Supplemental Materials for
Improving Scientific Research and Writing Skills through Peer Review and Empirical Group Learning

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Group Building Questionnaire

NAME

YEAR

MAJOR

DO YOU LIVE ON CAMPUS, IF NOT HOW FAR IS COMMUTE?

PREVIOUS SCIENCE CLASSES (BIO/CHEM)

DO YOU HAVE RESEARCH EXPERIENCE

WHAT ARE YOUR CAREER GOALS

HOBBIES/EXTRACURRICULARS
Guide and Questions: Introduction section

In order for scientific progress to be made, researchers must communicate their findings to their peers in either oral or written form. Individual scientists perform experiments to test hypotheses, and after experiments are completed, researchers write a research article to present their data and interpretations. The scientific article acts as a vehicle of persuasion. When the paper is published, it is available for other scientists to review and decide whether to accept the hypotheses and conclusions as put forth in the paper. If the results stand up to criticism, they become part of the accepted body of scientific knowledge.

A scientific report consists of the following:

1. Title
2. Abstract
3. Introduction
4. Materials and methods
5. Results
6. Discussion
7. Literature cited

The title of a research article should be straightforward and informative. Most titles of a scientific research article are not “catchy” or “fancy”. They should include key words that help researchers in the field identify the paper as being relevant to their work, as well help scientists locate the paper in a database. In a lab report, using a title such as “Lab 1” or using the same title as in the lab manual is not acceptable.

The abstract is a brief summary of the entire paper. It should be very concise (about 100-200 words maximum) and summarize the purpose of the paper, the major hypotheses, the data presented, and the major conclusions. The abstract should be the last part of the paper that is written, as it summarizes all the major sections of the paper.

The introduction outlines the purpose for the research performed and gives the reader any sufficient background needed to understand the rest of the report. It is important to note that the amount of background given does not need to be extensive and should focus on key details that help the reader understand why the authors arrived at their hypotheses. If the reader is not familiar with the information in the paper, he or she can read the references listed in the literature cited section. Most introductions are a few paragraphs, no more than a full page. An introduction should answer several questions:
1. What is the biological significance of this study?
2. What knowledge already exists about this subject?
3. What is the specific question of the study?
4. What are the hypotheses?

GUIDED READING ASSIGNMENT

Please read the introduction of the paper “Characterization of the Cross-Reaction Between Type 19F(19) and 19A(57) Pneumococcal Capsular Polysaccharides: Compositional Analysis and Immunological Relation Determined with Rabbit Typing Antisera”, which was published in Infection and Immunity in 1978.

Please type brief responses to the following questions. These questions will help you think about the information that is present in a research article.

1. What is the significance of this study?
2. What was unknown before the study was performed?
3. What knowledge already exists about the pneumococcal capsular polysaccharides discussed in the paper?
4. What is the specific question of the study?

GUIDED WRITING ASSIGNMENT

Now, using the knowledge you have just gained on the Introduction of a research article, write an introduction based on the lab you just finished, “Lab 2. Antibody-Antigen precipitation”. Be sure to include any appropriate citations, whether it is your textbook, the lab manual, etc.

Give the paper an appropriate title, as if you were writing a full report on this lab.
Guide and Questions: Methods and results (MR) section

Once the authors of a research article have stated their research questions and hypotheses, the next steps are to describe what methods they used to answer the question, and the results of their experiments.

The methods section contains all the methods that were used in the experiments reported in the article. The goal of this section is to provide the reader with enough detail to understand the experiment and potentially replicate the experiment without giving overwhelming detail. When explaining the methods, it is extremely important to note all materials such as reagents, correct antibody nomenclature, controls, temperatures, incubation times, cell culture information and equipment used. Additionally, this section should be broken up into subsections for each technique that was used. Often, the most difficult part of writing this section is not what should be discussed, but rather what shouldn’t be discussed. A materials and methods section should not be directly copied from the lab manual. Often, the lab manual will include notations such as “wear gloves” or “dispose of in biohazard waste” – this information is inappropriate to include in a research article because this is considered standard knowledge for a scientist. The methods section should be written in past passive voice, because the techniques have been completed. For example, you should say “The samples were centrifuged” rather than “We centrifuged the samples”.

The results section is the most important section of the research paper. This section summarizes the data from the experiments without discussing their implications. Results sections contain three parts: text, figures, and figure legends. The text of a results section should be short, concise, and explain the results obtained from the experiment. As in the Materials and Methods section, data should be referred to in the past tense, since the experiments have been completed. Figures and tables should be numbered referred to in the text by number, for example: “Figure one shows phosphorylation decreased after an hour” or “Phosphorylation was decreased after an hour (Fig.1)”.

Figures and tables should be self-explanatory. The reader should be able to understand a figure without referring to the text. Figures must include properly labeled axes. For example, if the y-axis is showing concentration of IL-2 secreted, the axis must include units, such as “IL-2 secreted (ng/mL)”. Legends include figure number, a short title that states what the figure is showing, and a few sentences stating what technique or method was used and a brief description of the figure. A more thorough description of the figure should
be reserved for the text portion of the results section. See below for an example of a figure with an appropriate figure legend (Ronet et al. 2008).

![Figure 1](image_url)  
**FIGURE 1.** B cells from BALB/c mice secrete IL-10 after stimulation in vitro by *L. major* LV39. Purified splenic B cells from naïve BALB/c mice were cultured in presence of medium alone, *L. major* LV39 (five parasites/cell), SLA, or 1 μg/ml of LPS or CpG. After 24 h of stimulation, IL-10 production in culture supernatants was measured by ELISA. Data are the mean ± SD of 10 experiments. *p < 0.05 compared with unstimulated B cells.

**GUIDED READING ASSIGNMENT**

Please read the **Methods** and **Results** of the paper “Characterization of the Cross-Reaction Between Type 19F(19) and 19A(57) Pneumococcal Capsular Polysaccharides: Compositional Analysis and Immunological Relation Determined with Rabbit Typing Antisera”, which was published in *Infection and Immunity* in 1978.

Please type brief responses to the following questions. These questions will help you think about the information that is present in a research article.

1. What methods were used to answer the authors’ research questions? Briefly describe the methods.

2. What question did the researchers try to answer using precipitation analyses in this paper?

3. What conclusion can you draw from the results of their precipitation analyses (Figure 1)?

4. What question did the researchers try to answer using agglutination analyses in this paper?

5. What conclusion can you draw from the results of their agglutination analyses (Table 2)?

**GUIDED WRITING ASSIGNMENT**
Now, using the knowledge you have just gained on the Methods and Results of a research article, write methods and results sections based on the lab you just finished, “Lab 3. Agglutination”.
Be sure to include any appropriate citations, including citing the lab manual in the methods section.
Don’t forget to give the paper an appropriate title as well.
Guide and Questions: Discussion section

In a research article, it is not enough for the authors to just simply state their findings in the results section; they must also interpret, justify, and explain the significance of their findings. The interpretation, justification and significance of results belong in the discussion section. This section should not just be a restatement of the results, but rather emphasize the interpretation and relate the results to existing knowledge on the topic. An explanation of whether the data supports the initial hypothesis should also be included. If the data show deviations from the hypotheses, the author should acknowledge this and speculate why this occurred. This section needs to address the significance of the study and how the data and conclusions fit into the “big picture” of the subject being studied. This includes relating findings to previous work and discussing the implications of the conclusions. Additionally, new hypotheses can be explored and future experiments based on the conclusions should be discussed.

