Appendix 1 – Suggested activity schedules, delivery modes, and examples of research questions

Suggested activity schedules, delivery modes

| Activity Step | Option 1 | Option 2 | Option 3 | Option 4 |
|---------------|----------|----------|----------|----------|
|               | **One 90-minute session** | **One 90-minute session** | **Two 90-minute sessions** | **Ongoing course project** |
| Proposal drafting | 30-minutes | 45-minutes | 45-minutes (session 1) | 1-week |
| Peer Review | 30-minutes | 20-minutes | 45-minutes (session 1) | 1-week |
| Proposal revision | Due within 1-7 days of session (Take-home) | Due within 1-7 days of session (Take-home) | 45-minutes (session 2) | 1-week |
| Class discussion | 30-minutes | 25-minutes | 45-minutes (session 2) | 60-90 minute session |

All steps may be conducted via online or in-person delivery modes. While all steps are designed for synchronous modes of delivery, instructors may adapt to accommodate asynchronous delivery.

Examples of focused research questions

Examples of focused research questions are listed below. These suggestions are centered on molecular and cellular biology concepts but may be adapted for specific pathways, fields, and levels of difficulty.

- Does [Protein X] interact with [Protein Y] in [cell line/model system]?
  - Does “Protein X interact with “Protein Y” in S. cerevisiae?”

- Does [Protein X] localize to [organelle] during [cell cycle phase] in [cell line/model system]?
  - i.e. Does “Protein X” localize to the nucleus during mitosis in S. cerevisiae?
  - i.e. Does “Protein X” localize to the plasma membrane in HeLa cells?

- Does [Protein X] expression change in response to [treatment] in [cell line/model system]?
  - i.e. Does “Protein X” expression change in response to DNA damage in HeLa cells?
  - i.e. Does “Protein X” expression change in response to nutrient starvation in E. coli?

- Is [Gene X] required for [process/pathway] in [cell line/model system]?
  - i.e. Is “Gene X” required for antibiotic resistance in P. aeruginosa?
  - i.e. Is “Gene X” required for apoptosis of fibroblasts?

- Is [Protein X] [post-translational modification] in [cell line/model system] or [under specific condition/cell cycle phase]?
  - i.e. is “Protein X” acetylated in HeLa cells?
  - i.e. is “Protein X” phosphorylated in S phase in S. cerevisiae?
Appendix 2 – Proposal Template

Team Members: _______________________________________________________________

| Proposal Title |
|----------------|
| Generate a focused title that accurately reflects the content of your proposal. |

| Background (4-5 sentences) |
|----------------------------|
| Provide relevant background information on your proposed topic. Generate a final statement that will provide a transition to your research question (below). |

| Research Question & Rationale (2-3 sentences) |
|----------------------------------------------|
| State the question that will serve as the basis for your proposal. Consider including a statement(s) on why this question is important to address. |

| Hypothesis & Aims (2-4 sentences) |
|-----------------------------------|
| State a central hypothesis for your proposal. Follow the hypothesis with general statement of the experimental aims. |

| Aims (2-3 Aims, 5-6 sentences each) |
|-------------------------------------|
| Organize aims into subsections, each of which adheres to the following format: |
| - Aim X: Title |
| - Rationale (what is the logic of this aim?) |
| - Hypothesis (what is the hypothesis of this specific aim?) |
| - Methodology (how will this aim be address experimentally? How will the results be analyzed?) |
| - Anticipated Outcome (what are the expected results of the experiment?) |
| - Caveats & Alternatives (what is a caveat of the method? Can an alternative approach be proposed?) |

| Summary/Significance (2-3 sentences) |
|--------------------------------------|
| Provide a summary of the proposal that highlights the overall significance of the work (i.e. why is this research important? How will this research advance the field?). |

| Transfer of knowledge (4-5 sentences) |
|---------------------------------------|
| How does your proposal relate to at least two concepts introduced in previous courses (i.e. theory, techniques, etc.)? For example: (i) in organic chemistry we learned about X technique. In this proposal, X is used to…(ii) in molecular biology, we learned about concept Y. In this proposal, concept Y is illustrated by the fact that…. |
Appendix 3 - Peer Review Evaluation Template
Evaluators: _______________   Peer Proposal Title: ______________________

**Strengths**
Indicate at least three strengths of the proposal. Briefly explain your logic on how these strengths contribute to the overall proposal.

- **Strength 1:**
  Explanation:

- **Strength 2:**
  Explanation:

- **Strength 3:**
  Explanation:

**Suggestions for improvement**
Indicate at least 3 aspects of the proposal that may benefit from revision. Briefly explain your reasoning on why/how these revision will strengthen the proposal. Provide suggestions on how to improve each of the indicated issues. Ensure that your feedback is constructive & supportive.

- **Area of improvement 1:**
  Explanation:
  Suggestion for improvement:

- **Area of improvement 2:**
  Explanation:
  Suggestion for improvement:

- **Area of improvement 3:**
  Explanation:
  Suggestion for improvement:

**Transfer of knowledge**
Provide the team with additional insight into how the proposal integrates at least two concepts (i.e. theory, techniques etc.) learned in previous courses.
Appendix 4 – Evaluation Rubrics

A. Assessment of team’s peer review feedback (Instructor evaluation)

The instructor completes the following evaluation for each team’s peer review feedback.

