

Bi116 Research Proposal Writing Assignment

Assignment:

Respond to a scientific “Request for Proposals” (RFP). This complex task will be broken into a number of sub-assignments to help students achieve a complete, final proposal.

Purpose:

The purpose of this assignment is to teach you how to **write an innovative and effective scientific proposal to test an original hypothesis, while inspiring you to think creatively about current biological problems**. Proposals are amongst the most challenging, interesting, and important documents written by scientists and engineers. Our goal is to teach you how to formulate a strong proposal in a way that will help you achieve this in any discipline in the future. The stages of this comprehensive assignment closely match how scientists write hypothesis-driven research proposals.

Schedule:

Assignment	Page no.	Due Date	Fraction of Writing Grade	Fraction of Overall Bi116 Course Grade
1. Topic Selection and Literature review	7 – 8	Jan 21	10%	3%
2. Introduction	10	Feb 4	15%	5%
3. Approach	11	Feb 18	15%	5%
3.5 Peer Review	12	Feb 25	10%	3%
4. Complete draft of proposal	13	March 3	20%	7%
5. Revised proposal	14-15	March 17	30%	10%

The entire writing assignment accounts for 33% of your Bi116 grade.

All assignments are due by the beginning of class on Tuesdays unless indicated otherwise. **Submit all assignments to the course website on Moodle as Word documents. In some cases, you will also need to hand in a printed copy of your work.**

Additional resources included in this document:

- What is a hypothesis? p. 3-4
- Bi 116 citation guidelines p. 5-6
- Understanding and Avoiding Plagiarism p. 9
- Proposal Template p. 16-20

Request for Proposals (RFP), Winter 2020

Bi 116 Research Proposals

Bi 116 seeks to support the creation of new ideas for scientific research. Proposals must incorporate the methods and logic of microbial genetics as the core approach you take to approach a problem. We encourage, but do not require, interdisciplinary proposals.

Proposal Guidelines

Proposals must contain the following elements in this order: (1) Title, (2) Introduction, (3) Approach, (4) Discussion, and (5) References.

The proposal should be 4 pages (double-spaced; Arial at font size 11; 1-inch margins). Tables and figures do not count toward the 4-page maximum, and should be placed after the References section. Use a single-column format.

Review Criteria

Successful proposals will:

- Identify a specific unanswered question or problem in microbiology or another field
- Apply the methods and logic of microbial genetics to approach this question/problem
- Develop a valid hypothesis and an approach to test it
- Explain how the hypothesis will be tested, including the use of appropriate controls
- Explain what impacts the research will have in a clear and compelling manner
- Focus on producing new scientific knowledge instead of design optimization
- Be written in clear, correct academic English
- Address an audience of scientists who are not specialists in the field your proposal addresses

Successful proposals do not need to:

- Demonstrate the technical expertise of a professional scientist. Our primary interest is to identify a viable project and reward logical reasoning and clear communication at the level that one can reasonably expect from a scientist new to the particular field of research.
- Submit or meet any budgetary criteria. The methods may be inexpensive or expensive, and this will not impact the success of the proposal.
- Have an immediate practical impact (e.g., implications for human health or national defense). The impacts should be compelling, but they may be conceptual (advancing knowledge) or practical (advancing applications of interest to humans).

What is a hypothesis?

It is NOT an optimization problem.

In a scientific research proposal, your hypothesis should provide one possible explanation or answer to a problem that you have clearly defined. The best hypotheses for research proposals are novel, specific, and testable. **Your hypothesis must be testable**, meaning that **there is a way for you to disprove it**. In this assignment, we are **NOT** looking for a method optimization.

What distinguishes a scientific hypothesis-driven proposal from something with an engineering focus that proposes a method optimization or novel design?

- ✗ For a design/method optimization, you already know what you're looking for, and are actively trying to prove that your idea is correct. The end result is often something you can use in some application.
- ✓ A research proposal, by contrast, identifies a problem or unsolved question that has more than one possible explanation. Thus the proposal outlines what the potential outcomes of an experiment could be, and how those would allow one to discern an underlying explanation or answer, or to be better able to evaluate alternative explanations. **The hypothesis is a testable assertion of a set of experimental outcomes, and the researcher's goal is to try to disprove it.** Only when an explanation withstands numerous rounds of scrutiny aimed at proving it false do people begin to say that the hypothesis is supported. Remember, you can never prove a hypothesis to be true, since there may be other information you don't yet know; you can only disprove it or get results that are consistent with it.

