## SUPPLEMENTAL MATERIALS

### SM 1 - Writing Assignments

***Writing Assignment 1, Comments for Instructors:***
*This assignment serves as a pre and post assessment for measuring students' scientific writing and experimental design skills. This take-home assignment is given in Session 1 as a pretest without prior formal instruction in scientific writing or experimental design. Along with the assignment, students are given an example of an outline and an abstract of a paper, from which the outline was generated. The same assignment is administered in Session 11 for comparison. The assignment is graded with the rubric (see Grading Rubric below). Students receive independent scores (0-3 points) for the following sections of this writing assignment: Following Instructions, Outlines, Writing Structure, Experimental Design, and Writing Mechanics. Shortly after the first writing assignment, students receive extensive feedback in each of these areas. During Session 2, students are given the rubric and are formally instructed in scientific writing. During session 3, students are formally instructed in experimental design. Other skills such as graphing, data analysis, and statistics are incorporated into subsequent writing assignments after instruction.*

**Assignment**
Your biology professor has a room that houses turtles. While waiting for the dozens of incubating turtle eggs to hatch in the room, she leaves for a two-week vacation. When she returns, she notices that all of the turtle eggs have hatched but that there is something strange about the hatched turtles. Instead of the turtles being roughly half males and half females, all of the hatched turtles are males! Your professor also happened to notice that the temperature in the room is about 5ºC cooler than normal, and thinks this may have something to do with the phenomenon. Your professor then asks for your help to solve this mystery.

**Instructions:**
Design an experiment that helps to explain why all of the hatched turtles are all males.

Generate a simple outline of your writing assignment on its own page.

Write a brief introduction and then describe your experiment. Predict results that you might expect to see from your experiment and briefly discuss these results.

This assignment should be typed, double-spaced, 12 point font and only 1 page! Please attach this sheet as a cover, and the outline as a second page.

***Writing Assignment 2, Comments for Instructors:***
*The purpose of this assignment is to have the students generate hypotheses from proposed research questions and design an experiment to test the hypotheses. Students are divided into groups designated as either clinicians or researchers and are given different questions that serve as the starting point for designing experiments. This method allows students to compare the approaches and types of experiments from different groups within a larger scientific community. This assignment requires students to write more closely in the format of a primary literature paper than the first assignment. The group work is preceded by a lecture that outlines some of the key elements of experimental design and provides the background information for understanding this assignment. Content pertaining to retroviruses, packaging lines, and the use of viral vectors for gene therapy was presented at an earlier date. The day of the assignment, students are given a short lecture about Severe Combined Immunodeficiency and stem cell differentiation.*

*Students are first given the background information in class, and then are allowed to work together in pairs for 30 minutes. During this time, students discuss the topic and ideas for their experimental designs. Students then complete the written homework assignment as individuals. This assignment is an example of the type of "challenge" discussed in the paper that students struggle with initially in order to realize that they don't necessarily understand the principles of good experimental design.*

*The following documents include the initial handout for the group discussion and the writing assignment instructions.*

**Assignment: Student Handout for Group Discussion**

**Background**
Severe Combined Immunodeficiency (SCID), is a primary immune deficiency. The defining characteristic is a severe defect in white blood cell production. This usually results in the onset of one or more serious infections within the first few months of life. Common life-threatening infections in SCID patients include pneumonia, meningitis, and bloodstream infections. SCID is often called "bubble boy disease" because of the publicity David Vetter received during the late 1970's. David was a boy who lived in a plastic, germ-free bubble for 12 years because he had X-linked SCID.

There are several forms of SCID, but the particular type we will be studying is a recessive disease caused by a mutation in the *adenosine deaminase* (ADA) gene, which leads to a deficiency of the ADA protein within afflicted individuals. One treatment option for this type of SCID is to give repeated injections of ADA. However, this treatment can cost well over $100,000 per year and is difficult for patients who must receive the weekly injections. Thus, our goal is to find another form of treatment for SCID.

