

DEPARTMENT OF BIOLOGICAL AND ENVIRONMENTAL ENGINEERING

Mission Statement

- Educate the next generation of professionals and discover new knowledge in biological engineering;
- Disseminate cutting edge research-based engineering information through scientific media and outreach programs;
- Conduct all programs in the context of a world-class university and deliver the highest value knowledge to our students, citizens, and global society.

Our Commitment

The educational objectives of the Biological Engineering program are consistent with those of the College of Engineering and Cornell University. We are committed to providing an excellent undergraduate engineering program in a nurturing environment where our graduates acquire knowledge and develop skills for professional success. Graduates of our program include a diverse group of leaders and problem solvers who contribute technically, professionally and personally to our society.

The Educational Objectives of the Biological Engineering Program are to

1. Advance in careers and opportunities related to Biological Engineering and other related fields and professions based on a solid educational background in appropriate mathematics, physical and life sciences, liberal studies (including communication and ethics) and engineering.
2. Pursued advanced degrees in engineering and related professional fields.

Undergraduate Program Department of Biological and Environmental Engineering 2012-2013

Cornell University is an equal opportunity, affirmative action educator.

INTRODUCTION

The Department of Biological and Environmental Engineering offers engineering degree programs in Biological Engineering and Environmental Engineering. A separate program guide for the Environmental Engineering degree is available on-line at www.bee.cornell.edu or from BEE Student Services, 207 Riley-Robb Hall.

We welcome your interest in our programs, whether that interest is as a prospective or continuing student, an alumnus, or as a prospective employer of our students.

For more information, visit our web site at: www.bee.cornell.edu

If you have questions about our undergraduate programs, please contact:

Professor Jean Hunter
Director of Undergraduate Studies
Biological & Environmental Engineering
207 Riley-Robb Hall
Cornell University
Ithaca, NY 14853-5701
Phone: 607.255.2297
Fax: 607.255.4449
E-Mail: jbh5@cornell.edu

Brenda Marchewka
Student Services Coordinator
Biological & Environmental Engineering
207 Riley-Robb Hall
Cornell University
Ithaca, NY 14853-5701
Phone: 607.255.2173
Fax: 607.255.4449
E-Mail: bls19@cornell.edu

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BIOLOGICAL ENGINEERING

"We Bring Engineering to Life and Life to Engineering"

Administrative Structure

Biological Engineering is an engineering program accredited by the Engineering Accreditation Commission (EAC) of the Accreditation Board for Engineering and Technology (ABET). There are two administrative pathways Cornell students may use to complete the Biological Engineering program. Students may matriculate in the College of Engineering and affiliate with the Biological Engineering major, or they may matriculate in the College of Agriculture and Life Sciences with a major in Biological Engineering. The curriculum and degree requirements are the same for all students in the Biological Engineering program regardless of the administrative pathway they use to complete it. Faculty advisors are assigned to each undergraduate at the time they formally enter the Biological Engineering major.

Affiliation (College of Engineering Enrolled Students)

Students who matriculate in the College of Engineering (CoE) may affiliate with the Biological Engineering program in their second year of study. (Transfer students entering the CoE affiliate with their major program at the time of transfer.) Affiliated students pay endowed tuition and complete all Biological Engineering requirements while enrolled in the engineering college.

Joint Program (College of Agriculture and Life Sciences Enrolled Students)

Students who enroll in the College of Agriculture and Life Sciences (CALS) as freshmen majoring in Biological Engineering complete a joint degree program with the College of Engineering. In the joint degree program, students register in CALS for their freshman and sophomore years and then are registered jointly with CALS and CoE for their junior and senior years (the registration process in years 3 and 4 is facilitated by the BEE department administration). The primary college in the junior year is CALS and in the senior year, the students' primary college is the College of Engineering. Starting with the freshman class entering in the Fall 2007 (the graduating class of 2011), students in the joint degree program will pay state contract college tuition all four years of their program.

