

Supplemental Material

CBE—Life Sciences Education

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Supplemental Materials

Student Completion of Assignment Components

Table S1

	Completed Initial	Completed Final	Completed Initial and Final	Received Peer Review	Gave Peer Review
Protein Structure	31	30	30	31	28
Photosynthesis	30	27	27	30	29
Enzymes	29	27	26	29	29
Recombinant DNA	30	29	29	29	28

Peer Review Summary

Table S2

	Peer reviews Addressed	Correct feedback Given	Incorrect Feedback Given
Protein Structure	18	16	2
Photosynthesis	5	4	1
Enzymes	2	2	0
Recombinant DNA	2	2	0
Total	27	24	3

Social Network Analysis Visuals

Figure S1: Protein Structure Assignment

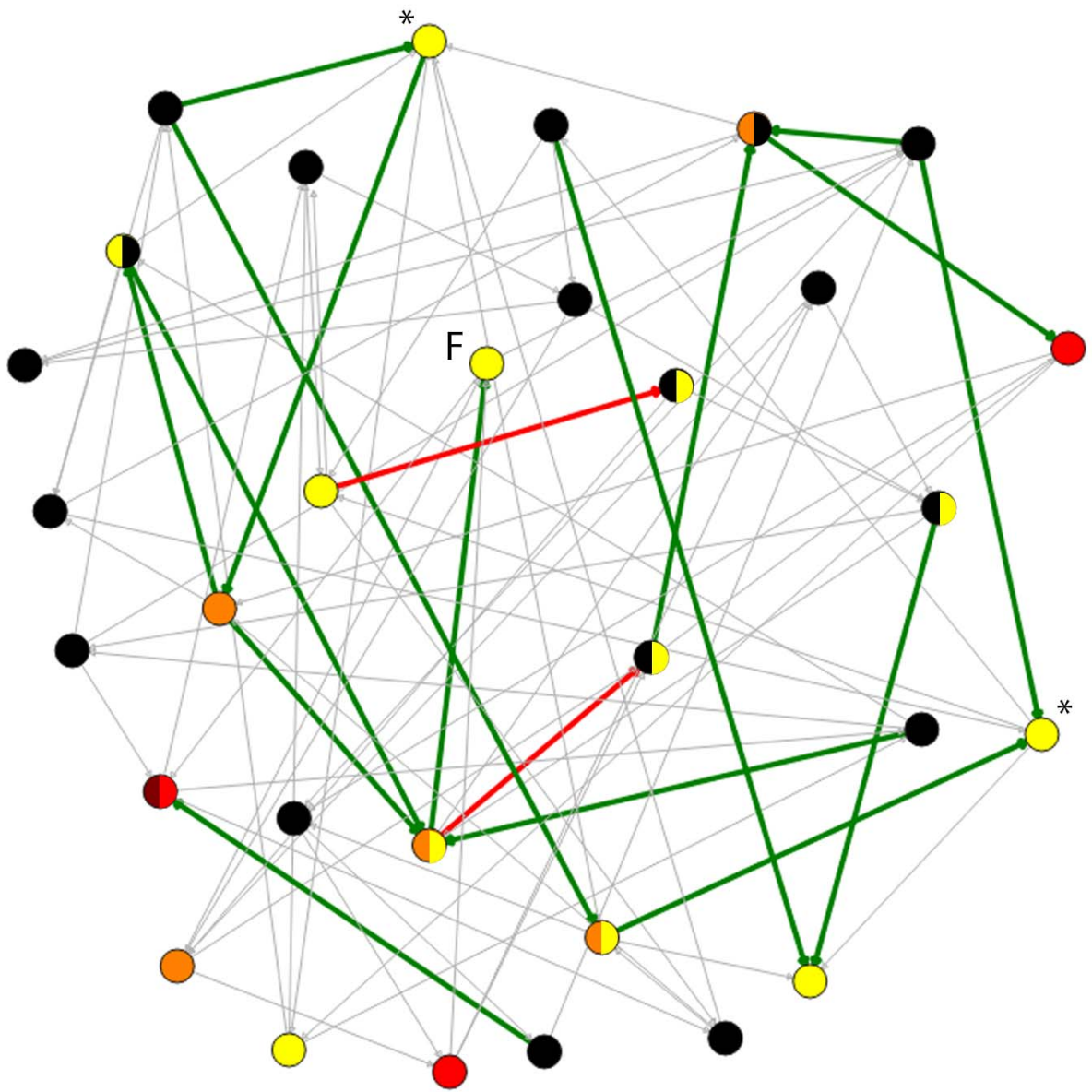


Figure S2: Enzymes Assignment

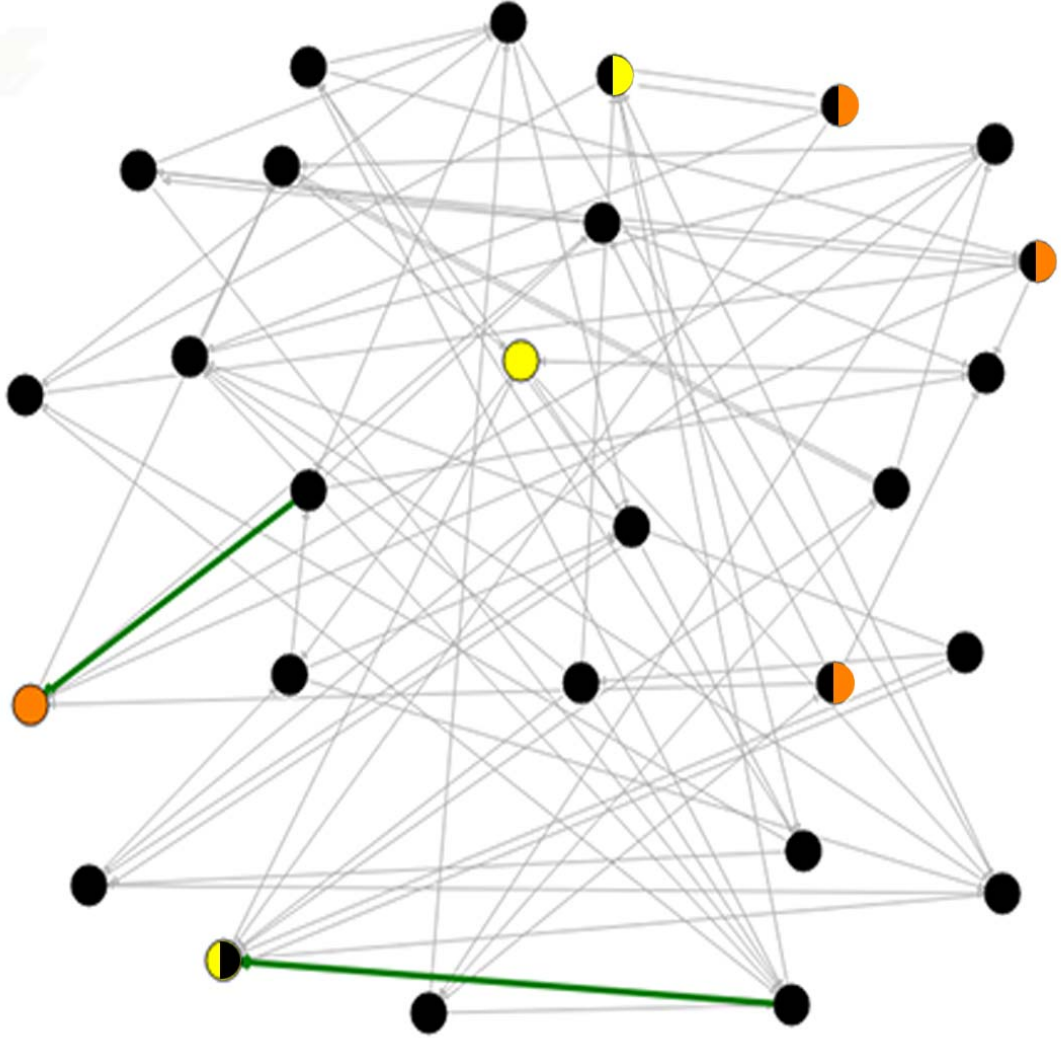
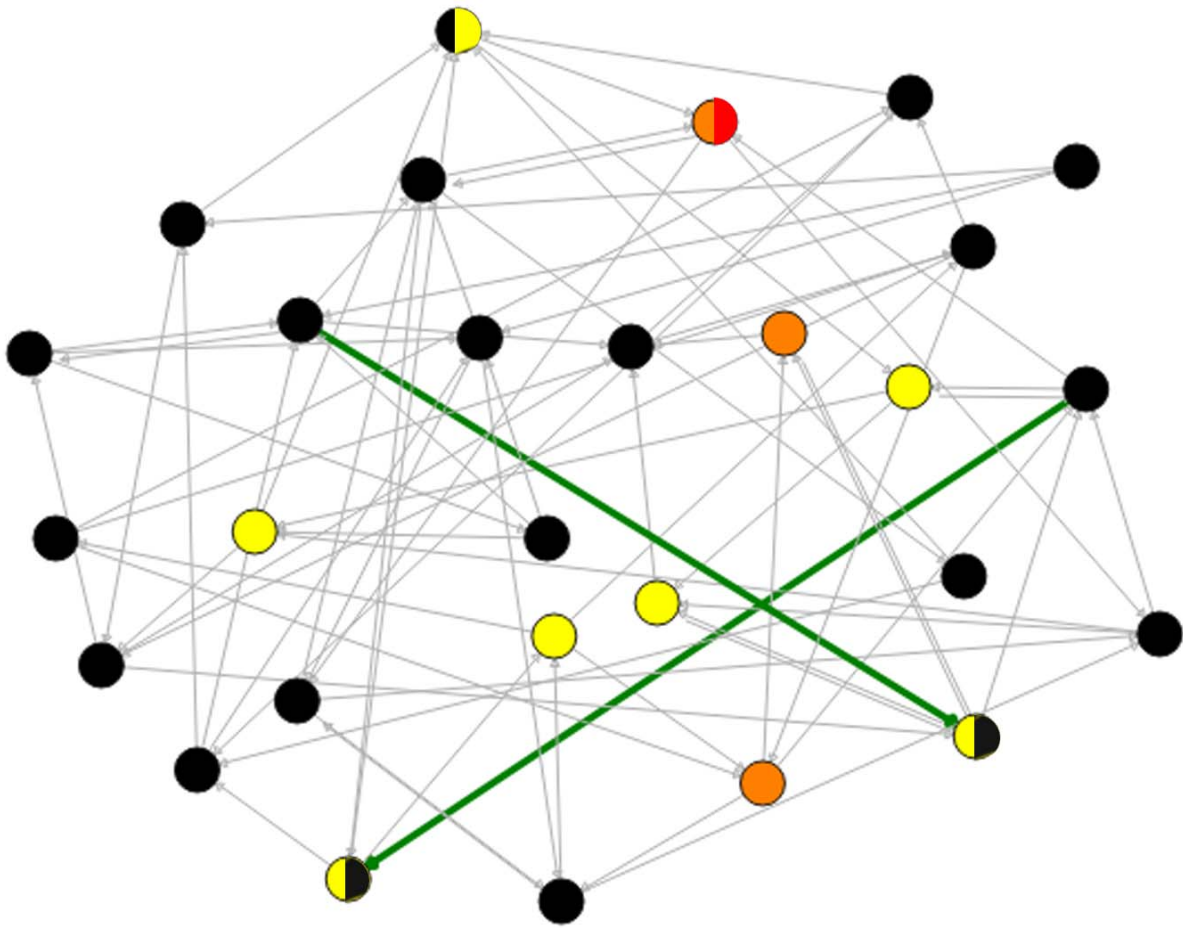


