

CWRU Action Form for Majors/Minors/Programs/Sequences/Degrees

Docket# \_\_\_\_\_  
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College/School: College of Arts & Sciences  
 Department: Chemistry

PROPOSED:       X major  
                   \_\_\_\_\_ **minor**  
                   \_\_\_\_\_, program  
                   \_\_\_\_\_ sequence  
                   \_\_\_\_\_ degree

**APPROVED**  
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TITLE: Bachelor of Arts in Chemical Biology

EFFECTIVE: Fall 2011 or ASAP

DESCRIPTION:

Chemical Biology investigates ways in which chemistry may be used to solve biological questions. Research in chemical biology focuses on small molecules in order to understand the fundamental aspects of living systems using chemical tools. It is distinct from other areas in that it uses chemistry as a foundation upon which to solve biological challenges.

A study of Chemical Biology requires a strong foundation in the traditional areas of biology and chemistry as well as an introduction to biochemical and analytical approaches to research. Supplementary coursework in math and physics rounds out the preparation for a degree in chemical biology.

This degree program is intended for individuals seeking careers that utilize chemistry to solve problems affecting living systems. Students intending to pursue post-graduate research or professional training, students seeking training as a health professional or students looking for a career in the biotechnology pharmaceutical industry will benefit from this major. Whether the goal is an **undergraduate, graduate or professional degree, this sequence of courses will provide strong preparation for further education or for a fulfilling career.**

Sample Sequence of Required Courses for the Major

	Fall	Spring
First Year	CHEM 105 (3) CHEM 113 (2) BIOL 214 (4) MATH 125 (4)	CHEM 106 (3) BIOL 215 (4) MATH 126 (4)
Second Year	CHEM 323 (3) CHEM 233 (2) PHYS 115 (4)	CHEM 328 (3) CHEM 234 (2) PHYS 116 (4)
Third Year	CHEM 301 (3) CHEM 304 (4)	ChemBio Elective' (3) CHEM 305 (3)
Fourth Year	ChemBio Elective" (3)	CHEM 398 (3)

# 6 credits of Advanced Electives are required. The following list includes courses within the chemistry department that could be used to fulfill this requirement. In addition, courses from other allied departments, e.g., Biochemistry, Biology, Chemical Engineering or Macromolecular Science and Engineering, numbered 300 or higher, could be used to fulfill this requirement. Course specific approval should be addressed with the Undergraduate Affairs Committee of the chemistry department.

NB: Courses listed in BOLD represent significant revisions of existing courses.

## Chemistry Courses

CHEM 105	Principles of Chemistry I
CHEM 106	Principles of Chemistry II
CHEM 113	Chemistry Laboratory
CHEM233	Introductory Organic Chemistry Laboratory
CHEM234	Chemical Biology Laboratory
CHEM301	Introductory Physical Chemistry I
CI-IEM 304	Quantitative Analytical Chemistry
CI-IEM 305	Introductory Physical Chemistry Laboratory
CHEM323	Organic Chemistry I
CHEM328	Introduction to Biochemistry
CHEM398	Chemical Biology Capstone or Independent Research/Senior Capstone

Elective Courses (Courses from other allied departments, e.g., Biochemistry, Biology, Chemical Engineering or Macromolecular Science and Engineering, numbered 300 or higher, could be used to fulfill this requirement.)

## Chemistry Courses

CHEM 302	Introductory Physical Chemistry II
CHEM 311	Inorganic Chemistry I
CHEM 324	Organic Chemistry II
CHEM 325	Physical Methods for Determining Organic Structure
CHEM 329	Chemical Aspects of Living Systems
CHEM 333	Medicinal Chemistry and Drug Development
CHEM 339	Bioinorganic Chemistry
CHEM 397	Undergraduate Research

## Biochemistry Courses

BIOC 308	Genes and Genetic Engineering
BIOC 312	Proteins and Enzymes
BIOC 334	Structural Biology

## Biology Courses

BIOL 300	Dynamics of Biological Systems
BJOL 306	Dynamics of Biological Systems II
BIOL 328	Plant Genomics and Proteomics
BJOL 334	Structural Biology
BIOL 343	Microbiology

## Chemical Engineering Courses

ECHE 361	Separations Processes
ECHE 364	Chemical Reaction Processes

## Macromolecular Science Courses

EMAC 303	Structure of Biologic Materials
EMAC 370	Polymer Chemistry and Industry

## Justification

**This new undergraduate curriculum is unique to CWRU. We can find no other institutions offering an undergraduate degree in Chemical Biology.** At the same time, several graduate programs in Chemical Biology have been introduced, e.g., University of California San Francisco (<http://ccb.ucsf.edu/>), Harvard College (<https://chembio.mcd.harvard.edu/>), University of California Berkeley (<http://cbgp.cchem.berkeley.edu/>) and the University of Michigan (<http://www.ehmbio.umich.edu/>).