GUIDED READING ASSIGNMENT

Please read the discussion of the paper “Characterization of the Cross-Reaction Between Type 19F(19) and 19A(57) Pneumococcal Capsular Polysaccharides: Compositional Analysis and Immunological Relation Determined with Rabbit Typing Antisera”, which was published in Infection and Immunity in 1978.

Please type brief responses to the following questions. These questions will help you think about the information that is present in a research article.

1. What conclusions did the authors make based on the results?
2. Why did the authors need to use both precipitation and agglutination to answer their question?
3. How do their findings fit in with previous work on the subject?
4. What new hypotheses can be formed based on the data in this paper?

GUIDED WRITING ASSIGNMENT

Now, using the knowledge you have just gained on the discussion of a research article, write the discussion section based on the lab you just finished, “Lab 4. Immunofluorescence”. Be sure to include any appropriate citations, whether it is your textbook, the lab manual, etc, as well as a title.
Guide for Analysis and Presentation of Research Results

In addition to writing scientific articles, scientists communicate their research by presenting their own work at conferences where they either give an oral or a poster presentation. To keep up with current scientific research, scientists present and analyze research papers published in a particular field of interest while the audience participates in a discussion of the data presented. Such presentations and discussions are called journal club and are regularly held in graduate school and medical school.

Over the next few weeks you will work on presenting data from a research article published in the Journal of Experimental Medicine in 2005. This article was written by Paccani et.al. and entitled “Anthrax toxins suppress T lymphocyte activation by disrupting antigen receptor signaling”. The purpose of these discussions is to give you an idea of how to analyze and present research article in journal club. Additionally, you will learn how to analyze, process, and present data that were generated by many of the techniques you will learn over the rest of the semester, including western blotting, ELISA, and flow cytometry.

There are four figures in this paper. Each group will be tasked with presenting one figure. (Your TA will tell you which figure you are presenting.) As a group you will present your figure in a power point presentation. Every member of your group is required to participate in the presentation. This presentation should be approximately ten minutes. You must present ALL subfigures in a figure. As you are presenting your figure you must discuss the following:

- The particular question the authors were trying to address
- What was measured or observed
- What technique was used
- How the data are presented or plotted
- What do the results show
- What conclusion can be drawn from the figure
- Why are these results important

Your group will be graded on slide design/layout, and overall presentation skills. Each person in your group should speak for approximately the same time. Each person should make sure they understand the information being presented, as you will be in charge of answering any questions the audience may have. Remember this is a 20 point assignment!

SCHEDULE:
Introduce paper/guidelines, each group assigned one figure.
Guided Discussion of Research Paper Introduction
Presentation and discussion of figures 1 and 2
Presentation and discussion of Figures 3 and 4
Guided Discussion of Research Paper Discussion
Discussion questions for the Intro and Discussion are included. You will not be required to turn in written answers to these questions, but keep in mind that there are 30 points of participation assigned for this course and you MUST be able to actively participate in these discussions.

**Questions for Guided Discussion of Research Paper Introduction**

1. What is the significance of this study?

2. What was unknown before the study was performed?

3. What knowledge already exists about this topic? (T cell signaling, anthrax toxins, anthrax infections etc)

4. What is the specific question of the study?

**Questions for Guided Discussion of Research Paper Discussion**

1. What conclusions did the authors make based on the results? Make sure you know ALL of the results, not just the figure your group presented!

2. How do their findings fit in with what was previously known about this topic?

3. Why are their findings significant?

4. What new hypotheses can be formed based on their conclusions?
Guide for Group Research Paper

STEP 1: Draft a testable research question and hypothesis and identify two experimental techniques selecting from those learned in the course (10 points)

→ Given the scenario and available materials, please identify the following:
  • A specific research question that can be asked
  • Two experimental approaches that can be used to answer the research question

STEP 2: outline experimental procedures based on the two chosen experimental techniques (30 points)

STEP 3: Perform experiments

STEP 4: Write the Group Research Paper

This paper will be written as a group. No matter how many of you are in a group, you will write ONE paper with all your names on it as authors. Each person in the group must contribute to the writing. Your contribution to the experiments and report will be evaluated by your peers.

Format: Double spaced, 8-10 pages

Overall the format is the same as the lab reports you have been writing all semester, with 2 additional requirements. First you must include an abstract (details below). Secondly, you must include appropriate references such as textbooks, review articles, and primary research articles. Websites such as webmd.com and Wikipedia are NOT appropriate references. Points will be deducted if you use inappropriate references in your paper. Directions for citing references are below.

A few reminders:

The title of a research article should be straightforward and informative. Most titles of a scientific research article are not “catchy” or “fancy”. They should include key words that help researchers in the field identify the paper as being relevant to their work, as well help scientists locate the paper in a database. Using a title such as “Research Project” or using the same title as in the lab manual is not acceptable. (1 point)

The abstract is a brief summary of the entire paper. It should be very concise (about 100-200 words maximum) and summarize the purpose of the paper, the major hypotheses, the data presented, and the major conclusions. The abstract should be the last part of the paper that is written, as it summarizes all the major sections of the paper. (3 points)
The introduction outlines the purpose for the research performed and gives the reader any sufficient background needed to understand the rest of the report. It is important to note that the amount of background given does not need to be extensive and should focus on key details that help the reader understand why the authors arrived at their hypotheses. If the reader is not familiar with the information in the paper, he or she can read the references listed in the literature cited section. Most introductions are a few paragraphs, no more than a full page. An introduction should answer several questions: What is the biological significance of this study?, What knowledge already exists about this subject?, What is the specific question of the study?, What are the hypotheses? (9 points)

The methods section contains all the methods that were used in the experiments reported in the article. The goal of this section is to provide the reader with enough detail to understand the experiment and potentially replicate the experiment without giving overwhelming detail. When explaining the methods, it is extremely important to note all materials such as reagents, correct antibody nomenclature, controls, temperatures, incubation times, cell culture information and equipment used. Additionally, this section should be broken up into subsections for each technique that was used. Often, the most difficult part of writing this section is not what should be discussed, but rather what shouldn’t be discussed. A materials and methods section should not be directly copied from the lab manual. Often, the lab manual will include notations such as “wear gloves” or “dispose of in biohazard waste” – this information is inappropriate to include in a research article because this is considered standard knowledge for a scientist. The methods section should be written in past passive voice, because the techniques have been completed. For example, you should say “The samples were centrifuged” rather than “We centrifuged the samples”. (6 points)

