Teaching Portfolio

Katherine L. Hayden

khayden@bsc.edu
Visiting Assistant Professor of Chemistry
Birmingham-Southern College, Birmingham, Al.

It is the supreme art of the teacher
to awaken joy in creative expression
and knowledge.
-Albert Einstein

Teaching Philosophy and methods

I believe that teaching chemistry is much more than just the dissemination of information from instructor to student; rather it is the method through which we can ignite and nurture the development of young scientists. Thomas Caruthers once said that "a teacher is one who makes himself progressively unnecessary,"- that is to say that for our students to truly excel beyond the classroom, we must equip them with the necessary tools to become life-long learners. These tools, which I tend to call the "Four C's of Learning", are critical thinking, courage, confidence, and creativity. Equipped with these tools, students are able to do much more than just master the material.

Critical Thinking

Providing students with the ability to think critically ensures that they can approach any problem with logic by evaluating the best course of action, carefully examining the results, and assessing the conclusions. I develop critical thinking in my students through the use of guided inquiry in discussions and interactive problem-solving. Often, I begin class by asking the students what it is that we are doing today, allowing them to co-create the lesson plan with me while explaining to me what they already know. This approach not only encourages students to prepare for class but also motivates them to take responsibility and ownership for their own learning. To develop critical thinking through interactive problem-solving, I develop real life scenarios or problems chemists might encounter for the students to solve. Students then work in groups while employing outside resources, such as peer reviewed literature, texts, or even scientists themselves, to find the solution. For example, in the CH201 course (Research Methods in Chemistry) I developed at UAB (ref p. for more details), students were instructed how to derive their own spectroscopic and calorimetric experiments for the analysis of macromolecule-ligand interactions. This was a pretty daunting and intimidating task, especially for freshman; however, by the end of the semester, these students were able to develop, implement, and troubleshoot their own analytical methods. The critical thinking skills obtained through interactive problem solving and guided inquiry have enabled my students to become more independent, resourceful and thoughtful both in the classroom and in the laboratory.

Confidence and Courage

Students cannot become life-long learners if they do not have the confidence and courage to ask and seek answers to new questions. In order to build students' confidence and courage, I promote improvement rather than grades, make as much time for my students outside of class as they need, never use sarcasm in the classroom, answer emails in a timely manner, and most

importantly, remind my students that it is okay to be human; we do not have all the answers and we all make mistakes (mistakes that we should learn from). However, treating students with respect and patience is only part of my strategy for bolstering confidence and courage in these young scientists, instructors must also overcome the public stigma and fear associated with many of the hard sciences. On many occasions I have had numerous students tell me that they 'just don't get it, it's too hard'. I overcome these obstacles through encouragement and by working one on one with the student. Through the use of encouragement and guided questions in these one on one sessions students begin to understand how to derive their own answers giving them self-confidence when before they had only doubt. Fostering courage and confidence in my students through patience, respect and encouragement allows my students to overcome the trepidation of learning and exploring chemistry, helping them to mature as students and scientists.

Creativity

Students often think of chemistry as sterile and routine, leaving little room for imagination and creativity. Instead, I try to show my students that the art of learning and practicing chemistry requires a great deal of creativity. For a student to understand the relationship between two atoms bonded to form a molecule, or to comprehend the balance between proton and electron, he or she must be able to use their imaginations because we cannot physically show them. In every aspect of science, we as students, practitioners, and instructors must use our imaginations and creativity to come up with the new questions that allow science to continually evolve and grow. I inspire creativity through teamwork and by encouraging the development of a wide knowledge base in multiple disciplines. By working in groups to solve problems, students draw from the diversity of their peers, observing and absorbing different perspectives, and soon what may have seemed like a difficult problem for one person progresses into a clear and reasonable solution derived from the group. By encouraging and instructing students how to apply what they learn from all aspects of their lives, we can equip them with the tools necessary for seeing what has yet to be seen and for asking what has yet to be asked.

All in all, my philosophy and methodologies for teaching are not just targeted for ensuring my students learn their material, but for preparing my students to become life-longer learners by equipping them with the tools they need to be successful in any field. These tools of critical thinking, courage, confidence and creativity will enable my students to continue learning and evolving well after my class.

Statement of Research

For over a century, scientists have been fascinated with the cell's blue print of life: the genome. In a human cell the genome consists of 23 different chromosomes compiled from super coiled strands of deoxyribonucleic acids (DNA). Once the Human Genome Project completed decoding the entire 2 meters of DNA in a cell in 2012, scientists discovered that the actual coding regions of DNA only make up 2% of the genome. However, what sequencing has really revealed to us is that nearly all, or the remaining 98%, of the 3.2 million base pairs found in the human genome comprises non-coding regions of DNA. These regions include introns (segments within coding regions that are removed from the messenger RNA after transcription), promoter regions (segments upstream of a gene that typically initiate transcription upon binding certain proteins and/or small molecules), and telomeres (repetitive sequences of DNA found at the ends of chromosome that aid in protecting coding regions upstream). Interestingly, scientists have recently found that a number of these non-coding regions contain sequences that are able to form non-helical secondary structures, and just as we see in proteins, these secondary structures are believed to play important roles in the functions of these non-coding regions. My previous research as a graduate student in Dr. David E. Graves' laboratory at UAB encompasses the biophysical characterization of these non-helical DNA structures commonly found in these non-coding regions.

Recently our group has discovered that apoptotic DNA released from various cancer cell lines can induce a Toll-like receptor 9 mediated cell invasion, mimicking cancer metastasis. We hypothesized that nuclease resistant secondary DNA structures like stable hairpins or quadruplex forming fragments of DNA could be inducing this response. Indeed, when we added a synthetic DNA hairpin sequence that is very thermal stable and nuclease resistant, as well as quadruplex folding DNA sequences, to the cell invasion assay we see that invasion is increased in TLR9 expressing cancer cells. In TLR9 siRNA suppressed cells we see that this response is diminished. From qPCR analysis of these apoptotic DNA pools we have found comparatively large amounts of human telomeric DNA fragments, much more than the control α-Satellite DNA fragments commonly found in cell-free DNA. We believe that these results indicate that telomeric DNA sequences released from cancer cells can survive apoptotic degradation in the cell-free matrix and could then be taken up by surviving cancer cells to trigger a metastatic event by TLR9.

The Human Telomere

Telomeric DNA (5'-TTAGGG$_n$-3') is found at the end of the chromosome and serves to protect the coding regions of chromosomes from degradation due to the end replication problem. In adult somatic cells, single stranded telomeric overhands are cleaved by DNA repair enzymes after every replication cycle, thus shortening the chromosome. Once the telomeres reach a critical length after so many replications, apoptosis is triggered killing the cell before coding regions of the chromosome can be damaged. On average, these chromosomal ends lose 50 bases per replication cycle. During infancy and childhood, these ends can be re-extended by the reverse transcriptase enzyme, telomerase; however, in adult cells, telomerase is down-regulated. In the majority of known cancers, telomerase has been shown to be upregulated, subsequently allowing cancer cells to continuously replicate as the telomeric regions of chromosomes are re-extended making them 'immortal'. In order to overcome this pathway, treatments utilizing chemotherapeutic agents can still induce cancer cells to undergo apoptosis. Apoptosis results in the release of two major apoptotic nucleases: capase-activated DNase (CAD) and endonuclease G (endo G) that can fragment and destroy the majority of DNA from the apoptotic cell. However, the telomeric sequence is able to fold into the nuclease resistant quadruplex secondary structure and we have found that these fragments are able survive apoptotic degradation and are released into the cell free matrix. Because telomeres play such a critical role in cell aging, cancer, and other age related diseases; we believe that these cell free telomeric fragments released from apoptotic cells may also play a biological role in immunity pathways, such as those governed by Toll-Like Receptors.

Quadruplex DNA Characterization

First predicted by D. R. Davies in 1962, this non-helical structure exists when repetitive runs of guanines (minimum of three) are separated by short segments of single stranded nucleotides. As shown in Figure 1a, this structure occurs when four guanines, upon close proximity, form Hoogstein base pairs forming a square with a coordinated counter cation in the center (either potassium or sodium). These planar tetrads can then stack upon other tetrads to form a structure as shown in Figure 1b. These G-quadruplex structures are more thermodynamically stable than their duplex counterparts and are often found to be nuclease resistant. Often a G-quadruplex forming sequence will be found in oncogene promoter regions and are believed to play significant roles in the expression of cancer causing genes such as the c-MYC and B-cell CLLymphoma 2 (Bcl-2) genes.