Figure S3: Recombinant DNA Assignment



Writing to Learn Assignments

Prompt 1: Levels of Protein Structure

Prion diseases (like “Mad Cow Disease”) are neurological conditions that can damage brain tissue, causing mental and physical abilities to deteriorate. Prion diseases occur when a protein called the PrP protein becomes folded differently. Regular prion proteins have more alpha helices than beta sheets, but the reverse is true of diseased prion proteins. This can occur from a genetic mutation or from infection of a healthy individual with the diseased protein. The diseased proteins cause changes in the folding structure of other proteins, which disrupts normal brain function, leading to mental and physical decline and eventually death.

You are working for a hospital system creating a wiki library of diseases for health care workers and educators. You are working on an entry describing the protein structure of prion diseases. Explain at what level of protein structure these changes are occurring in the PrP protein and the implications of these changes for lower and/or higher levels of protein structure. Be sure to note what kinds of bonds are involved in each of these levels. The entry should also describe the

consequences of a change in the prion protein's structure-- if the structure changes, how does that affect its function?

Items to keep in mind:

- External references are not required, but if they are used they should be cited using MLA format.
- You should take care to carefully edit and proofread your entry.
- The entry should be 400 to 500 words long.

Peer Review Guidelines:

- Print and read over your peer's entry to quickly get an overview of the piece.
- Read the essay more slowly keeping the rubric in mind.
- Highlight the pieces of texts that let you directly address the rubric prompts in your online responses.
- In your online responses, focus on larger issues (higher order concerns) of content and argument rather than lower order concerns like grammar and spelling.
- Be very specific in your responses, referring to your peer's actual language, mentioning terms and concepts that are either present or missing, and following the directions in the rubric.
- Use respectful language whether you are suggesting improvements to or praising your peer.

Peer Review Rubric Prompts:

1. Would this entry be understandable to a person with a high school level scientific background? Which parts were difficult to understand? Which parts would be easy to understand?
2. Does the entry correctly identify the level of protein structure at which prions change from having a high ratio of alpha helices to having a high ratio of beta sheets?
3. How does the entry describe primary, secondary, tertiary, and quaternary protein structures?
4. How does the entry describe the bonds involved at each level of protein structure?
5. How does the entry describe the relationship between primary, secondary, and tertiary protein structures?
6. How does the entry describe the relationship between the structure and the function of the protein?

Revision Prompt

Revising writing means re-seeing it, and the process of reading and commenting on the writing of others as well as receiving feedback from your peers gives you a way of seeing your own writing differently. Meaningful revision means changes at the sentence and paragraph level, usually involving a minimum of three sentences. *You will not receive full credit for revision unless you make meaningful revisions to your writing.*

Revision Guidelines:

- Re-read the prompt
- Re-read the rubric and consider what a complete and effective response would include, noting what you do not fully address
- Make a list of effective content you noticed in the writing of your peers

- Read and summarize the feedback you received from your peers
- With these things in mind, re-read your draft and mark places where you can improve the content
- Revise and submit your response

Note: For ease of reading, the following three prompts are abbreviated in that the peer review guidelines and revision prompt remained unchanged and parallel what is shown above.

Prompt 2: Photosynthesis

You are working as an employee for a company that provides grass seeds to farmers. Part of your job requires you to help farmers select seeds that best fit their requirements. One of your current clients is a farmer who wants to grow grasses to produce hay as feedstock (or fodder) for cattle. Like other plants, grasses rely on photosynthesis to fix carbon dioxide into carbohydrates (i.e., sugars). Grasses can then use these carbohydrates to meet their own energy needs. In general, plants will use some of these carbohydrates to first meet their basic metabolic needs. Any sugars that remain are then available for the plant to use for growth and reproduction. As plants grow, they use this extra energy to create more biomass in their roots, stems, and leaves.

