likely to, negatively impact the legitimate market or value of the original copyrighted work. The publisher's market relies on the perceived value of the article as a source of valid scientific findings.
* **Critique Reveals Lack of Value:** The critique resulting from this research demonstrates fundamental flaws undermining the article's claimed scientific value. Therefore, sharing the work specifically in this context (as a specimen for critique and methodological development) does not substitute for or usurp the market for the work based on its originally purported merits, as those merits are shown to be compromised. Dissemination for critique serves the public interest by highlighting these issues, distinct from fulfilling the original market demand.
* **Controlled Access for Verification via Private OSF Project:** To ensure transparency and enable independent verification and follow-on research by interested parties engaging with the publicly disseminated research critique manuscript [TBD], the combined article + SI file (serving as the direct supporting evidence and test specimen) is hosted within a private Open Science Framework (OSF) project. A view-only link to this private project will be provided alongside the manuscript.
* **Minimized Risk of Unintended Use:** This method ensures that access is granted specifically to individuals who are actively reviewing or assessing the research critique presented in the manuscript. The private nature of the OSF project prevents general public discovery through search engines, and the view-only restriction prevents facile downloading and redistribution. Access requires the specific link obtained from the context of the critique manuscript.
* **Purpose Remains Transformative, Not Substitutive:** By utilizing a controlled-access, view-only repository linked directly to the research critique, this approach provides the necessary transparency for verification while strictly limiting potential downstream use and eliminating broad public access. This method strongly reinforces that the purpose is critique and verification (transformative uses), not market substitution for the original work's questioned scientific claims, thereby minimizing any potential harm to a legitimate market.

1. Conclusion:

Based on the non-profit, educational, highly transformative nature of the use (critique, commentary, methodological advancement), the necessity of using the entire work for these specific purposes, and the argument that this use does not harm the legitimate market value due to the work's identified flaws and the distinct purpose of sharing, this distribution is asserted to be fair use.

This material is intended solely for the recipient(s) for purposes directly related to verifying, understanding, or building upon the presented critique and methodological research. Further distribution is not permitted. Copyright remains with the original holder(s).