PROPOSAL FOR A DOCTOR OF PHILOSOPHY PROGRAM IN CHEMISTRY ON THE INDIANAPOLIS CAMPUS

DEPARTMENT OF CHEMISTRY AND CHEMICAL BIOLOGY
PURDUE SCHOOL OF SCIENCE

INSTITUTION: Indiana University – Purdue University, Indianapolis (IUPUI)

SCHOOL: Science

DEPARTMENT: Chemistry and Chemical Biology

DEGREE PROGRAM TITLE: Chemistry

FORM OF RECOGNITION TO BE AWARDED/DEGREE CODE: Doctor of Philosophy (Ph.D.)

SUGGESTED CIP CODE: 400501

LOCATION OF PROGRAM/CAMPUS CODE: Indianapolis, IUPUI

PROJECTED DATE OF IMPLEMENTATION: August 2011

DATE PROPOSAL WAS APPROVED BY INSTITUTIONAL BOARD OF TRUSTEES:

_____

SIGNATURE OF AUTHORIZING INSTITUTIONAL OFFICER

_____

DATE RECEIVED BY COMMISSION FOR HIGHER EDUCATION

_____

COMMISSION ACTION (DATE)

A. ABSTRACT

Doctor of Philosophy (Ph.D.) in Chemistry

To be offered by the Purdue School of Science on the
Indiana University – Purdue University Indianapolis (IUPUI) campus

Objectives:

This proposal was prepared at the request of the Indiana Commission of Higher Education (ICHE). The objective of the proposal is to convert a well-established Purdue Ph.D. program in chemistry to a Purdue Ph.D. program in chemistry that is site-approved for Indianapolis (IUPUI). The Department of Chemistry & Chemical Biology at IUPUI has graduated a total of 318 graduate students since 1973 (273 Purdue M.S. degrees and, since 1986, 45 Ph.D. degrees). We have been training Ph.D. students for twenty-five years with 43 of 45 graduates earning the Purdue University Ph.D. degree, and two earning Indiana University degrees. The vast majority have gone on to successful careers in science, with destinations including academic institutions, industrial laboratories, and non-profit organizations. Our productivity in graduate degrees, while currently attributed to Purdue University, already exceeds the expected ICHE standards for productivity of graduate degrees. As an already mature program, strategic growth is cautiously expected in the future.

At present, by arrangement with our departmental counterpart at Purdue University West Lafayette (PUWL), the program is entirely delivered on the Indianapolis campus. However, its graduates are attributed to the graduate school at PUWL. An objective of the proposed degree is to train productive researchers that contribute to the economic development of central Indiana and beyond. Our program makes a Purdue graduate degree accessible to many Indiana residents, or place-bound students, that would otherwise be unable to take advantage of opportunities to advance their graduate education. A final objective for this research-focused Purdue Ph.D. program in the Department of Chemistry & Chemical Biology is to meet our expanded research faculty's own expertise to provide students with training in the latest research and investigative techniques to advance our scientific and technological frontiers. In addition, by selective and distinctive specialization, we are able to drive increased research collaboration across campus, enhancing externally funded scholarship at IUPUI. Historically, the Department has successfully attracted major funding from Federal agencies that have recognized that our program meets national needs for training in the sciences, a critical challenge to achieve global competitiveness in science and technology.

Clientele to be Served:

The program will continue to serve highly qualified, research-motivated baccalaureate and master's degree holders from Indiana, the U.S., and beyond.

Curriculum:

Our proposed Purdue Indianapolis Ph.D. program will require the traditional 90 credit hours of registration and the Graduate Advisory Committee of each student will determine the course work component. After decades of close ties to the Purdue West Lafayette Ph.D. program in chemistry, our curriculum has evolved to accommodate a range of student backgrounds and needs, as well as our regional requirements. The diversity of the research opportunities available in our program has demonstrated a capacity to attract excellent students, and allowed them to achieve scientific success in a variety of collaborative research endeavors. Students will typically enroll in at least 20 credit hours of course work. In parallel with the PUWL Ph.D. program, students will be required to present two one-hour seminars on topics unrelated to their research during the Oral Candidacy Examination and a Formal Seminar Presentation. These experiences will appear as two separate credit hours of CHEM 69500, Seminar, on Plans of Study and on transcripts.

Most students will enter the program with undergraduate and/or masters degrees in chemistry; we also seek talented and highly motivated students from allied fields including biochemistry, biology, chemical engineering, and other programs who have sufficient preparation to enable their success in the program. The blending of rich curricular backgrounds with ours has led to a distinctive, successful program producing capable students strongly impacting our scientific workforce needs in Indiana and elsewhere.

Employment Possibilities:

Our students have gone on to prominent postdoctoral appointments at research universities and, ultimately, have taken permanent positions in academia or in government and industrial laboratories (see Section C2 and accompanying table). Other graduates have gone directly into industry. In general, Ph.D. programs do not necessarily funnel graduates to local employers. That said, it is notable that a significant number of our graduates remain in the greater central Indiana workforce.

A. Program Description

1. Program description and objectives

The prime objective of this proposal is to recognize that we currently have an established Purdue Ph.D. program in chemistry at IUPUI, and to confirm this by converting that program to one that is site-approved for Indianapolis (IUPUI). The Department of Chemistry & Chemical Biology is a key contributor to research and learning on the IUPUI campus, an urban research university that has been designated by the Indiana University System as its "Health & Life Sciences" campus. It provides the course work foundation for undergraduate health programs, as well as the undergraduate degree programs that feed into professional programs and health-related graduate programs on campuses statewide. The Department is also the setting for an assemblage of externally funded research programs with strengths in sub-

disciplines that emphasize basic chemical research. The Ph.D. program currently provides training in the highest degree offered by institutions of higher education and complements the advanced degree programs in the professional schools on campus. The Department of Chemistry & Chemical Biology has been training Ph.D. students for twenty-five years with the vast majority earning the Purdue University Ph.D. in Chemistry, a degree awarded on the West Lafayette campus despite the fact that *100% of the course work and research is completed at IUPUI*. The Department of Chemistry & Chemical Biology of the Purdue School of Science is in the midst of a hiring initiative that will bring additional research-focused faculty members on board. Allowing IUPUI to retain rightful ownership of the degrees awarded by establishing a Purdue Ph.D. program that awards degrees in Indianapolis will prove to be more attractive to prospective new faculty. Further, as we undergo expansion, it will facilitate increased research collaboration across campus, and will make IUPUI more competitive for external funding. The latter is particularly important, as the present system has been seen to be confusing to grant reviewers.

The research focus of IUPUI has generated economic benefits for central Indiana. Since 1980, external funding for the Department exceeds $22 million and there is an auxiliary impact from additional millions from allied goods and services accompanying this figure. The graduate programs (45 Ph.D. and 273 M.S. graduates since 1986 and 1973, respectively) have made a significant contribution to this research enterprise. Right now, there are thirteen full time and many hourly individuals supported by external funding. Our chemistry research programs are contributing at ever-increasing levels to the transformation of the Indiana economy and its emphasis on the life sciences. The availability of Ph.D. students is essential in the recruiting of high-caliber research faculty and in the completion of the work contracted for in funded proposals.