Program Focus

The Biological and Environmental Engineering (BEE) department focuses on three great challenges facing humanity today: protecting the world's natural resources, including water, soil, air, biodiversity, and energy; developing engineering systems that monitor, replace, or intervene in the mechanisms of living organisms; and ensuring an adequate and safe food supply in an era of expanding world population. The Undergraduate Engineering program in Biological Engineering has a unique focus on biological systems, including the environment that is realized through a combination of fundamental engineering sciences, biology, applications courses, and liberal studies.

Biological engineers work on problems related to nonpoint-source pollution, such as chemical movement through watersheds, the soil, and aquifers. They develop processes to create novel value-added products from biologically derived feedstocks. They develop innovative technology for expanding the use of food and biological products in an ethical and sustainable way. They are involved in the development and application of biotechnology in ways that help people and protect our environment. Finally, they apply their knowledge of biology and engineering principles to solve biomedical problems.

Because biological engineers work at the interface between biology and engineering, they must be knowledgeable in both disciplines. They are rigorously educated in the core courses of mathematics, physics, and the engineering sciences as well as biology and chemistry. They select additional foundation

and advanced courses in subjects like molecular biology, biochemistry, microbiology, animal and plant physiology, and emerging engineering subjects like biocomputing. This integration of engineering and biology is the distinguishing feature that makes Biological Engineering unique among the engineering disciplines and an excellent preparation for advanced study. Many graduates from the Biological Engineering Program continue their education at the finest graduate schools in the world. They pursue Master of Engineering (M. Eng.), Master of Science (M.S.), or Doctoral (Ph.D.) programs in various related engineering disciplines, or they sometimes complement their engineering degrees with a Master of Business Administration (MBA), a Doctor of Medicine (MD), or Doctor of Law (LLD) degree.

Students in the Biological Engineering Program may pursue minor programs. Minors in biomedical engineering, engineering management, mechanical engineering, and operations research and management science tend to fit well with Biological Engineering students interests and academic programs. Minors in other areas, for example music, German Studies, or food science, are also available to our students.

Careers

Career opportunities for Biological Engineering graduates cover the spectrum of private industry, public agencies, educational institutions, and graduate and professional programs in engineering, science, medicine, and law. In recent years graduates have pursued careers in consulting, biotechnology, and pharmaceutical industries, biomedical engineering, management and business, and international development.

The curriculum proves an excellent preparation for biomedical engineering and public health, medical or veterinary studies or for a career in research or manufacturing in bioprocess-based industries, health and medical technology industries, and biotechnology firms. For example, biological engineers may develop sensors and devices to monitor physiological systems, or design and improve processes and product recovery systems for bio-based industries. Biological engineers are also well equipped to solve environmental problems by developing models to better understand the interface between humans and their surroundings, by designing bioremediation systems for pollution abatement, and advising state and local municipalities in developing guidelines and laws for sustainable land use.

After graduation, biological engineers may pursue advanced degrees or work in research and industry, usually as a member of a team of scientists and engineers, and often as a team leader. They work with consulting firms, manufacturers, and government agencies. Products of their efforts help insure a safe and adequate supply of food and water, create new medicines, diagnose and cure diseases in people and animals, and enable people to utilize plant, animal and microbial systems in a more efficient and sustainable way.

The living world is all around us and within us. The biological revolution continues and it has created a demand for multidisciplinary problem solvers, engineers fluent in both the physical and life sciences, who can communicate effectively, who are sensitive to the needs of people and who are interested in the solving the challenges facing society. The Department of Biological and Environmental Engineering is committed to educating Biological Engineers to meet these challenges.

