2020 Chemistry Department External Review

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Background:

Hanover College is a Liberal Arts College located in Hanover, Indiana. The college is currently home to approximately 1065 students and is loosely tied to the Presbyterian church. The campus is situated in a small rural town and boasts beautiful vistas of the Ohio River. As is the case with small liberal arts colleges, Hanover has seen declining enrollment over the last three years due to less high school graduates and certainly COVID has likely contributed to lower enrollment in the current year.

The College is divided into four Divisions. The Chemistry Department is in the Natural Science Division which includes nine departments: Chemistry, Biology, Kinesiology and Integrated Physiology, Geology Physics, Engineering, Computer Science, Mathematics, and Psychology. The Natural Science Division is currently the largest Division at Hanover College graduating nearly 50% of all students from the College up from about 35% a decade ago. In addition, Hanover College has started a Doctor of Physical Therapy program which will likely add more students to the Sciences. It is likely more graduate programs will be forthcoming, most of which will further strengthen the sciences at the College.

The Department of Chemistry has four full time tenure lines and one 0.8 full time visiting position. Craig Philipp is the current Chair of the Department and is responsible for teaching courses Introductory Chemistry, Instrumental Chemistry and Quantitative Analysis, and Inorganic Chemistry. Tim Cunningham's primary teaching responsibilities are teaching Introductory and Physical Chemistry, both Quantum Mechanics and Thermodynamics, along with a Communication in Chemistry course. Ed Hall is our organic professor and in addition to teach two semesters of organic chemistry, he also teaches a required Spring Term course called Advanced Lab. Sarah Fantin is currently our Biochemistry Professor and teaches first semester Introductory Chemistry as well as a Biochemistry Seminar. Our current visiting professor is Kevin Sullivan. He teaches two courses of Introductory Chemistry per semester. Over the past five years, the Department has seen an average of just over 20 Chemistry/Biochemistry majors nearly double that of the previous five years. The department offers a BA and BS degree in Chemistry along with a BA degree in Biochemistry.

Chemistry Department Goals and Objectives

Notes:

Sarah Fantin was added to the department at the beginning of this school year as our Biochemistry professor. She did not participate in this report. She is open to speaking with reviewers.

Many portions of this document mention biochemistry. This review is over the department of Chemistry. Biochemistry will be evaluated separately. However, many of the statistics, comparisons to peer institutions, and outcomes include Biochemistry students. The Chemistry Department has always kept records for both chemistry and biochemistry, and thus it is difficult to separate them.

The Department Supports the College's Mission

Hanover College's mission is Lifelong Inquiry, Transformative Learning, and Meaningful Service. We have aligned our goals with this statement along with the goals of the current Hanover College Strategic Plan

Educational Goals and Learning Objectives

Goal 1: To enable Chemistry majors to develop a strong foundation in the discipline.

Learning outcome 1: At least 80% of the graduating class obtain a minimum score of the 50th percentile nationally on the standardized portion of the senior comprehensive exam.

Learning outcome 2: Students should be able to follow standard protocols for general, organic, and analytical chemistry.

Goal 2: To help Chemistry majors develop excellence in technical writing through chemistry department 4 year writing plan.

Learning outcome 1: Year 1 introductory chemistry; 80% of students will demonstrate competent or higher laboratory note-taking and data compilation skills based on the departmental rubric.

Learning outcome 2: Year 2 organic chemistry; 80% of students will demonstrate competent or higher introductory formal writing skills based on the departmental rubric. (Focus on abstracts, citations, and a cohesive "story" modeling journal style)

Learning outcome 3: Year 3 communications in chemistry; 80% of students will demonstrate competent or higher advanced writing skills based on the departmental rubric. (focus on writing skills reinforced in upper division lab courses)

Learning outcome 4: Year 4 senior thesis; 80% of students will demonstrate competent or higher on all senior thesis writing criteria based on the departmental rubric

Goal 3: Develop the broader scientific skills of experimental design, visual literacy, and data interpretation

Learning outcome 1: Given an unseen scenario, students should be able to design simple experiments to determine a variety of chemical unknowns

Learning outcome 2: Students should be able to draw conclusions, mark key trends, and/or create descriptive tables and figures based upon laboratory data.

Learning outcome 3: Students should be able comprehend and communicate key points of journal articles found in modern chemical literature.

Strategic Goals

Goal 4: To evaluate student outcomes and satisfaction with the Chemistry

Track post graduate outcomes with a goal of 100% of graduates are placed in post-graduate programs including graduate and professional schools or employment commensurate for a bachelor's degree chemist within 1 year of graduation.

Continue 1, 5, and 10-year alumni satisfaction surveys to understand what we do well for our graduates and to learn what we can do better.

Goal 5: The Department of Chemistry will engage and inspire students by leading the college in undergraduate research opportunities, internships, externships and summer placements with our majors.

This aligns with Goal 2 Objective 2.3 and 2.4 of the Hanover College Strategic plan.

To achieve this goal, our 5-year plan is:

Encourage majors to participate in experiential learning opportunities by sponsoring information sessions on research experience on and off campus, internships through local institutions, national opportunities, and possible study abroad opportunities.

Extend support to the development office to raise money for the summer research programs so that more students can participate.

Develop and implement a strategic plan for purchase of new instrumentation and maintenance of current instrumentation so that students have the opportunity for hands on experience with state-of-the-art instrumentation for chemical analysis.

Encourage intra-Department, inter-Department and inter-College collaborations whenever possible.

Retain and strength our relationship with Kings Daughter's and look for other potential externship opportunities for our Health Sciences program.