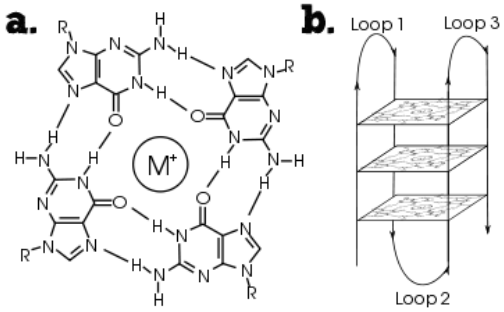


Figure 1. The G-quadruplex. A) Orientation and hydrogen bonding of the 4 guanines found in one layer of the G-quadruplex and it's coordinated counter cation in the center. B). One possible structure for three tetrad stacks of a unimolecular G-quadruplex.

Depending on the number of strands, salt conditions, and loop sequence these quadruplexes can fold into a variety of topological structures as depicted in Figure 2.

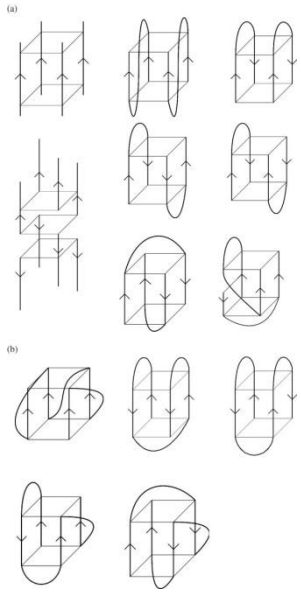


Figure 2. Different possible folding topologies of quadruplex DNA for a) tetramolecular and bimolecular complexes or b) unimolecule strands. Figured borrowed from S. Neidle, Nucleic Acids Res. Nov 2006; 34(19): 5402–5415.

For many years there has been debate in the scientific community as to whether or not the quadruplex structure actually exists *in vivo* or is just an artifact of *in vitro* studies. However, the existence of these structures in the cell has received growing support from recent studies utilizing fluorescent probes or antibodies that can bind specifically to quadruplex structures within the cell. In light of this recent evidence and the fact the a quadruplex folding sequence can be found in a number of oncogene promoter regions as well as in telomeres, there has been a push in the scientific

community to further research targeting the quadruplex structure for anti-cancer drug development as well as increase understanding of the biological role this structure must play.

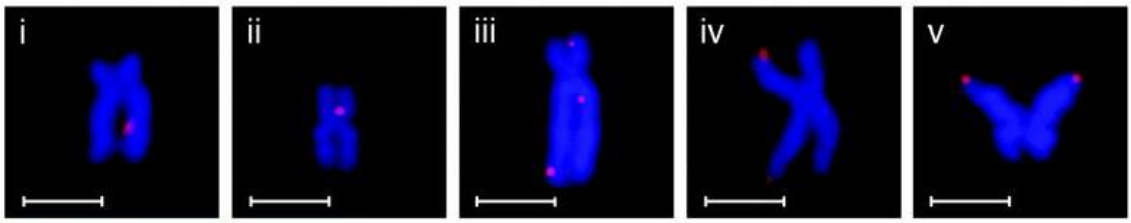


Figure 3. Immunofluorescence of a quadruplex structure specific probe, BG4, on metaphase chromosomes of HeLa cells. The red foci of BG4 were observed in interstitial regions (i, ii, iii) and at the telomeres (iv, v). The DNA was counterstained with DAPI (blue) and the scale bar corresponds to 2.5 µm. This figure was adapted from Biffi, G. et al. Nat Chem. Mar 2013; 5(3): 182–186.

As can be seen from above, understanding the structural and thermodynamic properties of the quadruplex structure will further our understanding of the human telomere as well as how telomeric fragments within the cell free matrix may behave. In my previous research as a graduate student I found that different length human telomere fragments have different thermodynamic and structural properties and this may play a vital role in the biological function of these cell-free telomeric fragments. It is my plan as a research mentor to continue basic structural and thermodynamic characterizations of different length human telomere fragments ranging from 12 to 200 bases. Currently, the 22-24 base length telomere models have been well characterized using NMR, X-ray crystallography, DSC, CD and UV-Vis studies, however, this length only encompasses one quadruplex unit. I believe that these cell-free fragments released from cells may also exist in longer or shorter fragments, and little is understood about how these lengths behave *in vitro*. To study this, I will employ structural characterization techniques such as NMR, CD and X-ray crystallography and thermodynamic characterization techniques such as DSC, ITC, UV melts, CD melts, and PPC-DSC, all of which can be done at UAB with the given support from my mentor and chair of the chemistry department, David Graves. This research project will give my students valuable hands on experience with a wide range of instrumentation and can be easily modified to meet the work demands of each individual student who is interested in participating.

Cell-Free DNA Analysis

While at UAB I designed a magnetic bead pull down assay utilizing peptide nucleic acids that could isolate and purify telomeric DNA based on either the quadruplex structure or on primary sequence. This assay is the first of its kind due to its flexibility to isolate any quadruplex forming DNA from the cell free matrix based on structural recognition or by targeting the sequence to isolate

a specific quadruplex forming DNA fragment such as the telomere sequence. The general bead capture scheme can be found in figure 4.

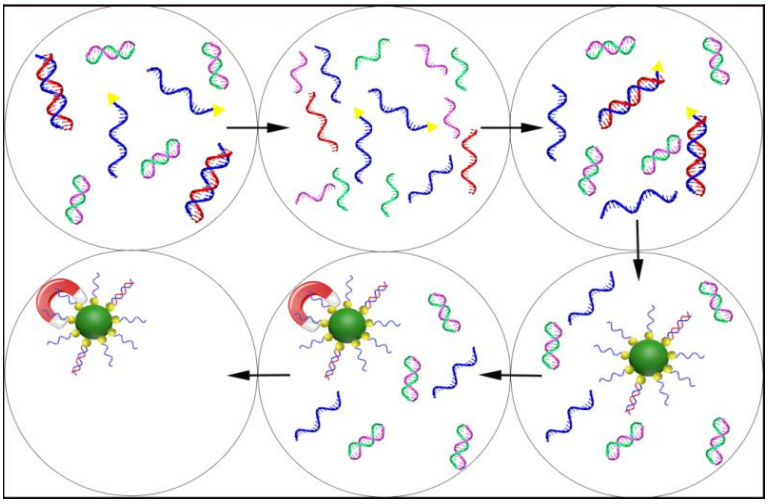


Figure 4. The generalized procedure for DNA capture and purification with magnetic beads. In this method a biotinated capture strand complementary to our target strand is added under denaturing conditions. Denaturant is removed allowing the target strand to hybridize with the capture strand. Streptavidin beads are then added, allowing the biotin tag to bind to the magnetic bead, thus isolating our target strand. Once a magnetic field is applied to the sample, the beads are fixed to the vial wall and the remaining impurities can be removed and rinsed from the sample. The now pure and isolate sequence can then be released from the bead by adding denaturant to de-hybridized the target strand from the biotinated capture stand.

This assay has novel flexibility because of the use of peptide nucleic acids developed by our collaborator Dr. Bruce Armitage, Professor of Chemistry at Carnegie Mellon University in Pittsburgh, PA. The Armitage laboratory is a leader in the design and synthesis of peptide nucleic acids (PNAs), nucleic acid like molecules that can hybridize to target DNA and RNA molecules. As shown in Figure 5A, instead of the normal sugar-phosphate backbone as found in native nucleic acids, PNAs contain a peptide-like backbone. The bases attached to each PNA unit are oriented in such that they can form regular Watson-Crick base pairs with either complementary DNAs or RNAs with high selectivity and affinity while also imparting nuclease and protease resistance. Armitage and coworkers have also demonstrated that PNAs can be designed to hybridize with G-quadruplex DNA either through Watson-Crick base pairing with a complementary strand to form a DNA/PNA duplex or alternatively through the formation of Hoogstein base pairs with a PNA G-quadruplex forming a hybrid PNA/DNA G-quadruplex as shown in Figure 5B.

