

## HOW TO STRUCTURE A SCIENTIFIC PAPER: SUMMARY

INTRODUCTION	
	1 <b>Importance.</b> Justify why the research topic is important (e.g. relevant to many people, answering a critical research question, etc.). Identify a <b>GENERAL</b> gap in understanding.
PARAGRAPH	2,3 <b>The MEASURABLE GAP in understanding.</b> DEFINE all terms necessary to understand your arguments. Explain why <u>past</u> discoveries lead to <u>current</u> understanding using REASONED ARGUMENTS (DEDUCTIVE and/or INDUCTIVE) and LOGICAL TRANSITIONS (THEREFORE,BUT,AND) between ideas. Reference <u>each</u> statement of fact, definition, or example using peer-reviewed, quantitative studies (all references at the END of sentences). Laws of physics, mathematical derivations, or reasoned conclusions do not require references. Explain current understanding as a logical progression that uses the RESULTS of previous studies as PREMISES (i.e. statements of fact) of arguments with CONCLUSIONS that identify a measurable GAP in understanding.
	4 <b>Hypotheses.</b> Briefly state the OVERALL GOAL to fill the general gap in understanding. Explicitly state the GENERAL hypotheses. Explicitly state <u>how</u> each GENERAL hypothesis directly leads to one or more MEASURABLE hypotheses. Explain ALTERNATIVE hypotheses (e.g. that would arise from different assumptions). <u>Briefly</u> preview the specific approach (e.g. experiment) used to test each measurable hypothesis.
METHODS	
	1 <b>Study participants.</b> How many participants enrolled, and why the number of participants was appropriate. Age, sex and other important characteristics of participant population (e.g. mass, anthropometry, etc.), and reasons why the population was appropriate.
SECTION (Sections can have >1 paragraphs if necessary. Use subheadings to identify sections.)	2 <b>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. A REASONED framework that explains how each procedure contributes to testing a measurable hypothesis is stronger than a chronological framework for explaining procedures.
	3 <b>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.
Final Paragraph	<b>Hypothesis test(s).</b> The specific criteria (calculations, statistics, and judgments) that will be used to support or reject each measurable hypothesis.
RESULTS	
	<b>Summary (optional).</b> Brief summary of data and conclusions (i.e. hypothesis tests).
SECTIONS (Sections delimited by bold/italicized subheadings that directly relate to hypotheses)	<b>Sub-conclusion Sections.</b> Each section follows a bold/italicized <b>subheading</b> concisely stating the <u>conclusion</u> of the section using a complete sentence. The conclusion directly relates to a measurable hypothesis (e.g. explicitly states the reasons for rejecting or not rejecting the measurable hypothesis). The body of each section defends why the data lead to the conclusion using using deductive and/or inductive reasoning. Link ideas with logical transitions. If comparisons are statistically significantly different, (1) put differences into PERSPECTIVE by expressing as percentages, and (2) report statistical tests (e.g. P-values, etc.). Comparisons that are not statistically significantly different are NOT different (no "trends," "non-significant differences," etc.). Place references to figures, tables, and the results of statistical comparisons <u>only</u> at the END of sentences.
DISCUSSION	
	1 <b>Concise summary of the Results.</b>
	2 <b>Assumptions</b> made. Reasons why the assumptions are unlikely to affect the conclusions.
	3 <b>Limitations</b> of the methodology or analysis. For each limitation, reasons why the limitations are unlikely to affect the conclusions of the study.
PARAGRAPH (Sections delimited by bold/italicized subheadings)	4,5 <b>Supporting general hypotheses and/or generating new hypotheses.</b> Explain how the results support a change to our understanding. Explain how the results are CONSISTENT or CONFLICT with existing understanding (previous studies). If the results are <u>consistent</u> with past findings, explain how the results strengthen our confidence in general hypotheses. Hill's criteria (Reproducibility, Diversity, Plausibility, Strength, Temporality, Specificity, Dose-response, etc.) can be useful for organizing and grouping arguments. Explain how the potential <u>reasons</u> for <u>conflicts</u> with previous understanding lead to <u>new</u> general and measurable hypotheses.
	6 <b>Implications</b> of the study. 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 several Measurable Hypotheses that:
  - a. Make specific predictions that are distinct from alternative hypotheses
  - b. You can cleanly test based on your capabilities and constraints
  - c. Directly help to test the General Hypothesis
- 5) Design an experiment that allows you to test the Measurable Hypotheses. 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 hypotheses. 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 hypotheses. Each measurable hypothesis 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 (supporting the 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 (decreasing support of the General Hypotheses and suggesting that new General Hypotheses are needed).
- 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.