Goal 6: The Department of Chemistry will engage our students through innovative teaching pedagogy, integrating technology, and best advising practices.

This aligns with all objectives under Goal 2 and Objective 3.2 under Goal 3 of the Hanover College Strategic Plan.

To achieve this goal, our 5-year plan is:

Continue to write compelling proposals to maintain proper staffing to teach all aspects of modern chemistry

Continue to improve our already strong Communication in Chemistry Course (CHE 372)

Provide easily accessible advisement information to students via complete renovation of department website (updating structure, ensuring information is current, annual review) and creation of a department-specific advisement guide for students.

Encourage all faculty members to invite at least one seminar guest per academic year with topics related to chemistry, biochemistry or general chemical sciences. Encourage all students to attend those seminars.

Apply research examples in the classroom from either faculty's own work or published work and encourage open student discussion to promote critical thinking.

Encourage our top performing students to pursue post-graduate studies.

Encourage faculty to develop courses with a study abroad component.

Encourage professors that are eligible for Sabbatical to take them in their first two years of eligibility.

Goal 7: The Department of Chemistry will grow its majors by expanding its recruitment and retention efforts.

This aligns with Goal 1, Objective 1.1, and Goal 2, objective 2.1 of the Hanover College Strategic Plan

Recruitment:

Use spaces in the building to showcase the department, including hallways and display cabinets.

Invite students who do well in CHE 161 to participate in an advising session to learn more about our programs and research opportunities. Support these students through tailored advising and mentoring.

Develop "degree tracks" in chemistry so incoming students can understand what options they have with a chemistry degree including food chemistry, materials, forensics, and medical.

Review and update promotional materials that are designed to explain our programs to new and continuing students including our website.

Participate in area science fairs to recruit high school students to Hanover College and the Chemistry Department.

Advertise the accomplishments of the chemistry and students research-related activities (e.g., fellowships, graduate schools, medical schools, industry, etc…) using our hallway and social media.

Develop advisory group of industry professionals and alumni to help direct future progress in chemistry.

Have students and or professors assist admissions staff by visiting local high schools.

Actively recruit traditionally underrepresented populations

Retention:

Increase our out of classroom interaction with our students by offering receptions each semester to highlight department activities.

Celebrate our students who have won awards and scholarships through a spring awards ceremony and social media.

Expand opportunities for student-faculty interaction and networking outside the classroom (e.g. recruiting for student-based clubs).

Introduce students to professional opportunities as early as possible, such as using gift funds to sponsor free introductory memberships in science organizations such as the American Chemical Society, Institute of Food Technologists, and the American Society for Biochemistry.

Partner with College Career Services to make students aware of career opportunities that do not necessarily involve graduate school, professional school, or STEM education.

Encourage and support student and faculty participation in the local chapter of ACS, and outreach programs

Develop a database of department alumni in order to solicit involvement through information exchange and mentorship.

Aligning with the Mission of the College, the members of the department have taken great strides to pass on our support to students and the mission of Lifelong Inquiry, Transformative Learning, and Meaningful Service to the students, campus and community.

Support to Students:

The Department of Chemistry, along with Biology, are the most present departments on Campus. You can almost always find one or more professors in the building for additional help and advising. Even in the age of COVID, using technology to teach, communicate and meet has become the norm for the department. More specifically to students, the Department takes the time to help students get where they want to go. Whether that is the medical field, graduate school, or trying to find a job. Specifically, we advise on resume building and give students opportunities to make their resume stronger so that they have a resume in a place that will make them competitive. Whether that be helping them find internships, performing summer research, assisting their applications to Research Experiences for Undergraduates (REU) or externships and shadowing in the medical field, or finding summer jobs in their field.

Lifelong Learning:

The biggest part of lifelong learning in the Department is the continued research both during the school and over the summer mostly with students. Details of Research will be outlined later in this document. In addition to the continued research with students, the recently retired Dr. Steve Steiner, our former Biochemistry Professor and Current Science Support Manager and Current Department Chair, Dr Philipp both recently took Sabbaticals. During this time, we both performed research, but, more importantly, learned outside of chemistry as both took on construction projects and traveled afar to learn more about the world we live in. Both bringing it back and presenting their work and their experiences to the college. Another example of lifelong learning was that Dr Philipp, who had never had a collegiate level biology class, took the time to sit in on an introductory biology class.

Transformative Learning:

All professors in the department are highly student centered. As such we designed our curriculum to help students succeed. Some examples of this which, will be outlined more later in this documents, are the initiation of the Communication in Chemistry course which has given our students an advantage in the many forms of technical, scientific communication, and also has led to multiple student winning top abstracts or posters at REU programs. The advance lab course is also being changed to have a very

interactive and research feel to help in student decision making. The course has not been run yet, due to COVID, but hopefully it can be run this year. In addition, courses in Forensic Science and Fermentation Science has provided students with opportunities to travel off campus and learn from professionals how certain aspects of the field work.

