Annual Assessment Report of Student Learning Outcomes

Biological and Chemical Sciences Major

2017-2018

I. Program Assessment Meetings

March 22, 2018 (1 hour)- The NMS faculty met to appoint point people for assessing each of the majors in the division; Professor Schmidt agreed to assess the BCS major.

May, 2018 - Meetings were held via email between Professors Schmidt, Schnurr, Elliot, Burwell and Bailey.

II. Closing the Loop

For AY 2017-2018, we focused on Program Goal 1, Objective b, Learning Outcome i.

Goal 1: Students learn the fundamental basics of biology and chemistry, and appreciate the interconnections between them.

> <u>**Objective b:**</u> ***Demonstrate the interrelationships of chemistry and biology***
>
> > **Learning Outcome i:** Understand basic biochemical pathways such as photosynthesis and respiration.

We evaluated the outcomes for the following assignments/activities in the major to determine if this goal being successfully met.

> BIOL 130L- diagrams of photosynthesis and respiration
>
> CHEM 213L - lab activity
>
> CHEM 214L - final exam question

Our criteria for success was that 100% of students to score at or above C level; 70% at or above B level; 30% at or above A level on the assignment/activity. Based on these criteria, Learning Outcome 1.b.i was successfully met for CHEM 214L, but was not met for CHEM 213L (less than 30% scored an A). Diagrams for BIOL 130L were not formally graded as they were used as group activities during lecture, however all students demonstrated an understanding of the pathways involved in both systems.

III. Examination of data collected for this year's targeted learning outcomes

BIOL 130L - Biology of Organisms diagrams

Students were given diagrams of the pathways of photosynthesis and aerobic cellular respiration which they had to complete in class. Students first worked on completing the diagrams on their own, and then collaborated with a partner. The diagrams were then reviewed as a class to ensure that everyone understood the steps involved in each process. Thus, all students that were present in lecture (95-100% attendance) during these days successfully completed the activities.

CHEM 213L - Organic Chemistry I Labs

Learning Outcome:
Isolation of beta carotene: we talk about how vitamins and nutrients are extracted from vegetable a fruit sources to make dietary supplements. We also talk about the biochemical pathway that converts beta carotene to vitamin A and what happens if you have too much or too little vitamin A. Student learning is assessed through a lab report.

Evaluation of the Data:
This assignment was the first lab report students had to write in Organic Chemistry I. Before writing the lab report students had to isolate and quantitate the amount of beta carotene from a food of their choosing, compare the value to what was recorded on the USDA food table, and reflect on how the procedure could be done more efficiently. For the lab report students also had to emphasize why this type of experiment is important and that required them to demonstrate the interrelationships between biology and chemistry. For example, students needed to explain how the chemical structure gives rise to the biological activity of beta carotene and its metabolic breakdown product vitamin A. This explanation needed to be at least a main component of the lab report introduction.

The grade breakdown for the beta-carotene lab report is as follows (data and rubrics are in faculty files):
100% scored a C or above
76% score a B or above
17% scored an A or above
The success criteria for the assignment was not met since only 17% of the students scored an A or above (the criteria stated >30% should score above an A). There are a few factors that could been associated with this discrepancy. For example, this was the first lab report of the year in a two semester course. Students were very good at describing what they did in lab but needed more help framing their results in terms of why this experiment is relevant (i.e. emphasizing the interrelationship between biology and chemistry). In subsequent lab reports they got much better at doing this. Next year more time will be spent in Organic Chemistry I emphasizing this point in the lab report writing workshop at the beginning of the Fall semester. Also the success criteria suggested for this learning outcome might not fit this assignment as well as the other measurable learning outcomes such as the homework assignments described below.