You have investigated several different varieties of grasses in order to find a type that will grow efficiently in order to produce the largest amount of biomass and thus most hay. You have focused on grasses that have the C3 form of photosynthesis, since you have read that these plants are more digestible for cattle. You also know that the farmer wants to do this in order to maximize the amount of food she can produce for cattle. To help her, you need to select the grass that will grow the fastest and produce the most plant material.

Based on your research, you have created the following table of information to help you compare photosynthesis and respiration rates of different grasses. Photosynthesis rates are reported as the amount of carbon fixed per leaf area per second. Respiration rate is reported in the same way. These data have been collected from grasses grown in the farmer’s area, under average summer temperatures and water conditions:

Grass type	Photosynthesis Rate (mgCO ₂ /dm ² /hr)	Respiration Rate - basic metabolism (mgCO ₂ /dm ² /hr)	Respiration Rate - to support growth (mgCO ₂ /dm ² /hr)
Tall fescue	35	20	15
Perennial ryegrass	25	15	10
Brome grass (Timothy)	20	16	4

Based on this table, write a letter to the farmer in which you recommend one type of grass she should grow in order to maximize the amount of hay produced from the grasses. You can assume that maximum growth is represented by the amount of carbon used to support plant growth. As part of your recommendation, be sure to discuss photosynthesis and respiration in terms of what they mean for plant growth. In your description of photosynthesis, you should define and use terms that will help you describe this process in detail. You should also include a description of C3 types of plants. You should then be sure to link your descriptions of these processes to your final suggestion for grass selection.

Items to keep in mind:

- When we read your memo, we will serve the role of the farmer, who is someone that has some knowledge of plants, but who does not have specific knowledge or training in the sciences.
- External references are not required, but if they are used, they should be cited using MLA citation style format.
- Since you want to impress the farmer, you should take care to carefully edit and proofread your recommendation.
- Your letter to the farmer should be 400-500 words in length.

Peer Review Rubric Prompts:

1. This summary is intended to be specific and understandable to a general audience. Based on this, what parts of the recommendation need to be revised to make them understandable for the target audience? How should they be improved to achieve this goal?
2. How well has the writer described the process of photosynthesis? Discuss the terms or descriptions that could be revised to improve clarity.
3. For the process of respiration, explain whether the writer explained what it is and how the plants are using respiration to meet their energy needs? Identify what the writer could do to improve this explanation.
4. What aspects of the recommendation about which grass to choose are clear? Which sections should be revised to clarify the recommendation? What can the writer do to make this clearer?

Prompt 3: Enzyme Action

Enzymes are biological catalysts that play an important role in many biochemical reactions. Because of this, enzymes are increasingly being studied as potential targets for treating certain diseases. Cancer is one type of disease that might be a particularly good candidate for the development of drugs that target enzymes, particularly the enzyme telomerase. This enzyme plays an important role in cell division by protecting the ends of chromosomes during the chromosome replication process. Telomerase is usually present in stem cells but is normally absent or found only in low concentrations in somatic cells. In cancer cells, however, telomerase

may play an important role in allowing for the uncontrolled division of abnormal cells, which characterizes the various types of cancer. Since cancer is characterized by uncontrolled growth and division of abnormal cells and the formation of new cells, one treatment approach is to target enzymes involved in cell division (for background information about telomerase, see this article in [Scientific American](#)). Recently, a group of researchers¹ identified a key aspect of the structure of telomerase. The researchers hope that by better understanding the structure of this enzyme, their findings might lead the way to the development of a drug that targets the enzyme and thereby helps advance cancer treatment.

As a research assistant at a pharmaceutical company, you are part of a research group that focuses on developing drugs that target enzymes. Your group is thus particularly excited about the findings from this study and in the possibility of developing drugs that might target telomerase. The leader of your research group wants to send a summary of the findings from this article to the Head of Drug Discovery at your company. To do this, he asks you to write a short summary that describes the importance of the enzyme telomerase as well as discusses the key findings from this study. As part of your summary, you will need to define enzymes and then both describe the importance of enzymes in biochemical reactions as well as discuss the way in which enzymes can inhibit or accelerate chemical reactions. You should also discuss the ways in which the structure of enzymes affects their activity and how drugs could be developed to interfere with enzymes to alter their activity. You can then end your summary with a description about the importance of the research findings reported in this article.