The results section is the most important section of the research paper. This section summarizes the data from the experiments without discussing their implications. Results sections contain three parts: text, figures, and figure legends. The text of a results section should be short, concise, and explain the results obtained from the experiment. As in the Materials and Methods section, data should be referred to in the past tense, since the experiments have been completed. Figures and tables should be numbered referred to in the text by number, for example: “Figure one shows phosphorylation decreased after an hour” or “Phosphorylation was decreased after an hour (Fig.1)”. Figures and tables should be self-explanatory. The reader should be able to understand a figure without referring to the text. Figures must include properly labeled axes. For example, if the y-axis is showing concentration of IL-2 secreted, the axis must include units, such as “IL-2 secreted (ng/mL)”. Legends include figure number, a short title that states what the figure is showing, and a few sentences stating what technique or method was used and a brief description of the figure. A more thorough description of the figure should be reserved for the text portion of the results section. (10 points)

The interpretation, justification and significance of results belong in the discussion section. This section should not just be a restatement of the results, but rather emphasize the interpretation and relate the results to existing knowledge on the topic. An explanation of
whether the data supports the initial hypothesis should also be included. If the data show deviations from the hypotheses, the author should acknowledge this and speculate why this occurred. This section needs to address the significance of the study and how the data and conclusions fit into the “big picture” of the subject being studied. This includes relating findings to previous work and discussing the implications of the conclusions. Additionally, new hypotheses can be explored and future experiments based on the conclusions should be discussed. (8 points)

References- Any and all information obtained from another source should be referenced in this section, as well as cited within the text. You will need a minimum of THREE sources. All sources must be peer reviewed, as is standard when publishing papers. Remember that websites do not count as peer reviewed articles. The following format is acceptable for citation within the text and the reference section. (3 points)

In text:
Paccani et al. (1) have previously shown that anthrax toxins suppress T cell signaling.

OR

Previous work has shown that anthrax toxins suppress T cell signaling (Paccani, et al, 2005).

In references:


Alphabetically:

**Introduction Rubric**

**Guided Discussion**

➔ Student answered and turned in questions ______ /5 pts

**Guided Writing**

Introduction section for Lab 2: Antibody/Antigen Precipitation (total 10 pts)

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<td>• Adequately descriptive, concise +2</td>
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<td>• Poorly descriptive or too wordy +1</td>
<td>• Title not original or relevant +0</td>
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<td><strong>Introduction (8 pts)</strong></td>
<td>• Appropriate amount of background given +2</td>
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<td>• Little or no background 0</td>
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<td>• States significance +2</td>
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<td>• Does not state significance 0</td>
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<td></td>
<td>• States specific question +2</td>
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<td>• Includes hypotheses +1</td>
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<td>• Weak hypotheses +.5</td>
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<td>• Includes appropriate citations +1</td>
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TOTAL ______/15
# Methods/ Results (MR) Rubric

## Guided Discussion

- Student answered and turned in questions  ______ /5 pts

## Guided Writing

Methods and Results section for Lab 4: Immunofluorescence (total 10 pts)

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<td>• Results clearly summarized in text +1</td>
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<td>• No figure legends +0</td>
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**TOTAL**  ______/15
## Discussion Rubric

### Guided Discussion

rq: Student answered and turned in questions ______ /5 pts

### Guided Writing

**Discussion section for Lab 4: Immunofluorescence (total 10 pts)**

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<td>• Title not original or relevant +0</td>
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<td>• Less than half of data discussed +.5</td>
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<td>• Includes interpretation of results and clear conclusions +2</td>
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<td>• Does not interpret results or draw conclusions +0</td>
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<td>• Contradictory data attributed to “human error” only +.5</td>
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<td>• Contradictory data not explained +0</td>
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<td>• States possible follow up +1.5</td>
<td>• Follow up weak +.5</td>
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**TOTAL** _______/15
# Lab Report Rubric: 25 points

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<td>• Includes interpretation of results and clear conclusions+1.5</td>
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Analysis and Presentation of Research Results Rubric

Oral Presentation (Paper #2)
20 Points Total

Results: _____/12
MUST EXPLAIN:
- The particular question the authors were trying to address
- What was measured or observed
- What technique was used
- What do the results show
- What conclusion can be drawn from the figure
- Why are these results important

Slide design
- Slides are readable, layout of graphics/text appropriate _____/2

Presentation _____/2
- How smooth is transition between each presenter?
- Volume, pace are appropriate
- Do the students understand the information they are presenting?

Time _____/2
- Kept to appropriate time (~10 minutes)
- All students in group spoke for about the same time

Questions _____/2
- Students are able to answer questions from audience

TOTAL: _____/20
Peer Review Rubric of Group Research Paper

Names of authors: ___________________________________________________________

Names of reviewers: _________________________________________________________

If the answers to any of these questions are “no”, please provide comments and suggestions.

1. Does this paper have all the requirements? (Title, Abstract, Intro, Methods, Results, Discussion, References)

2. Does the intro clearly state a specific research question and hypotheses?

3. Based on the experiments they performed (from the methods), are all the results present?

4. Are all graphs/figures formatted and labeled appropriately?

5. Do the authors describe all the results in text format?

6. Does the discussion contain all appropriate conclusions?

7. Do the authors discuss why these results are significant?

8. Are all the references peer reviewed? Are these sources cited properly both in-text and in the “literature cited” section?
Peer Review of individual contribution in a group

Please evaluate each member of your lab group with respect to the following tasks that were part of the Experimental Design Project. Give each member a score from 1 to 10, with 1 signifying contributed little to nothing and 10 signifying contributed significantly. If a group member is consistently given a low score, it may affect his or her grade for that task. You do not need to sign this form. Turn this in at the end of the class to your TA.

<table>
<thead>
<tr>
<th>Group member name:</th>
<th>Research Report</th>
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<td>Correct format for citations and references +1</td>
<td>Includes some non-peer reviewed sources +0.5</td>
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<tr>
<td>Contains only peer reviewed sources +1</td>
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</table>
1. I am aware of the type and scale of scientific research that is occurring in labs at the University of Maryland.
   AGREE       DISAGREE       DON’T KNOW

   Explain why.

2. I have an understanding of how the research process is conducted by scientific researchers working in a research lab.
   AGREE       DISAGREE       DON’T KNOW

   Explain why.

3. I am comfortable in asking questions and sharing my ideas in my science classes.
   AGREE       DISAGREE       DON’T KNOW

   Explain why.

4. Team work (collaborative work) is valuable for scientific advances.
   AGREE       DISAGREE       DON’T KNOW

   Explain why.

5. Research designed to address basic science questions is vital to addressing problems of global significance.
   AGREE       DISAGREE       DON’T KNOW

   Explain why.

6. The format of lab reports in science classes are modeled after the style of primary research articles in scientific publications.
   AGREE       DISAGREE       DON’T KNOW

   Explain why.

7. A lab report has the same depth as a published research article.
   AGREE       DISAGREE       DON’T KNOW

   Explain why.
8. Basic lab research is interesting and I would consider a career in research.  
   AGREE  DISAGREE  DON’T KNOW  
   Explain why.  