BIOLOGICAL ENGINEERING CURRICULUM

Biological engineering is engineering applied to living systems on a range of scales from molecules to whole organisms. Our discipline has progressed from the interface of biological and engineering systems to the development of biological components and the design of systems with these biological components. Cells and enzymes are used as sensors. Nucleic acid is engineered to make molecular structures for drug delivery and nanobar codes to identify specific biological and chemical elements. Phytochelatins synthesized by plants, yeast and algae are employed to detoxify metals in the environment. Engineered microbial films are used to biodegrade man-made and toxic organics. Metabolic pathways in target organisms can be engineered to enable novel biological function. Complex enzymatic systems are modified with “designer” enzymes to convert plant material to biobased products, including liquid fuels. Animals and plants serve as pharmaceutical “factories”. Tissue engineering is used to develop compatible biological components on a large scale. Novel medical devices and drug delivery systems are developed by altering biological systems on a small scale. Engineering analysis is used to develop predictive tools for design of biological, environmental and food products providing improved efficiency, quality and safety.

Conceptually, biological engineering involves: 1) characterizing, measuring and modeling of systemic processes within biological systems; 2) understanding the relationships between biological systems and their environment; and 3) designing components, processes and systems that protect, influence, control, and employ biological materials, components and organisms. Biological engineering integrates engineering topics, such as mechanics, fluid flow, chemical kinetics, electronics, and computer applications with basic biology.

YOUR ADVENTURE IN BIOLOGICAL ENGINEERING

The foundation of our undergraduate program in biological engineering is built upon fundamental physical and life sciences, mathematics, core biological engineering sciences, biological engineering concentrations and liberal studies. Our fundamental courses provide a depth of knowledge in both the biological sciences and the physical sciences. Courses within our core engineering sciences are uniquely designed for our curriculum and integrate biological principles with the engineering sciences. The department and college have invested significant resources in laboratory facilities and new faculty whose interests support our concentrations of Biomedical Engineering, Bioprocess Engineering and Bioenvironmental Engineering. These people and facilities provide our undergraduates with excellent educational and research opportunities in our overall program and concentrations.

The biological engineering curriculum stresses a basic knowledge of the biological sciences, chemistry, physics, mathematics and engineering sciences. This knowledge is used to develop new biological components, to employ biological components as engineering tools and to solve engineering problems involving biological systems.

Biological science requirements include: a year of introductory biology, biochemistry and an advanced biology elective course. A strong background in chemistry is required to most effectively understand the underlying functions found in biological systems. Therefore, we require general chemistry, organic chemistry and biochemistry.

All engineering disciplines build upon a set of fundamentals in mathematics, physics and engineering sciences. Our mathematics and physics requirements are the same as other engineering disciplines: four semesters of math and two semesters of physics. Each engineering discipline has a set of the engineering distribution courses that the student needs as background for upper level courses. Like all engineering fields, we require two distribution courses: 1) mass and energy balances (ENGRD/BEE 2600 or ENGRD/BEE 2510); and 2) mechanics of solids. Many students elect to take additional distribution courses in order to fulfill minor requirements and general interest.

The *core biological engineering courses* of our program include an introduction to biological engineering, molecular and cellular bioengineering, biological transport processes, bio-fluid mechanics and bioengineering thermodynamics. All of these courses provide strong biological content and reinforce engineering problem solving. The biological engineering major is further defined by your choice of a concentration in Biomedical Engineering, Bioprocess Engineering or Bioenvironmental Engineering. Within the concentrations, students can take courses that provide laboratory and design experiences as well as other “hands-on” experiences with biological applications.

Communication, both written and oral, is important for all professionals. Technical communication is stressed throughout our curriculum. We also recommend courses in the history of technology and medical or environmental ethics to reinforce the relevant social and ethical responsibilities shared by all engineers who apply new technologies to living organisms.