Meaningful Service:

All professors in the department have a history of service to the college and the outside community:

Hall: Teacher Evaluation Committee (2 years, 1 as chair); SAAC (1 year); Committee on Learning and Teaching (1 year; coordinated college efforts on criterion 3 and 4 for HLC accreditation); Chemical Hygiene Officer (3 years); Summer Research Scholars Mentor (4 years); Institutional Review Board (1 year); Health Science Summer Academy Instructor (3 years); Volleyball Faculty Representative (2 years); chemistry department chair (2 years)

Cunningham: Curriculum Committee (2 years); Honors Program Committee (2 years); Committee on Learning and Teaching (1 year; coordinated college efforts on criterion 3 and 4 for HLC accreditation); Faculty Evaluation Committee (1 year); Summer Research Scholars Mentor (3 years); ACS Club Faculty Advisor (3 years); Brewing Experience and Education Retreat Co-Director (2 years); First Year 101 Instructor (3 years); Academic Coach (1 year); Fast Pass Summer Camp (1 year)

Philipp: Division Head (7 year), Department Chair (3 years), Faculty Development Committee (4 years) Committee on Teaching and Learning (2 years) 4C'c committee (2 years), Teacher Education Committee (2 years) Hanover Town Council (3 years, Vice President 1 year) Brewing Experience and Education Retreat Co-Director (2 years), Rugby Coach (7 years) Faculty Representative to Volleyball (4 years) Faculty Representative to Lacrosse (2 years) Associate Director of the Rivers Institute (4 years) Advisor to ACS (6 years) Advisor to the Fermentation club (2 years), Advisor to the Rugby Club (7 years) Science Fair Judge (2 years)

The Department has high academic Standards

For this external review, the department looked at the programs of several peer colleges and aspirant colleges. Peer colleges included: Albion, Alma Austin, Juniata, and Randolph Macon Colleges, and Washington and Jefferson. Aspirants included Alleghany, Beloit, Hendrix, Kalamazoo, Knox and Wheaton. Peers where selected by the college and determined by the US News rank, endowment, test scores, and enrollment, though all colleges in the peer list where 20% or more larger. The following data is a snapshot of the 2019 graduating class. We have reviewed the Peer Schools and have found that Hanover College has much higher student to faculty ratio (SFR) 13:1 than all schools on the list except Austin College. It also the highest chemistry/biochemistry (B/C) SFR than all other schools on the list by over one student per faculty. Hanover was higher than the average number of graduates for the colleges in the Peer group and had the highest percent of graduates from chemistry/biochemistry, though not significantly higher than Austin and or Jefferson and Washington.

In looking at the programs of these colleges, the biggest difference that we could find is that every one of our peer schools, as chosen by the administration, has an ACS certified chemistry degree. While there was subtle difference in the curriculum at every school with the curriculum was by-in-large the same with two exceptions 1) Our communication in Chemistry course is not common to most curricula we have looked at and 2) the Hanover College Biochemistry degree is significantly different than most programs. The Hanover College Biochemistry degree requires much more biology and a little less chemistry than the peer schools. We do this because the degree is truly a collaboration between the two departments. We believe that the biochemistry degree will serve student planning on going into medicine, but also

prepares chemist and biologist to study on the molecular biology side and/or the biochemistry side of the gray line between the two. Communication in Chemistry is a course we added three years ago to get students to read, write, and speak better in chemistry. We have seen immediate benefits from this course as three of our students who have done REUs have won the best abstract or poster of their cohort at the REU in the past couple of years.

Because of the finding from our research, we felt it not worth the trouble to benchmark our aspirant schools. Our learning from the peers has given us the following information. The Chemistry department has a very high student to faculty ration compared to other schools like Hanover. Our degree paths are in line with other colleges, except for biochemistry as noted above. While we do not have an ACS certified degree, we are keeping up with peer schools with the number of B/C majors. However, we think that adding the accreditation would make sense for the department. The biggest drawback is the need for a fifth tenure professor, something the college has yet to allow. More details of that are below.

The American Chemical Society (ACS) is the only nationally recognized accreditor of college and university chemistry programs. We are currently not accredited, nor have we made an attempt at accreditation. However, President Lambert has recently shown interest in gaining accreditation:
"As you may have seen in the draft strategic plan goals and KPIs, seeking national program accreditation—when available—is a strategy we are actively exploring. The idea is twofold. First, we think that nationally accredited programs have the potential to improve recruitment, and this may be especially true when we are trying to enter a new recruiting market (e.g., Nashville or Atlanta) where Hanover has low or non-existent name recognition. Second, we think that nationally accredited programs help our graduates in those programs achieve even better outcomes."

We have reviewed the extensive list of ACS requirements for accreditation and we meet the majority of requirements (budgeting, contact hours, infrastructure, information resources, safety, transfer student support, curriculum, pedagogy, capstone experience, undergraduate research, student development, self-evaluation).

We have assessed the following areas of weakness with our potential application:

1) A minimum of 5 full time faculty is required. We generally operate on 4 3/5 to 4 4/5 FTE, so we are very close to this requirement. No part time faculty are allowed for accreditation.
2) Lab may not exceed 25, but our current general chemistry labs are capped at 32 and are frequently run with over 25 students.
3) "The program should have access to support facilities such as machine, electronic, and glass fabrication shops to support both teaching and research." With the size and mission of our program, it seems unsustainable to have such excessive research infrastructure in place. I believe we can get around this criteria without additions to the department.
4) "Characterization and analysis of chemical systems require an appropriate suite of modern, high quality, and properly maintained instrumentation and specialized laboratory equipment that are utilized in undergraduate instruction and research." We have a full suite of currently operating equipment that serves the needs of the department. That said, some critical components of our instrumentation lab are certainly not "modern" (20+ years old). We have been able to make substantial improvements in this area since the introduction of lab fees. We have purchased a set of 4 UV/Vis spectrophotometers for the biochemistry lab, a new infrared spectrometer, and a new research grade fluorimeter among other small scale additions. It is my understanding that our current instrumentation will meet the needs of accreditation, but some of the older equipment will not last forever.

5) We lack any "industry standard" computational capabilities for calculating chemical properties. Currently, we make limited use of free software, and it has met all of our needs given the type of research performed in the department.
6) Our curriculum currently lacks what could be simplified as "macro-scale chemical systems". If we were able to hire a 5th full time faculty member, we would search for someone specializing in materials chemistry (we have already submitted this request to PPRC in the past) which would allow us to easily meet this requirement.
7) There are a few other small and correctable issues that we have chosen not to mention in this report for brevity.