**Details for your studies**
You are part of a team of clinicians and researchers who are studying the form of SCID caused by a defect in a single gene, *adenosine deaminase*. This form of SCID causes a severe immunodeficiency and any viral or bacterial infection could be deadly to the patient. However, a small amount of ADA production would cure the disease and excess amounts of ADA are not

toxic to the patient. One possible cure could be to express the ADA protein in stem cells, thereby providing the patient with a source of ADA.

The relevant target stem cells can be removed from the patient's body and cultured for short period of time. You have just received a sample of a new retrovirus in your laboratory, referred to as "Retrovirus B". This viral vector contains a functional version of the ADA gene and you want to test it as a vector to treat this disease**. You have been designated by your instructor as either a clinician or a researcher. Here are the questions you want to answer depending on your role:**

| **Researchers**<br>***In Vitro studies – testing outside of an organism***<br>1. Does Retrovirus B infect stem cells?<br>2. If so, how efficient is the infection?<br>3. Do the infected stem cells produce ADA protein? | **Clinicians**<br>***In Vivo – testing within the organism***<br>1. Assuming that Retrovirus B infects stem cells, do the cells survive once they are put back into the patient's body?<br>2. Are the infected stem cells within the body producing ADA protein?<br>3. Have you cured the person afflicted with the SCID disease? |
|---|---|

**Tools at your disposal:**

| | |
|---|---|
| Stem cells from patients with the disease<br>Stem cells from patients without the disease<br>A way to count stem cells<br>Patients with SCID<br>Normal patients<br>A ball of string<br>A way to determine whether the immune system is functioning properly in a patient | An unlimited sample of Retrovirus (A) that efficiently infects stem cells and expresses GFP, which turns the cells green<br>An unlimited sample of Retrovirus (B) that expresses both the ADA gene and GFP - but you don't know if and how well this retrovirus infects stem cells!<br>A way to measure the amount of ADA protein in cells |

Formulate hypotheses addressing the above questions pertaining to your role as either a clinician or a researcher. Design experiments to test your hypotheses. If you are a researcher, indicate all of the variables for which you are controlling. If you are a clinician, define your treatment versus non-treatment group.

**Instructions:** The objective of this assignment is to help you identify your strengths and weaknesses in writing and experimental design. We will read your work and provide you with feedback so that you can develop your organizational and writing skills, as well as your ability to design experiments. In class you have worked through the exercise of designing experiments that will lead to important findings about the potential use of retroviruses for delivering the ADA gene to SCID patients' stem cells. Please write up all of the experiments that you designed as either a clinician or a basic researcher. Provide an outline of your report followed by your designed experiments on the subsequent pages. Include a one paragraph introduction and conclusion based on the background material you received in class. Be sure to include all falsifiable hypotheses that you are testing and indicate all variables for which you are controlling. Your report should be typed, double-spaced, 12 pt font. Staple all pages together, with this page as the cover. Lastly, please write your name on the backside of the last page.

***Writing Assignment 3, Comments for Instructors:***
*The first part of this assignment is a computer activity that is typically done in class by pairs of students, but could be assigned as homework. The purpose of the activity is to teach students to graph experimental data (modified from the author's own work) using Excel, showing them the different ways to display data in graphs, and introducing them to basic statistics. The students also learn which parts of a data set should be averaged together and which should not. This activity is preceded by a short lecture on standard deviation, error bars, and sample size.*

*Another important goal of this writing assignment is to get students to write their paper in the form of a primary research paper. The expectation is that students will be able to design experiments that are capable of generating the data that is provided, as well as interpret the data and draw reasonable conclusions about the results.*

*Students are required to hand in two graphs prior to their assignment due date. One graph is a linear scale presentation of the data and the other is a log scale. This method helps students to recognize that data can be displayed in a variety of ways, but that the author must select the best representation and to understand why.*

*The following documents include the graphing assignment handout and writing assignment instructions.*

**Assignment: Experimental Design and Graphing Data Handout**
You are a virologist working at the Center for Disease Control (CDC) and you were given a new deadly virus (NDV) obtained from Australia. This virus was demonstrated to be highly infectious in sheep, causing numerous deaths in infected sheep flocks. Your goal is to determine the host range of the virus and evaluate the threat that this virus may pose to humans. As part of your study, you added NDV to several different cell lines to determine the host range of the virus. In order to easily detect the event of virus entry and thus infection, you inserted a gene that encodes for protein Alkaline Phosphatase (AP) into the NDV genome and called this genetically modified version, NDV-AP. When cells are infected with this virus, they produce the AP protein and grow into a colony called a focus; the AP protein can be detected by adding a chemical interacts with it, thereby turning the focus purple.