Although design / method optimization is also very important, it is NOT ACCEPTABLE for this proposal. Bi116's goal is to teach you how to articulate testable hypotheses that can be addressed using the tools of microbial genetics, as this is one of the best ways to bring clarity, rigor and elegance to complex subjects.

It is specific.

One of the most challenging aspects of this assignment is articulating a hypothesis of the appropriate specificity. How can you tell if your hypothesis is on the right track? Consider these guidelines:

- You can cover the essential experiments and relevant controls in reasonable detail within the constraints of the proposal parameters. The Methods section should be approximately 1 page.
- In a textbook, the outcome of your completed work might contribute a sentence or one short paragraph, not a whole chapter.

You are required to meet with one of the TAs or instructors to discuss possible hypotheses, to confirm that your hypothesis meets our criteria. Please attend office hours or email the instructors or TAs ahead of Jan 21 to arrange a meeting before the hypothesis is due.

Examples of hypotheses that do/do not meet the criteria:

Strong: In microbial fuel cells, the addition of electron shuttling compounds stimulates anaerobic respiration at the anode, leading to enhanced current generation.

Weak: Electron shuttles support microbial growth.

Not a hypothesis: Adding electron shuttles to microbial fuel cells will improve their efficiency.

Bi116 Citation Guidelines

CSE citation-sequence (c-s) style

Why cite?

For many students, citation is one of the final elements added to a paper before submission. This is a **major error** for two reasons. First, it is a frequent cause of plagiarism, which often happens when a writer has an unrealistic confidence in his or her memory. Putting off citation opens up possibilities for forgetting and running out of time to attribute sources accurately. More than this, though, it fundamentally misunderstands the centrality of the work of others to academic writing. Rather than being an afterthought, thinking and writing in relation to the work of others is a constant focus for professional academic writers.

What do my readers expect?

For your work in Bi116, we expect you to very carefully cite the ideas and language you borrow from other researchers. We expect there to be as much citation in your writing as there would be in the work of a professional scientist or even more, because many of the concepts, claims, and methods you present in your writing will be new to you and borrowed from other writers. You should not worry about citing too much in your proposal; you should worry about presenting others' work without attribution.

How do I cite?

In scientific fields, there are hundreds of citations styles linked to various journals, and the style you choose is dependent upon the place you wish to publish your work. Since we are not publishing your proposals, we want you to use CSE (Council of Science Editors) citation-sequence (c-s) style. This requires in-text citation using endnotes and a list of references.

In-text documentation

Citation-sequence format calls for you to put a superscript number after any use of ideas or language from a source. Once you number a source, use that same number each time the source is mentioned. Sources should be numbered in the order you mention them.

In scientific writing, unlike most writing in the humanities, it is rare to use signal phrases or to quote directly from sources. Instead, the most common approach is a cited paraphrase. This is because it is less immediately important to scientific readers *who* has shown something to be true; as a result, that information is not presented until the reference list. Here is an example of in-text citation of one, two, and more than two sources in CSE c-s style:

Modern scientific nomenclature really began with Linnaeus in botany¹, but other disciplines^{2,3} were not many years behind in developing various systems^{2, 4-7} for nomenclature and symbolization.

List of references

In-text documentation corresponds to a list of sources offered at the end of the paper. In CSE citation-sequence format, you will arrange and number your sources in the order in which they are mentioned in your proposal.

You can find detailed guidelines for formatting citations for various types of texts on the Penn State University Library website:

<https://guides.libraries.psu.edu/friendly.php?s=CitationStyles>

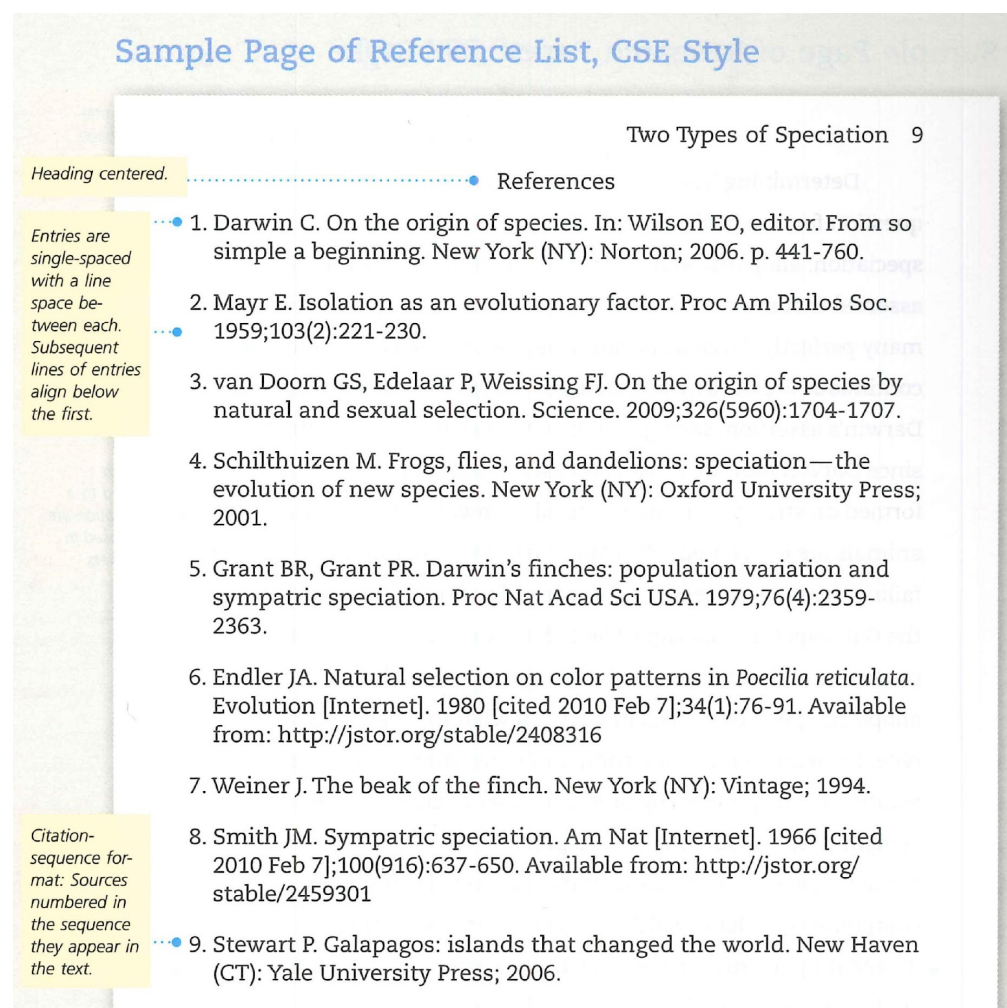
For questions that are not answered on these webpages, consult *Scientific Style and Format*, available in our library: <http://clas.caltech.edu/record=b1394560~S0>

Remember that we are using citation-sequence style (c-s), not name-year style (n-y).

Can you give me any tips for doing this efficiently?

Cite as you write. Do not put this off until the end of writing.

Consider using citation management software, which can help automate much of this process for you and assist in keeping your uses of sources organized. Caltech offers you the ability to use Zotero for free, and the library offers workshops on how to use it. More info here: <https://libguides.caltech.edu/citationmanagement>



Stage 1 Assignment: Topic selection and Literature Review

Due Tuesday Jan 21 (30 points)

>>Please type this assignment and upload the file to Moodle, as well as the three research articles selected for question 3<<

Your goal in this first assignment is to find and explore a proposal-worthy topic, conduct a literature review on topics of interest, and develop potential hypotheses. Using questions 1-3 below, explore some subjects of interest and identify ways in which they might interface with biology.

After identifying potential subjects of interest, conduct a literature review of publications in those areas. Your goal in this part of the assignment is to explore your stated area of interest and ensure that you ultimately settle on a research proposal topic area and hypothesis that are appropriate for the Request for Proposals. It is often necessary to skim through dozens of articles in order to get a good “read” on the state of the field. For the purposes of this stage, we encourage you to skim widely, but to deliberately assess three articles in terms of their relevance to your emerging research proposal (at least 2 of which must be original research papers, while the third paper can be another primary research paper, or a review article that summarizes several primary research papers, or an opinion paper in the peer-reviewed literature). After reading the papers, complete question 3 below.

To assist with the assignment, you should meet with an instructor or TA (~ 20 minutes) some time before the due date of January 21st to discuss your readings and possible hypotheses for your proposal. Also be prepared to go over a specific paper in depth. When discussing with the instructor or TA, keep in mind that you will need to center your proposal on a testable hypothesis, so discuss topics that interest you, but that have a biologically related question for which you could pose an answer. Your grade for this assignment will be based on your preparation for the meeting (10 points) and your work on the written assignment (20 points, values below).