Chemistry Department Assessment of Post Graduate Outcomes.

The Chemistry Department has been tracking postgraduate outcomes for chemistry majors for the last 12 years and biochemistry majors since the inception of the major in 2014, as well as the 3 previous self-designed biochemistry majors. We have information on 94% of our graduates during this time through the 2019 class and are still in the process of gathering data for last year's class. This report will focus on the past four years of data. As a department, we use six basic categories to determine placements 1) Medical field; which includes medical school, doctor of osteopathic medicine, dental, optometry, pharmacy, physician assistant, doctor of physical therapy, etc. We also include student taking a gap of no longer than two years to get into these programs, 2) Graduate school including masters and Ph.D. programs, 3) A job commensurate with a B.A. degree, including students obtaining a B.S. in nursing, 4) a job below that of a B.A. chemist, 5) unemployed whether by choice or not, 6) unknown outcome.

Table 1. Summary of graduate outcomes for the past 5 years.

Graduation year	Number of students	Medical School	graduate School	Job In Field	Under employed	Not Employed	Unknown
2015	20	5	8	6	1	0	0
2016	24	5	5	13	1	0	0
2017	26	9	7	9	0	1	0
2018	16	3	4	6	1	0	2
2019	18	6	6	5	0	0	1
Total	104	28	30	39	3	1	3
Percent		26.9	28.8	37.5	2.9	1.0	2.9

Table 1 is a summary of first Graduate outcomes as of August 31, 2020. We do not typically look at outcomes for students in the most recent graduating class until 9 months after graduation. At first glance the class of 2020 will have several students in medical programs, and a handful in graduate programs. Most of those not seeking additional education have already found jobs within their field. For those who are taking a gap year before medical program we list them in "medical school, but after the second gap year, we list them and not or under employed unless they have found employment in their field or progressed to a graduate program.

Chemistry has placed 93% of their graduates working in a job commensurate with their education, in a graduate program or in the broad field of medical college. A little over half of chemistry/biochemistry majors are going on to further their education in the medical field and or graduates; three of which are in MD/Ph.D. programs with nearly a 50/50 split between the two. Most of the remaining students have found employment in their field with less than 7% either not working in their field or unaccounted for.

Of these students going onto Medical school, to the best of our knowledge, none of them have dropped out, and all of them have either completed their program or are still currently working toward their degrees. Of those who have completed their degrees, to the best of our knowledge, they are all practicing in their discipline. Some of the schools they have attended include Indiana University, Ohio State University, University of Kentucky, University of Cincinnati, University of Wisconsin, University of Louisville, University of St. Martin, Pikesville, and Marion.

A little over a quarter of graduating chemistry/biochemistry majors go on to graduate programs. While most of them are furthering their chemistry knowledge, we have also put students into Master of Public Health programs, Ph.D. programs in Chemical Physiology and Public Health and Master of Teaching programs. To the best of our knowledge, of those going to Master and Ph.D. programs, all but two of them are either graduated or still making progress towards their degrees. We feel that this (5% attrition) is an excellent accomplishment considering a large attrition rate for Ph.D. programs; the neighborhood of 20%, for some programs. Interestingly, in calendar year 2017, we had four students obtain their Ph.D. including one obtaining the Ph.D. portion of their MD/PH.D. We surpassed that success this past year with five Hanover Alums successfully defending their thesis. Some of the schools attended by our graduate students include Stanford University, Boston University, the University of Pennsylvania, the University of Arizona, N.C. State University, Indiana University, the University of Virginia, Purdue University, South Carolina University, Colorado State University UC Riverside, Vanderbilt and Northeastern University.

A little over a third of chemistry/biochemistry graduates find jobs within their field upon graduation from Hanover. These jobs are in a number of fields including environmental science, consumer goods, medical research, pharmaceuticals, medical device sales, computer modeling, marketing, and advertisement. It is clear that the Liberal Arts education that they received at Hanover College is paying off for many of our chemistry graduates in the workforce. Some of the companies that have employed our recent chemistry/biochemistry graduates include Proctor and Gamble, Ely Lily, Dow, Vanderbilt School of Medicine, Norton Cancer Center, Kentucky State Police Crime Lab, Hewlett Packard, Thermal Instruments, Tree House Foods, MGP Group (one of the largest distilled beverage companies), Bristol Myers Squibb, and AstroZeneca.

Currently about 3%, who are underemployed, 1% are unemployed by choice, (she is employed as a stay at home mom) and seven students over the past decade we do not know what they are doing. Of the seven unknown graduates, five are in the past three years and we assume they have not started their careers yet.

We believe that the important data that the Chemistry Department does and needs to continue to show perspective students our success rate at placing people into medical programs, graduate programs and/or jobs. With a success rate of around 93% of students either furthering their education or finding employment in their field and over 98% employed in a field of their choosing, Hanover Chemistry is doing some great things. Much of this comes from helping chemistry students, through advising. It is important for students to understand there are options other than the medical field with a chemistry degree. While there was a belief that the number of students going to medical school was decreasing, and

the number of those going to graduate programs was increasing, this is not the case. The percentages have been relatively consistent over the past ten years barring a few anomalies.