The following is the procedure you used to perform your study:
1. Cells that were to be infected were plated into cell culture dishes on day 0.
2. On day 1, the cells in each dish were infected with 10 µl of NDV-AP and placed in a 37 C incubator for two days to promote cell division.
3. On day 3, all cells were stained with a chemical that turns cells purple if they contain the AP protein. The number of AP foci per 1ml of virus was determined for each dish.

At the same time, you did the same experiment with a well-studied virus, the Bongo Virus (BV), which also contains AP (BV-AP). You also did not infect one plate of each cell type but treated the cells the same in all other ways.

For more accurate results in each experiment, you did the infections in duplicate for both viruses at the same time. The entire experiment was repeated three times within a period of two weeks. The data you obtained is found in the table on the backside of this paper.

Work with a partner to answer the following questions and complete the following tasks.

A. Draw a schematic of the entire experiment on a new sheet of paper. Clearly label all drawings so that an outside audience could interpret what you did.
B. What is your hypothesis?
C. What is the prediction for your hypothesis?
D. What is your null hypothesis?
E. What is your prediction for your null hypothesis?
F. Describe the controls in your experiment and state why they are the controls.
G. What were the variables for which you controlled in this experiment?

**Next, review the following data from your experiments.**

| **Cell Type** | **Organism** | **Number of AP + Foci per 1ml virus** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **NDV-AP** | | | **BV-AP** | | |
| | | Experiment 1 | Experiment 2 | Experiment 3 | Experiment 1 | Experiment 2 | Experiment 3 |
| HT1080 | human | 10, 7 | 5, 3 | 7, 8 | 2030, 2130 | 2567, 2455 | 2454, 2300 |
| COS | monkey | 4040, 4500 | 4546, 4566 | 3998, 3890 | 5090, 5432 | 4885, 4998 | 5402, 5400 |
| D17 | dog | 2457, 2433 | 2676, 2546 | 2100, 2203 | 3200, 3243 | 2985, 2999 | 2899, 2888 |
| SF9 | moth | 2, 1 | 5, 2 | 8, 9 | 3593, 3455 | 3455, 3344 | 2998, 3000 |
| SSF | sheep | 3543, 3544 | 3654, 3600 | 3455, 3455 | 2456, 2344 | 2423, 2344 | 2577, 2556 |
| ZF4 | zebrafish | 1, 1 | 2, 1 | 1, 2 | 2, 2 | 1, 3 | 2, 1 |

To analyze your findings and present them to your colleagues, you must first make a graph that includes ALL of the data generated in the experiments. Please graph your data using both linear and log scales (2 graphs) and include Y error bars calculated from the standard deviation in your experiment. When you are done, work with your partner to answer the following questions:

A. Which graph should be used to represent your data to your colleagues, linear or log scale? Why?
B. Based on these findings, what are your conclusions of this study?
C. Does anything in the data suggest a potential future problem for zoonoses (transmission from animals to humans)?
D. Was your posed hypothesis valid?
E. What questions do you have now?
F. What experiment would you like to do next?