**This new degree represents a significant change from the traditional chemistry major.** While some of the classes intended for this program would also meet expectations of a "regular" chemistry major, substantial changes in several courses are intended to highlight the interdisciplinarity of this new field of research and study. Courses undergoing significant change include the following:

**CHEM 323 Organic Chemistry I**—This is the foundational course for this new major. The course will introduce organic chemistry with particular emphasis on the chemistry of carbonyl compounds. Understanding the reactions and mechanisms of these compounds is critical to understanding the chemical foundation of biochemical pathways. This course will supplant the traditional approach to

Organic Chemistry and will serve as the prerequisite course for further studies of biochemical pathways (CHEM 328). In addition, CHEM 324, Organic Chemistry II, will be revised to build on the material presented in CHEM 323. CHEM 324 will expand **discussions to include other functional groups and explore reaction mechanisms in more detail. Traditional chemistry majors could** replace the CJ-DEM 223/224 sequence with CHEM 323/324.

**CHEM 234** Chemical Biology Laboratory-this updated and revised second semester course will incorporate new experiments into a mature synthetic curriculum. The first semester course, CHEM 233, will introduce the techniques of chemical synthesis and will be applicable to both Chemical Biology majors and Chemistry majors. CHEM 234 will be offered in two "flavors": the traditional laboratory for those students wanting to pursue the traditional major and a new lab course that emphasizes the techniques of biochemistry. These techniques include peptide and nucleic acid synthesis, PCR, high throughput screening and chemical tagging of **biomolecules.**

**CHEM 301** Physical Chemistry I-Like CHEM 323, this course presents a foundation upon which chemical biology will build. It represents a major overhaul of the traditional first semester course. The emphasis of the course will be the energetics of chemical biology and it will include thermodynamics, kinetics, electrochemistry and quantum mechanics. The follow-on course, CHEM 302, will also be revised to build on the material presented in CHEM 301 and to incorporate examples more pertinent to chemical biologists. CHEM 302 will investigate the spectroscopic and quantum nature of living systems.

**CHEM 398** Chemical Biology Capstone-The new major will require a specific capstone course. A new Chemical Biology Capstone course will be developed that will emphasize the use of computers to study biological molecules and systems. This new capstone will have an enrollment limit as do all SAGES capstone courses. Multiple sections of the course will be offered to meet the expected demand. In addition, students may still choose to pursue the traditional independent research capstone currently offered.

**BIOL 214 and 215**-These classes are required of all Chemical Biology majors. No other chemistry major requires these classes.

**Further modifications are anticipated as a result of this new major. These include new elective courses in Biophysical Chemistry, Advanced Chemical Biology Laboratory and Bioinformatics.** In addition, interdisciplinary courses codeveloped between chemistry faculty and faculty from other departments in the College of Arts & Sciences are being considered. An example of this is a course in Synthetic Biology.

### **Financial Impact**

A significant factor in designing this new major has been the observation that nearly 70% of all BA Chemistry majors enroll in both BIOL 214 and 215. (Only 30% of BA Chemistry majors also enroll in BIOL 216.) We believe these students represent a cadre of preprofessional students seeking to pursue further education and a career in the health sciences. It is felt that this new major will better prepare these students for that career path as well as open additional career opportunities previously unavailable to them. Further, significant changes are anticipated for the MCAT as well as admission requirements to medical school. This new major will meet **those requirements.**

We do not anticipate a significant cost to implement this program immediately. By redesigning existing courses and introducing **several new courses, we can immediately meet the needs of the first cohort of students pursuing this major. Our initial estimates** are that about 90 (70% of 135 students) of our current BA Chemistry majors will opt to switch to a Chemical Biology degree. This switch will not overburden the department significantly at the outset.

However, because of recruiting strategies currently in place at CWRU and anticipated changes to the MCAT, we expect the program to grow by 30% within four years. This will put additional strain on both the human and physical resources available to the department. We will need additional faculty, graduate students and both teaching and research laboratory space to meet the demand. Specific information on these costs is included in the additional information attached.