The proposed program will be structured much like the Purdue West Lafayette Ph.D. program in the Purdue Department of Chemistry, the one in which we have been participating. The program is structured similarly to most Ph.D. programs in chemistry in that it is research intensive and requires 90 credit hours of registration. This program is characterized by an extensive research element that is closely monitored by a Graduate Advisory Committee. Our primary academic objective is to produce Ph.D. graduates who are trained in the latest technologies and techniques, who have the foundational skills to direct an independent program of research and who are competitive for positions in academia, industry and government.

2. Admission requirements, student clientele, and student financial support

All applicants must have earned, at the minimum, a four-year baccalaureate degree from a U.S. institution or an equivalent degree from a foreign institution. For admission, applicants must complete an online application and submit the Graduate Student Questionnaire, a personal statement, and original transcripts from all institutions previously attended. A minimum cumulative GPA 3.0 (on a 4.0 scale) is required for admission. Applicants must also arrange for letters of recommendation from three individuals who can evaluate the applicant's past work and comment on the applicant's potential for success at the graduate level. International applicants must also submit their official general GRE and TOEFL scores unless their undergraduate

degrees were earned from U.S. institutions or select international institutions where instruction was delivered exclusively in English.

The program will serve highly qualified, research-motivated baccalaureate and masters degree holders from Indiana and beyond. Applicants will be expected to have completed basic course work in biology, chemistry, physics, and mathematics for admission. Because the curriculum (see Section B3) is built for maximum flexibility, deficiencies can be addressed while in the program. The primary traits we seek in applicants are intellectual and research ability and motivation. We can adjust for academic background within the program through supplementary course work and tutorials. Our history is that approximately 26% of our Ph.D. students come from IUPUI B.S. and M.S. programs in Chemistry. This serves to the benefit of place-bound students in Indiana that may otherwise be unable to pursue a graduate degree elsewhere.

The Admissions Committee, comprised of graduate faculty members from the Department of Chemistry & Chemical Biology, reviews completed applications. The committee screens for GPAs of at least 3.0 in all degrees completed, supportive letters of recommendation, and a commitment to a research career as evidenced by previous research experience and/or a strong motivation for research revealed in the personal statement section of the online application. For international students, competitive GRE scores and minimum TOEFL scores (Paper 550, Computer 213, and Internet-based Testing (iBT) 79 with minimum sub-scores of 19 reading, 16 listening, 22 speaking and 18 writing) are required. These are also our current admission criteria. It should be noted that they are equal to and, in some cases, more stringent than those at PUWL. Applicants we wish to pursue are normally interviewed on campus unless this is not feasible (e.g. overseas or international); these students will be interviewed by phone or by Skype. The number of students admitted each year will be dependent on the quality of the applicant pool, the level of available institutional and faculty support, and the number of available laboratory openings. We anticipate recruiting an average of five to six students a year initially. Our program has traditionally been highly selective; graduate students are selected for their potential success as researchers.

Under our current arrangement with the PUWL Ph.D. program, students recommended for admission at IUPUI receive administrative approval from the Purdue West Lafayette Department of Chemistry. When the Chemistry & Chemical Biology Ph.D. is site-approved for IUPUI, admissions will be handled on the Indianapolis campus by the faculty of the Chemistry Ph.D. program as currently carried out; however, administrative approval will also be granted in Indianapolis, using the same criteria used by the PUWL Department of Chemistry.

Student support will be derived from institutional, departmental and faculty sources. At the institutional level there are competitive first-year fellowships and block grants to schools (distributed to departments) for one-year fellowships. In addition, there are funds to support graduate Teaching Assistants (TAs). Students whose native language in not English must pass a language test administered by the Department of English before they can be assigned to teaching. Our department has regularly supported 5-6 Ph.D. or thesis M.S. students as TAs, particularly during the first year of their degree program and another 3-4 on internal research fellowships. The department has recently

received additional funds through the IUPUI School of Science to support another 4-6 Ph.D. students. These students are critical to our teaching mission as they lead laboratory sections of courses in our growing undergraduate program. Finally, a number of students are supported on faculty research grants as Research Assistants (RAs). Faculty routinely include graduate support lines in their federal grant proposals. Recently, the School of Science has taken over the costs of most of the tuition for graduate students. This is critical for the support of the research faculty recently hired and those who will come on board in the future. Current support for TA or RA positions is a stipend of $21,000 for Ph.D. and M.S. students. With respect to the teaching and research duties of our students, both TAs and RAs receive tuition remission and paid health insurance premiums.

3. The program curriculum

Program requirements include selecting a Research Advisor, passing five Cumulative Exams, establishing a Graduate Advisory Committee, submitting a Plan of Study, passing an Oral Candidacy Exam, satisfactorily presenting a Formal Seminar, submitting a Research Progress Report, and submitting and defending a thesis. To provide degree consistency, the Purdue Indianapolis Ph.D. in Chemistry will be operated and managed in the same way as the current Purdue West Lafayette Ph.D. in Chemistry. Students who continue on from an IUPUI M.S. degree may select a Research Advisor at the outset of the Ph.D, and begin the other program requirements. Students new to IUPUI will commonly interview with prospective mentors early in the first fall semester and from that experience will select a Research Advisor as soon as feasible, but before the beginning of the second semester.

Cumulative examinations are started during the first month of the Ph.D. program, consistent with the system at PUWL. Notably, since 1993, IUPUI Chemistry faculty have been invited to write and grade cumulative examinations for PUWL students and administer PUWL-authored exams to our Ph.D. students. As our faculty and graduate student composition has changed and will continue to do so, we expect that the subdisciplinary foci of the examinations will change over time. Students take cumulative exams until they have succeeded in passing five sub-discipline tests in 20 opportunities.

Within six months of passing the fifth and final cumulative exam, Ph.D. students establish a Graduate Advisory Committee. The Committee is comprised of the Research Advisor, one member of the graduate faculty from the student's area of focus, and one member of the graduate faculty from outside the student's area of focus. Two members of the Committee must be from the Department of Chemistry & Chemical Biology. Under the current Ph.D. arrangement, the Committee is comprised of two faculty members from the IUPUI Department of Chemistry & Chemical Biology and two members of the Purdue West Lafayette Graduate Faculty (one as a thesis reader and one that participates fully in the thesis reading, oral exams and defense). The proposed Ph.D. program would not require a committee member from the Purdue West Lafayette Graduate Faculty. Based on experience it would seem that this is an onerous task for PUWL faculty, although one could be invited based on an expertise match with the student's research area. The Graduate Advisor meets with the student and

establishes a Plan of Study, subject to the approval of the Graduate Advisory Committee and the Graduate School. This document lists all courses and seminars the student is to complete. Research credits are not listed. Submission of this document to the Graduate School also establishes the membership of the Graduate Advisory Committee.

Six months after the Plan of Study has been approved, the Oral Candidacy Exam takes place. The Graduate Advisory Committee functions as the examining committee. This exam is an oral exam that is a defense of a written original research proposal and the student's research progress. The Committee will receive the comprehensive research proposal and the progress report two weeks before the exam. Passing this exam officially admits the student to candidacy for the Ph.D.

