FRAMEWORK FOR A SCIENTIFIC PAPER: SUMMARY

INTRODUCTION

SECTION	1	**Importance.** Justify why the research topic is important (e.g. relevant to many people, answering a critical research question, etc.). Identify a GENERAL question. (1 paragraph)
	2	**The GAP in understanding.** Explain why past discoveries lead to CONCLUSIONS about current understanding using REASONED ARGUMENTS (DEDUCTIVE and/or INDUCTIVE) and LOGICAL TRANSITIONS (THEREFORE,BUT,AND,OR) between ideas. Reference each 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. The CONCLUSIONS of the arguments are POSITIVE (supported by evidence), but separated by a clearly-stated and specific GAP in understanding. DEFINE all terms necessary to understand your arguments within the context of each argument. (3-5 paragraphs)
	3	**Hypotheses**. Briefly state the OVERALL GOAL to fill the gap in understanding. Explain how testing the GENERAL hypotheses will achieve the goal. Explain how each GENERAL hypothesis directly leads to one or more MEASURABLE predictions (Hypotheses). Explain ALTERNATIVE hypotheses (e.g. hypotheses that would arise from different assumptions). (Optional) briefly preview the specific approach (e.g. experiment) used to test each Measurable Hypothesis. (1-3 paragraphs)

METHODS

SECTION (Sections can have >1 paragraphs if necessary. Use *subheadings* to identify sections.)	1	**Study participants**. How many participants enrolled, and why the participant number was appropriate. Age, sex and other important characteristics of participant population (e.g. mass, anthropometry, etc.), and reasons why the population was appropriate.
	2	**Procedures and Protocols**. Overall design of study (cross-sectional, cohort, etc.) and why. Procedures for group selection and why. 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. Use a REASONED framework that explains how each procedure contributes to testing the Measurable Hypotheses (use a chronology ONLY when time is critical).
	3	**Data Analysis**. How and why collected data were conditioned (e.g. filtered) and reduced. Normalizations employed and why appropriate. Mathematical calculations employed and why (use an Appendix for long derivations). Statistical tests employed and why each test is most appropriate.
Final Paragraph	4	**Testing Criteria**. The specific criteria (calculations, statistics, and judgments) that will be used to support or reject each Measurable Hypothesis.

RESULTS

SECTIONS (Sections delimited by bold/italicized *subheadings* that directly relate to hypotheses)	**Summary (optional)**. Brief summary of data and conclusions (i.e. hypothesis tests).
	Sub-conclusion Sections. Start each section with a bold/italicized *subheading* that concisely states the conclusion of the section using a complete sentence. The conclusion directly relates to a Measurable Hypothesis (e.g. explicitly states the reasons for rejecting or supporting the Measurable Hypothesis). The body of each section defends WHY the data lead to the conclusion using deductive and/or inductive reasoning (e.g. *modus tollens*). Link ideas with logical transitions. If comparisons among sampled data 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 significantly different are NOT different (no "trends," "non-significant differences," etc.). Place references to figures, tables, and the results of statistical comparisons only at the END of sentences.

DISCUSSION

SECTION (Sections delimited by bold/italicized *subheadings*)	1	**Concise summary of the Results**. (1 paragraph)
	2	**Defending the Conclusions**. For each *limitation* of the methodology or analysis, explain reasons why the limitations are unlikely to affect the conclusions of the study. (1 paragraph)
	3	**Supporting General Hypotheses** and/or **generating new General Hypotheses**. Explain how the results support a change to our understanding. Explain how the results are CONSISTENT or CONFLICT with existing understanding (e.g. previous research findings that led to the General Hypotheses). * If the results are consistent with past understanding and the General Hypotheses, explain why the assumptions are unlikely to affect the conclusions. Explain how placing the study results in the context of other research findings strengthens confidence in the General Hypotheses. Hill's criteria (Reliability, Diversity, Plausibility, Experimental Interventions, Temporality, Strength, Specificity, Biological Gradient) can be useful for organizing reasoned arguments that support the General Hypotheses. * If the results conflict with past understanding and the General Hypotheses, explain how the assumptions of the study or other research findings are potential reasons for conflicts with the original General Hypothesis. Use the results of the current study and other research findings to construct reasoned arguments (e.g. using *Strong Inference*) that support the plausibility of NEW General Hypotheses. (3-5 paragraphs)
	4	**Implications** of the study. Why the findings are important. Potential contributions to future research or applications (e.g. to clinical practice, technology development, public policy, etc.). (1 paragraph)

POSSIBLE STEPS FOR PERFORMING A SCIENTIFIC STUDY (AND DOCUMENTING AS A SCIENTIFIC PAPER)

1) Perform a literature search to gain a comprehensive understanding of a particular field or problem.
2) Identify an overall research QUESTION that is IMPORTANT to answer.
3) Enumerate all of the independent and dependent VARIABLES related to the research QUESTION.
4) Select the independent and dependent variables likely to have the most IMPACT on the question.
5) Use current understanding of the most important variables to make positive arguments that identify a specific gap in understanding. Hierarchies, dichotomies, and tree structures can greatly help to develop clear arguments.
6) Find (in the literature) or create a General Hypothesis that, when tested, will help fill the gap in understanding.
7) 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.
8) Design an experiment that allows you to test the Measurable Hypotheses. To Design an experiment:
    a. Select a 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 statistical tests for comparisons. Statistical design may involve selection of parametric vs. non-parametric statistics, choice of specific statistical tests, and power analysis.
    i. Ensure that all methods are approved by relevant oversight authorities (e.g. IACUC or IRB).
9) Perform the experiment as thoroughly and consistently as possible. Collect quantitative data.
10) Normalize, Reduce, and Analyze collected data. Perform planned statistical tests.
11) 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 overstate conclusions).
12) 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.
13) 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).
14) Defend overall conclusions about whether to either:
    a. Support existing General Hypotheses or
    b. Create NEW General Hypotheses.
15) Discuss why your findings are important. Explore potential implications and applications of your conclusions to research, technology, clinical practice, policy, etc.

For a written paper, steps 1-7 above are typically explained in the INTRODUCTION, step 8 in the METHODS, steps 9-11 in the RESULTS, and steps 12-15 in the DISCUSION.