Peter R. Andreana: Teaching Philosophy

Section I.

Science, in particular chemistry, is a field of great discoveries and opportunities and this is central in my goals for teaching. My philosophy concentrates on a retrosynthetic approach to teaching. I want the students to fully appreciate where science can lead them before teaching them how to arrive there. In order to fully engage the interest of students, I feel it is important for them to first understand what can be achieved with the principles and concepts they will learn. Once they are aware that there is a defined purpose for learning the material, my hopes are they will be more interested and more involved in the learning process. It is not only about teaching the fundamental basics of the science at hand, but also where those fundamentals are applied and used. I expect every student to walk away from my class with a new appreciation for science, as well as a knowledge base of science that will lead them beyond the classroom.

I am aware that class sizes will vary and I welcome that challenge. I am confident that my teaching philosophy can be adapted to any size class or subject. I believe it is also important for me to be able to adapt to different students needs, as not every student will become a chemistry or chemical engineering major. I believe that science is a complex subject to teach and learn and it requires the ability to distinguish between what needs to be memorized and what needs to be understood. I will help the students to make this distinction by outlining facts that should be memorized and guiding them through what needs to be understood by presenting them with the appropriate study tools. I encourage study groups and group discussions in order for the students to see how other students approach problems and integrate the positive aspects into their own approach to fully take advantage of the learning process. For graduate students, I will evaluate what they know and how they think through in-class discussions and participation. I will then help them to refine or build their skills, by offering new insights and concepts for them to absorb and utilize in their own research. I will encourage them to stay current in their knowledge of the field by presenting and discussing new journal articles, as well as using recent publications in my class discussions and examples.

My goal is for every student to enjoy science and not just learn the subject matter for tests/quizzes, but to retain the knowledge they learn. Although I am realistic that not every student will fully understand or appreciate the science, I feel it is important for them to be involved and take away as much as possible, without being intimidated. I feel that the best way to encourage learning and independent thinking is to allow the students to first understand the basics, and then present them with more in-depth material, either with a homework problem or class project, that will encourage them to apply what they have learned in a way not have thought about. I plan to always make myself available, beyond office hours, when appropriate, to offer extra help or encouragement. I do not appreciate laziness and I expect all students to push themselves to do the best they can and not rely on a grading curve. Each student will be assessed appropriately and fairly. I will rely on the student's feedback to guide me in my teaching process, encouraging them to be open and honest with their assessment of my skills and knowledge, and my teaching style. Teaching is an evolving process, especially in the first few years and I intend to rely on my own high standards and goals as a guide, as well as student evaluations.

I am also interested in offering classes in carbohydrate-based chemistry and in sustainable small molecule synthesis. I am interested in sharing my knowledge and background with students on subjects that are not widely known, thereby allowing them to become more familiar with different branches of chemistry. It is important to have a well rounded knowledge of all areas of chemistry and I am excited by the idea of sharing that knowledge with students. I feel it is also important for

students to be able to present science effectively and clearly and will encourage this by assigning topics for presentations, to allow them to demonstrate and practice their research, reporting and presentation skills.

I am motivated by the concept of sharing knowledge with other people as a mentor, but I also look forward to opportunities to discuss science and engage others in thought provoking discussions. I would like to do this by setting up small informal discussion sessions for any student interested to participate in. There is no greater reward than people pondering new concepts or ideas I have introduced to them and applying them to their own thoughts and processes.

I believe that it is important to facilitate a highly productive environment in which to do chemistry. Through the publication of manuscripts, each student will learn the importance of communicating science to their peers. I have had a very positive experience in working with undergraduate, and graduate students as well as postdoctoral associates over the past six years and feel that they have also fared well with my guidance. It is clearly evident that science is continuing to change at a very fast pace and I believe that success of young scientists for tomorrow will rely on a diverse array of skill sets.

Section II.
Which specific courses or subjects do you consider your special areas of strength?