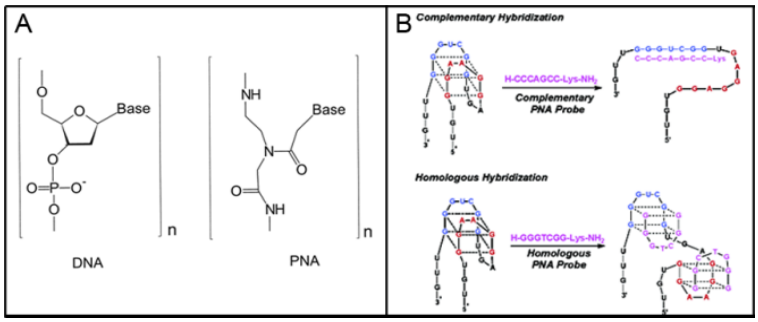


Figure 5. A. Comparison of building blocks of DNA and PNA. B. Two hybridization modes of PNA to quadruplex DNA. Both figures were adapted with permission from the Armitage lab.

Preliminary findings from my graduate work demonstrate that utilizing PNAs to pull down quadruplex DNA and telomeric DNA specifically is effective at ranges of 70-80% capture efficiency with a release of approximately 90%. However, I would like to see this assay increase to above 95% capture efficiency and 99% release efficiency so that we could utilize this technique for not only the isolation and purification of quadruplex and telomeric DNA in cell-free or serum samples but also eventually as a quantitative tool to measure telomeric DNA in any sample matrix. In order to do this, I have continued collaborations with Dr. Armitage to developed γ-modified PNA ligands which enchances to PNA/DNA binding affinity to fentamolar concentrations. We plan to explore various PNA sequences and structural motifs to enhance binding and release, as well as "catch and release" motifs where bound DNA can be released from the PNA by adding a fully complementary PNA strand that will bind to the bead bound PNA, displacing the capture DNA.

This bead capture assay development project requires minimal instrumentation, only needing a UV-Vis spectrophotometer to monitor DNA capture and release, and possibly a fluorometer to monitor fluorescently labeled PNA assays, and can be done on campus. Just as in the quadruplex characterization project, we would also like to further characterize the PNA/DNA interactions which will expand the scope of this project and expose students to instrumental techniques described previously and can be done with the instrumentation available to me at UAB. Eventually we could expand this project further by creating PNA capture strands for other known DNA sequences of interest such as known genetic mutations or cell-free fragments that could be used as biomarkers in serum samples. This research project will give my students valuable hands on experience with a wide range of instrumentation and general lab technique and can also be easily modified to meet the work demands of each individual student who is interested in participating.

Teaching Roles and Responsibilities

Since I began teaching chemistry in 2009, I have taught in various capacities such as a teaching assistant in chemistry recitations and laboratories, as a mentor for undergraduate and high school researchers, and as an instructor helping to further develop and teach a course on current research methods in chemistry. Because my roles as a teacher have been so varied I find that my teaching responsibilities are also just as varied; however, I still have the responsibility for teaching the 4 C's of learning to all my students and it is with these responsibilities that I approach each teaching opportunity.

Course Design/Instruction

CH308 – Biochemistry		2014
	Total number of students:	27
	Total number of sections:	1
	Institution	BSC

CH308 is an elective course for both biology and chemistry majors; although for most pre-health majors it is required to admission into various professional health programs. This course aims to provide an overview of a variety of biochemical principles such as metabolism, enzyme kinetics, biosynthesis of macromolecules, structure and function of macromolecules, and energetics. This course also aims to explore the physiological pathways with in the cell and how they become dysfunctional in disease states. After completion of this course students should be able to discuss and apply concepts of biochemistry such as the structure and functions of macro-molecules, enzyme catalysis, and metabolism, define and use common biochemistry terminology, discuss current techniques and methodologies in biochemistry, evaluate the differences between chemical equilibrium and steady state, and explain and discuss how cells maintain a steady state through metabolic and anabolic pathways, and how these pathways are altered in disease states.

CH308 is designed as a "flipped" course, meaning that lectures are video recorded and students are expected to watch the lectures and read the assigned material prior to class. In class, time is taken to discuss the material and students then work on guided inquiry assignments in groups to further their understanding of the material. In addition to watching lectures and reading material, students are encourage to participate in online discussions about the material and participate in online journal clubs discussing current peer-reviewed literature germane to the topics discussed in class.

As I near the end of my first semester teaching a fully flipped course, I have found that utilizing these blended learning techniques have enabled my students have to delve deeper into the content. By utilizing video lectures, we are now to spend every day in class tackling advanced biochemical topics and problems using guided inquiry activities, case studies and group discussions.

CH201 – Current Research Methods in Chemistry	2012-2014
Total number of students:	26
Total number of sections:	3
Institution	UAB

For the last few years I have been working on re-developing the chemistry course "Current Research Methods in Chemistry" (CH201). This course is generally offered in the spring to 1st year chemistry majors within the UAB Sci-tech program that are interested in pursuing undergraduate research opportunities in Chemistry. Previously the course was taught utilizing teacher centered learning techniques such as lectures and demonstrations on current instrumentation and lab techniques; however, these methods of instruction have been shown time and time again to be minimally effective in learning. In order improve this course and make it more student centered, instead of teacher centered, I have restructured the course. In the redesigned course, lectures are replaced with active learning techniques developed to encourage classroom and group discussions, and demonstrations are replaced with a semester long group research project that culminates with a poster presentation at the annual UAB Undergraduate Research Fair.

In order to prepare students in this class for the critical thinking skills required of a researcher, students are not given a lab manual, but instead are taught to derive their own procedures and background research from given objectives, and literature handed out in class as well as literature they find on their own. In the final poster session at the UAB undergraduate research expo the students are be able to showcase their experience in the class as well as interact with other students and faculty currently participating in research. Ultimately, the goal of the class is to facilitate these students in finding a chemistry research lab that they are interested to work in as well as equip them with the skills to feel capable and confident in implementing their future research projects. My responsibilities for this course were to design the course as a whole as well as design and implement all of the experiments in the course; teach the students how to research and discern reputable literature in order to help design an experiment; teach good lab techniques basic to all research labs; foster independent thought and critical problem solving skills; grade all lab reports and projects while giving feedback for improvement; and assist in finding guest speakers from research labs on campus.

Teaching Assistant

CH118 – General Chemistry II Laboratory	Fall 2013
Total number of students:	60
Total number of sections:	2
Institution	UAB

CH118 is a required second semester general chemistry laboratory course designed for freshman or sophomore science majors. This course is designed to allow students hands on experience with chemistry experiments reflective of the lecture material. It was my responsibilities as

the teaching assistant for this lab to design and give pre-lab lectures explaining the week's experiment; facilitate during the experiment; ensure every student was working safely and in a safe environment; and grade all lab reports, quizzes, tests, writing assignments and projects.

CH236 – Organic Chemistry I Laboratory	Fall 2012
Total number of students:	30
Total number of sections:	1
Institution	UAB

CH236 is a required first semester organic chemistry laboratory course designed for sophomore or junior chemistry majors. This course is designed to allow students hands on experience with chemistry experiments reflective of the lecture material. It was my responsibilities as the teaching assistant for this lab to design and give pre-lab lectures explaining the week's experiment; facilitate during the experiment; ensure every student was working safely and in a safe environment; and grade all lab reports. As this class is very writing intensive, I also find it my responsibility to help teach these students proper writing technique and grammar specifically for scientific writing by designing and implementing a writing rotation program.

CH325L – Physical Chemistry I Laboratory	Fall 2011,2010
Total number of students:	42
Total number of sections:	4
Institution	UAB

CH325L is a required first semester physical chemistry laboratory course designed for junior or senior chemistry majors. This course is designed to allow students hands on experience with chemistry experiments reflective of the lecture material. It was my responsibilities as the teaching assistant for this lab to design and give pre-lab lectures explaining the week's experiment; facilitate during the experiment; ensure every student was working safely and in a safe environment; and grade all lab reports. As this class is very writing intensive, I also find it my responsibility to help teach these students proper writing technique and grammar specifically for scientific writing.

CH116 – General Chemistry I Laboratory	Fall 2010
Total number of students:	39
Total number of sections:	1
Institution	UAB

CH116 is a required first semester general chemistry laboratory course designed for freshman or sophomore science majors. This course is designed to allow students hands on experience with chemistry experiments reflective of the lecture material. It was my responsibilities as the teaching assistant for this lab to design and give pre-lab lectures explaining the week's experiment; facilitate during the experiment; ensure every student was working safely and in a safe environment; and grade all lab reports, quizzes, tests, writing assignments and projects.