The Graduate Advisory Committee will meet with the student annually to help direct the research and to monitor progress. A written progress report, due at that meeting, will be filed with the department. The Graduate Advisory Committee will also serve as the thesis examining committee at the end of program.

The Plan of Study will list a set of courses that will support and facilitate the research area and two seminar experiences (CHEM 69500, Seminar), where the student delivers one-hour presentations on subjects inside and outside of the research area. The overall expectation of the Purdue Indianapolis Ph.D. program in chemistry is one that is heavily research-oriented with the thesis and publications derived from the research being the primary outcomes. Because there are no core requirements, the course work component of the Ph.D. can be individually crafted. This is particularly important in chemistry, a discipline that covers a wide range of sub-disciplines from theoretical to experimental chemistry: physical, organic, inorganic, and analytical chemistry; biochemistry, and chemical education. Finding an acceptable core to serve all of these areas would not be possible. The minimum number of credit hours needed to qualify for full-time status for domestic (international) students at IUPUI is six (eight), six (eight) and one (one) credit for fall, spring and a summer semester, respectively. Below is a sample Plan of Study for a student entering the program with a B.S. degree; a plan for an entering M.S. student would be expected to contain transferred coursework, approved by the Director of Graduate Studies on consultation with appropriate departmental faculty.

First Semester:	CHEM 62100 Advanced Analytical Chemistry	3 cr. hrs.
	CHEM 69600 Special Topics: Biomaterials	3 cr. hrs.
Second Semester:	CHEM 69600 Special Topics: Analytical Spectroscopy	3 cr. hrs.
	CHEM 65100 Special Topics: Advanced Organic Chemistry	3 cr. hrs.
Third Semester:	CHEM 53300 Introductory Biochemistry	3 cr. hrs.
	CHEM 69600 Special Topics: Bioanalytical Chemistry	3 cr. hrs.
Fifth Semester:	CHEM 69500 Seminar	1 cr. hr.
Sixth Semester:	CHEM 69500 Seminar	1 cr. hr.

The Ph.D. requires 90 credit hours of course work and research. Students who enter the Ph.D. program with an M.S. degree can apply a maximum of 30 credit hours toward the 90 credit hours required for the Ph.D. degree. Specific requirements for the Ph.D. degree are summarized below (these align with the requirements currently employed at PUWL):

1. Select Research Advisor and Graduate Advisory Committee
2. Cumulative Exams (details given below)
3. An approved Plan of Study form submitted by the end of the third semester
    a. 20 credit hours of approved graduate courses including:
        i. 9 credit hours in a major area of concentration
        ii. 9 credit hours outside the major area, in at least two other areas
        iii. Among items 3a(i) and 3a(ii), 12 credit hours must be 600-level courses.
        iv. 2 credits of CHEM 69500 Seminar
4. Written Research Report:
    a. During the 4th semester each student will provide a written research report to the Graduate Advisory Committee describing research progress and future plans.
5. Oral Candidacy Examination (details given below).
6. Formal Literature Seminar:
    a. Before the end of the 6th semester students must present a Formal Literature Seminar. His/her Graduate Advisory Committee and the faculty member in charge of the seminar program must approve the timing and content of the seminar.
7. 69900 Ph.D. Thesis Research
8. A thesis approved by the student's Graduate Advisory Committee
9. Defense of thesis

In addition to the above formal requirements, from their 3rd semester on, Ph.D. students are expected to participate in the Departmental Poster Session held every fall semester; this important event serves partially as a progress review for thesis students and also assists in developing presentation skills and preparation for the final thesis defense. Students admitted in January are expected to participate on or before their 4th semester in residence.

Cumulative Examinations

Ten Cumulative Examinations are offered each academic year. The student must pass five cumulative examinations by the end of the 4th semester (summer semesters are not counted). All students take the exam in a preannounced sitting, scheduled at the beginning of each academic year, when they write responses to as many of the offered sub-discipline tests as they wish to attempt. Traditionally, cumulative examinations are given once each month on Saturday mornings from 10:00 am to 12:00 noon in LD 326T. Occasionally, topics are posted. The Graduate Advisor will provide information on a topic as it is received. Students continue to take cumulative exams until they have succeeded in passing five sub-discipline tests within 20 or fewer opportunities. The counting of opportunities begins at the first sitting, normally the first semester of the

Ph.D. program, and runs contiguously thereafter. A hiatus from cumulative exams occurs during the summer semester.

Faculty members write individual questions, evaluate the responses, and set the passing level. Our faculty have shared examination responsibilities during the collaborative period thus ensuring expertise in appropriate levels of expectation. IUPUI Chemistry & Chemical Biology faculty will be administering and grading their students' cumes.

Oral Candidacy Examination and Research Summary

The Oral Candidacy Examination consists of an Original Proposal (OP) and a summary of the student's dissertation research and must be taken after the cumulative examinations have been completed but no later than the end of the fifth semester. The OP must originate with the student and not be related to their doctoral research.

The Original Proposal should include a concise statement of the problem or hypothesis to be tested, a statement of its significance and originality, why the proposal is superior to previous approaches (if applicable), how it is proposed to attack the problem, what difficulties can be expected in the course of the project and their solutions, and what will be accomplished by addressing the project. Although the student is expected to have a complete knowledge of the area(s) related to the OP, the written OP should not include an extensive review of the area but should outline a research program as opposed to a single experiment. The Original Proposal is to be the student's own work; consultation with any faculty member is not permitted.

The Research Summary should consist of a statement of research already accomplished as well as a discussion of directions that further research might take.

The Oral Examination will consist of a presentation by the student and discussion of the OP and Research Summary. Members of the committee are free to interrupt the student at any time and probe, by detailed questioning, the depth of the student's understanding of the proposed research.

4. Form of recognition

The degree offered would be a Purdue University Doctor of Philosophy (Ph.D.) in Chemistry through the Purdue University Graduate School. The degree would be offered exclusively on the Indianapolis campus, in a manner similar to the long-standing relationship with PUWL on undergraduate degrees.

At the time of degree creation, campus administration will identify an appropriate CIP code that will be approved by the Indiana Commission of Higher Education.

The diploma will read Doctor of Philosophy in Chemistry, Purdue University School of Science, Indianapolis.