CHEM 214L - Organic Chemistry II Final Questions

Learning Outcome:
Thyroxine is a master hormone that regulates several pathways in the human body. Before mature thyroxine leaves the thyroid iodine is added to the molecule. Below is a picture of thyroxine. Knowing what you do about how things are added to benzene rings explain why the iodine molecules are added at those specific positions. In your answer identify the directing group on each ring and what position the iodine atoms are added with respect to the directing group.
Evaluation of the Data:
Instead of being a final question, this was given to the class as a homework problem so students had more time to think about and reflect on why electrophilic aromatic substitutions are important in Biology. This assignment required students to review the ortho, meta, and para positions in these type of molecules and how the chemical structure drives the addition of substituents at specific sites within the molecule. When this assignment was introduced, we discussed as a class what happens when this chemistry breaks. Students had to think about what thyroxine specifically does and what pathways it regulates in the body. Students really liked this assignment and will be used again in Organic Chemistry II.

The grade breakdown for the thyroxine assignment (data and answer key are in faculty files):
100% scored a C or above
86% score a B or above
41% scored an A or above
The success criteria for this learning outcome was met.

Learning Outcome:
Proteins are synthesized by reacting the carboxylic acid end of one amino acid with the amine end of another amino acid. Can this reaction occur spontaneously? Where is this reaction catalyzed in the cell and what is the process of synthesizing proteins called? What does the cell covert the carboxylic acid to before it reacts with the amine of the other amino acid? Draw out a mechanism for this reaction.
Evaluation of the Data:
Once again this was given as a homework assignment rather than a final exam question so students could spend more time thinking about the problem. This was the last assignment in Organic Chemistry II since it starts getting students to think about Biochemistry (most students will be taking this upcoming Fall). This assignment was used to show students the importance of carboxylic acid and amine chemistry to the synthesis of proteins. While working through the problem students also realized that this is not a favorable reaction on its own, but Biology can make difficult reactions work through the use of enzymes. Also, most of the students in Organic Chemistry II were also taking Genetics at the same time so they were able to draw connection with this process and what was actually going on inside the ribosome during protein translation.

The grade breakdown for the thyroxine assignment (data and answer key are in faculty files):
100% scored a C or above
85% score a B or above
35% scored an A or above
The success criteria for this learning outcome was met.

IV. Program Changes for the Upcoming Year

There are no anticipated changes for the upcoming year.

V. Action Plan for the Upcoming Year

We will be focusing on Goal 2, Objective a, and both of its outcomes (i and ii) using the assignments/activities included below.

Goal 2. Students investigate scientific questions using the scientific method and proper research techniques, and learn to evaluate data and communicate their results both orally and in writing, using proper technology.

<u>Objective a.</u> ***Learn the scientific method and how to properly conduct a scientific study***
Learning Outcome i. Design a lab or field study using the scientific method
Learning Outcome ii. Present results in a lab report and in oral presentation formats

Specific course assessments:

Ecology and Evolution (Biol 119L) Students in Ecology and Evolution are tasked with investigating the answer to the question: Why are there no seedlings under hemlock trees? They are required to come up with 2 hypotheses that they propose on their own in their groups, investigate them in the field (after instructor approval), and write a research paper that uses 5 literature sources and the proper statistics to analyze their data. Finally, they present their findings in a scientific talk to their classmates. Assignment and rubrics are at the end of this report.

Organic Chemistry II (CHEM 214L). For the 2018-2019 academic year Lindsay Burwell will assess Learning Outcome 2ai in Organic Chemistry II (CHEM 214L) where students will have to write up their own method document before conducting their independent research projects at the end of the Spring semester. For these independent projects, students are required to utilize the techniques taught throughout Organic Chemistry I (CHEM 213L) and Organic Chemistry II (CHEM 214L) to answer a scientific question that interests them. Step one of this independent project is to have students work with their research group to come up with a method they can use to conduct the intended experiment. The method will be assessed based on the document having the relevant details (materials, equipment, cost, procedure, and anticipated time to complete) needed to complete the research independently. Students will also have to defend how their procedure efficiently addresses the research question before starting the project. This method will be graded using a rubric that will be developed prior to the Spring semester.