1. a) What areas do you find interesting? Identify at least two areas; these do not need to be biology related. (2 points)

b) In what ways does microbial genetics interface with your interests? (1 point)

2. a) In one or more topic areas you identified above, what kinds of problems are currently being studied? (Consider looking for websites of lab groups in the fields that interest you.) (1 point)

b) Why is this topic (or these topics) important? How could you motivate a reader/funder to take interest in your topic(s)? (1 point)

3. (9 points total, 3 points per article) For each peer-reviewed article (total of 3 articles, at least 2 of which are primary research articles, the third may be a review or hypothesis article), upload the PDF of each papers to Moodle and identify below for each:

- a) Citation of the article, following the designated citation format (see Bi116 Citation Guidelines, in this PDF, p. 5-6)
- b) What ideas you now have after reading the article with respect to refining your hypothesis, choosing methods, etc.

4. Based on your literature review for your topics of interest, how might you contribute to the research being done in this field? Provide at least three possible hypotheses that you might like to craft into a research proposal. For each hypothesis, identify at least one reason that this would be a compelling research topic (think: novelty, potential impact on society or on the relevant scientific field). Remember, a hypothesis must be testable (see “What is a hypothesis?” on p. 3 of the proposal assignment PDF). (2 points per hypothesis)

- 1.
- 2.
- 3.

5. Cite any sources (blogs, news articles, scientific papers) that have led you to the topics and questions listed above. Follow the citation format given in the Bi116 Citation Guidelines (in this PDF, p. 5-6).

6. Optional (+1 bonus point)

Record citations (in proper formatting) for other works you identified as potentially useful, but that you did not report on in this assignment.

Additional Resources

Bi116 Citation Guidelines (in this PDF, p. 5-6)

Understanding and Avoiding Plagiarism (in this PDF, p. 9)

Caltech Librarians

Grading – Worth 30 points.

10 points for being prepared for meeting with instructor or TA. Remaining point values listed after each question.

Understanding and Avoiding Plagiarism

What is plagiarism?

Plagiarism occurs when a writer takes language or ideas from another writer without properly attributing them. There are three primary kinds of plagiarism:

1. **Outsourcing** is borrowing, commissioning, and/or purchasing an essay or other text entirely composed by someone else and submitting it under one's own name.
2. **Non-attribution** is writing one's own paper, but including passages or ideas from outside sources without providing both citation and, as appropriate, quotation marks.
3. **Patch writing** is using wording that is very similar to that of an original source (regardless of attribution)

None of these kinds of plagiarism are acceptable in the work you prepare for Bi116 or any other course, or any future scientific writing you might do.

How do I avoid plagiarism?

Avoid **outsourcing** by always authoring your own papers and following the rules in collaboration policy statements.

Avoid **non-attribution** by always using citations and quote marks when appropriate and making sure your reader can tell which ideas in your writing are yours and which came from other sources.

This will require that you:

- learn and understand a scholarly citation style
- take careful notes as you read, so that you don't end up forgetting which ideas came from outside your own thoughts
- be willing to consult experts with questions about whether your citations are clear and correct (professors, TA's, and Hixon Writing Center tutors are all available to answer these questions)

Remember that you need to cite ALL borrowed ideas that are not common knowledge, no matter where you found them or who wrote them. In addition to citing quotes, you must cite paraphrase and summary. Any idea that came from reading that you did must be clearly attributed.

Avoid **patch writing** by learning how to create an acceptable paraphrase. You must change key words and sentence structure. A good practice is to always close the document you are using and create a paraphrase from memory. Then check it against the original to make sure your writing represents the same ideas in significantly different language. Do not run a passage through a thesaurus. Changing words to synonyms is a recipe for patch writing.

When am I at risk for plagiarizing?

Plagiarism is especially common among writers who are asked to complete a demanding project in a field that is unfamiliar to them. That is precisely your situation in this class. Therefore, you must be informed and vigilant to prevent plagiarism in this assignment. You may sometimes feel that it is very difficult or even impossible to avoid plagiarism, but that is never the case. Ask for help.

Where can I learn more?

Check out this webpage for more information and links to further resources:

<https://www.writing.caltech.edu/students/plagiarism>

Stage 2 Assignment: Introduction

Due Tuesday February 4 (45 points)

Your goal in this assignment is to pull together what you have developed in your previous assignments (topics, literature review) and further refine your topic of interest, its importance, and the novel question you will be asking in your proposal.