As of right now, we do not think that incoming students are informed about the strength of chemistry graduates we are producing and the success rate of our graduates unless they actually visit with one of the professors during a campus visit. We should probably be turning these numbers over to admissions for them to use with perspectives as well. We believe that more students, both at Hanover College and perspective students would be convinced to study chemistry if they understood the success rates and career paths that chemistry provides as evidenced by our chemistry alums. We believe that one of the biggest barriers to this is that incoming freshman students during LEAP are being advised to take either biology of chemistry during their first year, and many are choosing, or being advised, to take biology first. We believe that this is particularly true (with no data other than hearsay) if they are indicating a desire to go to medical school and/or they are playing a sport. The percentage of upper division students in our introductory chemistry series is approaching half the enrollment. It is very difficult to complete a chemistry major in three years so if they are not in the introductory sequence their first year, they have lost this opportunity. We have had a number of students who have taken the introductory chemistry sequence their sophomore year and said they wished they had taken it as freshmen because they would have majored in it.

There are two additional opportunities that are being missed by the chemistry department. The first is computational chemistry. This would be effectively a double major or major/minor with computer science. Not only is this a large emerging field, it is also one that pays very well. The Chemistry Department has not had much expertise in this area until recently and the Computer Science department is also stretched, but a combination of these majors could produce a new stream of incoming students that would be very marketable in chemistry, computer science, or any field that would combine the two disciplines. A second area that the department, and the college is missing is in materials science. This is also a very hot field of chemistry, and most undergraduate institutions do not have expertise in this area. We have proposed getting into this area, but it would require an addition faculty, a proposition that has already been put for to the PPRC. This major, or pathway would also fit in great with the Engineering program.

In sum, the Chemistry Department has been monitoring student outcomes for the past 13 years. The department has been correctly advertising that about 25% of our graduates go to medical programs, 25 % to graduate programs, and 1/3 get jobs in their desired field. What we probably have not been advertising well enough is the percentage of chemistry students who are gainfully employed and where they end up. We continue to place students in excellent positions at well know companies, and in some of the top graduate programs in the country. This should also be better advertised to prospective students. We should also be advertising that not only are our students getting into these top graduate programs and good medical schools, but that they are also well prepared for them and completing them. As a department, we feel that there are a couple of opportunities out there that we are missing; computational chemistry and materials chemistry. Both of these fields are in high demand and also have high paying entry level positions and certainly open doors to excellent graduate programs. Finally, the growth of the department should not be overlooked. There must be something that the department is doing right to sustain growth over the past 7 years. We believe that the outcomes of our students, and advising them that there is life outside of medical school in chemistry has helped this.

Summary of Research Projects

Hall: My research has primarily been used as a tool to prepare advanced students for graduate studies in chemistry. In my first 5 years of summer research and directed research courses, I have mentored 11 total students all of whom have either attended graduate school or have gained employed as chemists after graduation. I've had students present their research at the national meeting of the American Chemical Society in Orlando last year. My project goals are multifaceted and assigned based upon individual student interests. Currently I have a small research program which focuses 3 main goals:
1) development of new chemical probes used to study the growth and division of bacterial cells
2) synthesis of new organic catalysts and evaluating their effectiveness is chemical reactions
3) design, synthesis, and evaluation of antibacterial compounds.

Cunningham: My research background is biophysical chemistry and in my graduate career, I worked on the development of spin-labeling methodologies for use primarily with electron spin resonance (ESR) spectroscopy. My work here in my first few years focused on continuation of my graduate work despite not having an ESR spectrometer. In addition, I have begun to focus on research problems that are more feasible in an environment such as Hanover. Most recently, I am beginning work to better understand aqueous two-phase systems (ATPS) using polarized fluorescence spectroscopy. It is hypothesized that ATPS may have played a role in the formation of the first cells from primordial soup and my goal is to develop fluorescence polarization probes that are sensitive to local viscosity as an indication of phase separation occurring. Once this phase-separation reporter is developed, I will be able to better study the energy driving this phenomenon and gain insight on the fundamentals of this biologically relevant process.

Philipp: While working at Tropicana, we discovered that the volatile profile of a mechanically stressed living orange (still on the tree) was significantly different than that of a picked orange stressed in the same manner. Specifically, the living orange produced significantly higher levels than the dead oranges, 10X or more, of several volatile compounds many of which are known, or suspected, insect repellents emitted to stop the attack on the fruit. I recently postulated that if the orange had a mechanism to ward off an attack there likely is a mechanism for cellular repair. I also proposed that the repair would use non-volatile phytochemicals that could easily be detected by high performance liquid chromatography (HPLC). Initial studies have shown higher levels of polymethoxylated flavones in mechanically stressed living oranges than control samples. I have had continued success looking at anthocyanins in raspberries, blackberries, and most recently mulberries which are a completely different fruit than any of the others. I would like to continue this research by stressing different fruits and to elucidate the mechanism for making this important health compounds. This project will give students experience with experimental design, making and using calibration curves, and use of HPLC. To date I have four student presentation at the National ACS meeting on this work with nine different students credited on the posters.

My father was a chemist at NASA for many years. Several of his patents are around ion-exchange materials (IEM) that have several advantages over similar products that remove heavy metals from aqueous solutions. The films are inexpensive and simple to produce, are easily regenerated, non-toxic, can be made into many shapes, and have a high loading capacity. Probably the most important benefit is that they are preferential for heavy metals such as lead and cadmium. Most IEM are preferential for calcium, thus are rendered useless for heavy metal removal in many natural systems. The IEM that we use begins in the calcium form and exchange calcium for the heavy metals. We are now able to make the IEM into a powder and next steps in this area are continuous flow columns and kinetic studies. I would also like to run trials to see if the IEM can block or hinder heavy metal uptake by vegetables. This project will give students an opportunity to work with simple organic chemistry reactions and use atomic

absorption or atomic emission spectroscopy. This project seems to attract a growing number of students who are interested in our environment and ways to improve it. To date I have 3 ACS presentations on this work with 9 unique students doing the work.