Biochemistry (CHEM 323L). For the 2018-2019 academic year Lindsay Burwell will assess Learning Outcome 2aii in CHEM 323L where students will orally present the results obtained from an enzyme kinetics experiment. For this project students must design their own method to investigate a condition that impacts glutathione peroxidase isolated from *Brassica rapa* (turnip). Students will present their results in a lab meeting style oral presentation where they will have to describe to their peers what conditions were tested (temperature, enzyme concentration, substrate concentration, pH, etc.), how they developed a method to test this condition, the data they obtained, and conclusions they obtained based on the data analysis. Assessment of this oral presentation will be based on a rubric that will be developed prior to the Fall semester. The rubric used during previous years is provided below.

Microbiology (BIOL 310L). For the 2018-2019 academic year Leah Elliott will assess Learning Outcome 2aii through a final, formal lab report based on student research conducted throughout the semester. Students will spend several weeks on a project-based experiment isolating bacteria from the soil around campus and screening for those that produce antibiotics, with the hope of discovering a novel antibiotic. This is an entirely new laboratory assignment that is being developed for Fall 2018. Students will be assessed on a rubric that will be developed prior to the Fall semester.

Molecular Biology (BIOL 312L). Spring 2019 will be the first time Leah Elliott is teaching this course. She will develop an inquiry-based laboratory for students where they design an experiment to create a particular gene or protein, construct their product and collect data on how well they achieved their goal(s). Students will present their findings to the class in a lab meeting style oral presentation. The designing of the experiment fits outcome 2ai, while the oral presentation addresses learning outcome 2aii. Both the design of the experiment and the oral presentations will be assessed using rubrics developed prior to the Spring 2019 semester.

Biology of Organisms (BIOL 130L) Students observe general *Daphnia* behavior, read papers on the effects of caffeine, nicotine and ethanol on heart rate, and then generate a hypothesis about how of one of these compounds might affect heart rate in Daphnia. They then design an experiment to test their hypothesis (Learning Outcome i), collect and analyze data, and write up their findings in the format of a peer-reviewed journal article (Learning Outcome ii). Assignment description and rubric are included at the end of this report.

Bioinorganic Chemistry (Chem 385) This course looks at the role of transition metals in biological systems, such as hemoglobin, oxygen transport, photosynthesis, etc. Students need to integrate what they have learned in both chemistry and biology courses in order to be successful. To test overall comprehension of the principles behind bioinorganic chemistry, the final project for the course requires students to select a bioinorganically important system (e.g. a particular protein), not otherwise covered in the course, and prepare an electronic poster, displayed via PowerPoint, with the goal of teaching their colleagues about this system. Each student gives a 10-15 minute poster presentation, followed by discussion. Assignment description is included at the end of this report.

Assignments:

BIOL 119L **FALL 2018**

Effects of Eastern Hemlock (*Tsuga canadensis*) on the establishment of interspecific seedlings

INTRODUCTION

Background

Some years ago, ecologists noticed that fewer seedlings and saplings of broadleaved woody species seemed to grow beneath the canopies of Eastern Hemlock trees than beneath the canopies of other species. Since that time, a number of projects have confirmed this pattern, but none have been successful in determining the mechanism by which Eastern Hemlocks inhibit the other species.

Procedure

During this week in lab, we will conduct a brief orientation walk on campus, during which you will observe the spatial distributions of seedlings and saplings relative to Eastern Hemlock trees. We will then collect data to address the question: "Are the densities of seedlings and saplings of woody broadleaved plants lower beneath the canopies of Eastern Hemlock (*Tsuga canadensis*) than beneath those of broadleaved trees?"

To address this question, each group of 3-4 students will sample seedlings and saplings beneath 5 Hemlock and 5 Sugar Maple canopies. So that the physical conditions and seed rain will be as similar as possible between the two canopy types, you should choose your Hemlocks at random, but choose your Maples such than they are the nearest canopy-level ones to each of the 3 Hemlocks. We will identify and count the seedlings and saplings within a 1 x 1 meter quadrat to the southwest of the trunk of each of the trees sampled. There's nothing special about that location, of course. In fact, that's the point: by choosing the site to sample before we even look at the trees, we reduce the possibility of biasing our results by choosing sample sites on the basis of their seedling density. Within each quadrat, count the total number of seedlings/saplings of woody plants (beech, maple, hemlock, oak, shrubs, etc.) separately. Don't count herbaceous
plants like grasses, forbs, mosses, etc.