>>Please type this assignment and upload the file to Moodle.<<

For a hypothesis to be compelling, it needs some context. Accordingly, you will need to situate your hypothesis in the context of the current work in a field and/or indicate a reason why people should care about this work. The literature review you performed in the previous week should form the backbone for your introduction. Following the lead-in, you should formulate your research proposal topic in the form of a testable hypothesis, with is the core of your proposal. This entire write-up should fit on 1 page (double-spaced).

The format of this stage of the proposal writing process is outlined below:

Context and Motivation: Provide a brief explanation (2 – 3 short paragraphs) of why someone should take interest in your question. Identify what is interesting about your proposed area of research. Include citations in the proper format and a References section.

Hypothesis: Write a clear, testable hypothesis.

References: As needed, in the proper format

Additional Resources

“What is a hypothesis?” (in this PDF, p. 3)

Bi116 Citation Guidelines (in this PDF, p. 5-6)

Proposal Template

Grading – Worth 45 points

Up to 27 points for Context and Motivation:

- | | |
|----|---|
| 27 | Excellent. A sufficient amount of relevant background is stated clearly and concisely. This information logically sets up the importance of testing the hypothesis that follows. Discipline-specific words are defined. |
| 21 | Good. |
| 14 | Poor. |
| 0 | Missing. |

Up to 18 points for Hypothesis:

- | | |
|----|--|
| 18 | Excellent. Hypothesis is clearly articulated, specific, testable (i.e., it could be proven wrong), reasonable, and novel according to the reviewed literature. |
| 13 | Good. |
| 9 | Poor. |
| 0 | Missing. |

Stage 3 Assignment: Approach

Due Tuesday February 18 (45 points)

Your goal in this assignment is to pull together the most important elements of your proposal-to-be. You will take what you have developed in your previous assignments (topic, hypotheses, literature review, and questionnaires) and use them to design an approach for answering your hypothesis, which will contain the detailed methods you will follow.

>>Please type this assignment and upload the file to Moodle.<<

The format of this stage of the writing process is outlined below and should fit on ~2 pages:

Hypothesis: State your current working hypothesis

Specific Aims: Articulate at least two specific aims that you have for testing your stated hypothesis. The second aim should build off of the results of the first aim, and focus on the logic of your experimental plan.

Approach containing detailed methods: For each specific aim, briefly detail the approach you will take to addressing the aim (~1 short paragraph) and then detail the experimental methods used. Your Methods may take on a number of different formats at this stage, for instance, a bullet-point list of procedures, a flow-chart of how to proceed given different experimental outcomes, or 2-3 short paragraphs (per aim). Choose whatever format is most productive for you, and that will allow us to give you helpful feedback prior to the rough draft due date. Eventually, methods will be written out in paragraph format, with referenced figures if they are helpful. Be sure to include justifications for selecting the methods as you have, with citations as necessary. Be sure to include reference to potential pitfalls that you may encounter through your experimentation and how they will be addressed.

References: As needed, in the proper format (see Bi116 Citation Guidelines, p. 5-6).

If you need help to identify appropriate technical methods, don't hesitate to ask.

Grading – Worth 45 points

Up to 15 points for Specific Aims:

- 15 Excellent. Two aims are outlined clearly, and have a logical flow. They specifically test the hypothesis.
- 12 Good.
- 8 Poor.
- 0 Missing.

Up to 30 points for Methods:

- 30 Excellent. Appropriate methods are presented and justification is clear, including citation of prior work. Any discipline-specific words that specifically relate to a technique or method are defined. You suggest relevant controls and consider potential outcomes as well as alternative approaches in the event your approach fails to test your hypothesis. Your methods are suitable for the scope of the proposal.
- 24 Good.
- 15 Poor.
- 0 Missing.

Stage 3.5 Assignment: Guided Peer Review of Introduction and Approach

Due Tuesday February 25 (30 points, 15 points each)

Your goal in this assignment is to provide helpful, critical feedback to your peers to strengthen their proposals while also practicing the skills of peer review. The comments made by your peers regarding your proposal will be made available to you and may help to improve the quality of your final submission. In addition, we hope that the process of engaging in peer review will develop your editing skillset and lead to enhancement of your own proposals.

>>For each of the two peer proposals you receive, please download and fill out a 'Peer Review Form' and upload the file to Moodle.<<

Grading – Worth 15 points for each review:

- 15 All criteria have been graded and detailed explanations are provided for each score.
- 7 Criteria have been graded but explanations are scant or missing.
- 0 Missing.

Stage 4: Complete draft of proposal

Due Tuesday March 3 (60 points)

Your goal here is to put together all of the pieces for a complete draft of the research proposal in response to the Request for Proposals. In addition to your previous sections, this will contain a Discussion section, in which you will discuss the potential outcomes of your experimental approach, as well as the impact of your findings to a specific field, society as a whole.