**Instructions:** You have just completed your experiments with the NDV-AP and BV-AP viruses. You have created graphs displaying your data. Now you must report your findings in the form of a paper to the head of the Center for Disease Control. Your paper should contain the following sections in this order: abstract, introduction, materials and methods, results, and conclusions. The results section of your paper should contain the graph that you feel best represents the data based on your predictions. Your document should be type written in 12 point font, double-spaced. Also, you should have a title page with your contact information followed by an outline of your paper. The document must be stapled and contain these things in this order:

PAGE 1: Paper title and contact information
PAGE 2: An outline of the document in proper format
PAGE 3 and 4: Report, typed, 12- point font and double spaced

***Writing Assignment 4, Comments for Instructors:***
*This assignment is based on several content lectures on human immunodeficiency virus, the eukaryotic cell cycle, mitosis, and the technique of flow cytometry.*

*The primary goal of this assignment is for the students to synthesize multiple skills and concepts that they have learned throughout the program. Students design appropriate experiments using flow cytometry and are asked to generate graphs of different experimental outcomes. The experimental design, predicted outcomes, and associated graphs are all included in the written assignment which follows the format of a primary literature paper. In order to successfully complete this assignment the students must have a good understanding of the basics of the cell cycle. This assignment is limited to 2 pages to give the students practice at writing in a concise manner.*

*The following text is the assignment which is given out in class so that students may work in groups to discuss the types of graphs that are to be generated. We have provided the sample graphs that are given to the students when they turn in their assignment. We then devote half of a class session for discussing the experimental design and the graphs.*

**Assignment and Instructions:**
You have already learned about retroviruses and recently we discussed the cell cycle and flow cytometry in class. This assignment asks you to use all of this information to design an experiment to test your hypothesis.

Human immunodeficiency virus (HIV) has been shown to arrest infected cells in a particular stage of the cell cycle. As a researcher, you want to know what phase of the cell cycle is affected. Design an experiment to determine what stage of the cell cycle is arrested by HIV infection.

The written part of the report should be a maximum of 2 pages long, double-spaced, typed.
The third page will contain 5 graphs, drawn by hand or a computer, as follows:
Graph 1 - showing what uninfected human T-cells look like in your experiment
Graph 2 - showing what you expect to see if HIV arrests cells in G1- phase of the cell cycle
Graph 3 - showing what you expect to see if HIV arrests cells in G2- phase of the cell cycle
Graph 4 - showing what you expect to see if HIV arrests cells in S- phase of the cell cycle
Graph 5 - showing what you expect to see if HIV arrests cells in M- phase of the cell cycle

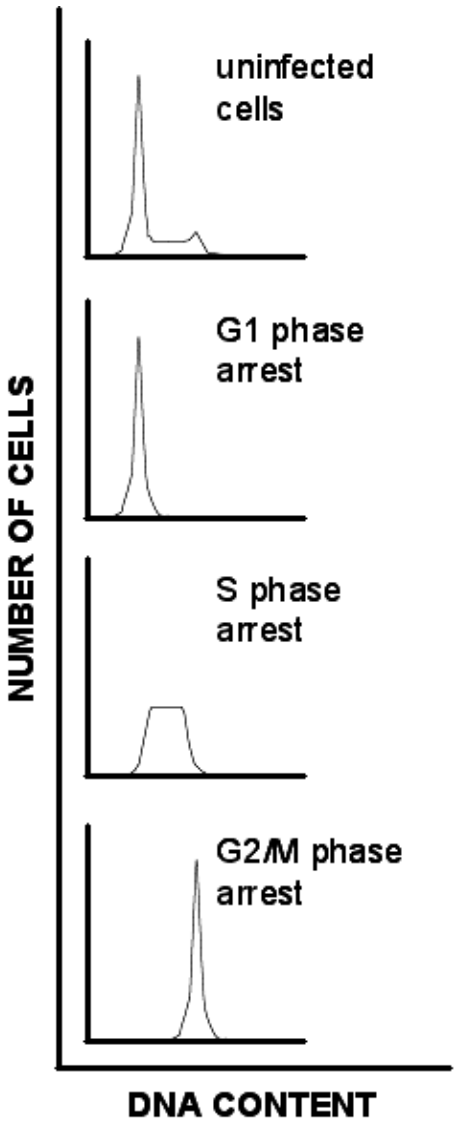
These are graphs of the DNA content of cells, as measured by a stain that binds DNA and is detected using flow cytometry. Be sure that each of your graphs are properly labeled!