CH117R – General Chemistry II Recitation — Summer 2010

Total number of students:	81
Total number of sections:	3
Institution	UAB

CH117R is a required supplementary course when taking second semester general chemistry for freshman or sophomore science majors. This course is used to allow students time to practice problems related to lecture material that may be encountered in homework assignments or in-class exams. Here, students are able to work in groups with assistance from the TA in order to develop and learn these problem solving skills they will need for the general chemistry course as well as future courses in chemistry. It was my responsibility as TA to design in-class assignments as well as facilitate the students as they work. I took care in making sure at the end of the class that each student understood and finished the assignment before leaving and if they needed extra help or time, I made sure I was available. I was also responsible for attending all of the general chemistry lectures (CH117) in order to stay current on what the students have learned in class as well as facilitate the instructor during in-class exercises.

CH114 – General Chemistry I Honors Laboratory — Fall 2009

Total number of students:	65
Total number of sections:	3
Institution	UAB

CH114 is a required first semester general chemistry laboratory course designed for honors freshman or sophomore science majors. Students get hands-on experience with experiments while learning how to write scientifically. Each week, these students are taught to investigate and write a section from a scientific article such as the abstract, introduction, methods, results or discussion. The honors students are also expected to complete an end of term group project where each group picks a current research peer reviewed article to summarize and present to the class. It was my responsibilities as the teaching assistant for this lab to design and give pre-lab lectures explaining the week's experiment as well as writing assignments; facilitate during the experiment; ensure every student was working safely and in a safe environment; teach the students how to write scientifically; and grade all lab reports, quizzes, tests, writing assignments and projects.

MENTOR

Mentoring high school and undergraduate students in chemistry

Total number of students:	12
Total number of years:	4
Institution	UAB

Throughout the years, I have mentored various high school and undergraduate students while working in the research lab. A number of high-school students have worked in our lab as part of a work-study project in partnership with the Jefferson Country International Baccalaureate School (JCIB) giving these students real life experience in a research laboratory while working on their

science fair projects. My responsibilities for these students were to teach good basic lab technique and safety while facilitating them with their science projects for school. It was also my responsibility to help them develop their own project while teaching them the experiments and instrumentation that they could use to test their hypothesis. Undergraduate students have worked in our lab either for experience or for class credit. In either case, it was my responsibility to teach them good basic lab technique, lab safety, current instrumentation and experiments done commonly in our lab, and facilitate progress in their own projects. The following is a list of students I have mentored in our lab, their projects, and their achievements.

- **Michael Longmire, 2012-2014, Undergraduate Student**
  - **Project:** Structural and thermodynamic characterization of Ethidium Mono-azide binding to DNA
  - **Achievements:** Recipient of Beckman Fellowship (2012)
- **Victoria Stringfellow, 2010-2012, High School Student**
  - **Project:** Characterization of Ethidium Bromide binding to ctDNA
  - **Achievements:** Honorable Mention in Chemistry Division at UAB-CORD Central Alabama Regional Science and Engineering Fair (2012), 1st Place Science Fair at JCIB School Fair (2012), Finalist for the Gorgas Scholarship Program (2012), 1st Place Science Fair at JCIB School Fair (2011), 3rd Place at the Junior Science and Humanities Symposium (2011)
- **Bhakti Desai, 2011-2012, High School Student**
  - **Project:** Characterization of TMPyP4 binding to quadruplex DNA
  - **Achievements:** 1st place in chemistry division of the Alabama Junior Academy of Science Paper Reading Competition
- **Andrew Thim, 2011-2012, High School Student**
  - **Project:** Effects of salt potentials on spectroscopic properties of small molecules
- **Anthony Broach, 2011, High School Student**
  - **Project:** Differential Scanning Calorimetry of DNA hairpins
  - **Achievements:** Manuscript in progress
- **Viet Huynh, 2011, Undergraduate Student**
  - **Project:** Characterization of Ethidium Bromide binding to ctDNA
- **Heather Moore, 2011, Undergraduate Student**
  - **Project:** Characterization of Ethidium Bromide binding to ctDNA
- **Emily Cowart, 2011, Graduate Student**
  - **Project:** Characterization of Ethidium Bromide binding to ctDNA
- **Charles Sides, 2010-2011, High School Student**

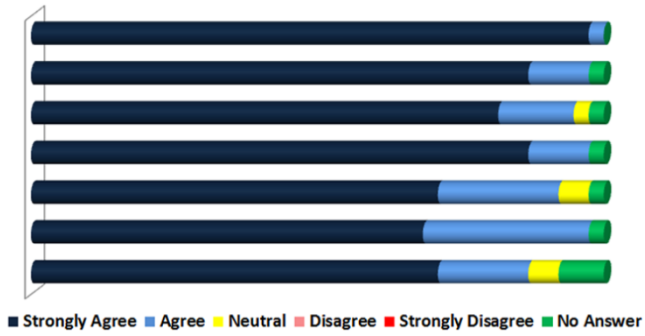
  - **Project:** Characterization of Ethidium Bromide binding to ctDNA
  - **Achievements:** Recipient of James M. McKelvey Undergraduate Research Award
- **Medora Pepper, 2010-2011, High School Student**
  - **Project:** Characterization of Ethidium Bromide binding to ctDNA
- **Elise Ottenfield, 2010-2011, Undergraduate Student**
  - **Project:** Thermodynamic and Structural analysis of non-helical DNA
- **Timothy Fernandez, 2009-2010, Undergraduate Student**
  - **Project:** Expression and purification of proteins using E.Coli vectors (2009), Isothermal Titration Calorimetric analysis of macromolecule/ligand interactions (2010).
  - **Achievements:** Recipient of Beckman Fellowship (2012)

Course Evaluations

After each course, students were asked to fill out an evaluation anonymously. The evaluation, which can be seen in detail on page 31 of the appendix, consist of seven questions in regards to the teaching assistant and six questions in regards to the course itself. The students were asked to assign a letter grade to each question of either A for strongly agree, B for agree, C for neutral, D for disagree and E for strongly disagree. These responses were then converted to a numerical point system for a total of 5 points, 5 points for an A, 4 for B, 3 for C, and so on. The responses were then average for each question. Each figure below, corresponding to each course taught, displays the question, the numerical average, and a graphical depiction for the response distribution.

CH114 - Honors General Chemistry Lab I

Question	Average
1. My lab instructor was one time.	4.97
2. My lab instructor was well prepared.	4.89
3. My lab instructor was helpful to me.	4.81
4. My lab instructor is knowledgeable in chemistry.	4.89
5. My lab instructor communicated well.	4.67
6. My lab instructor was fair.	4.70
7. I would take another lab from this TA.	4.71



Selected Student Comments

"Thank you so much for dealing with all our stuff. You taught all of us so much about chemistry. You rock. You made chemistry fun!"

"The opportunity to work under you has been amazing. Thank you so much for all the time you spent with us. I appreciate everything that you have done for me, and the things that I have learned will continue to help me through my career in medicine. Thank you for everything."

"Thank you so much for all the guidance you gave us over the year! I really enjoyed doing my work-study here because of all the new information and techniques we learned. Thank you so much for all your help with my project."

"Thank you for all your time and effort! I have learned so many new skills and cannot wait to take them with me to Auburn next year! I would not have won the science fair if it was not for your help and guidance! I am going to miss coming here for work-study every Monday. Thank you for everything!"

"Kate is probably the most knowledgeable TA that I have had in Chemistry for she seems to have a strong foundation in linking concepts with experiments due to her extensive research background. She also is extremely enthusiastic about Chemistry and often expressed that in her lab teachings by stating something was "cool" and "awesome." She was a hard TA for Genchem 1 according to some students yet in my opinion she graded lab reports fairly and consistently. Overall, she's a great TA who's able to effectively and clearly communicate the lab material!"

"Although the laboratories were tedious and time consuming, I felt like Kate made the whole experience informative. She is very nice and helped anyone who needed it. I was hoping she was a TA for CH 326 when I took it last semester. All in all, she is a great TA and is able to communicate well with students."

"The lab instructor was very knowledgeable. If there was ever a question she was able to clarify the misunderstandings and really made the material make sense. She was always prepared for the lab and gave great prelab lectures so everyone knew what was going on. I would definitely recommend her to any student."

"Kate was very helpful throughout the entire semester. Once we got going and learned the format of the labs, she would give us help as needed, but mainly allowed us to do the labs on our own. During the actual procedures, she was there showing us how the machines worked and giving us an example so that we could proceed on our own. I would definitely take another lab from Kate!"