At this stage of the proposal writing process you get to synthesize all aspects of your work into a single document (ideally, about four pages long, double-spaced). It may seem as though writing a four-page proposal should be easy, but in fact, given all of the background research you have done and the many ways that you have thought of to test your hypothesis, the four-page limit is a challenging constraint. It is common to feel as though there is quantitatively very little to show for all of the time you've put into planning and thinking about your proposed research. In the end, your goal should be to have a proposal that is specific, complete, concise, and clearly articulated. Some of the most lucrative and prestigious awards given to scientists to pursue their ideas only consider short proposals, so this is good practice for the real world. Use the guidance provided in the *Proposal Template* and in the annotated example proposals to properly structure your proposal.

Although you will have opportunities to revise this document, be sure to include all of the components that you expect to include in the final draft so that you can get relevant and useful feedback. A quick reminder: proofread your work before turning it in!

Additional Resources

Bi116 Citation Guidelines (in this PDF, p. 5-6)

Proposal Template (in this PDF, p. 16-20)

Annotated proposals (Moodle)

Grading

We will grade this first draft according to the same criteria as the final draft (90 points), and multiply the score by (2/3), for a score out of 60 points. See p. 14-15 for the full-draft grading rubric.

Stage 5: Final, revised proposal

Due Tuesday March 17 by 5pm (90 points)

Your goal in the final stages of crafting your research proposal is to evaluate all of the feedback you have received, and then to incorporate any remaining improvements as you see fit.

Please note that clarity is essential. Confusing wording or lack of a logical progression may lower your score for the relevant section as well as for overall writing. Be sure that multiple readers are able to follow your logic and writing.

In addition to revising your complete draft, we encourage you to reflect on the writing process as a whole. You can earn additional bonus points by completing the Stage 5 Assignment: Reflections on writing and revision, which will guide you through the process of considering the entire writing assignment.

Additional Resources

Bi116 Citation Guidelines (in this PDF, p. 5-6)

Proposal Template (in this PDF, p. 16-20)

Grading

Up to 15 points for Introduction:

- 15 Excellent. Your question is well developed and contextualized with respect to what is known/has been done before. You define any specific terms that are mentioned outside of the Methods section, and cite relevant literature in a scholarly way, with at least 5 sources. Your motivation for the proposed study is evident, at the level of specialists as well as non-scientists.
- 12 Good.
- 9 Acceptable.
- 5 Poor.

Up to 10 points for Hypothesis:

- 10 Excellent. You clearly articulate an original, specific, reasonable, and testable hypothesis.
- 8 Good.
- 6 Acceptable.
- 4 Poor.

Up to 12 points for Specific Aims and Approach:

- 12 Excellent. You've defined two specific aims aimed at disproving your hypothesis, with the second building logically on the first. For each aim, your experimental goals are clear, logical, and concise; their results will enable you to distinguish between your explanation (hypothesis) and other possible explanations.
- 10 Good.
- 8 Acceptable.
- 6 Poor.

Grading (continued)

Up to 15 points for Methods:

- 15 Excellent. You clearly indicate why you have selected your methods and define any discipline-specific words that specifically relate to a technique or method. You include relevant controls and discuss potential outcomes as well as alternative approaches in the event your approach fails to test your hypothesis. Your methods are suitable for the scope of the proposal and contain an appropriate amount of detail.
- 10 Good.
- 8 Acceptable.
- 6 Poor.

Up to 15 points for Discussion:

- 15 Excellent. You discuss what would now be possible as a result of your work, whether within a specific field or more generally, citing relevant publications when appropriate. You articulate the novelty and larger societal impact of your proposed research in a way that is true to the scope of your proposal.
- 12 Good.
- 10 Acceptable.
- 8 Poor.

Up to 12 points for Overall Writing, including addressing suggested changes (final draft):

- 12 Excellent. Your proposal is logically organized and has a clear flow. There are no grammatical or spelling mistakes. Your sentences are clear and concise (vs. awkward run-ons). You use professional rather than colloquial language. (For final draft: your overall writing and specific content have improved in the areas identified as needing work.)
- 10 Good.
- 8 Acceptable.
- 6 Poor.

Up to 5 points for Overall Formatting:

Requires that your proposal follow all of the guidelines listed at the end of the Proposal Template, worth 1 point each (name and title, spacing/margins, total length, font size, section headings/emphasis, proper order of sections).