**Further justifications and financial impacts are included in the attached documentation.**

Is this major/minor/program/sequence/degree:  new  
,modification  
,replacement

If modification or replacement please elaborate:-----

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Does this change in major/minor/program/sequence/degree involve other departments?  Yes  No

If yes, which departments? Biochemistry, Biology, Chemical Engineering, Macromolecular Science & Engineering

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Contact person/committee: Mike Kenney, Chair, Undergraduate Affairs Committee of the Chemistry Department

SIGNATURES:

Department Curriculum Chair(s)/Program Directors:

Michael Kenney 3-4-11

Chemistry Department Chair:

Mary Barber 3/4/11

Biochemistry Department Chair:

Michael H. ...

Biology Department Chair:

ll 3/4/2011

Chemical Engineering Department Chair:

Mal ... 3/10/2011

Macromolecular Science & Engineering Department Chair:

... 3/2/11

College/School Curriculum Committee Chair:

M. Kenney/cas 3-17-11

College/School Dean(s):

J. Robin/cas 3-17-11

~~Curriculum Committee Chair:~~

File copy sent to:

**gistrar**  
 -----Other:

T

Mathematics Department Chair:

... 3/11/2011

Physics Department Chair:

Ralph ... 3/8/2011

# CHEMICAL BIOLOGY BACHELOR OF ARTS

FALL SEMESTER- Year 1		SPRING SEMESTER- Year 1	
<i>Courses</i>	<i>Credits</i>	<i>Courses</i>	<i>Credit</i>
CHEM 105 – Principles of Chemistry I	3	CHEM 106 – Principles of Chemistry II	3
MATH 125 – Mathematics I	4	MATH 126 – Mathematics II	4
BIOL 214 – Genes and Evolution	3	BIOL 215 – Cells and Proteins Laboratory	3
BIOL 214L – Genes and Evolution Lab	1	BIOL 215L – Cells and Proteins Laboratory	1
Sages First Seminar	4	CHEM 113 – Principles of Chem. Lab	2
PHED activity course(s) or Varsity Sport	0	Sages University Seminar	3
<b>Total Hours</b>	<b>15</b>	<b>Total Hours</b>	<b>16</b>
FALL SEMESTER – Year 2		SPRING SEMESTER – Year 2	
<i>Courses</i>	<i>Credits</i>	<i>Courses</i>	<i>Credit</i>
CHEM 323 – Organic Chemistry I	3	CHEM 328 – Intro. to Biochemistry	3
CHEM 233 – Organic Chemistry Lab	2	CHEM 234 – Chemical Biology Lab	2
PHYS 115 – Introductory Physics I	4	PHYS 116 – Introductory Physics II	4
Sages University Seminar	3	Arts/Humanities Elective	3
PHED activity course(s) or Varsity Sport	0	PHED activity course(s) or Varsity Sport	0
Open Elective	3	Open Elective	3
<b>Total Hours</b>	<b>15</b>	<b>Total Hours</b>	<b>15</b>
FALL SEMESTER – Year 3		SPRING SEMESTER – Year 3	
<i>Courses</i>	<i>Credits</i>	<i>Courses</i>	<i>Credit</i>
CHEM 301 – Physical Chemistry I	3	CHEMBio Elective	3
CHEM 304 – Quantitative Analy. Chem.	4	CHEM 305 – Physical Chemistry Lab	3
Social Science Elective	3	Sages Departmental Seminar	3
PHED activity course(s) or Varsity Sport	0	Global & Cultural Diversity Elective	3
Open Elective	3	Open Elective	3
Open Elective	3	Open Elective	3
<b>Total Hours</b>	<b>16</b>	<b>Total Hours</b>	<b>15</b>
FALL SEMESTER – Year 4		SPRING SEMESTER – Year 4	
<i>Courses</i>	<i>Credits</i>	<i>Courses</i>	<i>Credit</i>
CHEMBio Elective	3	CHEM 398 – Sages Capstone	3
Arts/Humanities Elective	3	Social Science Elective	3
Open Elective	3	Open Elective	3
Open Elective	3	Open Elective	3
Open Elective	3	Open Elective	3
<b>Total Hours</b>	<b>15</b>	<b>Total Hours</b>	<b>15</b>

CHEMICAL BIOLOGY REQUIREMENTS	61
GENERAL ED REQUIREMENTS	25
OPEN ELECTIVES	36
<b>TOTAL</b>	<b>122 CREDITS</b>

1. How is the proposed program important to the department?
  - a. Discuss the relationship between the proposed new program and the current undergraduate program, including its impact with respect to allocation of resources.