Having been trained in Organic Chemistry/Chemical Biology, I know my strengths are in teaching courses that are defined in those areas. Having had the opportunities to teach Advanced Organic Chemistry, Chemical Synthesis Laboratory and Organic Chemistry for undergraduates has enabled me to disseminate my knowledge in those areas but has also allowed me to redefine my knowledge-base and consistently update myself with current literature. For example, I normally use Problem Sets as a method for independent learning and as a result I frequent the literature for pertinent problems that pertain to lecture material covered in class. I feel as though the Problem Sets are a true highlight for students beginning to recognize their increasing understanding of Organic Chemistry which ultimate accumulates into a high level of confidence. By adapting real-world Organic Chemistry problems, I feel as though the students begin to realize the importance of what they are learning. I normally fill their minds with the conclusion first, giving them a sense of what we want to accomplish, and then paint the picture of the entire story as we move back to the beginning only to commence a journey towards the end. The Problem Sets are the benchmark in my classes for grasping the material in an otherwise difficult subject to learn.

It has been said by many a student, that Organic Chemistry is the most difficult course to master on any campus. However, once mastered, it can have a profound effect on one's life. First and foremost, in understanding Organic Chemistry, a sense of pride and confidence ensues which ultimately transcends into a fearless attitude when it comes to learning. That statement may be true with other "hard" or even all courses taught on campus as well, *but* I would argue that no other subject can be as impactful as Organic Chemistry. For example, in lecture we learn how to create carbon-carbon, carbon-oxygen and carbon-hydrogen bonds which are the basis for the creation of life as we scientists know it. Although we do not know how these bonds synergize into actual life, we can and have, as scientists, synthesized some awesome things, such as catalytic proteins from de nouveau and pharmaceutical compounds that have changed the world in many ways. For example, chemist, Carl Djerassi ('52 – 57') invented the "pill" that essentially altered our entire prospective on life. Now that is awesome!

Having noted all of that above, in the end I do feel confident to teach any course provided that I be given ample time for preparation. With that being said, however, I'd always prefer to teach Organic Chemistry because it is what I chose to specialize in and it is truly exciting to come to work knowing that each and every day I can learn something new that I can potentially incorporate into my lectures. Organic Chemistry excites me!

Section III.
What do you consider your three most significant contributions to teaching?

a) Use of Tools in Teaching

It is well understood, that in current times, the educational landscape has changed and continues to move in various directions. Committees around the nation have formed to answer the mandated questions posed by Bush's "No child left behind" policy. One thing is certain and will remain an ever growing cornerstone for the future of education in the US and other nations and that is the advent of computers and the world wide web (www). Whereas sometime ago when I started as an assistant professor, not a single student asked about e-books, however, in my current classes it had become an option of choice. Whereas in years past, student organizations would work to photocopy and disseminate (for a small fee) previous exams for a particular course, now professors/lecturers post this material on Blackboard®. Blackboard®, in fact, has become one of my electronic tools that I use on a regular basis for all my courses. It has become an instrument for electronic connection between my class and myself and when used appropriately connects students to students. I initiated E-office hours with Blackboard® utilizing a "chat" box mechanism that worked extremely well. In fact, towards the end of one of my chemistry courses students were unknowingly using the mechanism in a group learning fashion, something that I express as being extremely important in one's learning process. For example, in the beginning and with the onset of E-office hours, I led most, if not all, of the discussion but as the students became increasingly more knowledgeable with the material, they were answering other student's questions and then verifying their answers with me. What started out to be an E-office hour session of 2-3 students, turned into an ever increasing number of participants with the high reaching 23. I noted the sessions to be successful because of various reasons including common fears around peers (judging), scheduling conflicts with work or other related responsibilities outside the class room and directionality in the E-office hour chat session. Providing the students with another opportunity to have their questions asked without feeling rushed or anxious in front of peers or professors was well worth the minimal effort it took. Aside from that, I used www links in chat to direct students to the answers but more importantly I knew I was providing them the tool-set to become independent learners and giving them new resources by using the www. I rationalized that my time constraints in lecture would never have allowed the students to find various other reputable and reliable resources such as the ones I provided. On top of that, these new learning tools could be accessed directly from the computer in which they were working on.