Items to keep in mind:

- When we read your memo, we will act as the Head of Drug Discovery at your company and will have adequate scientific knowledge about biology, but will likely not remember all of the specifics about enzymes and enzyme reactions.
- External references are not required, but if they are used, they should be cited using MLA citation style format.
- Since you are trying to impress your boss and establish your credibility as a research assistant, you should take care to carefully edit and proofread your memo.
- The memo should be between 400-500 words in length.

Peer Review Rubric Prompts:

- In the memo, the writer should clearly communicate about enzymes by providing definitions and descriptions of the following terms: enzymes, catalyze, enzyme inhibition, and irreversible and reversible inhibitors. Based on this, which terms are well defined and which ones are missing or are not well defined? What does the writer need to do to improve the presentation of these terms?

¹Linnea I Jansson, Ben M Akiyama, Alexandra Ooms, Cheng Lu, Seth M Rubin, Michael D Stone. **Structural basis of template-boundary definition in Tetrahymena telomerase.** *Nature Structural & Molecular Biology*, 2015; DOI: [10.1038/nsmb.3101](https://doi.org/10.1038/nsmb.3101) also see <https://www.sciencedaily.com/releases/2015/10/151005120917.htm>

- As the reader, you should be given enough information to understand the basic properties of an enzyme. Given this, what should the writer expand on to improve the description of the properties of enzymes?
- How does the writer describe the way in which the structure of an enzyme affect its activity? In what ways could the writer improve the description of enzyme structure and activity?
- Does the writer summarize the main findings of the article by Jansson et al. (2015)? How could the writer improve the summary to better describe the main results of this study?

Prompt 4: Recombinant DNA

Intravenous immunoglobulin (IgG) therapy can be used to treat a variety of medical conditions, including immune deficiencies, acute infections, and autoimmune disorders. Traditionally, these products are manufactured from human blood and plasma, but this is very expensive and labor-intensive. Currently, a four dose course of traditionally produced IgG therapy for a 70 kg person at 2 g/kg would cost \$25,000-\$26,000².

You are working for a biotech company that is beginning to conduct research to develop a recombinant DNA technology so that cultured bacteria can be engineered to produce IgG. Write a memo to your funders justifying why you have decided to reallocate resources to pursue recombinant DNA technologies in lieu of traditional manufacturing processes.

In your memo, be sure to explain:

1. How the process would work: What steps would be involved in creating recombinant bacteria to produce IgG? What reagents or products would be needed at each step? How you would obtain them?
2. Why the process would be less expensive than traditional methods: Why is bacterial production of IgG more efficient than human production?

Items to keep in mind:

- External references are not required, but if they are used they should be cited using MLA format.
- You should take care to carefully edit and proofread your entry.
- The entry should be 400 to 500 words long.

Peer Review Rubric Prompts:

²Jordan, S. C.; A. A. Vo; A. Peng; M. Toyoda; D. Tyan. "Intravenous Gammaglobulin (IVIg): A Novel Approach to Improve Transplant Rates and Outcomes in Highly HLA-Sensitized Patients." *American Journal of Transplantation*. 2006; 6(3): 459-466.

1. Would this entry be understandable to a person with minimal scientific background?
Which parts were difficult to understand? Which parts would be easy to understand?
2. Does the memo provide a clear description of the process of creating recombinant bacteria? Does it describe the reagents and products involved in the process?
3. How does the memo define or explain the key concepts involved in the process?
 - a. Template DNA
 - b. Vector
 - c. Plasmid
 - d. Restriction enzyme
 - e. DNA ligase
 - f. Transformation
4. How does the memo compare bacterial production of IgG and human production?