9. Please rate your SKILL in the following areas.  
   (none - 1, very low - 2, low - 3, moderate - 4, high - 5, very high - 6)  
   a. Able to work as an effective group member  
   b. Able to read and understand scientific research articles  
   c. Able to interpret information presented in graphs, tables and figures of a scientific research article  
   d. Able to present data from lab in a graph or table.  
   e. Able to suggest a reasonable hypothesis or ask a “next question” following analysis of data (from lab or presented in a research article)  
   f. Able to distinguish a peer reviewed article from one that is not peer reviewed  

10. Give examples of how antibodies are used as a tool to detect antigens.  

I give my permission for responses to be used for educational purposes.  
Yes  
No
1. Based on my experience in this class, I became more aware of research being done on this campus.
   AGREE   DISAGREE   DON'T KNOW
   Explain.

2. I felt comfortable in asking questions and sharing my ideas in this class.
   AGREE   DISAGREE   DON'T KNOW
   Explain why.

3. Team work (collaborative work) benefitted me in this class.
   AGREE   DISAGREE   DON'T KNOW
   Explain why.

4. The format of lab reports in science classes are modeled after the style of primary research articles in scientific publications.
   AGREE   DISAGREE   DON'T KNOW
   Explain why.

5. A lab report has the same depth as a published research article.
   AGREE   DISAGREE   DON'T KNOW
   Explain why.

6. Reading and presenting primary research articles helped me understand how data is presented.
   AGREE   DISAGREE   DON'T KNOW
   Explain why.

7. The independent project helped me understand the scientific research process.
   AGREE   DISAGREE   DON'T KNOW
   Explain why.
8. Basic lab research is interesting and I would consider a career in research.
   **AGREE**   **DISAGREE**   **DON'T KNOW**
   
   Explain why.

9. My skills in the following areas improved as a result of this course.
   a. Able to work as an effective group member
      **AGREE**   **DISAGREE**   **DON'T KNOW**
   b. Able to read and understand scientific research articles
      **AGREE**   **DISAGREE**   **DON'T KNOW**
   c. Able to interpret information presented in graphs, tables and figures of a scientific research article
      **AGREE**   **DISAGREE**   **DON'T KNOW**
   d. Able to present data from lab in a graph or table.
      **AGREE**   **DISAGREE**   **DON'T KNOW**
   e. Able to suggest a reasonable hypothesis or ask a “next question” following analysis of data (from lab or presented in a research article)
      **AGREE**   **DISAGREE**   **DON'T KNOW**
   f. Able to distinguish a peer reviewed article from one that is not peer reviewed
      **AGREE**   **DISAGREE**   **DON'T KNOW**
      Explain.

10. Give examples of how antibodies are used as a tool to detect antigens

11. What did you like about this course?

12. What suggestions do you have to improve this course?
Unmethylated CpG may treat asthma by inhibiting the Th2 response

Abstract:

Asthma is a respiratory disease that causes coughing, wheezing and shortness of breath as a result of inflammation of the bronchiolar tubes. The inflammatory factors are caused by agents of the Th2 response, which includes secretion of various cytokines such as IL-4. CpG-containing immunostimulatory DNA oligodeoxynucleotides (CpG ODN) are unmethylated bacterial DNA that bind and activate toll-like receptor 9 (TLR9) (Latz et al., 2004). Although it was shown that CpG ODN was able to treat asthma symptoms by changing the immune response from Th2 to Th1 (Sur et al., 1999), the mechanisms of inhibition of Th2 response is unclear. It was hypothesized that CpG inhibits the Th2 response by inhibiting IL-4 secretion and the activation of dendritic cells. This experiment used ELISA and flow cytometry to determine the mechanisms of Th2 inhibition by CpG ODN stimulation of murine models. CpG ODN treatment of asthmatic mice decreased IL-4 levels in the bronchoalveolar lavage and prevented CD86 expression by dendritic cells in lung tissues. Therefore, CpG ODN could be considered as a strong candidate for an effective asthma treatment due to its ability to inhibit the Th2 responses.

Introduction:

Asthma is a respiratory disease that affects millions of individuals worldwide. It affects the airways in the affected individual resulting in inflammation of the respiratory pathway, causing cough, shortness of breath, increased mucus secretion, bronchoconstriction and wheezing (Kindt et al., 2007). If left untreated, the consequences of an asthmatic episode can be fatal. Asthma is mediated by a Th2 response characterized by the secretion of cytokines such as IL-4, IL-5, IL-9 and IL-13 (Sur et al., 1999). Currently, there is no cure for asthma, and the
treatments are only designed to prevent and treat asthma attacks. As a result, there is much interest in developing more adequate and effective treatment for asthma.

CpG-containing immunostimulatory DNA oligodeoxynucleotides (CpG ODN) are unmethylated bacterial DNA that bind and activate toll-like receptor 9 (TLR9) (Latz et al., 2004). Research has shown that CpG is a strong candidate for treatment of asthma due to its ability to induce cytokine production that deviate the immune system from a Th2 to a Th1 response (Sur et al., 1999). Previous research has shown CpG stimulation in mouse asthmatic models increases the production of Th1 cytokine IFN-γ and decreases the production of Th2 cytokine IL-4. It was also shown that CpG reduces the severity of asthma episodes by reducing the amount of allergen-induced eosinophils, IgE antibody production, and airway hyper-responsiveness in general (Sur et al., 1999).

It still remains elusive how CpG inhibits the Th2 response and causes immune deviation to a Th1 response in asthma. In this investigation, we hoped to further examine the potential of CpG as treatment for asthma by observing its possible inhibitory effects in murine models. It is hypothesized that the levels of IL-4, a Th2 mediated cytokine, will be reduced directly by the stimulation with CpG. It was shown in mouse asthma models that activation of certain CD86 (commonly known as B7) costimulatory molecules induces a Th2 response (Nagashima et al., 2008). It is also hypothesized that CpG stimulation will inhibit the expression of CD86 (or B7), a costimulatory molecule for Th2 cell presentation, by dendritic cells in the lungs. This was investigated by using enzyme-linked immunosorbent assay (ELISA) and flow cytometry, respectively. The ELISA was used to quantify the amount of IL-4 secreted by bronchoalveolar lavage (BAL) from lung tissues of CpG–treated and CpG-untreated asthma mice, and untreated normal mice. Flow cytometry was used to measure the amount of dendritic cell activation in
lungs of CpG-treated and CpG-untreated asthma mice, and untreated normal mice using CD86 activation marker.