Team members (all receive same mark): _____________________________

|                     | 0                                                                 | 1                                                                 | 2                                                                 |
|---------------------|-------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------------------------------------------|
| **Content**         | Team does not identify 3 strengths & 3 areas/suggestions for improvement of the proposal and/or does not provide examples of knowledge transfer. | Team identifies less than 3 strengths and/or less than 3 areas/suggestions for improvement for the proposal. One or more suggestions for improvement and/or knowledge transfer do not demonstrate critical thinking of the research question and/or experimental aims. | Team identifies 3 strengths & 3 areas/suggestions for improvement for the proposal. Suggestions for improvement and knowledge transfer demonstrate critical thinking of research question & experimental aims. |
| **Respect for Peers** | One or more suggestions for improvement do not demonstrate respect for peers (i.e. suggestions are not constructive, direct criticism of peers etc.). |                                                                 | All suggestions for improvement demonstrate respect for peers. |
| **Deadlines & Completion** | Team did not submit peer feedback form and track-edited peer proposal to the instructor. | Team submitted peer feedback form and/or track-edited peer proposal after the indicated deadline and/or the peer feedback form was incomplete. | Team submitted peer feedback form and track-edited peer proposal by the indicated deadline; peer feedback form was fully completed. |

**Total** /6
B. Assessment of team proposal (Instructor evaluation)

The instructor completes the following evaluation for each team’s proposal.

Team members (all receive the same mark): ______________________

|                          | 0 | 1                                                                 | 2                                                                 |
|--------------------------|---|-------------------------------------------------------------------|-------------------------------------------------------------------|
| Title                    |   | Proposal title is unfocused and/or does not accurately reflect    | Proposal has a focused  |
|                          |   | content.                                                          | title that accurately reflects content.                         |
| Background               |   | Irrelevant background information is provided and/or content is   | Relevant background information is provided. Content follows a    |
|                          |   | described in a poorly organized or unclear manner.               | clear and logical flow of information.                           |
|                          |   | Final statement does not provide a transition to research question.| Final statement provides transition to research question.         |
| Research Question &      |   | Research question and rationale for selecting the question is not | Research question and |
| Rationale                |   | provided.                                                       | rationale is clearly stated.                                    |
| Hypothesis & Aims        |   | Hypothesis is provided but is unclear/poorly defined and/or      | Clear hypothesis is |
|                          |   | experimental aims are introduced in an unclear manner.          | provided. Hypothesis is |
|                          |   | Proposal contains less than 2 aims and/or aims do not include    | followed by a general |
|                          |   | clear rationale, hypothesis, methodological approach, and        | introductory statement of |
|                          |   | anticipated outcomes. Potential caveat(s) and alternative         | the experimental aims.                                         |
|                          |   | approach(es) are not clearly indicated.                         |                                                                   |
| Aims                     |   | No aims are provided.                                           | Proposal contains 2-3 |
|                          |   | Proposal contains less than 2 aims and/or aims do not include    | aims. Each aim includes a |
|                          |   | clear rationale, hypothesis, methodological approach, and       | clear rationale, hypothesis, |
|                          |   | anticipated outcomes. Potential caveat(s) and alternative        | methodological approach, |
|                          |   | approach(es) are not clearly indicated.                         | and anticipated outcomes.                                       |
|                          |   | Proposal indicates less than 2 ways how the work relates to     | Clearly indicates potential |
|                          |   | content learned in previous courses.                           | caveat(s) and alternative approach(es).                         |
| Summary/Significance      |   | Summary poorly reinforces the rationale and significance of the | Summary reinforces the |
|                          |   | proposed work.                                                | rationale and significance of the proposed work.               |
| Knowledge transfer        |   | No indication of how proposal links to previous course material. | Proposal indicates at least |
|                          |   | Proposal indicates less than 2 ways how the work relates to     | 2 ways how the work |
|                          |   | content learned in previous courses.                           | relates to content learned in previous courses.               |
| Total                    |   |                                                                  | 14                                                               |
C. Peer evaluation
Each student within a team provides an evaluation of each team member’s contributions to the activity based on the following rubric.

Group member you are evaluating: ____________       Evaluator: __________________

| Attendance       | 0                                      | 1                                      | 2                                      |
|------------------|----------------------------------------|----------------------------------------|----------------------------------------|
| Student did not attend the peer review session. | Student attended a portion of the peer review session. | Student attended the entire peer review session. |

| Engagement       | 0                                      | 1                                      | 2                                      |
|------------------|----------------------------------------|----------------------------------------|----------------------------------------|
| Did not contribute to the group discussion. Did not remain on task at all during the session. | Rarely contributed to the group discussion and/or remained on task during the session. | Consistently contributed to the group discussion and remained on task during the session. |

| Attitude         | 0                                      | 1                                      | 2                                      |
|------------------|----------------------------------------|----------------------------------------|----------------------------------------|
| Did not demonstrate respect for peers. | Occasionally did not demonstrate respect for peers during the session. | Consistently demonstrated respect for peers during the session. |

| Total           | /6                                     | /6                                     | /6                                     |
|-----------------|----------------------------------------|----------------------------------------|----------------------------------------|