This new major will be the first of its kind in the United States. While other schools have renamed their departments or marketed their course work to reflect the growing field of Chemical Biology, we are unable to find any other institution offering an undergraduate degree in the discipline. At the same time, several graduate programs in Chemical Biology have recently been launched, e.g., University of California San Francisco, University of California Berkeley, University of Michigan and University of Massachusetts.

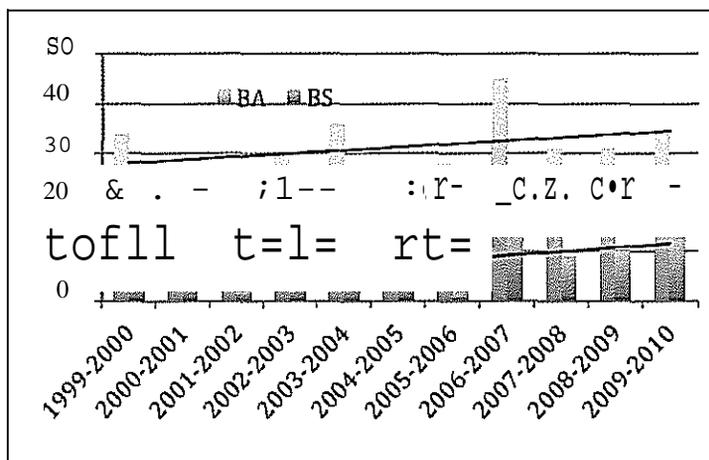
Chemistry, as a discipline, is very mature. Most chemistry departments and majors are based on the traditional divisions of analytical, biochemical, inorganic, organic and physical chemistry. At the same time, the research emphasis of most departments, including our own, has shifted to a more interdisciplinary format. While a strong foundation in chemical principles is still a requirement for research and development, greater integration of multiple areas within chemistry and outside of chemistry is needed. This new major represents an interdisciplinary approach to chemistry.

Initially, we anticipate a simple redistribution of students within the department. The number of BA Chemistry majors will decrease by the same amount as the number of BA Chemical Biology majors will increase. Within three years, we anticipate that the number of Chemical Biology majors will increase resulting in a 30% growth in the number of chemistry majors. This is based on the recent growth in the number of "premed" students enrolling at CWRU.

As a result, the initial financial impact will be negligible. However, the growth in the number of majors will quickly require additional resources in the form of faculty, laboratory space (both teaching and research), graduate student support and supplies. Details are provided later in this document.

2. What is the perceived need or market for the program? Please provide supporting documentation.

The chemistry department at CWRU continues to experience growth in the number of students majoring in the traditional discipline.



Of those students pursuing the BA in chemistry, 74% [96/129] recent and current students also completed the BIOL 214, Genes and Evolution, course. Almost all of these students [94/96] then completed BIOL 215, Cells and Proteins. It is our conclusion that most of these students complete the biology courses and the BA in Chemistry in preparation for postgraduate education in the health sciences. One of the requirements of the new major is the BIOL 214 and 215 sequence. We anticipate many of the BA majors will shift to the BA in Chemical Biology. At the same time, we anticipate that the new major will also attract new students as the university is experiencing growth in the number of students expressing an interest in a health related science major and career. Additionally, course revisions underway for this major are likely to appeal to students pursuing other majors within the university.

On top of this, the Association of American Medical Colleges [AAMC] is currently assessing the effectiveness of the MCAT exam in identifying students for admission to medical school. [<https://www.aamc.org/initiatives/mrS/>] Current data collected by AAMC suggests that a change in the format and content of the exam may result in a decreased emphasis of organic chemistry and increased emphasis on biochemistry and genetics.

[[https://www.aamc.org/download/143506/data/summer\\_2010\\_science\\_report.pdf](https://www.aamc.org/download/143506/data/summer_2010_science_report.pdf)] A timeline has been established that would introduce a new exam in early 2014.

([https://www.aamc.org/download/143504/data/summer\\_2010\\_update.pdf](https://www.aamc.org/download/143504/data/summer_2010_update.pdf))

The chemical biology major is designed to enable students to complete degree requirements mandated for admission to medical school while decreasing the amount of organic and physical chemistry and increasing the amount of biology and biochemistry.