"Kate was very helpful in all aspects. She taught both with words and in the lab itself. The lab experience was invaluable. I would most definitely work with her again. Her insight, knowledge and patience was greatly appreciated."

Service

As I begin my career in academia and as my company Blondin continues to grow, I have begun to think of ways in which I can become more involved in the community both as a professor of chemistry, a representative of Blondin, and as a Christian woman, In the past, I have assisted with the undergraduate student ACS section at UAB, mentored both high school and undergraduate students, have ran a couple 5K races for charity, encouraged student community through planning events with the chemistry graduate students at UAB, and volunteered to help clean up and restore areas of Pleasant Grove, Al., after the tornadoes of 2011. In addition to my involvement at BSC within the student ACS section and various science clubs, I also hope to further increase my community involvement through the creation of two new programs: A summer internship program for STEM majors, and a STEM outreach program for women and minorities in rural areas of Alabama.

STEM Summer Internship Program

As an assistant professor in chemistry, I am currently developing and piloting a summer internship program between STEM related departments such as Chemistry, Biology and Physics of BSC, and the local biotech community. This program will allow BSC to increase awareness of the growing biotech industry in Birmingham, Al. as well as give STEM majors at BSC a chance to receive valuable working experience and hands on training. I believe because of my involvement with Blondin Bioscience, and my connections with almost every biotech company in the area, I am uniquely positioned to develop this program; and I have already received very positive feedback from a number of company executives in the area who want to participate.

Almost every other discipline, such as Education or Business, utilizes internship programs that continue to demonstrate effectiveness in preparing students for the job market. However, this has not yet happened in Chemistry, at least not in our area. True, undergraduate research opportunities do exist for most STEM majors, but even at larger institutions, it is difficult to place each student into a research laboratory and for those students who may not be interested in research as a long term career, a summer workplace internship program at a local lab would be immensely more beneficial.

After speaking to various heads of the local biotech companies, this program will utilize two aspects. First, the student will be paired with an in-house mentor from the company to work on a mini-research style project that is within the scope of the company's vision. On campus mentorship will also be available through me as the head of the program, via weekly meetings reflective of the course "Current Research Methods in Chemistry" and I can also transform these meetings for an online environment should travel be difficult. Secondly, the student will work side by side with employees

performing routine duties as deemed appropriate by the company mentor in order further develop the professional skills required by that discipline's industry.

STEM Rural Outreach Program

Recently, a friend and mentor (Victor Brown of the BBA) approached me with an idea: to create a program designed to increase awareness and involvement for women and minorities in STEM disciplines within rural areas. There are currently a number of programs targeting local urban areas in our state, such as Birmingham and Montgomery, but there are few, if any, that I know of that target specifically suburban or rural areas outside of the cities in our state. From my own experience, I have seen that there are a number of women who enter as STEM majors at the undergraduate level (at Montevallo, I believe we may have even outnumbered our male peers), but a number never finish, and few go on to pursue their Master's or a PhD. I believe one of the major obstacles that women face in upper level STEM disciplines is the ability to find that work/life balance as we age. To obtain a Masters or PhD in science would mean that our option to be a stay at home mom is pretty much out the window and chances are more often than not that women may feel discouraged in continuing their education and believe that they would have to choose between a career in science or a family. However, I would like to be an example of how that is not true. I am a wife to a wonderfully supportive husband, I am a mom to a beautiful little boy (whom I had while in graduate school finishing up my dissertation), and currently am a Visiting Assistant Professor of Chemistry at Birmingham-Southern College, and the Director of Research for my startup company (Blondin Bioscience). I would love to be this example for future women in science, that (although it's no walk in the park) you can follow your dream career in science, have a family and be an active and attentive member of that family.

With this program, we will go to local primary and secondary schools within the rural areas surrounding Birmingham, such as Shelby County, and establish a network of mentors and projects in which minorities and women can find assistance and guidance when considering their futures in science, much like the Big Brothers Big Sisters program except related specifically to science. We will also strive to increase the rural community involvement of science related camps, organizations, and businesses in order to reach more students that may be interested in STEM related fields.

Professional Development

CIRTL Teaching Certification

In addition to completing my Ph.D. in Chemistry at UAB, I participated in a teaching certification program designed and developed by the Center of the Integration of Research, Teaching, and Learning (CIRTL). This program was developed to help prepare and train STEM graduate students for a future in high education and requires 15 credit hours in courses designed for teaching at the college level, active participation in discipline centered journal clubs, development of a teaching portfolio, and allows the student to be mentored by a faculty member in their department.

Course Work

GRD715 – TA Training Course

Date	Fall 2009
Institution	UAB
Credit Hours	1

GRD715 is designed to prepare first year STEM graduate students for teaching assistance positions. This course prepares students for the first day, discusses how to handle problems that may arise, and walks students through lesson plan development.

GRD716 – Developing a Teaching Portfolio

Date	Summer 2012
Institution	UAB
Credit Hours	1

This hybrid course guides participants in developing a Teaching Portfolio for improving teaching practices and enhancing job search potential. The web-based curriculum introduces essential elements of the portfolio, provides tools for gathering necessary documentation, and through individual feedback from the instructor, assists participants in drafting a personal Philosophy of Teaching, upon which the Portfolio is built.

CH702 – Principles in Chemical Instruction

Date	Fall 2012
Institution	UAB
Credit Hours	1

CH702 is a journal club specializing in chemistry education. Each week, students share and evaluate current literature the focus on teaching in chemistry.

GRD705 – Teaching at the College Level and Beyond

Date	Spring 2013
Institution	UAB
Credit Hours	3

This course provides an overview of many important aspects of teaching at the college level and beyond. Topics include designing a course and writing an effective syllabus, writing learning

objectives, enhancing lectures, testing and grading, dealing with challenging students and difficult situations, learning and the brain, and accessing appropriate active learning strategies.

GRD750 – CIRTL Teaching and Learning Seminar I

Date	Summer 2013
Institution	UAB
Credit Hours	1

GRD751 – CIRTL Teaching and Learning Seminar II

Date	Summer 2014
Institution	UAB
Credit Hours	1

These seminars are designed to engage students in advanced topics related to teaching and learning at the university level, particularly as these topics relate to or are implemented in STEM classes.

GRD755 – Teaching Practicum

Date	Summer 2014
Institution	UAB
Credit Hours	3

This course provides students a structured observation and practicum experience in which they shadow a STEM faculty member as s/he teaches a semester-long course and engage in a variety of guided teaching activities.

GRD761 – CIRTL Special Topics

Date	Summer 2014
Institution	UAB
Credit Hours	3

These online courses addresses topics of current interest related to college teaching provided by the national CIRTL network. To satisfy this requirement I took:

Planning Your Career: Developing Your Academic Portfolio (1 hr)

Basics of Online Learning & Teaching (2 hr)

Development of CH201

Current Research Methods in Chemistry, UAB, 2012-2014

I developed CH201 as an elective course for freshman or sophomore chemistry majors, designed to give students hands on experience to instrumentation and methods commonly used in the biophysical chemistry lab as a means for preparing them for undergraduate research. Not only are the students expected to learn basic lab technique, they are also expected to learn how to think like a researcher. In many research lab situations, students are not given step by step instructions, but instead they are expected to search the current literature and problem solve on their own. In order to prepare the students in the class for this kind of critical thinking they are not given a lab manual, but instead were taught how to derive their own procedures and background from the given objectives and literature handed out in class. For their final project, each group of students prepared a poster presentation for the UAB undergraduate research expo on their semester long research project. In this poster session the students were be able to showcase their experience in the class as well as interact with other students and faculty currently participating in research. Ultimately, the goal of the class is to facilitate these students finding a chemistry research lab that they are interested to work in as well as feel capable and confident in their research skills.

To assess the effectiveness of this course, I with my colleagues, Mitzy Erdmann, Joe March and David E. Graves, performed pre and post course evaluations along with student interviews. The results of this analysis as well as an overview of this course will be presented at the BCCE conference in August 2014 and will be written up for publication in a suitable journal.

Closing Statement

First and foremost, I want to thank you, the reader, for taking the time and consideration for reading my portfolio. Even though I have always been devoted to chemistry and science in general, the passion and love for teaching that I have found within myself has been a relatively recent and surprising discovery. Throughout my years as a student, I have always been in awe of those teachers who were able to not only relay information, but were also able to also inspire the joy and passion of their subjects. I believe that through my constant effort in instilling my 4 C's of learning in my students, I too will one day become one of these great teachers enabling my students to become great scientists.