Use the data collected by all groups in your lab section to test the null hypothesis that the mean density of woody seedlings and saplings does not differ between Hemlocks and Sugar Maples. The alternative hypothesis in this case is directional: mean density of seedlings and saplings is higher beneath Hemlocks than beneath Sugar Maples. So you'll need to do a one-tailed t-test.

Assuming that we find a difference in seedling/sapling density beneath hemlocks and maples in the first part, your group should discuss factors that might be responsible for it. After doing so, your group should propose to test two different working hypotheses to explain the difference. You're free (encouraged!) to come up with other hypotheses, of course, but a few that I can suggest include:

* Light intensity is lower beneath Hemlock canopies, such that germination and/or
growth of woody seedlings is inhibited.

* The canopies of Hemlock trees act as "umbrellas" that shed seeds of broadleaved trees to the side, such that areas beneath Hemlock crowns receive fewer colonists.

* Hemlocks alter soil pH in such a way that germination or growth of broadleaved plants are inhibited.

* Hemlocks produce allelochemicals, which either leach from the stems or foliage or are exuded from the roots, and which inhibit either germination or growth, or both.

Each lab group will formally propose 2 different working hypotheses to investigate. Each group will work independently of the others, and write a short proposal that:

1) Presents the statistical analysis and conclusion from the first part of the investigation (the analysis discussed above);

2) Poses two hypotheses about the mode of inhibition (e. g., what is it about Hemlock trees that results in lower densities of other plants near them).

3) Briefly describes a series of experiments or other data collection procedures that you will use to test these hypotheses. Here again, be sure that you state explicitly what sorts of data you'll collect and how you'll analyze them, including statistical tests, etc;

4) Contains a brief list of materials that you will need to do your study. You can use space in the greenhouse, pH meters, PAR ceptometers (which are fancy light meters often used in photosynthesis labs), and just about anything else within reason.

Be aware that we can't realistically subject maple or other tree seeds from the forest to experiments you might think of to assess the effect of different pH's, soil extracts, etc., since this year's seeds won't germinate until next spring. Instead, if you plan a "bioassay," consider using seeds from a widely available and rapid germinating plant (such as sunflower, alfalfa, or lettuce - all of which are often used in these kinds of experiments).

The calendar of events for this study is as follows:

Week of…

This week: Collect initial data and enter it into an Excel spreadsheet. I'll email it around. Groups will include statistical analyses of initial data in their proposals.

Due Oct 11/12: Proposals due. I'll read through the proposals and make suggestions so you can start collecting data. Although you won't need any literature citations in your proposal, you should probably start looking for them. You will be required to have at least 5 literature citations in this lab report. Use JSTOR, Google Scholar, the library, the list at the end of this handout, etc. I have some available in the lab that you can use also.

Oct 11/12: Return to the field to make more measurements, collect soil, etc. You will be responsible for getting your experiments started and keeping them going. Work out a schedule in your group.

Oct 16: progress report: you'll need to show me your experiments if they're in the greenhouse, or the data you have collected thus far. You can use this lab to finish data collection and do statistical analyses. I'll help you if you have questions.

Nov 13: Group oral presentation of results using PowerPoint (more on this later), and written outline for the presentation (hard copy or electronic copy of the PowerPoint presentation preferred).

Nov 13: Final lab report due, in Ecology format and it must include 5 literature citations. Each student is responsible for their own write-up of the lab!