I have worked on two Chemical Education projects. The first was a project involved with my wife where she filmed me teaching a course on food product development. The class was taught in a much different way than other chemistry courses and was open to non-science students as well. The class was a very novel approach to teaching science with much hands-on work in the class. We are in the process of amending the first draft of the paper for publication. In this second project, a couple of students showed a paper to me that they wanted to try in their Instrumental Analysis course on determining alcohol by volume using NMR. This paper was well written, but quite complex. It used internal standards, making a calibration curve, analytically diluting samples, and required multiple NMR runs with a high number of scans. The lab took a long time to do. Instead, we can get the similar answers by running a single scan of an alcohol on the NMR and a fairly simple calculation to do it. For the past two years I have run this lab as the first lab in my first semester introductory chemistry course. In other words, me student were playing on our most expensive instrument week one of class. The lab teaches them stoichiometry, unit conversion, density, and use of a spreadsheet to make calculations, all concepts taught within the first three weeks of the class. A draft manuscript has been started, and with this years data it will be sent for publish in J. Chem. Ed and will have three student authors.

Assessment

The chemistry department has submitted two recent assessment reports within the college's new format. Our first report focused on the development a cohesive set of learning goals, and the level to which we achieve these goals will be monitored through subsets of learning outcomes for each goal. The department overall lacks sufficient data in which to draw conclusions on the effectiveness of our curriculum and pedagogical methods. It is an area of weakness that we have sought out to remedy with our current 5 year plan of assessment (we skipped a year due to this program review):

Program Goals	**Year 1 2017-18**	**Year 2 2018-19**	**Year 3 2020-21**	**Year 4 2021-22**	**Year 5 2022-23**
1) To enable Chemistry and Biochemistry majors to develop a strong foundation in the discipline.	X	X	X	X	X
2) To help Chemistry majors develop excellence in technical writing.		X	X		
3) Create effective upper division courses which emphasize the broader learning goals of critical thinking, experimental design, visual literacy, and data interpretation				X (experimental design)	X (visual literacy & data interpretation)
4) To evaluate student outcomes and satisfaction with the Chemistry and Biochemistry program.	X	X	X	X	X

There are two main areas that we historical data on to assess the success of our department: 1) senior comprehensive exam scores; 2) graduate placements

1) Through ACS exam scores we have a good picture of how well our students retain basic chemistry concepts. We think of it as a "you have to this stuff if you want to graduate" type of exam, and we expect our students to perform very strongly relative to national averages seeing that they are taking the exam as seniors, not freshmen. In order to get more detailed information on how our department could improve, we have recently begun to collect data on student responses to every question individually. We are meeting our initially determined goals, which is useful, but we have found problem areas to be improved (specifically nuclear chemistry). It is currently an underrepresented portion of our curriculum. This will be addressed in 2 stages: 1) incorporate this instruction into inorganic chemistry to expose upper classmen to this content before they take comps; 2) shift the discussion of nuclear chemistry topic into CHE 185 (introductory chemistry) for all future cohorts. We currently in the second stage, adding nuclear chemistry into our second semester of introductory chemistry. Plans are currently underway to restructure syllabi and course content.
2) A detailed description of graduate placements can be found in the appropriate section of this review. It is only mentioned here since it is also part of our assessment plan.
In our upcoming year's assessment report, we plan to create a continuous program of technical writing instruction. The department has broken down writing objectives for each year of study and will create specific rubrics to allow the collection of better data in support of annual improvements. Furthermore, this plan will allow for clearer goals when creating course content:

Year 1) Laboratory note-taking and data compilation

Year 2) Intro to formal writing. Focus on writing abstracts, including citation, and a cohesive "story" modeling journal style writing

Year 3) Complete formal training in Communications in Chemistry (writing skills reinforced in upper division lab courses)

Year 4) Independent application of these learning objectives in the senior thesis written document (writing skills reinforced in upper division lab courses)

3/4) **Department has an efficient and effective design and students are interested in the Department**

a) Annual enrollment

Table 2 Average enrollment in required major courses/major electives

	161	221	325	341	351	185	222	311/312	326/324	342	372
15/16	109	33	20	32	9	98	29	2	15	16	
16/17	122	40	22	32	3	95	32	8	6	18	
17/18	148	43	20	24	3	94	35	3	10	13	8
18/19	117	56	16	19	10	86	47	14	16	15	10
19/20	114	55	14	33	11	80	43	8	17	16	9
5 year average	122	45.4	18.4	28	7.2	90.6	37.2	7	12.8	15.6	9

*Courses with slashes are offered every other year 311/312 quantum/thermo, 326/324 quantitative analysis/inorganic
** CHE 372 was added to the curriculum in 2017
*** CHE 161 has 5 sections and CHE 185 has 4 sections all other courses have 1 section

From the above table, we can see that enrollment has been fairly consistent in the first semester of introductory chemistry, but we have seen a slow drift downward in the second semester of introductory chemistry. However, our retention in chemistry from intro to organic chemistry has been very good over the past couple years. Enrollment in upper division courses have increase in most cases as with the exception of biochemistry which has been holding steady for several years.