**Methods:**

*Bronchaveolar lavage (BAL) IL-4 assay using ELISA.*

A 96-well plate was coated with anti-IL-4 antibody and subsequently washed three times with 0.05% PBS/T and tapped dry. 200 µl of blocking buffer was added to each well and the plates were covered and incubated for 30 minutes at room temperature. Two sets of two-fold serial dilutions of 1 µg/ml IL-4 were prepared starting from the original concentration to a 1:2048 dilution. 100 µl of 1 µg/ml IL-4 was added to wells A3-A6, B1 and C1. 100 µl of each dilution of IL-4 was added to each corresponding well. 100 µl of BAL samples from normal mice were added to wells A7-A8. 100 µl BAL from asthma mice stimulated with CpG were added to wells A9-A10, and 100 µl of BAL samples from asthma mice without CpG were added to wells A11-A12. The plate was incubated for 48 hours at 4°C. The plate was then washed three times with PBS/T and blotted dry. 100 µl of mouse IgG anti-human IL-4 primary antibody was added to wells A1, A2, A5-A10, B1-B12 and C1-C12. The plate was covered and incubated for 30 minutes at room temperature. After the plate was washed three times with PBS/T, 100 µl of HRP-rabbit anti-mouse IgG (1:10,000 in PBS/T) was added to every well excluding A5 and A6. After a 30 minute incubation at room temperature, the plate was washed three times with PBS/T. 100 µl of fresh ABTS substrate diluted 1:100 in H2O2 was added to all wells and color absorbance was measured at 405 nm by a plate reader. (Song, 2010).

**Quantification of dendritic cell activation using flow cytometry.**
Dendritic cells were isolated from lung tissue of normal and asthmatic mice. Dendritic cells from normal and asthmatic mice were divided into two subsets. One subset of asthmatic mice was stimulated with CpG. All cells were resuspended with 1 ml of FACS buffer and 2 µl of FITC-rat IgGα anti-mouse CD86 activation marker was added to a subset of normal cells and both subsets of asthmatic cells. The second subset of normal cells was treated with 2 µl of FITC-rat IgGα as an isotype control. Cells were incubated for 30 minutes on ice in the dark. Cells were washed three times with FACS buffer and fixed with 100 µl of ice cold 2% paraformaldehyde. 500 µl of PBS was added to each sample and all contents were transferred to individual FACS tubes for flow cytometer analysis. (Song, 2010).

**Results:**

**ELISA**

ELISA plates were read by a 96-plate reader which generated optical density (OD) values. The standard curve (Figure 1) was generated by the two-fold serial dilutions IL-4 of known concentrations. Based on the best fit line from the standard curve, the equation

\[
\text{OD} = 0.5 \ln[\text{IL-4}] + 2.978
\]

was generated to calculate the IL-4 concentrations secreted by BAL of the lungs of untreated normal mice, untreated asthma mice and CpG ODN-treated asthma mice. The IL-4 concentration in normal mice BAL was 0.004 µg/ml, whereas the untreated asthma mice had a much higher concentration of 0.302 µg/ml (Figure 2). When the asthma mice were treated with CpG-ODN, the concentration of IL-4 in BAL decreased to 0.0595 µg/ml (Figure 2).
Figure 1. The standard curve of Optical Densities of known IL-4 concentrations. The values on the graph represent the average OD values of a serial dilution with known concentrations of IL-4. The line represents the regression equation that was used to calculate the IL-4 concentration of untreated normal mice, untreated asthmatic mice and CpG-treated asthmatic mice.

Figure 2. Comparison of IL-4 concentrations of experimental BAL samples. IL-4 concentrations of the three samples were calculated from the regression line of the standard curve in Figure 1. The graph compares concentrations of IL-4 secreted by BAL of lung tissues of normal, asthmatic, and CpG ODN-treated asthmatic mice. CpG ODN-treated asthma mice showed a decrease in IL-4 secretion as compared to the untreated asthma mice, though both asthma groups had higher IL-4 secretions than normal mice.

Comment [10]: A standard curve wouldn’t be included in a published article but for the purposes of the class this is okay.

Comment [11]: Nice figure, shows that students were able to manipulate raw data to determine the concentrations of their unknowns and plot on an appropriate graph.
Flow Cytometry

Lung dendritic cells from healthy mice were treated with FITC isotype control and analyzed using flow cytometry. Live cells were gated for the subsequent samples based on the size and morphology of the dendritic cells from the forward scatter and side scatter patterns (Figure 3). 20,000 events were recorded for each sample for analysis. The fluorescence intensity of the isotype control without CD86 markers was displayed in Figure 4A. These cells of low FITC fluorescence were considered CD86- cells. Based on the isotype control, it was shown that dendritic cells of normal mice did not express the CD86 activation marker (Figure 4B). 48% of dendritic cells from asthmatic mice expressed CD86 (Table 1, Figure 4C), but the expression was removed upon stimulation with CpG (Figure 4D).

Figure 3. Gating of live lung dendritic cells. Dendritic cells of the lungs were analyzed by flow cytometry and gated for live cells based on the forward scatter using FITC isotype control.
Figure 4. Flow Cytometry Analysis of live lung dendritic cells of normal mice and asthmatic mice. A: Isotype control sample of unstimulated dendritic cells from lungs of healthy mice labeled with FITC-rat IgG2a to observe any nonspecific background. B: Negative control sample of unstimulated dendritic cells from healthy mice labeled with FITC-anti-CD86 to show absence of activation. C: Positive control sample of unstimulated dendritic cells from asthmatic mice labeled FITC-anti-CD86 to show presence of activated dendritic cells by CD86 marker. D: Asthmatic dendritic mouse cells were stimulated with CpG and labeled with FITC-anti-CD86 activation marker.

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<th>% of CD86- cells</th>
<th>% of CD86+ cells</th>
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<td>Dendritic cells of normal mice</td>
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<td>Dendritic cells of asthmatic mice(-CpG)</td>
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<td>Dendritic cells of asthmatic mice (+CpG)</td>
<td>81.7%</td>
<td>100.0%</td>
<td>0.0%</td>
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Table 1: Percentage of live cells and cell distribution of activated and unactivated dendritic cells. The percentage of live cells was calculated based on the gating of live and dead dendritic cells using flow cytometry from Figure 3. Of these live cells, the percentage of activated and unactivated dendritic cells was calculated from flow cytometry data based on the presence of the CD86 activation marker.

Comment [13]: Nice summary table
Comment [14]: Results: 10/10
Discussion:

ELISA results showed a notable difference between the amounts of IL-4 secretion by BAL in the asthmatic mice without treatment with CpG and the asthmatic mice treated with CpG. The untreated asthma mice had higher levels of IL-4 in the BAL as compared to the untreated normal concentration (Figure 2). In the normal mice, there was only a 0.004 µg/ml IL-4 detected in the BAL (Figure 2). When comparing the asthmatic mice, the unstimulated mouse BAL had 0.302 µg/ml of IL-4 whereas the CpG-treated mouse BAL had decreased IL-4 levels of 0.0595 µg/ml (Figure 2). These results indicate that CpG stimulation in asthmatic mice inhibit Th2 response by inhibiting IL-4 secretion. Although CpG treatment did not reduce IL-4 secretion to levels as low as those in the normal mice, the observed decrease of IL-4 is promising. In future experiments, the dosages of CpG administered to the mice can be increased as a possible way to reduce the IL-4 levels even further. The optimal amount of CpG would maximally reduce IL-4 levels in the lungs without harming the mice.