The structure of the paper should contain:
1. A brief introduction with your hypothesis
2. Your experimental design inclusive of relevant controls and a discussion of variables
3. A brief paragraph discussing your predictions (not conclusions)
4. The five graphs

Lastly, please staple all of the pages together with this page as the cover.

List of materials available:
HIV-1 virus (assume it will infect every cell in your experiment)
Human T-cells (permissive to HIV infection)
A chemical called ceasin that arrests cells in G1
A chemical called interruptase that arrests cells in G2
A chemical called apprehendin that arrests cells in S-phase
A chemical called detainase that arrests cells in M-phase
Petri dishes and other necessary items for working with T-cells
A state-of-the-art flow cytometer
A blue DNA stain that binds DNA within whole cells and is detected by the cytometer

**For the instructor - sample graphs that students might generate:**



**SM 2 - Grading Rubric**

| FOLLOWING INSTRUCTIONS | | |
|---|---|---|
| **Level of Achievement** | **General Presentation** | **Reasoning, Argumentation** |
| **Exemplary (3pts)** | The written assignment contains all the required elements designated in the instructions (e.g. experimental design, introduction, etc . . .)<br><br>Document is typed, double-spaced, 12 point font, and meets specified minimum/maximum length restrictions.<br><br>Document is organized as instructed. (e.g. has a cover sheet, outline, etc . . .) | The writer demonstrates that they have read the instructions and understand the assignment. |
| **Adequate (2 pts)** | One of the above elements is lacking. | One of the above elements is lacking. |
| **Needs improvement (1pts)** | More than one of the above elements is lacking. | More than one of the above elements is lacking. |
| **Failed to follow instructions (0 pts)** | Did not follow any of the instructions provided. | Instructions are presented for one to follow. |

| OUTLINE | | |
|---|---|---|
| **Level of Achievement** | **General Presentation** | **Reasoning, Argumentation** |
| **Exemplary (3 pts)** | Conforms to standard format as designated in the sample provided.<br><br>Contains the topics discussed and does not contain topics that are not discussed in the writing.<br><br>Is logically organized. | The writer demonstrates that they know the proper format for an outline.<br><br>The writer demonstrates that the outline was used for structuring their writing.<br><br>The writer demonstrates how the topics within their outline are related. |
| **Adequate (2 pts)** | One of the above elements is lacking. | One of the above elements is lacking. |
| **Needs improvement (1pts)** | More than one of the above elements is lacking. | More than one of the above elements is lacking. |
| **No Outline (0 pts)** | No outline given. | A sample outline was provided. |

| WRITING MECHANICS | | |
|---|---|---|
| **Level of Achievement** | **General Presentation** | **Reasoning, Argumentation** |
| **Exemplary (3 pts)** | Almost the entire essay contains correct grammar.<br><br>Almost the entire essay contains correct spelling.<br><br>Almost the entire essay contains correct punctuation. | The writer clearly demonstrates that they can structure grammatically correct sentences using proper spelling and punctuation. |
| **Adequate (2 pts)** | The above elements exist, but are not entirely adequate. | The writer needs to spend more time practicing their writing skills. |
| **Needs improvement (1 pts)** | One of the above elements is lacking and the others are inadequate. | Please go to the university writing centers for help with your writing. |
| **No Essay (0 pts)** | All three of these elements are highly inadequate. | Please go to the university writing centers for help with your writing. |

| WRITING STRUCTURE | | |
|---|---|---|
| **Level of Achievement** | **General Presentation** | **Reasoning, Argumentation** |
| **Exemplary (3 pts)** | The writer has indicated the purpose of their paper and the paper contains an appropriate introduction<br><br>The writing is clear and concise. The design of the paper is logical, organized, and can be easily followed by the reader.<br><br>There is an adequate discussion of the assignment topic. | The writer clearly demonstrates that they have the ability to logically organize their arguments and be concise in their writing. |
| **Adequate (2 pts)** | One of the above elements is lacking. | One of the above elements is lacking. |
| **Needs improvement (1 pts)** | More than one of the above elements is lacking. | More than one of the above elements is lacking. |