3. What are the projected costs necessary to mount the program? More specifically, what are the projected needed near- and long-term resources and estimated costs for:
  - a. faculty?
  - b. staff?
  - c. graduate student support?
  - d. space [offices, research or instructional labs and/or equipment, if applicable] required for faculty or graduate students to carry out the program?
  - e. impact on university resources, such as increased library needs?

We estimate the cost to initiate this program to be relatively small. We have designed the new major to take advantage of the courses we already have in our curriculum and to update and revise several of these courses to meet the requirements of the new major. In fact, one of the core course sequences required of our BS chemistry majors, CHEM 323/324 (Foundations of Organic Chemistry and Organic Chemistry II), will change as a result of these

discussions. The revised CHEM 323 will be required of the new major and the second semester could be used to satisfy one of the chemical biology elective requirements. In addition, a revision of the yearlong organic chemistry laboratory course is also underway and will result in a revised chemistry laboratory course specifically intended for the chemical biology program. This new course would require an investment of release time for one faculty member for one semester and a modest budget (estimate, \$50,000) for supplies and equipment.

However, we expect this major will grow and that that growth will place a financial burden on the department. The new costs anticipated include the following:

**Faculty-** One or two additional faculty members will be needed to address the increased teaching responsibilities of this new major. We expect these positions to be new tenure track appointments within the college and to be interdisciplinary. These new positions would be intended to specifically attract both undergraduate and graduate students in the chemical biology area. Start-up costs for these faculty would be the major expense and would be similar to costs incurred with other recent hires in chemistry.

In addition, it is expected that the increased laboratory enrollment will benefit from a new instructor position as undergraduate laboratory coordinator. This individual would provide support and guidance for all the undergraduate laboratories with particular emphasis on the first and second year courses.

**Staff-** No additional staff is currently planned.

**Graduate Student Support-** As the program grows, there will be a need for an additional 2 graduate teaching assistants to maintain a safe laboratory environment. In addition, with the increase in total number of majors, we anticipate needing 1-2 more graduate teaching assistants to support the increased load on other lab classes. In total, 3-4 teaching assistant positions will be needed over a five-year time frame.

**Space-** This is the largest potential expense associated with this new major. Teaching and lab space is already at a premium within the department and the increase in undergraduate students expected from this major will further strain those resources.

**University Resources-** No increases are anticipated here. journals and databases needed to support the new major are already available.

4. What is the projected income associated with the new program? Identify likely sources and assess the near- and long-term likelihood of raising funds to support

the program in such categories as external and internal grants, philanthropy and other non-grant external funding, and tuition.

There are currently 150 undergraduate chemistry majors in any given year within the department. Seventy-five percent of these are BA majors. We anticipate growing the undergraduate chemistry major by 30% as a result of this degree. This estimate is based on recent enrollment trends experienced by the department. In the end, we anticipate growing the number of chemistry majors from 50 graduates per year to 60-65 per year with a total major pool of 180-200 majors at any given time.

Assuming an annual undiscounted tuition of \$40,000, the increase in chemistry majors is expected to result in an increase in tuition of \$1.2-2 million annually. We also expect this new major will attract other students to the university. A conservative estimate (considering discounted tuition) is that this new major will generate an additional \$500,000 in annual tuition receipts.

In addition, this interdisciplinary chemical biology major provides an opportunity to seek external funding from federal agencies. Because of the unique nature of this degree program, we will apply for grants from equipment organizations such as the National Science Foundation and The Camille & Henry Dreyfus Foundation Special Grant Program in the Chemical Sciences and training grants from the National Institutes of Health.

Finally, this new program provides a perfect opportunity for fundraising from our existing base of alumni. It will appeal to a diverse group of alumni. In fact, a new member of the CWRU Board of Trustees has a Ph.D. in chemistry and was a General Manager of the Life Sciences group at a Fortune 100 company. This individual will be consulted as we move forward.

5. What are the national and international competitive programs and their resources?

As stated previously, there are no similar programs at the undergraduate level that we can find. Graduate programs are being launched so our students will have opportunities for additional graduate education in Chemical Biology.

6. How does the proposed program
  - a. move the college's strategic plan forward in regard to the goals for undergraduate education? (See Appendix, page 3.)