5. List program faculty and administrators

Tenure -Track Faculty

Name	Rank	PhD	Postdoctoral
Haibo Ge, Ph.D.	Asst. Professor	University of Kansas	The Scripps Research Institute
John Goodpaster, Ph.D.	Asst. Professor	Michigan State University	National Institute of Standards and Technology (NIST)
Lei Li, Ph.D.	Asst. Professor	The Johns Hopkins University	University of Michigan
Eric Long, Ph.D.	Professor	University of Virginia	California Institute of Technology
David Malik, Ph.D.	Chancellor's Professor, Executive Vice-Chancellor, Indiana University Northwest	University of California, San Diego	University of Illinois
Michael McLeish, Ph.D.	Assoc. Professor	La Trobe University, Melbourne, Australia	University of California, Berkeley
Robert Minto, Ph.D.	Assoc. Professor, Director of Graduate Admissions	University of California, Berkeley	The Johns Hopkins University
Barry Muhoberac, Ph.D.	Assoc. Professor	University of Virginia	University of Texas Health Science Center at San Antonio
Christoph Naumann, Ph.D.	Assoc. Professor	Technical University of Munich, Germany	MPI for Polymer Research Mainz, Germany
David Nurok, Ph.D.	Assoc. Professor Emeritus	University of Cape Town, South Africa	AE and CI, North Rand, South Africa
Martin O'Donnell, Ph.D.	Chancellor's Professor, Director of Graduate Studies	Yale University	Université Catholique de Louvain, Belgium
Kyungsoo Oh, Ph.D.	Asst. Professor	University of Sussex, U.K.	University of Pennsylvania
Jingzhi Pu, Ph.D.	Asst. Professor	University of Minnesota	Harvard University
Rajesh Sardar, Ph.D.	Asst. Professor	The City University of New York, College of Staten Island	University of North Carolina
Jay Siegel, Ph.D.	Professor, Chair of Chemistry and Chemical Biology, Director of Forensic & Investigative Sciences Program	George Washington University	Virginia Bureau of Forensic Sciences
Pratibha Varma-Nelson, Ph.D.	Professor, Director of Center for Teaching and Learning	University of Illinois, Chicago	Stritch School of Medicine, Loyola University

Research Faculty (Non-Tenure Track)

Name	Rank	PhD	1st postdoctoral
Brenda Blacklock, Ph.D.	Asst. Research Professor	University of Alberta, Canada	The Johns Hopkins University
Donald Boyd, Ph.D.	Research Professor	Harvard University	Cornell University
Tax Georgiadis, Ph.D.	Asst. Research Professor	University of California, Los Angeles	Columbia University
Malea Kneen, Ph.D.	Asst. Research Professor	The University of Melbourne, Australia	University of California, San Francisco
James McCarthy, Ph.D.	Research Professor	University of Utah	Dow Chemical Co.
William Scott, Ph.D.	Research Professor	University of California, Los Angeles	Rockefeller University

Associate Research Faculty

Name	Rank	PhD	1st postdoctoral
Millie Georgiadis Ph.D.	Assoc. Professor, IUSM	University of California, Los Angeles	Columbia University
Samy Meroueh Ph.D.	Asst. Professor, IUSM	Wayne State University	Wayne State University

Curriculum Vitae for all faculty participating in training Ph.D. students and administering the proposed Ph.D. program can be found in Appendix C.

Although still below the high point of 18 tenure-track faculty in the mid-1990s, our faculty numbers have been partially restored in recent years (including four faculty hires in the last two years). Our Strategic Plan indicates additional research and teaching efforts will be needed. Two current faculty members, Drs. Jay Siegel and Martin O'Donnell, are approaching normal retirement age and will likely be replaced within three years. In addition, the opening of a new building in 2013 will provide the additional research space necessary to further increase the number of Chemistry & Chemical Biology faculty. Overall, an increase of one to two faculty per year is anticipated over the next five-year window. Concomitantly, additional Ph.D. students will be needed to drive faculty research and to provide instructional support for the large and growing undergraduate teaching mission at IUPUI.

In addition to the full-time faculty, Chemistry & Chemical Biology has two jointly appointed (official IUPUI appointments) faculty members whose primary appointments are at the IU School of Medicine (IUSM). These individuals also hold special graduate certification with the Purdue Graduate School that allows them to serve as outside members of Ph.D. and thesis M.S. committees.

6. Needed learning resources

Since we have been engaged in Ph.D. training for twenty-five years, we do not anticipate a need for additional learning resources. We have at our disposal excellent libraries on campus as well as online resources to successfully operate all aspects of Ph.D. training in Indianapolis. Other technical resources are available through core facilities in the School of Science, at the IUSM, and through Indiana University Bloomington. In addition, the Indiana Clinical and Translational Sciences Institute provides access to core facilities at Purdue University West Lafayette, at Indiana University Bloomington, and at the University of Notre Dame.

7. Other program strengths

In addition to covering all of the essentials of a sound undergraduate curriculum, offering an array of appropriate service courses, and delivering highly respected thesis and non-thesis Purdue M.S. degrees, the department has developed an extensive externally supported research program over the past 30 years. In 1999, we identified Life Science Chemistry as the organizational theme on which, where possible, we would concentrate our hires, while maintaining sufficient breadth to continue to support the aforementioned offerings. Beyond the strengths of individual research programs, departmental research expertise has evolved over time. This resulted in the formation of the Integrated Nanosystem Development Institute and the Center for Membrane Biosciences, centers of excellence incorporated as IUPUI Signature Centers that include other faculty on campus spanning departments in science and the professional schools, and throughout the central Indiana academic community. The Chemical Synthesis & Organic Drug Lead Development Core is operated through Chemistry and Chemical Biology to provide core facilities that allow departmental expertise to be more fully shared with the School of Medicine and local industry. There

are several faculty members in the department participating in other campus centers such as the Center for Computational Biology & Bioinformatics and the Indiana University Cancer Center. Several facilities centers provide research capabilities necessary for vibrant chemical research on the IUPUI campus, including the Nanoscale Imaging Center, and the Chemistry and Chemical Biology Nuclear Magnetic Resonance (NMR) and High-Resolution Mass Spectrometry (HRMS) Cores. The focus and expertise for science on both the atomic and molecular scales clearly gives us a distinction on campus that is fully compatible with the research goals in the Schools of Medicine as well as other programs, such as Engineering.

The Department of Chemistry & Chemical Biology has had a long-term commitment to including undergraduate students in the research enterprise. The presence of undergraduate students as active participants in research is a distinctive feature of the research environment in Chemistry & Chemical Biology and provides opportunities for graduate students to gain experience in mentoring and directing research projects.

B. Program Rationale

1. Institutional factors

IUPUI has identified itself as the urban research university of Indiana. Given the presence of a contingent of large health schools on campus, the Indiana University system has labeled IUPUI as the Health & Life Sciences campus in the state. Furthermore, the IUPUI Vision Statement is very clear about the future direction of the institution. The IUPUI Vision is:

> "to be the best urban research university by conducting world-class research, scholarship, and creative activities that develop knowledge and contribute to the economic growth and social advancement of Indiana and the nation and benefit humanity as a whole."

This vision together with the natural maturation of the IUPUI campus makes Indianapolis-based doctoral programs not just an aspiration but also a pressing need to fulfill the research and educational enterprise of central Indiana, the home of many life and health sciences industries. Building the research capacity of the Purdue School of Science at IUPUI has been on the agenda for at least 35 years. The Department of Chemistry & Chemical Biology began offering the M.S. degree in the early 1970s and admitted its first Ph.D. student in the mid 1980s. We are not new to this endeavor but we are on the cusp of a major expansion. The current hiring rate with more new positions planned will build the faculty and enhance external funding. Our new building (2013) will address the space shortage. With the growth of the undergraduate student population, the recruitment of more research-oriented faculty, and the increased external grant income, the Dean of the School of Science envisions a doubling of the Chemistry & Chemical Biology graduate student (thesis M.S. and Ph.D.) population in the next three years. A Ph.D program entirely delivered on the Indianapolis campus can only help make this vision a reality.