I felt and still strongly feel that although there is a plethora of information regarding Organic Chemistry, having access to www resources and the tools to disseminate knowledge to others is the way of the future in my field and in teaching the material. Students do not learn material like we used to learn it and insomuch as they are spending on a quality of education they deserve every opportunity to know about various resources available on the www. I do understand, however, that not everything on the www, regarding information, has been validated and verified but from what I have directed my students to access, I can honestly state that the material, although not free from error, is just and well described as that in the textbooks. I envision the day when Organic Chemistry can be taught in an entirely electronic format, although proponents of "old

school" Organic Chemistry would argue that students must learn how to draw proper structures. From what I have been witnessing in the advancement of electronic software (Java Soft and others) having students draw structures using online drawing tools would allow them to advance quicker and rather than spend time on hand illustrations, utilize powerful software that will instruct as well as make the student more efficient in learning the material to advance ideas of the future.

b) Mentorship in Research

Aside from my course teaching responsibilities, I run an active research group that pursues a number of different areas of active research. A few established areas of research are described below…more can be found on our website!!!

I. Isolation and Synthesis of Naturally Occurring Carbohydrate/Polysaccharides

Recently, a new class of bacterial polysaccharides, that have the ability to modulate the cellular immune system by eliciting a T-cell response, have been characterized. It has long been known that carbohydrate processing in the immune system occurs through the mechanisms of the MHC I $CD8^+$ pathway but never, until now, were they linked to the MHC II $CD4^+$ pathway. One of our objectives is to chemically prepare well-defined zwitterionic polysaccharides (ZPS), in which the oligosaccharide is amenable to chemical modifications, for the development of bioprobes. Understanding this process, in which carbohydrates are involved, will assist in clarifying the mechanism and potentially give insight on immune responses directed toward carbohydrate processing.

Several immunomodulatory zwitterionic polysaccharides (ZPSs) have been identified from different bacterial species, including capsule polysaccharide from type 1 *Streptococcus pneumoniae* **Sp1**, **PS A1** and **PS B** from *Bacteroides fragilis* strain 9343 and **PS A2** from *B. fragilis* 638. Although they share similar biological properties, these ZPSs have very different chemical structures. For clarity, **PS A1** is composed of a branched tetrasaccharide repeating unit with three monosaccharides in the polymer backbone and one residue at the side chain. Its sequence consists of [→3)-β-D-Gal*p*-(1→3)-α-D-Sug*p*-(1→4)[β-D-Gal*f* -(1→3)]-α-D-Gal*p*NAc-(1→], Sug is 2-acetamido-4-amino-2,4,6-trideoxygalactose. A pyruvate substituent spans O-4 and O-6 of the β-D galactopyranosyl residue. This is not a complete list of the ZPSs that exist in nature as other bacterial species synthesize polymers that have these motifs, however, there are relatively few bacterial polysaccharides that are capable of expressing zwitterionic charge character on their cell surface.

II. Carbohydrate Based Diversity-Oriented Synthesis

The current state of progress in glycobiology has opened a wide field for new therapeutic undertakings. A diversity oriented synthesis (DOS) approach toward the construction of skeletally diverse small molecules containing carbohydrates as a "privileged" scaffold would allow access to scarcely inhabited chemical space**.**

The structures and functions of natural products suggest that structural complexity may be positively correlated with macromolecule-perturbing function and specificity of action. This correlation is particularly striking in small molecules known to disrupt protein–protein interactions. Therefore, one goal pertaining to DOS is to develop small molecules with complex molecular skeletons. Moreover, in contrast to the relatively flat structures often developed in medicinal and combinatorial chemistry that have a tendency to project appendages outward along the perimeter of a circle, one aim in DOS is to access globular or spherical skeletons to which substituents can be potentially appended.