**BIOLOGICAL ENGINEERING
Sample 8-Semester Plan**

Fall Semester**Spring Semester****Freshman Year**

MATH 1910, Calculus I	4	MATH 1920, Calculus II	4
BEE 1510, Intro Computer Prog	4	PHYS 1112, Mechanics	4
Intro Biology ^a	3	Intro Biology ^a	3
BIOG 1500, Bio Lab ^a	2	BEE 1200 ^b , The BEE Experience	1
First Year Writing Seminar	3	First Year Writing Seminar	3
	<hr/> 16		<hr/> 15

Sophomore Year

MATH 2930, Differential Equations	4	MATH 2940, Linear Algebra	4
PHYS 2213, Electromagnetism	4	CHEM 1570, Organic Chemistry	3
CHEM 2070 or 2090, Gen Chem	4	BEE 2220, Biokinetics and Thermo	3
BEE 2510 or BEE 2600, MEB ^c	3	Liberal Studies Elective	3
		ENGRD 2020, Mech of Solids	4
	<hr/> 15		<hr/> 17

Junior Year

BEE 3500, Bio & Env Trans Proc	3	Bio. Sci. Elective, upper level	3
BEE 3310, Bio-Fluid Mechanics	4	Biological Engineering Elective	3
BIOMG 3300, Biochemistry	4	Biological Engineering Elective	3
CEE 3040, Uncertainty Analysis	4	Concentration Elective	3/4
Liberal Studies Elective	3	Liberal Studies Elective	3
	<hr/> 18		<hr/> 15/16

Senior Year

Concentration Elective	3/4	Concentration Elective	3/4
Biological Engineering Elective	3	Biological Engineering Elective	3
Biological Engineering Elective	3	Biological Engineering Elective	3
Approved Elective	3	Approved Elective	3
Liberal Studies Elective	3	Liberal Studies Elective	3
Liberal Studies Elective	3		
	<hr/> 18/19		<hr/> 15/16

^aStudents choose two of the three following: BIOMG 1350, BIOG 1440 or BIOEE 1610 plus BIOG 1500. May substitute BIOG 1105/1106. BIOG 1500 may be taken in the spring term.

^bBEE 1200 is not required of students who have taken an ENGR1 1XXX course.

^cMass and Energy Balances with a biological (BEE 2600) or environmental (BEE 2510) focus.

Minimum degree credits = 126

DEGREE REQUIREMENTS

Biological Engineering Program

A student earning a Bachelor of Science degree in the Biological Engineering Program must complete the following academic requirements. Degree requirements apply to students matriculating in the fall semester of 2012 or later. A minimum of 126 credit hours of courses is required.

Group	Subject Matter	Credit Hours
1.....	Mathematics (1910, 1920, 2930, 2940) All math courses in this sequence must be completed with a grade of C- or better.	16
2.....	Physics 8 Calculus-based Physics (1112, 2213)	
3.....	Chemistry General Chemistry (2070 or 2090) Organic Chemistry (1570 or 3570)	7
4.....	Biological Sciences Introductory Biology (8 credits) ^a Biochemistry or Microbiology (BIOMG 3300 or 3330 or BIOMI 2900 recommended) (3 or 4 credits) Advanced Biological Science (3 or 4 credits) ^b	15
5.....	Written Expression First Year Writing Seminars Technical Writing – one course required. Technical writing courses are listed in the <i>Courses of Study</i> , College of Engineering section. BEE 4530, BEE 4590, BEE 4730 and BEE 4890 are approved courses.	6
6.....	Liberal Studies (6 courses)..... Liberal Studies courses are listed in the <i>Courses of Study</i> , College of Engineering section. Minimum of 6 courses in at least 3 of the 7 groups, at least 2 of 6 courses at or above 2000 level. 1. Cultural Analysis (CA) 2. Historical Analysis (HA) 3. Literature and the Arts (LA) 4. Knowledge, Cognition, and Moral Reasoning (KCM) 5. Social and Behavioral Analysis (SBA) 6. Communications in Engineering (CE) 7. Foreign Language (FL, not literature)	18
7.....	Computer Programming Intro to Computer Programming - BEE 1510 (or CS 1112)	4
8.....	Engineering Distribution and Field Courses (all must be taken for letter grade, except BEE/BME 5010) ... <i>(a) Required Courses</i> Mechanics of Solids - ENGRD 2020 ^c (4 credits) Engineering Statistics and Probability - ENGRD 2700 or CEE 3040 (recommended) (3 or 4 credits) <i>(b) Biological Engineering Core Courses</i> The BEE Experience - BEE 1200 (1 credit) [Not required of students who have completed an ENGRI course] Engineering Distribution ^c - BEE/ENGRD 2600 (recommended) or BEE/ENGRD 2510 (3 credits) Biological and Environmental Transport Processes - BEE 3500 (3 credits) Fluid Mechanics - BEE 3310 or CEE 3310 (4 credits) [Students may petition CHEME 3230 (3 credits).] Thermodynamics - BEE 2220 or ENGRD 2210 (3 credits). [Students may petition to substitute CHEME 3130 (4 credits); MSE 3030 (4 credits); or AEP 4230 (4 credits).] <i>(c) Biological Engineering Concentration</i> – three courses from one concentration (minimum of 9 credits), see pages 12-15.	46