| EXPERIMENTAL DESIGN | | |
|---|---|---|
| **Level of Achievement** | **General Presentation** | **Reasoning, Argumentation** |
| **Exemplary (3 pts)** | The writer has designed appropriate experiments and those experiments are clear and logical. The experimental design is | The writer demonstrates that they fully understand the process of experimental design. |

| | | |
|---|---|---|
| | capable of falsifying or confirming the hypothesis.<br><br>The concept of variables is discussed and it is clear what variables are being controlled and which are being manipulated. If appropriate, positive and negative controls are included.<br><br>The author has included a clear, concise, falsifiable, and testable hypothesis. | The writer demonstrates that they understand how to set up and control an experiment.<br><br>The writer demonstrates their ability to generate a good scientific hypothesis. |
| **Adequate (2 pts)** | One element is lacking. | One element is lacking. |
| **Needs improvement (1 pts)** | More than one of the above elements is lacking. | More than one of the above elements is lacking. |
| **No Experiments (0 pts)** | No hypotheses or design experiments stated. | This was the focus of the entire assignment. |

| **GRAPH OR FIGURE** | | |
|---|---|---|
| **Level of Achievement** | **General Presentation** | **Reasoning, Argumentation** |
| **Exemplary (3 pts)** | The graph or figure is of the appropriate type, shows the correct scale, contains the appropriate data, etc. If appropriate, the independent and dependant variables are on the correct axes.<br><br>The axes, legend, and title are all clear, appropriate, and labeled. The general appearance of the graph or figure is good.<br><br>The graph or figure contains results that are appropriate and expected given the experimental design. Error bars are shown if possible. | The writer demonstrates that they understand the purpose of the graph or figure.<br><br>The reader needs to be able to clearly understand and interpret the graph.<br><br>The writer demonstrates their understanding of the relationship between experimental design and the representation of data. Display of error is critical for evaluation of data. |
| **Adequate (2 pts)** | One element is lacking. | One element is lacking. |
| **Needs improvement (1 pts)** | More than one of the above elements is lacking. | More than one of the above elements is lacking. |
| **No Essay (0 pts)** | No graph was included. | A graph was required. |

## SM 3 - Scientific Literature Pre- and Post-test

***Comments for Instructors:***
*This assessment is administered in Session 1, prior to instruction about primary literature papers, and then again in Session 15. Question 1 is worth a total of 6 points, with partial credit for an identified section or a description of the section. Questions 2-5 are each worth 1 point. This test assesses students' abilities to accurately identify and describe the following sections of a primary literature paper: Abstract, Introduction/Background, Materials and Methods, Results, Discussion/Conclusions, and References/Work Cited/Biblography. Students should also understand the purpose of literature papers, and the ways in which scientists communicate their research and related information through text. Please see the acceptable sample answers below.*

**Test questions**

**1. Please list the six main sections of a primary scientific literature paper and briefly explain what each section would contain.**

**2. What is the main purpose of a primary scientific literature paper?**

**3. How does a primary scientific literature paper differ from a secondary paper, such as a review?**

**4. In which section of a scientific literature paper would you be most likely to find a graph?**

**5. In which section of a scientific literature paper would you be most likely to find a statement about an experiment or a set of experiments that have not yet been conducted by the authors?**

Acceptable answers
1. Abstract: provides an overview of the entire paper; Introduction: provides background information for the reading and states why the work is significant; Materials and Methods: provides an in-depth description of the procedures that the authors used in their experiments in order for the reader to replicate the work; Results: provides a description and summary of the outcomes from each experiment; Conclusions/Discussion: summarizes what the overall results were from one or more experiments, discussing the results in the context of a bigger picture, and connects the work to previous findings and future work; references: lists all of the work cited in the article.
2. The purpose of a primary scientific literature paper is for authors to convey their new experimental findings to the scientific community.
3. A primary literature paper is a report of original new work whereas a review article is a summary of many scientific studies and results around a particular topic.
4. One would most likely find a graph in the results section of a scientific literature paper.
5. One would most likely find a statement about an experiment or set of experiments that have yet to be conducted by the authors in the conclusions or discussion section.