Activated dendritic cells were identified by the cell surface marker, CD86, in flow cytometry. The presence of the CD86 marker is an indication of cells activating Th2 cells. The isotype control was used to determine cells that were CD86- (Figure 4A). 100% of the normal dendritic cells were CD86- (Table 1, Figure 4B). The asthmatic mice had a population of CD86+ dendritic cells (Figure 4C), whereas upon CpG stimulation, all cells were CD86- (Figure 4D). It can be inferred that CpG treatment for mice had inhibited activation of dendritic cells as it inhibited expression of the CD86 activation marker. The expression of CD86 by dendritic cells was found to induce Th2 responses in asthmatic mice (Nagashima et al., 2008). This study showed that CpG was able to inhibit the Th2 response by inhibiting dendritic cell expression of CD86.
The effects of CpG on the BAL and the dendritic cells support the original hypothesis that CpG would inhibit Th2 responses by inhibiting IL-4 and dendritic cell activation in asthmatic mice. Overall, the data from this investigation indicates that CpG is a strong candidate as an effective treatment of asthma because of its ability to potentially inhibit Th2 responses in human patients. To further investigate CpG and its mechanisms of Th2 inhibition, it would be beneficial to determine the effects of CpG on the concentrations of other Th2 cytokines secreted by BAL in asthmatic mice. Other Th2–related cytokines for future studies include IL-5 and IL-10 (Kindt et al., 2007). Another possible follow up experiment would be to analyze the cellular signaling pathways involved in the activation of dendritic cells in asthmatic mice treated with CpG through western blot.

References


Peer Review of Group Research Paper

Names of authors: ____________________________

If the answers to any of these questions are “no”, please provide comments and suggestions.

1. Does this paper have all the requirements? (Title, Abstract, Intro, Methods, Results, Discussion, References)  yes
   
   Great abstract! It makes you want to read more.

2. Does the intro clearly state a specific research question and hypotheses?
   yes. what is the potential for cpg to be used as tk for asthma
   hypotheses: levels of IL-4 will decrease when stimulated with cpg,
   clear and easy to understand.

3. Based on the experiments they performed (from the methods), are all the results present?
   yes. also, i feel how you separated results by experiment
   with a paragraph, supporting figures, and a new data paragraph

4. Are all graphs/figures formatted and labeled appropriately?
   yes. easy to follow and understand.

5. Do the authors describe all the results in text format?
   yes. and they pair the picture to the text by
   placement and references to appropriate figures

6. Does the discussion contain all appropriate conclusions, significant of the results, and future
   directions?
   yes. all conclusions are appropriate and logically
   stated. significance is clear. future directions
   are thoughtfully and concisely.

7. Are all the references peer reviewed? Are these sources cited properly both in-text and in the
   “literature cited” section?
   yes. all from journal or lab manual.
   (term: “reference” not “literature cited”, but we get
   the point)
Peer Review of Group Research Paper

Names of reviewers: __ __

Names of authors: __ __ __

If the answers to any of these questions are "no", please provide comments and suggestions.

1. Does this paper have all the requirements? (Title, Abstract, Intro, Methods, Results, Discussion, References)
   - The Abstract/Yes. It was all present and in appropriate fashion. Don't point double sided for the first draft hypotheses.

2. Does the intro clearly state a specific research question and hypotheses?
   - The specific research question is exclusive. It should be clearly stated how your research will help further understanding of the CpG function. The hypothesis is present (2 of them).

3. Based on the experiments they performed (from the methods), are all the results present?
   - Yes. The graphs and tables nicely summarize the data provided.
     - SHOW visual representation of well plating.
     - WHAT is BAL?

4. Are all graphs/figures formatted and labeled appropriately?
   - Yes. Maybe label OD value on y axis, in graph.
     - The graph should have a table w/ the data in it.

5. Do the authors describe all the results in text format?
   - Yes: Data from ELISA and Flow Cyt. are present.
     - The RESULTS make conclusions! => change it. (Lines 57-58)

6. Does the discussion contain all appropriate conclusions, significant of the results, and future directions?
   - In last line 1st para - how do you know if the lung are being harmed?
   - You did not answer your scientific question. You had no hypothesis or assumptions on how CpG change

7. Are all the references peer reviewed? Are these sources cited properly both in-text and in the "literature cited" section?
   - Yes. The literature is recent but last and most important (last ref) is outdated rather you provided another (1999) - find something newer.
Peer Review of Group Research Paper

Names of authors:

If the answers to any of these questions are “no”, please provide comments and suggestions.

1. Does this paper have all the requirements? (Title, Abstract, Intro, Methods, Results, Discussion, References)
   Yes. Paper looks very neat, and sections are clearly labeled and easy to find.

2. Does the intro clearly state a specific research question and hypotheses?
   Yes. The question is not literally stated but easy to understand (3rd P, 2nd sentence).
   Yes, 3rd P, 3rd sentence.

3. Based on the experiments they performed (from the methods), are all the results present?
   Yes. (The equation in the ELSAT results section should be cleaned up)

   Minor note:

4. Are all graphs/figures formatted and labeled appropriately?
   The graphs were drawn by the authors, but they are not titles for the figures. Titles for the graphs are not given and not cited on the figure. I think it is more necessary for figures/figures’ titles are in bold in figure legends.

5. Do the authors describe all the results in text format?
   Yes. Clearly explain both ELSAT and Flow Cytometry data. Could provide more text about data/figures on page 7.

6. Does the discussion contain all appropriate conclusions, significant of the results, and future directions?
   Yes. Original hypothesis =

7. Are all the references peer reviewed? Are these sources cited properly both in-text and in the “literature cited” section?
   Yes, cited correctly. Only 1 source cited is dated after 2015. Perhaps find a more recent source to make this section even stronger.

Overall Great Paper.
Peer Review of Group Research Paper

Names of authors: 

If the answers to any of these questions are “no”, please provide comments and suggestions.

1. Does this paper have all the requirements? (Title, Abstract, Intro, Methods, Results, Discussion, References)
   Yes, all components have been nearly included and headings are labeled for clarity.

2. Does the intro clearly state a specific research question and hypotheses? Yes for question and hypotheses.

   [ALM is given] - Examine the potential of Gp90 as an atreatment for asthma.
   - Hypothesis: treatment with Gp90 will increase the Th2 response cause immune deviation to a Th1 response in asthma. The levels of IL-4, will be reduced.

3. Based on the experiments they performed (from the methods), are all the results present? Directly by the group.
   - Results show ELISA on Fig. 1 with concentrations to obtain data and curve, using p<0.05.
   - Fig. 2 shows ELISA concentrations of samples. Fig. 3 shows flow cytometry results of dendritic cells and Fig. 4.

4. Are all graphs/figures formatted and labeled appropriately? Each figure/graph has a title that describes briefly what the figure shows (e.g., Fig. 1: Comparison of IL-4...).
   - The legends in the figures captions describe the results. The graphs have titles and axes labeled.
   - Units are consistently displayed. The table summaries flow results well and clearly.