On a campus where many schools train a wide variety of health care professionals, a vital Department of Chemistry & Chemical Biology is a key element. At IUPUI, Chemistry & Chemical Biology provides fundamental education for students seeking admission to nursing, dental hygiene, physical therapy, and a number of other health-related programs in the Schools of Medicine, Dentistry, Engineering and Technology, Nursing, and Health & Rehabilitative Sciences. In addition, we train students at the baccalaureate and masters levels for application to medical and dental schools on campus as well as for programs in pharmacy, optometry and veterinary medicine elsewhere in the state. These responsibilities along with those associated with providing service courses to the general undergraduate population and graduating undergraduate majors who have the intention of joining the life sciences work force make our programs among the fastest growing on the IUPUI campus.

Our concept of the Urban Research University does not limit research to professional schools but rather raises the expectations across campus in order to elevate all units and provide multiple opportunities for cross-fertilization through collaboration. Our commitment to research is made clear in all of our hires. In order for us to be able to recruit top faculty talent and in order for them to be successful, we must have a robust, high quality graduate program at the Ph.D. level. We have already seen the impact of such programs over the past twenty-five years on faculty productivity, external funding success, and the overall intellectual climate of the department. We are also aware of the impact that these scientists-in-training can have as teaching assistants in our undergraduate laboratory courses. Indeed, they are essential to educating our undergraduate students yet, at the same time, they obtain their own teaching experience and credentials.

Our hope is to have this proposal approved for implementation as soon as possible. The new program will seamlessly replace our current one, so it will not impact other IUPUI units or those elsewhere in the state. The resources needed will be the same except for those associated with our plans for growth. We intend to generate these resources through increased enrollments and external funding success.

2. Student demand

We project admitting six to eight new Ph.D. students each year for the next two to three years. Beyond that our target number for recruitment will depend on faculty expansion that will accelerate when the new building opens. Because we have grown in the number of faculty with active research programs and in external funding that includes graduate student support lines, we anticipate that we will and must double the number of annual admissions. We foresee a Ph.D. program that emphasizes the quality of the student experience. We anticipate a steady-state enrollment of around 30 Ph.D. students plus a cohort of thesis-based M.S. students.

We have data on Ph.D. students thus far trained in chemistry as well as the students currently enrolled in the program. The vast majority of our graduates have gone on to successful careers in higher education and industrial or governmental positions. Below is a list of our Ph.D. graduates to date. One of the students was an Indiana University

Ph.D. student who, because of medical reasons, completed all the research for his doctoral thesis at IUPUI under the direction of one of our faculty.

Last	First	Degree Date	Last Known Position
Bennett (IU)	William	1986	Adv ChemTech, Louisville, KY – Sr. Scientist
Carfagna (IU)	Mark	1990	Eli Lilly, Indianapolis, IN
Steinmetz	Curtis	1991	Ctr. Ocean-Land-Atmospheric Studies, MD – Dir. Info. Sys.
Wu	Shengde	1992	Proctor & Gamble, Cincinnati, OH – Sr. Scientist
Parish	Carol	1994	Univ. of Richmond – Professor
Shen	Peidong	1994	Stanford Univ. – Genome Tech Center, Res. Assoc.
Liu	Shanghao	1995	Yale Univ. – Postdoctoral
Thompson	David	1995	Los Alamos National Lab
Peterson	Michael	1996	Duke University – Senior Analyst, Dept. of Chemistry
Stout	Joyce	1996	Eli Lilly, Indianapolis
Eason	Paula	1997	Meso Scale Technologies, Gaithersburg, MD
Lawin	Laurie	1997	Innovative Surface Technologies, St. Paul, MN – Scientist
Speelman	Brent	1997	Purdue Univ. – Postdoctoral
Ewing	Gregory	1997	Deceased
Roach	Steven	1997	Unknown
Liang	Qi	1997	NIST, MD – Staff Scientist
Ananias	Davina	1998	Roche Diagnostics, Indianapolis, IN
Huang	Xiaofen	1998	South China Univ. of Technology, PRC
de Oliveira	Glenisson	1998	Rhode Island College – Professor and Chair
Gao	Yang	1998	Genentech, San Francisco, CA – Sr. Scientist
Mattison	Kevin	1999	Malvern Instr., Westborough, MA – Principal Scientist
Hemkin	Sheryl	1999	Kenyon College – Assoc. Professor
Borts	David	1999	Univ. of North Carolina – Research Asst. Professor
Wang	Yingfan	1999	Univ. of Alabama – Postdoctoral
Chin	Frederick	2000	Stanford Univ. – Instructor, Radiology
Jalaie	Mehran	2000	Pfizer, La Jolla, CA
Turner	Jeffrey	2000	Roche Diagnostics, Indianapolis, IN
Cooper	Jeremy	2001	Wake Forest Univ. – Visiting Professor
Uhrhammer	Darrell	2001	Evert Software Systems, Chaska, MN – Scientist
Schefzick	Sabine	2002	Pfizer, La Jolla, CA

Chenoweth	Kimberly	2002	Smith College – Visiting Professor
Claussen	Craig	2003	Seradyn, Indianapolis, IN
Lecher	Carl	2003	Marian College – Assoc. Professor
Deverall	Miranda	2005	Roche Diagnostics, Indianapolis, IN
Seyrek	Emek	2005	Univ. Geneva, Switzerland - Lecturer
Murcia	Michael	2006	Nalco, Naperville, IL – Sr. Research Chemist
Lewis	Mark	2007	Entrepreneur, CA
Garg	Sumit	2008	Argonne Natl Lab – Postdoctoral
Kimble-Hill	Ann	2008	IU School of Medicine – Postdoctoral
Denton	Ryan	2009	IUPUI, Chemistry – Academic Specialist
Novotny	Allyson	2009	Univ. of Indianapolis – Asst. Professor
Trobaugh	Corey	2009	Cummins Automotive, Columbus, IN
Cissell	Kyle	2010	TransGenex Nanobiotech, Tampa, FL – Research Scientist
Goulding	Ann	2010	IUPUI, Chemistry – Instructor
Minner	Daniel	2010	IUPUI, Chemistry – Postdoctoral

3. Transferability

Generally, this is not a critical issue for Ph.D. students. We have admitted a few students who began Ph.D. work elsewhere and have allowed relevant course work to transfer.

4. Access to graduate and professional programs

The Ph.D. degree is a terminal degree for most students, therefore, this is not a common concern.

5. Demand and employment factors

Based on the success of our graduates (see above table in Section C2) over the past two and a half decades, we are confident that future graduates will continue to find excellent positions in industry, government and academia. To date 45 students have earned their Ph.D. degrees in chemistry at IUPUI. Forty-three have done so under the Purdue University West Lafayette Ph.D. and two under Indiana University Ph.D. programs. The summary of the placement outcomes for these graduates include sixteen who are in academic positions, eighteen who work in industry, and three who has found laboratory or management positions in government. Of the total, thirteen are presently employed in Indiana.

6. Regional, state and national factors

There are several chemistry Ph.D. programs in Indiana with the largest being at Purdue University West Lafayette (PUWL), the program through which we are now operating. The others are at Indiana University Bloomington (IUB) and the University of Notre Dame. The IUPUI campus also has a chemistry-related "life science" Ph.D. program in the School of Medicine as well as a biochemistry doctoral program, PUWL has both an agricultural biochemistry and medicinal chemistry and molecular pharmacology faculty and IUB has a Molecular and Cellular Biochemistry department. Each of these programs has a focus that makes each program different in some but not in all ways. For example, organic chemists may be on staff in most departments and each of these faculty will direct research in some aspect of organic chemistry. However, at other levels and in certain chemistry sub-disciplines, clear distinctions emerge. In most traditional chemistry programs, the six core areas include analytical, biological, chemical education, inorganic, organic and theoretical/physical chemistry.