CH201 – Current Research Methods in Chemistry

Course Description and Objectives

CH201 is an introductory course that will prepare 1st and 2nd year chemistry majors for undergraduate research. In this course students will be given hands on experience with state of the art analytical equipment while learning how to approach real world problems as a scientist. Students will work in teams on a semester long project culminating into a poster presentation at the annual Undergraduate Research Fair at UAB. Also, throughout the term guest faculty seeking undergraduate students for their research will be invited to present their research to the class and hopefully by the end of the semester each student will have successfully found a lab in which to begin their undergraduate research projects. The only pre-requisite for this course is completion of General Chemistry I (CH114/116).By the end of this course students will have:

- Acquired the basic lab skills essential for scientific research through hands on experience;
- Demonstrated the ability to develop and evaluate laboratory methods in order to solve a problem;
- Learned how to effectively present and share results with the scientific community.

Course Information

Meeting: Chemistry Building, Room 217, Monday and Wednesday, 10:10 – 11:35 a.m.
Instructor: Mr. David Graves (dgraves@uab.edu)
Graduate TA: Ms. Katherine Hayden (klanier@uab.edu)
Undergraduate TA: Mr. Michael Longmire (Longmire@uab.edu)
Office Hours: Monday & Wednesday, 3:00 - 6:00 p.m., by appointment.
Text: Handouts to be provided by the instructor.

Group Projects and Grades

Your grade in this class will be calculated based on your laboratory notebook, lab and class participation, literature review discussions, peer reviews, and one end of term poster presentation. Throughout the semester students will work in groups of three on a term project and will prepare a poster to present at the annual Undergraduate Research Fair at the end of April.

Item	Possible Points
Weekly Notebook Checks (12 X 25pts each)	300
Peer Reviews (5 X 10pts each)	50
Weekly Participation (15 weeks X 20pts each)	300
Literature Review Discussions (2 X 25pts each)	50
Poster Presentation	100
Total Points Possible	**750**

Group Member Names/Contact Information:

1.

2.

SCHEDULE

Date	Topic / *activity*
January 6	Course and student introductions. *The elements of a great experiment*
January 8	Searching and evaluating peer reviewed literature. *Jigsaw Paper*
January 13/15	Formulating a hypothesis *Literature Review Discussion*
January 20	**Holiday – MLK day**
January 22	Lab basics *Making a buffer and sample preparation*
January 27/29	UV-Vis spectrometry- Beers Lambert Law and Determining Concentration *Introduction to experiment design*
February 3/5	Thermal Denaturation of DNA by UV-Vis *Literature Review Discussion*
February 10/12	Thermal Denaturation of DNA by DSC – Part I: DNA *How to be a team player*
February 17/19	Thermal Denaturation of DNA by DSC – Part II – DNA/Ligand Complex *Research Ethics*
February 24/26	Spectroscopy – Analyzing the effects of binding on spectroscopic properties of DNA. *The role of collaboration in science*
March 3/5	Isothermal Titration Calorimetry - Measuring the binding affinity of ligands to macromolecules *Presenting scientific data – Posters and Papers*
March 10/12	Group Project: _____ *How to write an "Abstract"*
March 17/19	Group Project :_____

	"Abstract" peer reviews & how to write "Methods and Materials"
March 24/26	**Spring Break**
March 31/ April 2	Group Project :_____ *Methods and Materials peer reviews & how to write "Discussion/Conclusions"*
April 7/9	Group Project :_____ *"Discussion/Conclusions" peer reviews*
April 14/16	Undergraduate Research Expo *poster peer reviews*
April 21/23	Mock NIH review panel *Course review and reflections*

LAB NOTEBOOKS

There will be total of seven experiments in this course. Some experiments will only take one lab session while some will span two lab sessions, in that case, the pre-lab preparation will encompass both meetings. You are expected to write in paragraph form, using proper grammar and complete sentences. In instances, such as parts of the method section, a bullet point list for procedural steps may be used, but note that the methods section should be written clearly enough that anyone not familiar with the experiment should be able to repeat it.:

- **Prelab:** It is expected that every student come to lab fully prepared
  - Clearly state lab objectives and goals
  - Rewrite a methods section in your own words, leaving spaces for notes and observations (such as actual weights or temperatures) to use while performing the lab
  - State all safety concerns and proper techniques for avoiding an accident
- **During Lab:** First and foremost: **Participate** in the lab with your lab members and **pay attention**
  - Record all necessary observations such as actual weights or instrumental parameters used.
  - Record personal notes/observations that may help you to perform this experiment better in the future
  - Affix any raw data such as spectra directly into your notebook using tape and label appropriately**. Each individual is responsible for having his or her own data before leaving the lab**.
  - Note sources of error such as the error stated on glassware and balances, or manmade error from the sometimes unavoidable spill or bump.
- **Post Lab:** The post lab is made up of a calculations/result section and a discussion section. Simply restating the results in the discussion will not give you full credit, you must strive to find the implications of your results as they pertain to the real world. Feel free to research outside sources such as textbooks or peer reviewed journal articles to help you form a thoughtful discussion. This is also a good place to discuss error in the experiment, where it came from and how to avoid it. Feel free to also address problems in the experiment, or sections that were confusing so that we can strive to address these issues for future classes.

- Perform all required data analysis and calculations, clearly state results using a variety of means such as a tables or figures.
- Clearly discuss the results as they pertain to the experiment and draw conclusions on the physical meaning of your results. Address any additional questions that may appear in your handout, as these are meant to guide you in your discussion.

A composition notebook is required for a laboratory notebook. Keep all handouts in a ring-binder. Use pen with **BLUE INK** for your written portion of your notes. Date all pages. The copy of the notebook that you present to your TA is very important. Your notebook is the primary way you have to convey that you understand the laboratory exercises. All raw data should be handwritten directly into the notebook with **BLUE INK** and not onto scrap paper for later recopying into the notebook, if something was written in error, simply mark out the error with a single slash and rewrite the correct value next to it. Of course, legible handwriting is a key to effective communication. If we can't read it, it's wrong, should you prefer to type your pre and post lab sections you may, just cut and paste the sections into your physical notebook but remember to leave space for handwritten notes during the lab. Please note that while these experiments are performed while working in groups, your lab notebook should be your own personal work and not a team effort. Your TA will perform weekly lab notebook checks.

Example Lab Report Rubric

Score Levels	Prelab (20 pts)	Data (25 pts)	Calculations and Results (35 pts)	Discussion (20 pts)
Above Average	▪ Clearly and precisely states all of the lab objectives ▪ Fully describes all background theory/concepts and their relationships pertaining to the lab. ▪ Includes all necessary equations and sample calculations along with descriptions and relationships specific to the lab. ▪ Includes known literature values with proper referencing ▪ Includes multiple references cited properly ▪ Clear tables with proper descriptions, units, and format for recording of data. ▪ Includes instructions (including safety precautions if necessary) and calculations for lab preparation that are clear and concise. ▪ Proper significant figures used ▪ Typed neatly with no grammatical, spelling or punctuation errors. ▪ Information is clearly focused in an organized and thoughtful manner. ▪ Turned in on time and has all necessary TA initials	▪ Data tables are clearly labeled with a concise description using proper units and significant figures. ▪ Data is clearly focused in an organized and thoughtful manner ▪ Data is directly recorded neatly in the notebook using pre-constructed tables ▪ All data includes the correct units and significant figures ▪ Instrumental error recorded for each measurement. ▪ Measurements are accurately read ▪ Method of data collection is clearly stated ▪ Typed neatly with no grammatical, spelling or punctuation errors. ▪ If an appendix is used, data is properly cited and referenced within the text. ▪ Raw data has all necessary TA initials	▪ Calculations are performed neatly and correctly with easy to follow example calculations using the correct units and significant figures ▪ Associated error is calculated correctly using the correct units and significant figures ▪ How and why calculations are performed clearly explained ▪ All figures are properly labeled with clear and concise figure legends, with proper units and significant figures used. ▪ Information is clearly focused in an organized and thoughtful manner. ▪ Information is constructed in a logical pattern to support the solution. ▪ Typed neatly with no grammatical, spelling or punctuation errors	▪ Results are discussed and compared with known literature values. ▪ Theory and concepts introduced in the prelab are discussed clearly and concisely to support the results. ▪ Any associated error with measurement and calculation is discussed ▪ Proper use of references and citations ▪ Goes above and beyond to draw out possible new concepts and conclusions not discussed in the prelab ▪ Information is clearly focused in an organized and thoughtful manner. ▪ Information is constructed in a logical pattern to support the solution. ▪ Typed neatly with no grammatical, spelling or punctuation errors