This new program is truly a 21<sup>st</sup> Century educational opportunity. While both chemistry and biology are robust and rich fields of research and study, this interdisciplinary approach to understanding living systems from the basis of atoms and molecules. This strong foundational approach will enable our graduates to assess living systems in ways not currently available to them and to

apply this knowledge to solving some of the greatest challenges in human health and life sciences today.

b. strengthen the discipline through scholarship?

Scholarship is evidenced by an application of the basic knowledge an individual or group possesses to solve specific well-defined problems. This new major will provide students with a foundation of knowledge in both chemistry and biology that will then be supplemented with applications specific to living systems. Each student pursuing this major will be required to complete a capstone research experience that will enable them the opportunity to demonstrate their ability to gather information, apply their knowledge and solve a problem.

c. foster collaboration across disciplines?

This new program will enlist the collaboration of multiple departments on campus including biology, biochemistry, chemical engineering and macromolecular science and engineering. By creating a program that utilizes existing advanced courses, we hope to build a foundation that will facilitate the development of new courses that build on the strengths of each department while continually maintaining an emphasis on the underlying chemistry of the material.

d. increase attractiveness of the department and the college (to faculty, undergraduate students, graduate students, potential donors)?

Our hope is that this first-of-its-kind program will serve as a beacon to attract talented faculty and graduate students. However, our primary goal in creating this new major has been to create a unique program that will prepare today's students to face tomorrow's challenges. These future graduates will use the tools provided by this program to develop new drugs, new diagnostic tools and new treatments for the health challenges we all face.

In terms of potential donors, this program provides a truly one-of-a-kind opportunity to become a trailblazer. Potential donors will find this unique program particularly attractive and see it as a legacy they can leave for future generations.

7. How does the proposed program relate to the university's strategic plan? Might the program:

a. involve alliance areas?

Human Health and Infectious Diseases are two of the alliance areas delineated in the Strategic Plan. This new major is specifically targeted to this area and, in particular, to attracting the strongest undergraduate students to study the foundational concepts needed in this area.

- b. involve internationalization?  
While no specific objective has indicated an emphasis on internationalization, this program will attract significant attention and may serve as a recruiting tool for international students and collaborators.
  - c. involve other units?  
As described earlier, this new major represents collaboration with other departments and schools within the university. While this degree is granted by the College of Arts and Sciences, specifically, the chemistry department, students in this program will be taking classes and doing research across the university and at the Cleveland Clinic.
  - d. increase the university's impact by advancing our academic programs?  
Any new program that is the first of its kind is bound to generate national attention. That attention will serve to raise the stature of the institution and impact not only our undergraduate students but our faculty and national reputation as well.
  - e. increase the diversity on our campus?  
Human health is an issue that is, obviously, a diverse issue and impacts all persons. Individuals pursuing educational programs in human health are as diverse as any group on this campus. We expect that diversity of our students, our faculty and our research will come about as a natural consequence. We will, however, strive to utilize this program to increase the diversity of our undergraduate majors.
  - f. strengthen institutional resources?  
By developing a unique new program, we expect to garner the attention of many individuals and groups that will desire to partner with us in this endeavor. These partnerships are a potential source of new resources for the university.
  - g. foster collaborations/partnerships with other institutions?  
In our development of this new major we consulted faculty from several other institutions, e.g., Oberlin College and Harvey Mudd College, and individuals including the Director of Editorial Development at the American Chemical Society. All expressed interest in collaborating with us as we move forward. When asked why their own institutions were not considering a similar course of action, most indicated a lack of critical mass needed to launch and sustain a new program. We have that critical mass and are ready to move this program forward.
8. How will the program contribute to CWRU's reputation regionally, nationally, and internationally?

Case Western Reserve University is recognized as a major research university with emphases in biomedicine and engineering. This new major will demonstrate the forward thinking present in this institution and serve as a sign that it is our intent to continue to innovate in all areas of education and research. We are not content to maintain our reputation but we are willing to take risks that will make us stand out in the crowd.

9. To what extent does the new program reflect a change of departmental priorities and subsequent reallocation of resources?

Recent faculty hires within the department have focused on the areas of chemical biology as well as energy and materials. It has been a strategic intent of the department to recruit new faculty that complement existing faculty and build a strong base in chemical biology. Chemical biology is one of two research foci in the department's strategic plan. This major has been discussed over the course of several years and the department is now ready to move forward. The emphasis on interdisciplinarity within the department and university, the desire to recruit students with 21<sup>st</sup> century educational programs and our critical mass of faculty make this the perfect time to launch this unique and exciting program.