Paper Rubric:

Rubric for the Hemlock lab reports

Title: /2

Abstract:

- Briefly includes a sentence from each paper section /5

Introduction:

- Sets up question using literature /5
- Hypotheses and expectations explicit /5

Methods:

- Explains in enough detail to repeat project /5
- Statistics used and explained /1

Results:

- Explained in the text /3
- Graphs present and in correct format /2

Discussion:

- Brought back to hypotheses /2
- Used literature to explain results /5
- Remained positive /3

Literature Cited:

- Number of citations /5
- Format /2

Overall Project:

- Was it creative and showed scientific understanding? /10

TOTAL: /55

ORAL PRESENTATION RUBRIC:

(10 pts.) Introduction:_________

- gave necessary background and told why the study was interesting
- clearly stated hypothesis, goal or question

(5 pts.) Methods: _____________

· presented adequate detail on how study was conducted (where, how many samples, how determine where to sample, what was measured etc.)

(10 pts.) Results:______________

- clearly described major results
- provided visual aids to illustrate results

(25 pts.) Discussion/interpretation:___________________

- described how results related to hypothesis, goal or predictions
- proposed reasonable ecological explanations for patterns
- discussed errors in study *that were likely to influence results*
- discussed the next step, unanswered questions, etc.
- return to context, summary of the study

(25pts.) Delivery:____________________

- able to explain work without excessive pauses
- used appropriate language
- appropriate use of visual materials
- **all group members contributed equally**

Organic Chemistry (CHEM 213L) Independent Project Assignment. Throughout the course of two semesters in Organic Chemistry you have obtained several skills that can be applied to a variety of real world problems. For the remaining weeks in Organic Chemistry you will design and carry out an independent project using what you have learned in Organic Chemistry throughout the year. You are also free to use methods from other coursework or new methods you read about in the literature after to approach is discussed with Dr. Burwell. Your independent projects will be graded based on the following three components. Rubrics for each component will be posted on Moodle.

1. Written Procedure (100pts)
2. Lab Report (100pts)
3. Oral Presentation (100pts)

The rubric for the written procedure will be developed prior to the 2019 Spring semester. This is a new graded component to the assignment. Previously, students were required to write up their method and submit it just for feedback prior to starting the procedure. Having it as a graded component will hopefully improve the effort put into developing their methods.

Biochemistry (CHEM323L) Enzyme Kinetics Lab Assignment Throughout the course of this semester you have learned a lot about enzyme kinetics and how to use an UV spectrophotometer to study enzyme activity. For the remaining weeks in Biochemistry, you will design and carry out an independent project studying a specific condition that you think will impact the activity of glutathione peroxidase isolated from *Brassica rapa*. These projects will be graded based on the following three components. Rubrics for each component will be posted on Moodle.

1. Written Procedure (100pts)
2. Lab Report (100pts)
3. Oral Presentation (100pts)

The oral presentation rubric previously used is below. This rubric is going to be modified prior to the 2018 Fall semester.

Category	**20 points**	**15 points**	**10 points**	**5 points**	**0 points**
Preparedness	**1.** The presentation was appropriate for peers' background knowledge. **2.** 5-10 min presentation. **3.** Fielded answers well and promoted discussion **4.** Shared on Google drive.	3 out of 4	2 out of 4	1 out of 4	No criteria met

Content	Adequately described: **1.** Why the condition was chosen. **2.** How was the experiment carried out. **3.** What were the results. **4.** What did the results mean	3 out of 4	2 out of 4	1 out of 4	No criteria met
Engagement	**1.** Made eye contact and spoke clearly **2.** The presentation was easy to follow and presented in an organized manner. **3.** Slides were not cluttered and did not confuse the audience **4.** Encouraged class participation.	3 out of 4	2 out of 4	1 out of 4	No criteria met
Group Involvement	**1.** Everyone in the group participated in the presentation **2.** Everyone in the group participated in answering the questions. **3.** Apparent the group worked together on the presentation (nothing is repeated or forgotten)	2 out of 3	1 out of 3		No criteria met
Your participation and feedback (Filled out by Dr. Burwell)	**1.** Self reflected on your own presentation. What worked well and what could have been improved? **2.** Provides comments or ideas on how what could be improved **3.** Asks questions to other groups. **4.** Provides **<u>positive constructive</u>** feedback on other groups' presentations.	3 out of 4	2 out of 4	1 out of 4	No criteria met