PUWL Chemistry is subdivided into the six common core areas plus chemical biology and materials chemistry. Recently, it has been focusing its research into three strategic areas:

1. Drug Discovery and Disease Detection: this area includes natural product synthesis, chemical biology, human trials, target selection and validation, combinatorial chemistry, biomarker identification and detection, drug delivery, structure-based drug design, and chemical sensing and imaging.

2. Energy/Catalysis: this area includes solar/hydrogen, biofuels, organometallic synthesis, battery research, fuel cells, and hydrogen storage.

3. Soft Materials: this area includes membranes, DNA nanostructures, peptide assemblies and composite materials, carbohydrates, and chemical sensing and imaging.

IUB Chemistry has identified 26 research clusters and a program in Quantitative and Chemical Biology has been initiated recently. They participate in three interdisciplinary doctoral degrees in chemical physics, biochemistry, and a combined MD/Ph.D. program. Doctoral programs within their department, however, lie in the following six traditional areas:

1. Analytical Chemistry
2. Biological Chemistry
3. Inorganic Chemistry
4. Materials Chemistry
5. Organic Chemistry
6. Physical Chemistry

The **University of Notre Dame Department of Chemistry and Biochemistry** lists 13 research specialties, which are broadly represented in the following four fields of study:

1. Organic Chemistry
2. Physical Chemistry
3. Inorganic Chemistry
4. Analytical Chemistry

The **IU Schools of Medicine and Dentistry and the Purdue programs listed from departments outside of Chemistry** have research areas in the standard basic sciences with the obvious emphases on the appropriate applied areas of human health or agricultural science.

Chemistry at IUPUI, while relatively small compared to these long-standing programs, is growing in terms of faculty count and has Ph.D. opportunities in several areas including membrane biophysics, metabolic biochemistry, nucleic acids chemistry, protein chemistry, synthetic organic and medicinal chemistry, inorganic chemistry, combinatorial chemistry and analytical chemistry. As already mentioned, our major focal area is in Life Science Chemistry. This focus is synergistic with, and complementary to, research being done in biology, physics, medicine, dentistry and engineering on the IUPUI campus. In campus Signature Centers, there are labs working on bio-renewable products, structure and dynamics of membrane systems, nanotechnology, and tobacco cessation research.

There are Indianapolis-area residents with strong interests in graduate education who cannot relocate outside of the city for personal reasons. Many students are excited by the atomic/molecular level understanding of matter that is a central attribute of the chemical sciences. That interest cannot be satisfied by campus Ph.D. programs in the professional schools and, for those students, we are the only option. It is notable that at least eight of our Ph.D. graduates and four of our current students had/have such issues.

D. Program Implementation and Evaluation

There are no special steps we must take to implement the program. It will be operated in the same way as the current Purdue West Lafayette program except for the need to pass applications through the PUWL Department of Chemistry for administrative approval and the necessity of PUWL faculty representation on students' Graduate Advisory Committees. Students in the current program will migrate to the new program provided they are not too far along in their studies and provided that there are no burdensome procedures required.

The program will be evaluated using the following parameters:

1. Number of applicants and admitted students
2. Number of students attending

3. Number of students supported on grants and from institutional sources
4. Profiles of attendees (GPAs, GRE scores, graduate degrees, previous institutions attended)
5. Student performance in course work
6. Student performance on Cumulative Exams
7. Student research productivity (number of publications, presentations)
8. Awards and other special recognition
9. Time to degree
10. Number of graduates
11. Student placement: Number placed and quality of placements

Monitoring the above parameters will be the responsibilities of the Department Chair, the Director of Graduate Studies and the Chemistry & Chemical Biology Graduate Admissions Committee. Each year in early fall the recruiting data (Items 1 and 2) from the previous year will be collected and summarized. Historical data (Item 4) on matriculating students will also be compiled at that time. Each annual cohort will be followed through graduation to collect the information for items 9 and 10. Pass rates on the Cumulative Exams will be collected for the previous year in the summer (Item 6). Course work performance will be monitored semester by semester (Item 5). Data regarding student research productivity, awards and placement will be followed for three to five years post-graduation to capture program productivity that appears after leaving and to allow for a long-term view of career trajectory (Items 7, 8 and 11). We will also monitor annually the proportion of institutionally and grant-supported students (Item 3). It is an important measure of program effectiveness that institutional commitment and external research funding success be in balance.

We are prepared to change whatever is necessary if student performance does not measure up to expectations. What follows are steps that may be taken in cases where there are multiple examples of poor performance. In cases where the data indicate poor to mediocre performance on Cumulative Exams we will review students' academic history, preparatory materials made available to students, and courses taken prior to the exam. Solutions could involve changes in preparatory materials, changes within courses or among courses selected, and requiring more background of students admitted to certain areas of study. In cases of poor classroom performance, we will also consider instructional effectiveness and examination materials. In some cases, a change of instructor may be the best remedy. We will annually report the publications and other achievements of our students in order to publicly display expectations to all faculty mentors and students. This is a subtle way to support the notion that productivity (Item 7 above) is a critical outcome of the training. To this point in our history of Ph.D. training there have been no recurring problems with exams or courses that have required curricular or instructor changes.

E. Tabular Information

1. **Table 1: Enrollment and Completion Data**
2. **Tables 2A and 2B: Cost and Revenue Data**
3. **New Program Proposal Summary**

TABLE 3:
NEW ACADEMIC DEGREE PROGRAM PROPOSAL SUMMARY
26 January 2011

I. Prepared by Institution

Institution/Location: Indiana University-Purdue University Indianapolis
Program: Ph.D. in Chemistry
Proposed CIP Code: 400501
Base Budget Year: 2010-11

	Year 1 2011-12	Year 2 2012-13	Year 3 2013-14	Year 4 2014-15	Year 5 2015-16
Enrollment Projections (Headcount)	18	21	24	27	30
Enrollment Projections (FTE)	14	16	18	20	23
Degree Completion Projection	3	3	3	3	6
New State Funds Requested (Actual)	$ 0	$ 0	$ 0	$ 0	$ 0
New State Funds Requested (Increases)	$ 0	$ 0	$ 0	$ 0	$ 0

II. Prepared by Commission for Higher Education

New State Funds to be Considered for Recommendation (Actual)	$ _____	$ _____	$ _____	$ _____	$ _____
New State Funds to be Considered for Recommendation (Increases)	$ _____	$ _____	$ _____	$ _____	$ _____

CHE Code:
Campus Code:
County Code:
Degree Level:
CIP Code:

Comment:

Campus: Indiana University-Purdue University Indianapolis
Program: Ph.D. in Chemistry
Date: 26 January 2011

TABLE 1: PROGRAM ENROLLMENTS AND COMPLETIONS
Annual Totals by Fiscal Year (Use SIS Definitions)