Up to 6 points for Citations:

- 6 Excellent. Your proposal follows all of the citation format guidelines.
- 4 Acceptable. You include citations, but they are not properly formatted.
- 3 Poor. You are missing some citations.

Proposal Template

Use the format shown here for your proposal. Suggestions and guidance are provided for each section, including the process and organization used in successful proposals.

Student Name

Title

The title should be specific and descriptive, pertaining to the hypothesis presented.

Introduction (~ 1 page)

This is where you introduce your topic area, at first very broadly, progressing to the specific set-up of your problem statement and the hypothesis that is at the core of your proposal. When written well, the Introduction will logically lead into the statement of the hypothesis. Any reader should be able to predict the hypothesis by the time the Introduction section ends because the specific problem has been identified. This requires that the section do the following:

- orient the reader to the broad context in which your work is situated
- inform the reader of why this field or area of research is important
- provide sufficient background:
 - articulate what is well understood within the field, pertaining to your research
 - articulate what is NOT well understood, usually setting up your problem statement (which comes next) and WHY it is important to better understand this topic
- **focus the reader on an unresolved problem or unexplained observation, which leads directly into the Hypothesis—your proposed answer or explanation**

Process and organization

1. Start with the general question/problem at hand. This should be understandable to a broad audience and convince them that your overall topic area is interesting and worthy of study.
2. Discuss 2-3 previous works related or similar to the particular problem you want to address. For each work:
 - briefly state what the lab did, and
 - describe their findings and their relevance to your work

The sort of analysis that you did in your Literature Review assignment is relevant here, but the way you discuss your sources is quite different. In the Review, you summarized the research outlined in the paper in some detail. Here, it is essential to **only** include information that the reader needs in order to understand the question you want to answer and why the question is important. Distill your sources to the main point(s). You should be

able to discuss each source in one—or at most two—sentences, or even discuss several sources together.

Anything you cite should have passed your credibility check, unless you are clearly including a source to point out flaws in the experimental design or data interpretation.

3. From the results you described in (2.), lead into what you specifically want to address through your research. (*i.e.*, Has the previous work you described left some unanswered questions or inspired you to delve further into this topic? Why is there a need to do your research?)
4. Having followed the previous instructions, your Hypothesis, which will be found at the end of the Introduction, should come as a logical conclusion. The Hypothesis statement: a testable, specific and educated proposal of a research outcome, or explanation of a phenomenon (1 sentence). Indicate your hypothesis by underlining or otherwise **emphasizing** the relevant sentence.
5. This whole section should contain several sources (generally 5 to 8) related to the hypothesis, even if you are proposing something quite innovative. You should use these sources to tell the reader about things that are already known that have shaped your question and your hypothesis.

Additional Advice

When writing this section, keep it concise and exciting. Pitch it at the level that even a non-scientist would find interesting. Remember that those of us reading this are scientists, mathematicians, and engineers, but not necessarily familiar with your research question and area of inquiry. Any discipline-specific terminology that appears in this section, or any other section prior to the Methods, should be defined here. Try to be as specific as possible in reviewing background information, so that it is clear why you have focused in the way you have.

Approach (~ 2 pages)

Your Approach is a summary of how you will test your hypothesis. The Approach usually includes an introductory sentence or two, followed by two or three specific aims. Aims are like research “benchmarks;” they broadly describe the items that must be accomplished to adequately test your hypothesis. You will then propose methods for each aim which will detail the specific experiments needed to address it. Assume that your audience is composed of literate scientists, but not specialists in your field. Therefore, be sure to define any discipline-specific terminology that is relevant to the methods, and explain what you are testing and why your chosen procedure is appropriate. Relate your methods clearly to your aims and address potential pitfalls that may arise.

Process and organization

The Approach sections typically includes the following:

1. A transition that connects the Hypothesis arrived at in the Introduction to the Specific Aims (1 – 2 sentences).

2. A list of explicitly mentioned Specific Aims (including the previous transition, this should come out to 1 paragraph). **Aim 1** is your first goal, including the key points of how you will accomplish it. The key goals for each aim should easily be summarized within a sentence or two. Assuming you accomplish Aim 1, **Aim 2** should build on it in a logical way.
3. For each aim, you will provide an overview of the approach you propose to take in accomplishing it (a few sentences, up to a paragraph), as well as the detailed experiments making up the methods (~ 2 paragraphs).

Additional Advice

Pertaining to (1-2): Make the logical connection between your Hypothesis and Aims explicit. We recommend that you only propose two aims in order to better focus the assignment. **Do not include any experimental details here;** they belong in the methods which follow afterward.