Example Lab Report Rubric

Score Levels	Prelab (20 pts)	Data (25 pts)	Calculations and Results (35 pts)	Discussion (20 pts)
Average	▪ Clearly and precisely states most of the lab objectives ▪ Describes most of the background theory/concepts and their relationships pertaining to the lab. ▪ Includes all necessary equations and sample calculations along with descriptions and relationships specific to the lab. ▪ Includes known literature values with proper referencing ▪ Includes few references cited properly ▪ Clear tables with proper descriptions, units, and format for recording of data ▪ Includes instructions and calculations for lab preparation that are clear and concise. ▪ Proper significant figures used ▪ Typed neatly with few grammatical, spelling or punctuation errors. ▪ Organization of information could use improvement. ▪ Turned in on time and has all necessary TA initials	▪ Data tables are clearly labeled with a concise description using proper units and significant figures. ▪ Data is directly recorded neatly in the notebook using pre-constructed tables ▪ All data includes the correct units and significant figures ▪ Instrumental error recorded for each measurement. ▪ Measurements are accurately read ▪ The method descriptions are stated but need clarification, either not enough information, or too detailed. ▪ Typed neatly with few grammatical, spelling or punctuation errors. ▪ Organization of data could use improvement ▪ If an appendix is used, data is properly cited and referenced within the text. ▪ Raw data has all necessary TA initials	▪ Calculations are performed neatly and correctly with easy to follow example calculations using the correct units and significant figures ▪ Associated error is calculated correctly using the correct units and significant figures ▪ Description of how and why calculations are performed could be improved ▪ All figures are properly labeled with clear and concise figure legends, with proper units and significant figures used. ▪ Typed neatly with few grammatical, spelling or punctuation errors. ▪ Organization of information could use improvement.	▪ Results are discussed and compared with known literature values. ▪ Theory and concepts introduced in the prelab are discussed clearly and concisely to support the results. ▪ Any associated error with measurement and calculation is discussed ▪ Proper use of references and citations ▪ Does not attempt draw out possible new concepts and conclusions not discussed in the prelab ▪ Typed neatly with few grammatical, spelling or punctuation errors. ▪ Organization of information could use improvement.

Example Lab Report Rubric

Score Levels	Prelab (20 pts)	Data (25 pts)	Calculations and Results (35 pts)	Discussion (20 pts)
Poor	▪ States only a few or no lab objectives ▪ Poorly describes background theory/concepts and fails to define their relationship pertaining to the lab ▪ Missing necessary equations and sample calculations and fails to give proper descriptions ▪ Does not include known literature values ▪ Does not make use of proper citations and references ▪ Tables are not properly formatted, missing proper units and descriptions, or not included. ▪ Does not include instructions and calculations for lab preparation, or directions are not clear ▪ Does not use proper significant figures or units ▪ Typed with many grammatical, spelling or punctuation errors. ▪ Information is not organized. ▪ Either turned in late or not turned at all and missing proper TA initials.	▪ Tables are not properly formatted, missing proper units and descriptions, or not included ▪ Data is not organized ▪ Data is not directly recorded in the notebook or is illegible. ▪ Missing correct units and/or significant figures ▪ Instrumental error not recorded for every measurement ▪ Measurements are obviously not read/taken properly ▪ Method of data collection is unclear and sketchy ▪ Typed with many grammatical, spelling or punctuation errors. ▪ If an appendix is used, the data is not properly cited and referenced within the text ▪ Raw data is missing proper TA initials.	▪ Missing calculations and results, and\or contains math errors ▪ Associated error is not calculated or calculated incorrectly ▪ Sample calculations are hard to follow, or using improper units and significant figures ▪ Using the wrong formula/approach ▪ No or poor descriptions of how and why calculations are performed ▪ Figures and tables are not properly formatted with poor descriptions or are missing. ▪ Information is not organized ▪ Typed with many grammatical, spelling or punctuation errors.	▪ Results are not discussed and compared to known values, or are discussed poorly. ▪ Does not draw back to theory and concepts introduced in the prelab. ▪ Poorly or does not discuss error calculated in the results or from data collection. ▪ Does not reference outside sources or does not reference properly ▪ Poor explanation or grasp of the significance of the results ▪ Information is not organized ▪ Typed with many grammatical, spelling or punctuation errors.

Teaching Evaluation

Course: CH201
Semester: Spring 2012
Teaching Assistant: Kate

All responses are confidential, and will be used for improvement of instruction in this course.

Please use the space provided to indicate your level of agreement with each of the following statements:

A = strongly agree B = agree C = neutral D = disagree E = strongly disagree

1. My lab instructor was on time _____
2. My lab instructor was well prepared _____
3. My lab instructor was helpful to me _____
4. My lab instructor is knowledgeable in chemistry _____
5. My lab instructor communicated well. _____
6. My lab instructor was fair _____
7. I would take another lab from this TA. _____

The following questions are related to the laboratory:

A = strongly agree B = agree C = neutral D = disagree E = strongly disagree

10. The experiments required me to figure things out on my own. _____
11. There was enough equipment available for me to finish labs in a timely manner. _____
12. The equipment available was in good working order when I got to lab. _____
13. I could repeat some of the experiments without a laboratory manual. _____
14. This course has improved my understanding of concepts and principles in this field _____
15. Overall, this was a good course _____

In the space below, please give any additional comments about the laboratory or instructors that you feel would be valuable in evaluating the laboratory activities or teaching assistants.

Mentoring Evaluation

2011-2012

All responses are confidential, and will be used for the improvement of my teaching and mentoring methodologies.

Please use the space provided to indicate your level of agreement with each of the following statements:

A = strongly agree B = agree C = neutral D = disagree E = strongly disagree

1. My lab mentor was on time _____
2. My lab mentor was well prepared _____
3. My lab mentor was helpful to me _____
4. My lab mentor is knowledgeable in chemistry _____
5. My lab mentor communicated well. _____
6. My lab mentor was fair _____
7. I would work with this mentor again _____

In the space below, please give any additional comments about your mentor that you feel would be valuable in evaluating his or her methods. You may also comment on how you feel this experience has or will help you in the future.

Example Handout – Example lab write up for first experiment in CH201 handed out on the first day of class

In order to be successful in research, the student must master laboratory basics such as formulating a solution, accurately weighing material, pipetting, and measuring the pH of a solution. In order to practice these basic techniques, students will be preparing a buffer and stock solutions of DNA that they will use throughout the remainder of the semester.

A buffer is a type of solution commonly used in biochemistry labs that is composed of a weak acid and its conjugate base.

$$HA \leftrightarrow A^- + H^+$$

The properties of the conjugate acid/base pair allow the buffer to maintain a desired pH even if small amounts of strong acid or base are added to the solution, allowing the researcher to maintain a desired pH within the solution throughout an experiment. Maintaining a constant pH is crucial to the analysis of biological macromolecules such as DNA and proteins since the structure and function of biological macromolecules is highly dependent on pH. Take for instance the activity of the enzyme lysozyme, thermodynamic analysis of lysozyme at a range of pH's from 4 to 10 showed that as the pH decreased, the melting temperature (T_m or the temperature at which 50% of the macromolecule is unfolded) increases. At first glance, this would lead the researcher to conclude that at lower pH's, lysozyme has a high melting temperature and is therefore more thermal stable and probably more active. However, after an activity assay using fluorescence, it was shown that lysozyme was most active at the physiological pH of 7, and least active at both pH 10 and 4. So even though at the lower pH, the protein had a higher thermal stability, its activity was significantly decreased when compared to the sample at pH 7.