	Year 1 2011-12	Year 2 2012-13	Year 3 2013-14	Year 4 2014-15	Year 5 2015-16
A. Program Credit Hours Generated					
1. Existing Courses	288	324	378	432	486
2. New Courses	36	54	54	54	54
Total	324	378	432	486	540
B. Full-time Equivalents (FTEs)					
1. Generated by Full-time Students	14	16	18	20	23
2. Generated by Part-time Students	0	0	0	0	0
Total	14	16	18	20	23
3. On-Campus Transfers	11	11	11	11	11
4. New-to-Campus	2	5	7	9	11
C. Program Majors (Headcounts)					
1. Full-time Students	18	21	24	27	30
2. Part-time Students	0	0	0	0	0
Total	18	21	24	27	30
3. On-Campus Transfers	15	15	15	15	15
4. New-to-Campus	3	6	9	12	15
5. In-State	6	7	8	9	10
6. Out-of-State	12	14	16	18	20
D. Program Completions	3	3	3	3	6

Campus: Indiana University-Purdue University Indianapolis
Program: Ph.D. in Chemistry
Date: 26 January 2011

TABLE 2A:
TOTAL DIRECT PROGRAM COSTS AND SOURCES OF PROGRAM REVENUE

	Year 1		Year 2		Year 3		Year 4		Year 5	
	FTE	2011-12	FTE	2012-13	FTE	2013-14	FTE	2014-15	FTE	2015-16
A. Total Direct Program Costs										
1. Existing Departmental Faculty Resources	2.2	$ 198,000	2.2	$ 198,000	2.2	$ 198,000	2.2	$ 198,000	2.2	$ 198,000
2. Other Existing Resources		40,000		40,000		40,000		40,000		40,000
3. Incremental Resources (Table 2B)		61,100		122,300		183,400		244,600		305,700
TOTAL		$ 299,100		$ 360,300		$ 421,400		$ 482,600		$ 543,700
B. Sources of Program Revenue										
1. Reallocation		$ 238,000		$ 238,000		$ 238,000		$ 238,000		$ 238,000
2. New-to-Campus Student Fees		40,100		80,300		120,400		160,600		200,700
3. Other (Non-State): External Research Grants		21,000		42,000		63,000		84,000		105,000
4. New State Appropriations										
a. Enrollment Change Funding		0		0		0		0		0
b. Other State Funds		0		0		0		0		0
TOTAL		$ 299,100		$ 360,300		$ 421,400		$ 482,600		$ 543,700

Campus: Indiana University-Purdue University Indianapolis
Program: Ph.D. in Chemistry
Date: 26 January 2011

TABLE 2B:
DETAIL ON INCREMENTAL OR
OUT-OF-POCKET DIRECT PROGRAM COSTS

	Year 1		Year 2		Year 3		Year 4		Year 5	
	FTE	2011-12	FTE	2012-13	FTE	2013-14	FTE	2014-15	FTE	2015-16
1. Personnel Services										
a. Faculty	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
b. Support Staff	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
c. Graduate Teaching Assistants	0.5	21,000	1.0	42,000	1.5	63,000	2.0	84,000	2.5	105,000
Total Personnel Services		21,000		42,000		63,000		84,000		105,000
2. Supplies and Expense										
a. General Supplies and Expense		0		0		0		0		0
b. Recruiting		0		0		0		0		0
c. Travel		0		0		0		0		0
d. Library Acquisitions		0		0		0		0		0
Total Supplies and Expense		0		0		0		0		0
3. Equipment										
a. New Equipment Necessary for Program										
b. Routine Replacement										
Total Equipment		0		0		0		0		0
4. Facilities		0		0		0		0		0
5. Student Assistance										
a. Graduate Fee Scholarships		40,100		80,300		120,400		160,600		200,700
b. Fellowships										
Total Student Assistance		40,100		80,300		120,400		160,600		200,700
Total Incremental Direct Costs		$ 61,100		$ 122,300		$ 183,400		$ 244,600		$ 305,700

Appendix A

Graduate Course Descriptions for IUPUI Chemistry & Chemical Biology

Course Title:	Introductory Biochemistry
Course Number:	53300
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Prerequisites:	C342 or equivalent
Description:	A rigorous one-semester introduction to biochemistry.

Course Title:	Inorganic Chemistry
Course Number:	54200
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Prerequisites:	C362 or equivalent or consent of instructor
Description:	A survey of the chemistry of main group and transition elements in which descriptive chemistry is wedded to qualitative theories of bonding and structure.

Course Title:	Intermediate Physical Chemistry
Course Number:	57500
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Prerequisites:	C362 or equivalent
Description:	Quantum theory of atoms and molecules, theories of chemical bonding, molecular spectroscopy, methods for determining molecular structure, and electrical and magnetic properties.

Course Title:	Special Assignments
Course Number:	59900
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	1-4
Prerequisites:	Consent of instructor
Description:	Directed reading or special work not included in other courses.

Course Title:	Advanced Analytical Chemistry
Course Number:	62100
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Prerequisites:	C311 and C410
Description:	A critical survey of recent developments in chemical and instrumental methods of analysis.

Course Title:	Chromatic Methods of Analysis
Course Number:	62900
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Prerequisites:	C410 or equivalent or consent of instructor.
Description:	Principles and practice of modern gas and liquid chromatography are developed from an integrated point of view. Emphasis is placed on those features useful in practical analytical separations. Instrumentation is described and evaluated using chemical examples from recent literature. Although column techniques are emphasized, thin-layer chromatography and electrophoresis methods also are described. Offered in alternate years.

Course Title:	Biochemistry: Structural Aspects
Course Number:	63400
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Prerequisites:	C311, C342, C361, and C362 or equivalent.
Description:	Chemistry of materials of biochemical interest: carbohydrates, lipids, proteins, amino acids, nucleic acids, porphyrins, biochemistry of blood.

Course Title:	Biochemical Mechanisms
Course Number:	63600
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Prerequisites:	One year of physical chemistry and 651.
Description:	The chemical basis of enzymatic catalysis with particular emphasis on catalytic interactions important in aqueous media.

Course Title:	Advanced Inorganic Chemistry
Course Number:	64100
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Prerequisites:	C430 or 542 or equivalent or consent of instructor.
Description:	Survey of main group and transition metal chemistry. Main group special topics, bonding and structure of boron hydrides. Coordination chemistry, bonding models in coordination compounds. Transition metal organometallic chemistry, ligand types and reactivity patterns. Survey of inorganic NMR spectroscopy.

Course Title:	Advanced Organic Chemistry
Course Number:	65100
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Prerequisites:	C342 or equivalent
Description:	Modern structural organic chemistry, including introductions to molecular orbital theory and reaction mechanisms. Prerequisite: a year's course in organic chemistry.

Course Title:	Synthetic Organic Chemistry
Course Number:	65200
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Prerequisites:	651 or 657
Description:	An advanced treatment of methods for preparing major types of organic functionalities and bonds, stressing stereochemical control and involving mechanisms for understanding the reactions employed.

Course Title:	Reaction Mechanisms
Course Number:	65700
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Prerequisites:	C342 or equivalent or consent of instructor.
Description:	Modern structural organic chemistry, introduction to physical organic chemistry, mechanisms of representative reactions, and methods used for understanding reactivity in organic transformation.