DOS pathways aim to proceed in the direction of similar structures to diverse structures to gain access to broad regions of chemistry space efficiently. To achieve this requires planning a

series of products-equals-substrates relationships, that is, the products of one diversity-generating process should share some common inherent chemical reactivity. This common reactivity serves as a keying element that makes the products collective substrates for a subsequent diversity-generating process. The goal of achieving diversity can be simplified by considering distinct diversity elements: appendages, stereochemistry, and skeletons.

III. Carbohydrate-Based Vaccines

Current carbohydrate-based vaccines, while effective, do not protect against the carrier protein and, therefore, an immunogenic response is heterogeneous in nature. The objective is to prepare well-known carbohydrate antigens, such as the well-defined polysaccharide ($Man_9GlcNAc_2$-HIV gp120), in which the oligosaccharides are linked to a T-cell inducing ZPS.

Synthetic vaccine development is a very young field and structural requirements for a satisfactory synthetic vaccine are not currently all that clear. Through the chemical synthesis of a known carbohydrate epitope found on surface of the gp120 protein, the idea is centered on eliciting a humoral (antibody production) and cellular (cytotoxic lymphocytes) immune response by "piggy-backing" on ZPSs. This area of research is highly diverse and not only can these synthetic carbohydrate vaccines be prepared according to the figure illustrated above but other fundamental parameters about the immune system can be answered such as the size of the oligosaccharide hapten required for immunogenicity, the size of the ZPS required for eliciting an immune response and the overall geometry of the antigen. A synthetic carbohydrate vaccine without proteins as carriers and adjuvants as elicitors of immune responses should produce an antibody with Fab portions specific for carbohydrates exclusively. This will ensure specificity in binding as well as a strong binding affinity, vital for immunity against the HIV virus.

IV. Combinatorial Carbohydrate Libraries and Carbohydrate-Based Micro Arrays

To determine whether an alternating charge character is necessary to elicit a T-cell response, the Andreana group will take advantage of the split-pool concept of combinatorial chemistry and develop a carbohydrate-based library with electrostatic charge character.

Despite the difference in their helical compositions and monosaccharide sequences, **Sp1, PS A1, PS A2** and **PS B** share a striking structural feature, *i.e.*, they are all zwitterionic polymers that display a high density of positive and negative charges (refer to Section I). The zwitterionic charge motif, shared by these ZPSs, is rare among natural polysaccharides, leading to the hypothesis that charges play essential roles in immunological function. It would be of interest to determine, systematically, how the electrostatic charges of ZPSs interact with various modulators of APCs. This hypothesis could be supported by several studies in which chemical conversion of charged groups to neutral components (*e.g.*, conversion of primary amines to secondary amines and carboxylic acids to esters) eliminates the activity of ZPSs. Also, adjacent monosaccharide charge character could be altered so that the positively and negatively charged groups would be separated by one or more neutral species. This concept could then be extended to examine the ZPS fragment composition required for T-cell activation (*e.g.* combining one charged tetrasaccharide core with other neutral fragments, while maintaining the structural integrity).

V. Small Molecule Synthesis

Chemical genetics is a method that uses small molecules to alter the way proteins interact in a natural biological setting. It can be used to identify particular proteins that regulate different biological processes, to understand in molecular detail how proteins perform their biological functions, and to identify small molecules that may be of medicinal value.

We are interested in the MHC II pathway of extracellular pathogen processing specifically with a special class of molecules, namely zwitterionic polysaccharides (as noted above). The MHC

II pathway is relevant in immunological processes specifically for monitoring extracellular/exogenous pathogens or foreign invaders. The proposed small molecule development ties in extremely well with this platform for the development of modulators (Chemical Genetics) of the immune pathway to determine mechanistic insights of carbohydrate processing in the antigen presenting cell or dendrite cell. The tyrosine kinase p56 (lck) is present in T-cells and is known to be required to initiate the activation response from the T-cell receptor (TCR) intracellular domain to other signaling proteins. T-cells that lack lck are unable to respond to stimulation through the TCR.