Daphnia physiology

adapted from a lab at Davidson College and http://www.sciencebuddies.org

Introduction

Daphnia sp. are common freshwater cladocerans, often classified with other tiny crustaceans as "microcrustaceans." Cladocerans are commonly known as water fleas. Most species in the Order Cladocera are freshwater species, although there are some marine species. The classification of Cladocera is as an order within the Subclass Diplostraca within the Class Branchiopoda within the Subphylum Crustacea. *Daphnia magna* and *D. pulex* are both widely used experimental organisms in zoology, ecology, and toxicology. Ecological studies have determined their important role in aquatic food webs – they graze on phytoplankton and, in so doing, increase phytoplankton rate of production. At the same time, many insects and fish consume zooplankton, and the microcrustaceans are thus a key source of food for organisms at higher trophic levels in many aquatic habitats.

Daphnia magna (common name "water fleas") are tiny freshwater crustaceans. They are filter feeders, and can survive in culture by eating algae, bacteria, or yeast. The body diameter of adult females is about 3–5 mm (Clare, 2002). The outer carapace of the individuals is transparent, so you can see through to the internal organs (see Figure 1, below). This allows you to monitor the heart rate of individual *Daphnia* that you observe with a microscope.

Figure 1. Photomicrograph of *Daphnia*, the common water flea. Note the position of the heart.

You can use a microscope, placing the individual *Daphnia* in a small drop of water on a depression slide so that it cannot swim out of your field of view. You want to make your measurements quickly, so that the *Daphnia* does not become stressed in the small volume of water.

Unless you are specifically interested in the physiology of crustaceans (and there's nothing wrong with that!), the *Daphnia* in this experiment are what scientists call an *experimental model system* or simply a *model system*. You may be interested in how caffeine (or another drug) affects the human heart. However, designing such an experiment involving human subjects that would be both safe and scientifically valid is way beyond the level of an undergraduate lab. That kind of experiment is for scientific and medical professionals—maybe you, later in life! A model system provides a simpler way of approaching a scientific problem.

Like any model system, *Daphnia* have advantages and disadvantages. On the plus side, they are fairly easy to keep, easy to study, and inexpensive. On the minus side, they are evolutionarily far-removed from humans, so you need to be cautious when interpreting your results. What happens when *Daphnia* are exposed to caffeine (or another solution) may or may not have similarities to what happens when humans drink coffee.

For this lab you will test how different compounds affect heart rate. You will first consult the literature to determine what others have done and you will then design a study to assess the effects of one compound. Finally, you will write up a lab report on your results, using your literature and doing some statistics to support your claims!

Anatomy

Obtain an individual *Daphnia* using a pipet to extract one from the culture and place the individual on a watch glass with about 5 drops of water. Consult Figure 1 to review the anatomy of *Daphnia magna*. Using a dissecting microscope, observe foraging behavior and swimming. Introduce a minor disturbance in the colony of *Daphnia* and observe anti-predator behavior.

Answer the following questions:

1. How do *Daphnia* swim and what appendages are used for locomotion?

2. How do they feed and on what do they feed?

3. What internal organs do you recognize?

4. Were you able to see any individuals with young? Describe if observed.

5. What anti-predator defense mechanisms (morphology or behavior) did you observe?

Physiology

Measuring *Daphnia* Heart Rate

1. Before doing your experiment you need to establish the background heart rate for the *Daphnia*. Use a transfer pipette to pick up an individual *Daphnia*, and transfer it, and one drop of water, to a depression slide.
2. Place the slide under a compound microscope and focus on the *Daphnia* so that you can see the beating heart. If the *Daphnia* moves around too much, remove some of the solution in the slide.
3. Count the number of heart beats that occur in 10 seconds. Use either a count-down timer with an audible signal, or have a helper time 10 seconds for you as you count heartbeats.
4. Record the number of heart beats in the data table. Multiply the number by 6 to get the number of beats per minute.
5. Take at least three separate heart rate measurements for each individual *Daphnia* and calculate the average of the three measurements.
6. Add one drop of your experimental compound to the slide, and repeat steps 3-5.
7. Repeat this procedure with at least 10 Daphnia.