Course Title:	Quantum Chemistry
Course Number:	67200
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Prerequisites:	One year of physical chemistry
Description:	Basic principles of classical and quantum mechanics, exact solutions for simple systems, approximation methods, atomic structure, spectroscopy, application of group theory, theory of molecular binding.

Course Title:	Chemical Kinetics
Course Number:	67500
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	2-3
Prerequisites:	One year of physical chemistry
Description:	Experimental and theoretical considerations of chemical reaction rates and mechanisms.

Course Title:	Statistical Thermodynamics
Course Number:	68200
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Prerequisites:	C362 or equivalent.
Description:	Application of statistical mechanics to the description of imperfect gases, liquids, and solutions; to order-disorder phenomena in solids and surfaces; and to absolute reaction rate theory.

Course Title:	Seminar
Course Number:	69500
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	0-1
Description:	Groups meeting for review and discussion of important current literature in analytical, biological, inorganic, organic, and physical chemistry. Each graduate student is required to attend the seminar of his or her major subject.

Course Title:	Special Topics in Chemistry
Course Number:	69600
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Description:	Solid-Phase Synthesis and Combinatorial Chemistry: Theory and Practice This course will explore how the tools of solid-phase synthesis and combinatorial chemistry are being used to solve a wide variety of problems requiring chemical solutions. Examples range from medicinal chemistry and drug discovery to new catalyst creation, from new “chiral selectors” to new biochemical probes. The course will focus on the rationale for employing a combinatorial approach in chemical discovery. It will teach the basics of solid-phase organic chemistry, and the methodology, equipment, and analytical technology employed to use it as a tool to rapidly and effectively carry out a combinatorial approach to problem solving.

Course Title:	Special Topics in Chemistry
Course Number:	69600
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Description:	Seminars in Nucleic Acid Chemistry Discussions of the bio-organic chemistry of DNA and RNA including their chemical syntheses, structures, enzymatic manipulation, and analyses of ligand (drug, metal ion, and protein) binding.

Course Title:	Special Topics in Chemistry
Course Number:	69600
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Description:	Bioinorganic Chemistry This course aims to understand biological problems via the inorganic chemistry approaches. Inorganic elements are essential to the life processes. During the course, the role of naturally occurring inorganic elements in biology will be studied. How metals are introduced into biological systems as probes and drugs will be addressed as well. Specific topics include oxygen transportation, electron transfer, metal toxicity and control as well as metallodrugs.

Course Title:	Special Topics in Chemistry
Course Number:	69600
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Description:	Biomimetic Chemistry This highly interdisciplinary graduate-level course offers an introduction into the fascinating world of biomimetic systems considered from the perspectives of chemistry, biology, physics, and engineering. The course provides a basic overview of the fundamental principles of molecular assembly of polymers and biomolecules into supramolecular systems and discusses corresponding scientific and technological applications.

Course Title: Special Topics in Chemistry
Course Number: 69600
Home School: School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours: 3
Description: Chemical Analysis of Alcohol & Drugs
This course will focus on the analysis and identification of commonly abused chemicals such as ethanol, inhalants, controlled substances and prescription drugs. The history, legal issues, synthesis, chemical/physical properties, and laboratory analysis of these materials will be discussed. Special topics will also include source determination by isotope ratio mass spectrometry, impurity profiling or genetic analysis, newly introduced analytical methods such as desorption ionization techniques in mass spectrometry and investigations of the mechanisms for canine detection of drugs. An optional laboratory section will also be offered in which students will complete practical exercises utilizing spectroscopy, chromatography and mass spectrometry that reflect common practice in forensic science laboratories.

Course Title: Special Topics in Chemistry
Course Number: 69600
Home School: School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours: 3
Description: Biosynthesis and Physiology
Intermediary metabolism, biosynthesis and regulation.

Course Title: Special Topics in Chemistry
Course Number: 69600
Home School: School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours: 3
Description: Organometallics
This course covers a number of notable advances in the field of organometallic chemistry, and the particular emphasis will be made in the use of transition metals in synthetic organic chemistry. *The formation of carbon-carbon and carbon-heteroatom (O, N, S) bonds* will be examined through detailed reaction mechanisms and extensive synthetic examples.

Course Title: Special Topics in Chemistry
Course Number: 69600
Home School: School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours: 3
Description: Instrumental Analysis-Trace Evidence
This course will focus on the use of instrumental techniques to analyze trace evidence types such as ink, fibers, paint, adhesives, tape, ignitable liquids, and explosives. A separate lab section will include practical laboratory exercises utilizing spectroscopy, chromatography and mass spectrometry that reflect common practice in forensic science laboratories. Special topics will also include current research such as pattern recognition techniques, novel sampling methods, and provenance determination.

Course Title: Special Topics in Chemistry
Course Number: 69600
Home School: School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours: 3
Description: Drug Discovery
This one semester course will explore the strategies and chemistry underlying drug discovery. The student will also learn the chemical and biochemical basis of drug action for a representative series of drugs. Traditional screening and lead modification approaches will be discussed, along with the latest developments in drug discovery based on "rational" computer-assisted design, combinatorial technology, and biotechnology. The student should have taken a graduate level organic chemistry course and have a basic understanding of organic reaction mechanisms, amino acids and proteins. Taking the course without this background requires permission of the instructor. Previous coursework in biochemistry would also be helpful but is not essential.

Course Title: Special Topics in Chemistry
Course Number: 69600
Home School: School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours: 3
Description: Bioanalytical Chemistry
Introduction to concepts in biosensors and biosensing. The discussion topics include optical, electrochemical and novel biosensors, microarrays, SPR, proteomics, hybridization, immunoassays, reporters and labels, and nanotechnology.

Course Title:	Special Topics in Chemistry
Course Number:	69600
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Description:	Organic Spectroscopy Application of modern analytical techniques including 1- and 2-D nuclear magnetic resonance (NMR) spectroscopy, infrared spectroscopy, and mass spectrometry to the rational identification of organic structures.

Course Title:	Special Topics in Chemistry
Course Number:	69600
Home School:	School of Science, Dept. of Chemistry and Chemical Biology
Credit Hours:	3
Description:	Introduction to Medicinal and Agricultural Chemistry Topics will include the physiochemical properties of drugs and agrochemicals; drug structure and metabolisms; and enzymes, receptors and DNA as drug targets. Several Case studies of commonly used pharmaceuticals will be presented.

Appendix B

Demand and Employment Analysis

Rather than speculate or project demand for this program, we will rely on our experience with Ph.D. training in Chemistry & Chemical Biology at IUPUI. It is not typical to expect that a Ph.D. program will have significant local impact on the region in terms of permanent employment. Rather the Ph.D. is a global degree with recipients most frequently seeking high-level positions wherever they exist, sometimes including opportunities in other countries. Despite this we note that thirteen of our forty-five Ph.D. graduates are currently employed in Indiana. These are listed in sections C2 and C5 along with out-of-state faculty, governmental and industrial positions taken by the rest of our graduates. We are confident that such success in placement of our graduates, both locally and beyond, will continue even as our program grows.

Appendix C

Faculty Curriculum Vitae