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**HOW TO STRUCTURE A SCIENTIFIC PAPER: SUMMARY**


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<b>INTRODUCTION</b>	
<b>PARAGRAPH</b>	<b>1 Importance.</b> Justify why the research topic is important (e.g. relevant to many people, answering a critical research question). Identify a <b>GENERAL</b> gap in understanding.
	<b>2,3 The MEASURABLE GAP in understanding.</b> Explain current understanding (conclusions from quantitative theoretical or experimental studies that have been published after rigorous peer-review). Explain why past discoveries are important and relevant to current understanding using <b>REASONED ARGUMENTS</b> ( <b>DEDUCTIVE</b> and/or <b>INDUCTIVE</b> ) and <b>LOGICAL TRANSITIONS</b> between ideas. Reference <u>each</u> statement of fact (all references at the <b>END</b> of sentences). Laws of physics, mathematical derivations, or reasoned conclusions do not require references. Explain current understanding as a logical progression that uses the <b>RESULTS</b> of previous studies as <b>PREMISES</b> of arguments with <b>CONCLUSIONS</b> that identify a measurable <b>GAP</b> in understanding.
	<b>4 Hypotheses.</b> Briefly state the <b>OVERALL GOAL</b> to fill the general gap in understanding. Explicitly state the <b>GENERAL</b> hypothesis. Explicitly state the <b>MEASURABLE</b> hypothesis and <b>ALTERNATIVE</b> hypothesis(es). Briefly preview the specific approach (e.g. the experiment) used to test the measurable hypothesis.
	<b>METHODS</b>
<b>SECTION</b> (Sections can have >1 paragraphs if necessary. Use <i>subheadings</i> to identify sections.)	<b>1 Study participants.</b> How many subjects were enrolled and participated, and why the number of subjects was chosen. Age, sex and other important characteristics of population studied (e.g. mass, anthropometry, etc.), and reasons why the population was chosen.
	<b>2 Procedures and Protocols.</b> Overall design of study (cross-sectional, cohort, etc.). Procedures for group selection. Treatments used and the purpose of each treatment, explained in detail. Explain procedures used for controls and why necessary and appropriate. Explain all specific testing procedures and their purpose. Data collection: measurements employed and why chosen over other measurement methods, where appropriate. Specific equipment used and for what purpose. Calibrations employed and why necessary.
	<b>3 Data Analysis.</b> How and why collected data were conditioned (e.g. filtering) and reduced. Normalizations employed and why appropriate. Mathematical calculations employed and why (detailed mathematical derivations can be placed in an Appendix). Statistical tests employed and why they were the most appropriate tests.
<b>Final Paragraph</b>	<b>Hypothesis test(s).</b> The specific criteria (calculations, statistics, and judgments) that will be used to support or reject the measurable hypothesis(es).
<b>RESULTS</b>	
<b>SECTIONS</b> (Sections delimited by <b>bold/italicized subheadings</b> that directly relate to hypotheses)	<b>Summary (optional).</b> Brief summary of data and conclusions (i.e. hypothesis tests).
	<b>Sub-conclusion Sections.</b> Each section follows a <b>bold/italicized</b> subheading concisely stating the <u>conclusion</u> of the section using a complete sentence. The conclusion should directly relate to a hypothesis (e.g. actually be the conclusion of the hypothesis test). The body of each section defends why the data lead to the conclusion. Structure arguments using deductive and/or inductive reasoning. Use logical transitions between ideas. Place references to figures and tables <u>only</u> at the <b>END</b> of sentences. Explicitly state the justification/reasons for rejecting or not rejecting each measurable hypothesis.
<b>DISCUSSION</b>	
<b>PARAGRAPH</b> (Sections delimited by <b>bold/italicized subheadings</b> )	<b>1 Concise summary of the Results.</b>
	<b>2 Assumptions</b> made, and reasons why the assumptions are unlikely to affect the conclusions of the study.
	<b>3 Limitations</b> of the methodology or analysis, and reasons why the limitations are unlikely to affect the conclusions of the study.
	<b>4,5 Supporting general hypotheses and/or generating new hypotheses.</b> Explain how the results support a change to our understanding. Explain how the results are <b>CONSISTENT</b> or <b>CONFLICT</b> with existing understanding (previous studies). If the results are <b>consistent</b> with past findings, explain how the results strengthen our confidence in general hypotheses. Explain how the potential <u>reasons</u> for <u>conflicts</u> with previous understanding lead to novel, testable, general and measurable hypotheses.
	<b>6 Implications of the study.</b> Why the findings are important. Potential contributions to current or future research. Potential applications (e.g. to clinical practice, injury prevention, technology development, public policy, etc.)