After you are finished with an individual, gently rinse them with tank water and put them in the ‘recovery’ container.

Lab Report

When reporting the results of your experiment, the idea is that you need tell your readers why and how you did your experiment, what you found, and what it means!

You should have a:

1. **Title.** What is the name of your project?
2. **Abstract:** This is an overview of what you did – including the hypothesis, the methods, the results and the conclusion. Think of it as the "cliff notes" of your lab report – it allows people to decide if they want to read your whole paper or not.
3. **Introduction:** This will be a very comprehensive overview of the "problem". What have others found? (Thus, you should cite other studies in the intro. In scientific writing, we use the in-text-citing format of (Author year)). How do their results relate to each other? Is there something lacking in what others have done that you needed to research? That should be your question. You will have outlined the problem so well that when you finally get to the question you are asking it will make logical sense to your reader. Also include any expectations about what you thought would happen – your hypothesized answer to the question. If you include this here, in the discussion you can talk about whether your prediction was upheld!
4. **Methods:** What exact methods did you use? Make sure that you write this section in the past tense. Include everything that you did - in the field, in the lab, and on the computer. Although it may seem strange, statistical analyses are actually only methods that you used to determine if your hypothesis was supported or not. You don't need to include results here, just say, "I performed a t-test to determine if there was a significant difference between…"
5. **Results:** Here is where you present what you found. Include a graph of the data (average together multiple trials, and include error bars so your reader can see how variable the data were). **Don't include raw data** – and that includes t-test results from excel! Refer to the figures in the text when you explain what they mean: "There was a significant difference among my treatments ($P<0.05$); the *Daphnia* did… (Fig. 1)." That way you tell the reader what is important for them to know – and you point them to the data to see it for themselves. Be very explicit when you discuss what you found – but don't include any conclusions here. At first that seems pretty tricky, but the results are usually fairly dry – "just the facts, ma'am."
6. **Discussion:** In this section you wrap up the whole project. What did you find? What do your results mean? How do they relate to what others have found? Was your hypothesis supported? Why or why not? Again, since you are referring to what others have found you should have citations in the discussion.
7. **Literature Cited:** This is where you put all those citations you used in the introduction and discussion. In the sciences, we use the format:

Author Last Name, First Initial. Year. Title. Journal (or Publisher). Volume. Pages.

Data Table

	water					Solution: _________________________				
Daphnia #	1	2	3	ave.	ave. bpm (ave. x6)	1	2	3	ave.	ave. bpm (ave. x6)

Bioinorganic Chemistry (Chem322) Final Exam

Your final exam for this course will be in the form of an electronic poster that will be displayed via Power Point and discussed during the final exam period. The subject of your poster is up to you, however I will recommend that you talk to me about your subject prior to putting in a lot of effort. You may choose to focus on an individual protein (or other bioinorganically important system), a group of proteins, or an individual scientist. If you choose a system we have already discussed in class, your poster should go well beyond our previous coverage.

Physically, your poster should fit on a single Power Point slide (see some of the NCUR posters on display in Stratton Hall for examples). Your poster must be readable from at least six feet away as displayed in our classroom. There should be a title and beneath the title your name and the institutional address. It should appear as if for a professional meeting; the quality of the slide will count towards your grade.

Minimally, your poster should include the following:

1. Background material about your chosen system.
2. A RasMol or similar figure showing the protein of interest and/or its active site.
3. Current experimental detail.
4. An indication of the importance of your system/individual.
5. Its/their relationship to material already covered in our course (e.g. the four "Rules").
6. References (a *minimum* of five; at least three should be from the past two years).

Your poster should be ready for “display” by the first day of the final examination period. We will then meet as a class during our scheduled final exam slot. Each person will have 10-15 minutes to talk us through her/his poster; this will be followed by 5 minutes of questions and discussion. You will be graded on the appearance of your poster, your presentation of the material, your ability to generate discussion for your poster, and on your participation in the discussion period for your peers.