Table 1 earlier in this department lists our annual number of graduates. We are averaging about 21 graduates annually, and are looking at graduating classes of about 25 in 2021, and about 20 in 2022. The previous five year (not on the Table 1) we averaged less than nine students annually. So there has been a large increase in the number of graduates in our program in the past 5 years from the previous five years. Much of this, but not all of it, can be contributed to the biochemistry degree.

b) Is curriculum organized given available resources and pedagogical approach for efficiency/effectiveness (pros and cons)

Hanover has a 4-4-1 calendar. Student have 4 courses each in the fall and winter and have a month Spring Term course. We are a small department compared to our peer institutions and have little room to error on scheduling of classes. As such our curriculum is very well ordered. We have 4 full time faculty that need to teach 10 required courses in our fall/winter terms over a 2-year span so a few of courses are taught every other year. In the spring term we have one required course and have time to teach one or two non-required/non majors' courses. The department has played with the curriculum and believe we have it very close to locked in. In addition, we have consulted with the Biology Department to make sure that our schedules align so that students in Biochemistry will not be shut out of classes. However, this rigid schedule does not allow for any flexibility. If a professor does take a Sabbatical in either the Biology or Chemistry department it causes issues.

The department has worked hard to expand the schedule as much as possible to offer as many necessary courses to have a legitimate major. In the past 5 years, we changed our Junior Seminar, a ¼ credit course, into CHE 372 communication in chemistry, a full credit course to teach student how to read, write and speak as a chemist. This has had a profound effect on our students and graduates. We have reinstituted CHE 326 Quantitative Analysis that has not been taught for over a decade.

d) Changes for improvement

First and foremost, we look forward to seeing what you the reviewers think we can do better, but we understand some ways we can improve, most of which center on an additional person in the department.

While we think we are doing about as good of a job as possible, there is always room to improve. The best way to do that would be to add an addition faulty member that could significantly add to the curriculum. We would envision someone who could teach courses such as material science, computational chemistry or food chemistry among other, and would give the department the ability to teach a few additional courses. This would also certainly improve the workload in the department.

Another area that the department is worried about is our analytical equipment needs. We do have a new FTIR with ATR, and a new fluorescence/UV/Vis spectrometer, but we need to upgrade much of our analytical equipment. Our HPLC is 21 years old, but is still covered under service contract, but the mass spectrometer has not worked for a decade. Our GC/MS is also 21 years old and no longer supported by Agilent. We have no properly working GC with exception of the one attached to the mass spec. Other than the newer instruments mention above, most if not all are running on antiquated software an decades old computers. We finally threw away our last strip chart recorder about five years ago.

We have had a lot of discussion around our BA degree, and we all feel it is a little week. A student could graduate with a BA degree without having any physical chemistry. However, BA degrees have a maximum of 13 credits, including cognates, so it would be difficult to change the major.

We would also like to have a BS degree in biochemistry. The Chemistry Department would like to include a research component to the major, but we have received push back, with good reason, from the Biology Department. We are still in discussions about that now.

4) Questions we would like to ask to the reviewers.

What would you perceive as weaknesses to our current curriculum?

How does your department receive funds to update instrumentation?

5) The department is responsive to changes in institutional, disciplinary, or national trends

Curricular Changes

In recent years, the chemistry department has responded in numerous ways to the changing trends at institutional, disciplinary, and national levels. These changes have been made to keep the department up-to-date and to allow the best preparation for whatever path our students pursue.

The most drastic change for the chemistry program in the last few years was the incorporation of the Bachelor of Science (B.S.) degree. This addition occurred once the broader proposal to allow for the creation of B.S. was approved by the broader faculty with the chemistry department being one of the first departments to adopt this new degree. The new B.S. degree requires 16.5 units and a research-based thesis. In accordance to the requirements set by the college, we also had to update the Bachelor of Arts (B.A.) track such that a student could step down from the more rigorous B.S. track to the B.A. track at any point over the course of the major without risk of extending a student's time at Hanover past four years. As such, the B.A. degree requires only 13 units with a research-proposal-based thesis. Both degrees require most of the same courses, but the B.A. doesn't require calculus II, two less upper level chemistry courses, and a 0.5 unit of research.

As part of the overhaul of the degrees offered by the department, there were changes to the courses being taught. Some courses (such as Quantitative Analysis) were taught for the first time in a decade to support the new degree. Other courses (such as Advanced Lab) were adapted to be more relevant for more modern topics with chemistry, specifically drug design. Finally, and most notably, was the creation of a new course called Communication in Chemistry. The course is meant to introduce students to the many aspects of communicating in the sciences including finding/organizing relevant literature, journal article comprehension, scientific writing, figure design, oral presentations, and poster design and presentation. The course is taken at the beginning of the junior year for both B.A. and B.S. majors and requires the completion of two major projects. The first is a food-based research project where a change to an existing recipe is proposed, the student then makes the changes and presents food with surveys to an audience to collect data, the data is then analyzed to make a series of figures, a final research article, and finally a poster presentation of the overall project. The other project is writing a review article which requires students to pick their own topic, present a relevant paper related to their topic, write a final document that requires at least 25 references, and give a 15 minute oral presentation on their final paper. This course has led to a drastic improvement in the students' presentation and this has led to multiple students receiving a number of presentation awards at various summer research programs.