Pertaining to (3): The overview of your experimental approach should be relatively brief and transition quickly into the detailed experiments needed to address the specific aim. The bulk of this section will be taken up by these methods. Make sure to define any terms used that were not already brought up in the Introduction. The detailed methods will likely need to include the following elements:

- Relevant experiments and brief descriptions (1 sentence) of their purpose
 - For example, you would simply say, “I will use Tn-Seq to identify genetic determinants of [Biological Process X]. Tn-Seq is an appropriate technique because [Y...].”
 - If the technique has been developed or used in previous research, especially in applications similar to yours, cite the paper that describes the technique; this gives credit to the people who developed the method and gives your reader a place to look for more details if necessary.
- Necessary experimental detail, such as the type of organism to be used, how many samples will be tested, cutoffs for statistical significance, etc.
- Control experiments that allow you to rule out alternative interpretations of your experimental findings.
 - Note that control experiments help you convince a skeptic that your explanation is valid, and that results are not due to an artifact or alternate explanation. Think creatively about alternate explanations and use control experiments to test (and disprove) them.
- Possible outcomes of early experiments (*i.e.*, those in Aim 1), and how those results will inform subsequent experiments, including alternative ways to test the hypothesis if necessary.

Pay close attention to the format and content of the works you have read and referenced, and model your methods section accordingly. There are often a variety of methods available to tackle the same question; just make it clear why you're choosing whatever test or method you propose. One good reason to choose a method is because

it was successfully employed by another group, indicated by its publication in a relevant paper. However, given that your hypothesis and aims should be original, use other researchers' work only as a guideline. Do not copy their methods word for word, and instead remark on why the methods you are choosing are specifically appropriate for your proposal. Be careful to choose methods that you can detail sufficiently within the space limits of this proposal, and leave out any excessive or irrelevant components. In this section, be sure to justify your experimental design for the reader. For example, if you need twelve mice, explain why twelve mice are necessary and sufficient.

Discussion (~ 1 page)

The role of this section is to tie together the diverse possible results mentioned in the Methods with the potential impacts they might have on future work. Discuss what you might learn from the collection of experiments outlined above, and how this would add to the knowledge in the field. You should also consider the broader societal impact your findings may have. When done credibly, this section should make a funder feel his/her money is being well spent.

Process and Organization

As in the Introduction section, you will cite relevant sources that have addressed similar questions or are otherwise related to the field in which your work is situated. This should expand on the discussion in your Introduction, not restate it.

Additional Advice

Be ambitious but also realistic about how broadly the success of your proposal would affect future outcomes. Make sure that there's a clear link to the specifics of your proposed work. Like the Introduction, this section should be meaningful both to a scientist and to a general member of our society. This section is an opportunity to practice articulating the meaning of your work at a level that most taxpayers (who are often funding your research!) could understand. Details matter, but in this section, consider whether they are necessary for the reader to know why your research matters before you include them. Some questions to ask yourself:

- Why would doing this research matter both in the short term (*i.e.*, if you succeed in answering your question(s), what could be done next?) and in the longer term (*i.e.*, how would the knowledge gained propel the field forward)?
- What would success look like, and how would it impact our society/research community?
- What could be done next that would be important and that would not have been possible without your work?

In this section, the writing should be so clear and the main points so obvious that the reader can concentrate on those main points and potential impact – don't let the overall importance get lost in confusing sentences or too many if-then's.

References*

See Bi116 Citation Guidelines (in this PDF, p. 5-6). You may wish to use Zotero or another citation manager.

Tables*

If you present a table, be sure to provide clear labels for all columns and rows, and notes to anything shown in the table as appropriate (e.g., sources for information presented in the table, if taken from the literature). Tables should have a title and possibly a caption and be referenced somewhere in the main text.

Figures*

Include a figure caption so that the reader can understand what is shown in the figure without needing to read the text. Add a legend for interpreting components of the figure, if necessary. Your figure(s) should be referenced somewhere in the main text.

*Note that References, Tables, and Figures do not count toward the 4-page limit, and should be included at the end of your document.

Formatting Guidelines

- 4 pages, MAXIMUM
- Double-spaced with 1-inch borders
- 11-point Arial font
- Section headings and emphasis as outlined in the Proposal Template
- Citations via superscripts (such as^{1,2}) counting up from 1 according to the order of appearance in the text
- References list that includes the full reference of each citation, in order of appearance in the text