Andreana Group Mentoring

Since the summer of 2006 I have implemented a group learning course based on the fundamentals of Organic Chemistry. Underlying physical organic concepts where functional group transformations and retrosynthetic analysis of complex structures. My students also learned about various applications of small molecules (fluorophores, biotin…etc) in respect to chemical biology and the development of new tools for quantitative measurements. We engaged in this learning endeavor three times/week for approximately one hour. We have also incorporated "Show & Tell" research nights into our schedule. This opportunity allows for group members to discuss and present their results and ask for "group" feedback in direction and scholarship in their current project. These group meetings foster a sense of comradery through positive feedback and from a group question and answer time period. Meetings also instill a sense of pride and workmanship as productivity is not measured by how much work gets done but rather if the work that was accomplished has merit for the community. In all cases, we must admit that we deliberate long before we actually run experiments so that the best possible strategy can be obtained. Graduate and undergraduate students in my group partake in this activity and the general feedback has been extremely positive.

Use of a "Retrosynthetic" Approach

As has been previously noted, my philosophy centers around a *retrosynthetic* approach to teaching. I want the students to fully appreciate where science can lead them before teaching them how to arrive there. I do this in two ways: a) tell them about the end point and b) put the end point into the context of a "big picture" scenario. I do this for reasons affiliated with how, we as people, perceive the world around us. For instance, in one lecture the goal is for students to understand the reactivity of a carbonyl carbon. In knowing that there is no reference point to their understanding of a carbonyl carbon, I attempt to explain what a carbonyl carbon is and why it can react in a specific way. For example, I will tell them things that they may have already learned such as electronegativities of atoms and put that into the context of a carbonyl carbon (oxygen is more electronegative than carbon therefore a nucleophile will preferentially react with the carbon atom). Once we arrive at the point where they've gained confidence in what they've learned, we move forward towards the "big picture" objective. The "big picture" objective normally entails something in the real world that the students are familiar with but don't understand in great detail. For example, since I study cancer as a disease and am quite familiar with various hypothesis and mechanisms associated with it, I will use it as an entry point. In knowing that 99.9% of the students have, at one time or another, at least have heard of cancer, I begin to tie in carbonyl carbons to cancer. It turns out that one of the causes of cancer is when mismatched bases in DNA are corrected for in the cell. In turns out that purine or pyrimidine bases can be excised by various "repair" enzymes but reconstituting the correct base in the appropriate position is not all that simple. This leads to "abasic" DNA sites. It is these sites that lead to cancer as a diseased (occurs often in prostate cancer). However, when the base is cleaved from DNA, it is actually cleaved from the deoxy-ribose sugar. Sugars are found both in a cyclic state (pyranoses, furanoses) and their

respective acyclic state. The acyclic state is the open form of the sugar that contains the carbonyl carbon. It is this carbonyl carbon of the acyclic deoxy-ribose sugar that scientists can react with to diagnose potential cancer states of DNA in cells. One of the greatest achievements scientists have made to elongate the lives of cancer patients and in some instances “cure” cancer in patients has been in developing early diagnostic tools. One such chemical tool involves the conjugation of a reporter molecule to an abasic DNA site, which is the reaction of a nucleophilic reporter molecule to the acyclic ribose sugar!

I have found that students respond well to this mode of teaching as I’ve received comments that indicate so. Students have made note of my enthusiasm and my knowledge-base putting into perspective how chemistry can interact with all areas of life in positive ways. I also try to recruit students into chemistry as their major using this retrosynthetic technique by telling them how important it is to understand, on a molecular level, how things really work! In knowing that the majority of my undergraduate students want to be medical doctors or enter into pharmacy or dentistry, I let them think about the importance of chemistry as a whole and make them realize that their future diagnosis of a patient, the prescription or tooth that they fill had a chemist working behind the scenes to provide with the appropriate tools to move forward! Now that is truly exciting to me…enabling others!!!