In addition to updates to help our majors, the chemistry department has also made changes to help the broader college community be prepared/able to experience chemistry at Hanover. Regarding preparation, one consistent issue that the chemistry faculty run into at Hanover is the lacking math background of students taking introductory chemistry. It was all too common to see a student who understood the chemistry knowledge well enough but was held back by their inability to perform the mathematical steps to solve the problems on exams. Accordingly, we worked with the math department to encourage the generation of a math placement exam and a math 101 course for those who need it. The current system requires our introductory chemistry students to test above a certain level of mathematical aptitude, otherwise the student would have to take the math 101 course prior to or concurrently with introductory chemistry. Another way the chemistry department has appealed to the broader Hanover community has been the introduction of various non-majors chemistry courses, including both Forensic Science and Fermentation Science. The latter course features an intendedly approachable topic of fermentation and it's many uses in food production including alcohol production, fermented vegetables, kombucha, cheese, sourdough bread, etc. The course features a mixture of traditional lectures accompanied with numerous on-site visits and discussions with industry experts. To date, the course has run once domestically featuring a nine-day trip across St. Louis, Indianapolis, Louisville, and Lexington (with many places in between) and once abroad featuring a three-week abroad trip across northern England, Scotland, Northern Ireland, and Ireland. This course is expected to continue in various iterations in the future, with a current discussion with a professor in German to run the course in Germany.

Current Department Staffing and Facilities

The chemistry department has seen a large amount of turnover in the past 5 years. In that time, the department has hired new, tenure-track professors in 3 of the 4 tenured positions including organic chemistry, physical chemistry, and biochemistry. In addition to the tenure track positions, we also have someone constantly filling the non-tenured visiting position that teaches 3 to 4 courses a year, primarily helping teach the introductory chemistry sections. This visiting role has held by 4 different professors in this 5-year span as the position is only held for 1 to 2 years before the professor moves on. Most of this turnover has occurred only to maintain the status quo. However this level of turnover seemingly affects the number of majors as years with more turnover typically lead to a lower number of chemistry majors for those years. Given all the time and effort that goes into maintaining the normal amount of professors, it is unfortunate that we haven't been given the opportunity to grow our department with a fifth, full-time position to add to our repertoire of specializations and/or have a consistent roster of professors.

Although the number of positions in the chemistry department has remained the same, the demand on the department has increased. Over the past few years, the college has changed in ways (and is changing in ways) that require more students to take chemistry courses. First off, the introductory chemistry sequence has always supported biochemistry, biology, and kinesiology and integrated physiology (KIP) majors as all these majors require both sections of introductory chemistry. These majors make up much of the population taking introductory chemistry and each of these majors is continuing to grow. In addition, the geology major and the recently added engineering program both require their students to take the first semester of introductory chemistry. Furthermore, as more departments in the sciences add their Bachelor of Science degrees, there is a heavier chemistry requirement as the B.S. in both biology and KIP both include two semesters of organic chemistry as potential options for the majors. The college is also at different in starting both a physical therapy and veterinary medicine graduate programs. While the chemistry department is not teaching courses for these graduate students directly, it is expected that these programs will attract more undergraduates with the intention of completing both their undergraduate and graduate studies at Hanover. As enrollment increases and more students require chemistry courses, the strain on the department will continue to rise.

One area of needed growth that would likely help with the number of majors is the department's research capabilities. While we do generally have various sources of financial support from operational budgets, money from lab fees, Summer research stipends and individual faculty development grants. the ability to purchase high-quality, research-grade equipment is difficult at Hanover. Our current instrumentation is largely old with the exception of a new FRIR with ATR (paid for by a grant) and a research grade Fluorescence and UV/Vis paid for with lab fees money. Our NMR spectrometer was also completely refurbished 3 years ago with a new spectrometer. However, beyond that our GC and GC/MS and HPLC as well as all of our atomic spectroscopy instrumentation is over 20 years old and needs repair on a much more regular basis. We also lack rotary evaporation equipment needed for research level organic synthesis. Regardless, research does still regularly occur and attendance at national ACS conferences is common, but further support in this regard as a means to interest and excite potential majors would be ideal.

Newer instrumentation, providing better research opportunities would greatly benefit the department. Given the importance of LC/MS and the research our new biochemistry professor has proposed, this would greatly benefit our students in research. Upgrading our gas chromatography area with instruments built in the current century and that are actually still being serviced by the manufacturer would also greatly benefit students looking to work in such areas as flavor chemistry or environmental chemistry. While we have a working ICP/MS, it is also quite old. In fact, it was the beta model for the manufacturer. While it still works, and the guy that designed/built it lives around the corner from the college, it would be nice to upgrade this instrument as well.

In addition, we are running out of lab space. Any expansion to the department would also need additional laboratory space. Despite doubling in the number of majors, thus twice as many research student, we have not been able to increase our physical facilities, and other than an unused lab dedicated to another department, there is no space to grow.

Need for Department Growth

As has been made abundantly clear in other sections as well as above, the need for a 5th tenure-track/tenured professor is strong. We essentially always have a 5th person in the visiting position (which is already a 3/5 or 4/5 position) but given that that position has such high turnover that it is likely hurting our ability to recruit majors. In addition, a 5th full-time position would bring with it more expertise that the current department does not have. As mentioned, we are currently stretched as far as we can in terms of being able to support the large amount on non-chemistry majors who require both introductory and organic chemistry, while simultaneously being able to offer as many different upper division courses for our majors. In order to increase the flexibility of our department, while also increasing the number of upper level courses, we need a 5th full time professor at the very least.

Though we have not yet acquired a 5th full-time professor, the chemistry department has been considering new program branches so align with the non-majors course offerings mentioned above. Programs in forensics or food science have been in the conversation but with our current staffing, we have been able to expand the number of courses taught in these areas, let alone put together an entire new program based on these topics. In addition to stand-alone chemistry tracks, we are also interested in collaborating on tracks with other departments including neuroscience (with psychology), chemical engineering (with engineering), and environmental chemistry (with geology and biology). We again as a department desire to grow and have an increasingly diverse list of program options for students, but these ideas are only just that currently: ideas. In order to begin to grow our number of tracks and programs, a 5th tenure-track position is absolutely essential.