5. Do the authors describe all the results in text format? The results section describes results based on whether ELISA or flow cytometry was applied. There is a brief description of each technique's results with references to figures. The results were collated and did not include any interpretations.

6. Does the discussion contain all appropriate conclusions, significant of the results, and future directions? Yes.
   - Conclusion is that Gp90 stimulation induces Th2 response by inhibiting IL-4 secretion. Future experimental ideas are explicitly mentioned (e.g., future experiments, the dosages of Gp90...). The significance is mentioned as significant; the optimal amount of Gp90 would... explained what controls try and increase validity of the study.
   - This group had the point that their hypothesis was supported and why. Further conclusions can be made.

7. Are all the references-peer reviewed? Are these sources cited properly both in-text and in the "literature cited" section?
   Yes, cited in text correctly. (Kindt et al., 2007).
   - Listed as references in correct format with name (last) first. "The at work... source, p. pg. #/
   - All sources (except manual) are peer reviewed (4 total). reviewed.
Names of reviewers: 

Peer Review of Group Research Paper

Names of authors: 

If the answers to any of these questions are "no", please provide comments and suggestions.

1. Does this paper have all the requirements? (Title, Abstract, Intro, Methods, Results, Discussion, References)
   The paper does meet the requirements of all the sections. The title should state what does the immune system decide to ... via inhibition.

2. Does the intro clearly state a specific research question and hypotheses?
   The specific research question needs to be stated in a sentence starting with "The specific question of the study is ..." The hypothesis is 

3. Based on the experiments they performed (from the methods), are all the results present?
   The results did present the experiments from ELISH and flow cytometry.

4. Are all graphs/figures formatted and labeled appropriately?
   All graphs and figures were formatted correctly but I would suggest the tables/graphs should be presented at the end of the lab report.

5. Do the authors describe all the results in text format?
   The authors did describe the results in text format.

6. Does the discussion contain all appropriate conclusions, significant of the results, and future directions?
   The future studies should be written in one paragraph for all of the results. The paper does contain all of the conclusions.

7. Are all the references peer reviewed? Are these sources cited properly both in-text and in the "literature cited" section?
   The references are peer reviewed and the sources are properly cited in both in-text and reference section, except the intro does not cite (Son, 2010).
Three stages of the implementation

Stage 1: Understanding research paper components

This stage of learning used Research Paper #1 (6). This article was selected because it described the applications of a key immunological concept (the interaction of antibody with antigen), and the two antibody-based techniques that students learned in the first two weeks of the course. Research Paper #1 sections of “Introduction”, “Methods and Results”, and “Discussion” were introduced separately and sequentially using the same 3-step teaching strategy: guided reading, guided discussion, and guided writing. Here, the introduction section is used as an example.

Part a: Guided Reading of Research Paper #1 “Introduction”. Students were provided with the “Guide and Questions: Introduction Section” (Appendix II). This guide included information that helps students understand the overall purpose of and key elements in an “Introduction” section, and two guided assignments: “Guided Reading Assignment Questions” and a “Guided Writing Assignment”. Students were assigned to read the “Introduction” section of Research Paper #1 and were asked to write answers to the “Guided Reading Assignment Questions” and prepare for participation in a discussion (see Part b).

Part b: Guided Discussion of Research Paper #1 Introduction – After completion of Part a, students participated in a discussion about the “Introduction” section of Paper #1. The TA led this discussion based upon the “Guided Reading Assignment Questions”. We considered this a “guided” discussion as it was directed toward the topics highlighted in the “Guide and Questions: Introduction Section” and the TA provided direction and feedback. First the TA asked the students to work in their groups to compare responses to the questions. This step allowed students to corroborate ideas in groups before full class discussion. Next, each group was asked to report on their group discussion and the TA encouraged the full class to comment. The TA monitored and gave feedback to comments to ensure student understanding of the main components of the “Introduction” section according to the appropriate responses to the “Guided Reading Assignment Questions”. After the discussion, the TA collected student written responses to the “Guided Reading Assignment Questions”.

Part c: Guided Writing of Introduction Section - After the discussion of the “Introduction” section of Research Paper#1 students were asked as individuals to write an “Introduction” section based on the lab activity just completed in class (“Guided Writing Assignment”). For example, on the day the
“Introduction” section was discussed, students were assigned to write an “Introduction” section for their lab report on the Ouchterlony test that they just performed. Students were expected to write an “Introduction” modeled after the “Introduction” section of Research Paper #1. The student authored “Introduction” section was evaluated via the Introduction Rubric (Appendix VII).

Following guided reading, discussion and writing of an “Introduction” section, students completed guided reading, discussion and writing of a “Methods/Results” section and a “Discussion” section. Guided reading, writing and discussion of each section took place over 7 days. Students were allowed 2 days to complete each Guided Reading Assignment, which prepared them for guided discussion, and then 5 days to complete the Guided Writing Assignment. This completed Stage 1. The assignments in Stage 1 were designed to be “low stake” assignments and TAs were instructed to grade and return assignments within one class period to give students an opportunity to learn from mistakes and progress their writing skills for the “high stake” assignments in Stage 2 and Stage 3 (Table 3).

Stage 2: Learning to write a research paper

This stage used Research Paper #2 (11). This article was selected because it addressed an interesting immunology question, proposed a clear hypothesis, and applied multiple immunological techniques that were taught in the course. In Stage 2 students read Research Paper #2 and applied insights from Stage 1. The “Results” section of Research Paper #2 was analyzed and discussed in detail. Furthermore, students worked directly on data processing and presenting techniques using their lab generated data and then reported their work by writing four lab reports. Stage 2 included four parts:

Part a: Guided Discussion of Research Paper #2 Introduction-- Students read and analyzed the “Introduction” section of Research Paper #2 and discussed their findings in a discussion led by the TAs according to the “Guide for Analysis and Presentation of Research Results” (Appendix V).

Part b: Guided Analysis and Presentation of Research Results— Each group of students was assigned one figure from Research Paper #2 for analysis and oral presentation. Students were provided with a guide for assessing and presenting research results – “Guide for Analysis and Presentation of Research Results” (Appendix V). After 7 days allowed for preparation, each group presented their assigned figure orally to the class using a Power Point Presentation. Other groups were encouraged to ask questions. TAs evaluated
students thinking and presentation according to the Data Presentation Rubric (Appendix XI). After the presentations, the TAs returned the graded rubric to the group for “instant feedback”.

Part c: Guided Discussion of Research Paper Discussion -- Students read and analyzed the “Discussion” section of Research Paper #2 and discussed their findings led by the TAs according to the “Guide for Analysis and Presentation of Research Results” (see questions for guided discussion of research paper discussion) (Appendix V).

Part d: Guided Data processing and presentation - The instructor introduced data processing, presentation and analysis techniques using Paper #2. Students applied the data analysis techniques to the data collected from their experiments which utilized the similar experimental protocols used in Paper #2 and reported the processing, analysis, and presentation of data in a written report, which was assessed using the “Lab Report Rubric” (Appendix X).