Buffers are prepared on the basis of the Henderson-Hasslebach equation, which states that the pH of a solution is dependent on the pKa of a weak acid as well as the concentration of the weak acid and its conjugate base in the solution as seen in the equation below.

$$pH = pKa + \log(\frac{A^-}{HA})$$

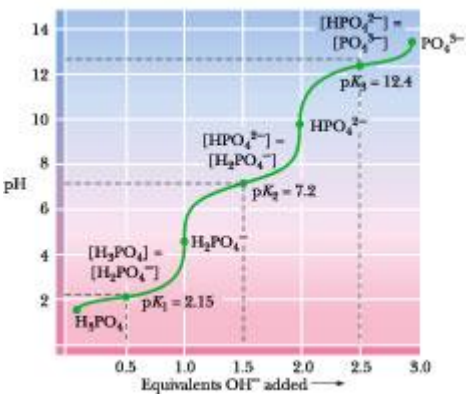


FIGURE 1. TITATION OF PHOSPHORIC ACID WITH BASE.

A buffer works best when the desired pH is within +/- 1 unit of the pKa as can be seen in figure 1 which depicts the titration of phosphate buffer with base. Phosphoric acid (H_3PO_4) is actually a polyprotic acid meaning that it can donate more than one proton, and therefore has multiple pKas, allowing it to be a good buffer for multiple pH ranges. In making a buffer with a desired pH of 7.0, a conjugate acid/base pair with a pKa of 6 thru 8 would be ideal. Tables of conjugate acid/base pairs and their pKa's can be found in most general chemistry text books such as the one seen below.

Table 2.4 Acid Dissociation Constants and pK_a Values for Some Weak Electrolytes (at 25°C)

Acid	K_a (*M*)	pK_a
HCOOH (formic acid)	1.78×10^{-4}	3.75
CH_3COOH (acetic acid)	1.74×10^{-5}	4.76
CH_3CH_2COOH (propionic acid)	1.35×10^{-5}	4.87
$CH_3CHOHCOOH$ (lactic acid)	1.38×10^{-4}	3.86
$HOOCCH_2CH_2COOH$ (succinic acid) pK_1*	6.16×10^{-5}	4.21
$HOOCCH_2CH_2COO^-$ (succinic acid) pK_2	2.34×10^{-6}	5.63
H_3PO_4 (phosphoric acid) pK_1	7.08×10^{-3}	2.15
$H_2PO_4^-$ (phosphoric acid) pK_2	6.31×10^{-8}	7.20
HPO_4^{2-} (phosphoric acid) pK_3	3.98×10^{-13}	12.40
$C_3N_2H_5^+$ (imidazole)	1.02×10^{-7}	6.99
$C_6O_2N_3H_{11}^+$ (histidine–imidazole group) pK_R†	9.12×10^{-7}	6.04
H_2CO_3 (carbonic acid) pK_1	1.70×10^{-4}	3.77
HCO_3^- (bicarbonate) pK_2	5.75×10^{-11}	10.24
$(HOCH_2)_3CNH_3^+$ (*tris*-hydroxymethyl aminomethane)	8.32×10^{-9}	8.07
NH_4^+ (ammonium)	5.62×10^{-10}	9.25
$CH_3NH_4^+$ (methylammonium)	2.46×10^{-11}	10.62

*These pK values listed as pK_1, pK_2, or pK_3 are in actuality pK_a values for the respective dissociations. This simplification in notation is used throughout this book.
†pK_R refers to the imidazole ionization of histidine.
Data from *CRC Handbook of Biochemistry*. Chemical Rubber Co., 1968.

Based on this table, if we wanted to use phosphoric acid to make a buffer at pH 7.0, calculate the ratio of HPO_4^{2-} to $H_2PO_4^-$ that would be required:

Now that we know the ratio of conjugate base to acid that we need, calculate, in grams, the amount of Na_2HPO_4 and NaH_2PO_4 that would be required for 1L of 10mM sodium phosphate buffer at pH 7.0:

Because DNA requires counter cations to stabilize its 3D structure, 100mM NaCl must be added to the buffer. Calculate, in grams, the amount of NaCl that is needed:

To minimize bacterial growth, 1mM of Na_2EDTA should be added to the buffer. Calculate, in grams, the amount of Na_2EDTA that should be added (MW Na_2EDTA: 372.2g/mol):

Based on the previous calculations, 1L of 100mM sodium phosphate buffer at pH 7.0 with 100mM NaCl and 1mM EDTA will be prepared in lab. Record the actual amount that was weighed for each component and add to a 1L volumetric flask. Partially fill the flask with ~500mL of DI water and mix till all solid has dissolved. Then QS (fill) to the line with DI water, mix well and filter through a 0.45 µm nylon filter into a 1L reservoir glass bottle, label and store on the lab bench at room temperature.

_____g Na_2HPO_4 _____g NaH_2PO_4

_____g NaCl _____g Na_2EDTA

Based on the actual weights of components, calculate the theoretical pH of the solution:

To confirm the pH of the solution, a Fisher Scientific Accumet pH meter will be used. The pH meter must first be calibrated against pH standards. First rinse the probe with DI water and gently wipe dry with a kim wipe. On the pH meter screen, select standard to enter the standardization mode. The instrument will give you two options: a. Press clear to clear previous buffers or b. Press standard to add a new standard. At this point we will press clear to erase all previous buffers. Once the previous buffers are cleared, the probe is submerged into pH 7 buffer (yellow solution). Select standard on the instrument to begin calibrating the probe. Once the probe has settled, it will automatically set the reading to pH 7. Rinse and dry the probe and submerge the tip into pH 4 buffer (pink solution). Select standard on the instrument to enter the standardization mode and select standard again to standardize a new buffer. After the instrument settles, it

will calibrate the probe to pH 4. Near the bottom of the instrument screen, you should take note of the instrument slope reading, FDA and GMP standards for acceptable slopes range for 90-110%. Should the slope fall above or below, you will get an error message stating "Bad Probe". If this occurs, simply follow the instruments protocol for thoroughly cleaning the probe and replace the current buffer solutions with fresh buffer. Repeat the process for calibrating the pH 4 buffer with the pH 10 buffer (blue) so the probe is calibrated for the pH range of 4-10. Record the slope value: _____.

Now that the pH meter is efficiently calibrated to measure pH's from 4-10; clean, dry and submerge the probe tip into the BPES buffer while stirring on a stir plate.

Record the pH _____

How does this pH compare to your theoretical pH?

If the pH is too low, add NaOH drop wise to the solution till the correct pH is reached. If the pH is too high, add HCl. *Caution – NaOH and HCl are both caustic and can cause severe burns if contact with skin or eyes occurs. Wear gloves, lab glasses and work with both solutions in the hood. Should contact occur, immediately rinse effected area with water for 15 minutes and contact your instructor.

Record final pH of the buffer _____

Now that the buffer is prepared, a stock solution of calf thymus DNA may be prepared for each group. Starting from a solution that is 7.5mM ctDNA , calculate, using $M_1V_1=M_2V_2$, how much volume you need from the initial solution to make a 25mL solution at 1mM ctDNA:

Preparing this solution will require using volumetric pipettes. Before preparing the solution, practice using the volumetric pipettes by pipetting known amounts of DI water into a zeroed beaker on a balance. Record the weights and calculate the %accuracy:

Table 2. Recorded weights of DI water delivered by pipettes compared to theoretical weights. Theoretical weights were calculated based on the density of DI water at 25°C (0.99705g/mL).

Volume delivered	Actual Weight (g)	Theoretical weight	% accuracy

(mL)		(g)	
0.1		**0.09971**	
0.55		**0.54838**	
1.0		**0.99705**	
3.0		**2.99115**	
5.0		**4.98525**	

Now that you have practiced with and assured that the pipettes are working properly, prepare your stock solution.

Record the initial ctDNA concentration: _____

Calculate how much volume of the initial solution you will need to prepare 25mL of a 1mM stock solution:

Record the actual volume of initial solution added to a 25mL volumetric flask: _____

QS to the line with your BPES buffer and mix well. Transfer the solution to a 50mL falcon tube, label and store at 4-8 ºC till use. Based on the initial concentration, the actual volume delivered and the final volume, calculate your theoretical concentration of ctDNA in your stock solution:

Example Quiz – Prelab Quiz for Experiment 1 in CH201, Spring 2012

Prelab Quiz 1

Determination of Concentration by UV-Vis

Name:_____

Score: _____/10

1. Write the equation for Beer-Lambert Law:

2. Describe Beer-Lambert Law in words:

3. At what wavelength will we monitor the concentration of EtBr? What is the molar absorptivity of EtBr at this wavelength?

4. At what wavelength will we monitor the concentration of ctDNA? What is the molar absorptivity of ctDNA at this wavelength?

5. Rearrange Beer-Lambert Law to solve for concentration.