## **SUGGESTED STEPS FOR PERFORMING A SCIENTIFIC STUDY AND WRITING A SCIENTIFIC PAPER (listed chronologically)**

- 1) Perform a literature search to gain a comprehensive understanding of a particular field or problem
- 2) Identify a specific gap in understanding that is important to fill
- 3) Find (in the literature) or create a General Hypothesis that, when tested, will help fill the gap in understanding
- 4) Create a Measurable Hypothesis that:
  - a. Makes specific predictions that are distinct from alternative hypotheses
  - b. You can cleanly test based on your capabilities and constraints
  - c. Directly helps to test the General Hypothesis
- 5) Design an experiment that allows you to test the Measurable Hypothesis. To Design an experiment:
  - a. Select the overall study design (prospective, retrospective, cross-sectional, longitudinal, cohort, etc.)
  - b. Select an appropriate subject population (animal or human, age, sex, traits or experiences, etc.)
  - c. Select appropriate controls (control for individual differences, environment, bias, artifact, etc.)
  - d. Design specific procedures and protocols, including necessary calibrations. Use objective, quantitative (not qualitative) research methods and measurements whenever possible
  - e. If experiments involve humans, write down the specific instructions that you will uniformly provide to all participants
  - f. Design specific data analysis to perform, including data normalization and reduction
  - g. Determine the specific criteria that you will use to test your measurable hypothesis(es). Establish reasonable conditions for rejecting hypotheses or null hypotheses
  - h. Design the statistical tests necessary to make comparisons. Statistical design may involve selection of parametric vs. non-parametric statistics, choice of specific statistical tests, and power analysis
- 6) Perform the experiment as thoroughly and consistently as possible. Collect quantitative data
- 7) Normalize, Reduce, and Analyze collected data. Perform planned statistical tests
- 8) Use the preponderance of the data and the outcomes of the statistical tests to make conclusions about the measurable hypothesis(es). The measurable hypothesis(es) can be either
  - a. Rejected (if the data are clearly inconsistent with the predictions of the hypothesis)
  - b. Not Rejected/"Supported" (if the data are clearly consistent with the predictions of the hypothesis)
  - c. (note that hypotheses CANNOT be "accepted" or "proven." Do not use this terminology)
- 9) Assess the strength of your conclusions based on assumptions and limitations of your study. Consider and discuss limitations associated with every aspect of hypothesis generation and selection, study design, data analysis, and reasoning
- 10) Relate your specific findings to the conclusions of other studies in the context of General Hypotheses
  - a. Identify areas where your findings and findings of other studies are consistent with the predictions of General Hypotheses
  - b. Identify areas where your findings conflict with the predictions of General Hypotheses and the other studies that have been used to support the General Hypotheses
- 11) Defend overall conclusions about whether to either
  - a. Support existing General Hypotheses or
  - b. Create NEW General Hypotheses
- 12) Investigate potential implications and applications of your conclusions to research, technology, clinical practice, policy, etc.

For a written paper, steps 1-4 above should be explained in the INTRODUCTION, step 5 in the METHODS, steps 6-8 in the RESULTS, and steps 9-12 in the DISCUSSION.