Part e: Writing a Full Lab report – By this stage students had authored and received feedback on “Introduction”, “Methods/Results”, and “Discussion” sections (from Stage 1) and had the opportunity to discuss two research papers. It was expected that students were now prepared to author complete lab reports in the style of a research article. During the remainder of the semester, students as individuals authored four full lab reports on the work performed in the Immunology Lab. These were due one week after the completion of the lab activity. Lab reports were graded with the “Lab Report Rubric” (Appendix X), a combination of the rubrics previously used to grade the individual section of lab reports in Stage 1. TAs graded and returned lab reports within one week to allow students to implement feedback into subsequent reports.

Stage 3: Practicing scientific research and writing

Part a: Performing Hypothesis-Based Group Research Project – In the third stage of R3, student groups performed a Group Research Project which culminated in writing the Group Research Paper using the skills developed in Stage 1 and Stage 2. Each lab group chose a project scenario from a set of four provided (12). Following selection of a project, students worked independently and outside of class to complete two assignments: (1) draft a testable research question and hypothesis, and identify two experimental techniques selecting from those learned in the course, and (2) outline experimental procedures based on the two chosen experimental techniques. We made this activity an individual assignment to
motivate each student to think independently prior to working collaboratively. TAs provided individual feedback for each of these two assignments. Once these two assignments were completed, students worked within their groups to develop a plan for executing proposed experiments as a group. The lab groups performed experiments during a two-week period. Instructors were available to provide reagents and help with equipment.

Part b: Writing the Group Research Paper – Students within their groups determined an approach to write the final “Group Research Paper” in a collaborative fashion. This involved assessing and interpreting findings and dividing the work among group members. Students were allowed one class period to work collaboratively on the “Group Research Paper” after finishing experiments. Instructors and TAs were available to provide guidance. Students submitted the papers either by email or paper copy.

Part c: Guided Peer Review of Group Research Papers - Students were guided through a peer review of their Group Research Papers using the “Peer Review Rubric” (Appendix XII). One class period was used for the peer review. According to the TAs direction, each group exchanged papers with another group. Each person in a group served as an individual reviewer of the assigned paper. Thus, four to five students reviewed each paper. At the completion of the class period authors and TAs received copies of the written comments. Students were allowed three days to make modifications and submit their final reports.
**Student Perceptions**

We used pre- and post-course assessment surveys to determine students’ perceptions on meeting our learning objectives. The ROLA Pre-Assessment had 10 questions [eight asking students to respond to statements with agree/disagree/don’t know, and explain your choice, one question asking students to rate their skill in various areas and one open ended question] (Appendix XV). The ROLA Post-Assessment asked students to report on their experience in the course responding to eight questions on the same topics as the Pre-Assessment, a gain in skill survey based upon the course experience, and three open ended questions (Appendix XVI). We are reporting on three questions that were in pre- and post-assessments that revealed insight into students’ perceptions on the scientific research and writing process.

Students’ responses were analyzed using mixed-methods analysis. Responses to the open-ended questions were analyzed qualitatively using an inductive approach (10), in which we grouped related responses into subcategories that can be quantified. A graduate teaching assistant from the course, two microbiology faculty members and a science education faculty member categorized the responses separately and then discussed their categories until they came to agreement. Their inter-rater agreement was 90%. The results of the analysis are described below.

To address the learning objectives related to gaining an understanding of the scientific research process and the steps for writing and publishing research results (Objectives 1 and 2), we used primary research papers as templates for research report writing and incorporated peer review process into the writing of the “Group Research Papers”. To assess students’ perceptions of understanding the process of writing scientific papers, students were prompted with the statement: “The format of lab reports in science classes are modeled after the style of primary articles in scientific publications”. In the pre- and post-assessments, most of the students (26 out of 33 and 30 out of 36 respectively) agreed with this statement. Analysis of student comments in pre-assessment revealed that they understood this connection between lab report writing and primary research articles because of their prior experience in writing lab reports (9 students). Analysis of comments in the post-assessment where students were prompted to respond to this statement “based upon their experience in this class” showed that students saw a similarity in structure and format between lab reports in the R³ course and research papers (19 students).
In the pre-ROLA assessment, students were also prompted with the statement: “A lab report has the same depth as a published research article”. In the pre-assessment, the majority of the students (28 out of 33) disagreed with this statement. Students commented that research articles are more detailed (13 students), contain years of research (3 students), are peer reviewed (3 students), and based on original work (2 students). In the post-assessment, 21 students out of 36 disagreed with the statement that “Based on my experience in this class a lab report has the same depth as a published research article”. Comments from 13 students who disagreed explained that they understood that the major difference between a lab report and a research article is the depth, but not the detail. Comments included, “We don't do nearly enough research to reach the same depth in our lab reports as scientists do with their published research articles.” These assessment results suggest that the R³ successfully illustrated the similarities and differences between a lab report and research article. However, students’ comments revealed that there was some confusion between “depth” and “detail” of research reports. Thus we suggest increasing discussions on differences in the depth of published research articles and lab reports, stressing different amount of research work that goes into writing a research paper and a lab report.

To explore if students appreciated the role of collaboration in the research process (Objective 4), students were prompted with the statement, “Collaborative work is valuable for scientific advances.” in the pre-ROLA Assessment survey. In the post-ROLA Assessment survey, students were asked to respond to “based on my experience in this course collaborative work is valuable for scientific advances”. In the pre-and post-assessments, most of students (33 out 33 and 27 out of 36, respectively) agreed with the statements. In the post-assessment, 19 students specifically commented that from their experience in the course they experienced a benefit of learning from each other and sharing ideas. Those who disagreed with the statement in the post-assessment commented that the lab groups were too large. The overall student perceptions supported a success of the R³ design in engaging students in a positive collaborative endeavor. Negative comments suggest that establishing the appropriate group size for team project and carrying out discussion on how to work as a group is important.

Students’ comments to an open-ended question on the post-ROLA Assessment “What did you like about this course?” further indicated the success of this course design in the perception of the students in reaching its learning objectives.
Comment 1: “I like that I am able to learn new techniques and become more experienced in the field of immunology. I know that these protocols are being used daily by our very own professors in order to further understand the functioning of our immune system. I feel that I am up to date with the current research by doing these protocols in lab.”

Comment 2: “I liked that the lab taught assays that are applicable to a real lab setting and that we got practice writing real lab reports instead of answering questions on a worksheet.”

Comment 3: “I liked the procedures that we learned in this course. I also liked working in groups, that it wasn't all independent. I did like having to read the articles so that I could learn to interpret data and understand what is needed and not needed in a paper. I like those papers we got early in the semester explaining each part of a scientific paper, what's included, not needed, etc. I like doing the independent project because it gave a little more freedom than we normally get in labs. Overall, I thought this was one of the better lab courses I have taken, despite having more work than I expected.”

Comment 4: “The material was very interesting. I also liked the organization and structure. The application of it to clinical settings is what made it even better since that is what I'm interested in.”

Comment 5: “I liked how the class slowly worked its way towards having us do our own experiment and research paper. It is the closest to an actual research experience that I have had in a lab here at Maryland.”