DEGREE REQUIREMENTS (CONT'D) Biological Engineering Program

Group	Subject Matter	Credit Hours
	<i>(d) Major-approved engineering electives to complete 46 engineering credits</i>	
	BEE and other Engineering courses at 2000 level or above from BEE or the College of Engineering. A maximum of 4 credits of Engineering research, teaching or independent study may be used in this category. BEE/BME 5010 may be taken twice. Engineering Laboratory (select one course) - BEE 3650, BEE 4270, BEE 4500, BEE 4550, or CEE 4530. Capstone Design (select one course) – BEE 4350, BEE 4500, BEE 4530, BEE 4590, BEE 4600, BEE 4730, BEE 4740, BEE 4810/4960, or BEE 4870. One course in this category must satisfy the College of Engineering Technical Writing requirement.	
9 Approved Electives These courses are selected by the student with approval of the Faculty Advisor.	6
TOTAL MINIMUM		126

^aStudents choose two of the three following: BIOMG 1350, BIOG 1440 or BIOEE 1610, plus BIOG 1500. May substitute BIOG 1105/1106 but will need to complete at least 15 credits in the Biological Sciences category. All bio courses must be taken for letter grade.

^bPrerequisite must be a biology course. Up to 4 credits of BIOG 4990 may be used in this category if taken for letter grade.

^cEngineering distribution requirement is satisfied by ENGRD 2020 and ENGRD 2600 or ENGRD 2510

Concentrations

All students are required to complete a concentration. Concentrations represent areas in biological engineering that relate to individual interests or preparation for careers or graduate study. They are intended to help in choosing electives while planning an individual curriculum. The three concentrations are *Biomedical Engineering, Bioprocess Engineering and Bioenvironmental Engineering.*

Special Courses

Courses numbered 10XX, such as PHYS 1012 do not count toward graduation requirements. Academic Excellence Workshops (ENGRG 1091, 1092, 2093 and 2094) may not be used as Biological Engineering Electives.

Transfer Credit

All transfer credit for the engineering major must be approved before it will be posted on the Cornell transcript. Courses completed prior to matriculation will be evaluated when the student matriculates at Cornell. Courses taken outside of Cornell after matriculation must be approved before the student enrolls in them to ensure credit will count toward the engineering degree. If a transfer course meets the subject matter content, but lacks full credit content, the student must fulfill the credit requirement by petitioning the College of Engineering to substitute engineering credits.

Physical Education

Two semesters of physical education are required. All students must pass a swim test prior to graduation. Transfer students are exempted from one semester of PE for each full-time semester they transfer into Cornell.

Letter and S/U Grading

All courses must be taken for letter grade except for Liberal Studies and Approved Electives.

Additional program information is provided at the Courses of Study website in the College of Engineering section and in the College of Engineering Undergraduate Handbook.

BIOLOGICAL ENGINEERING PROGRAM PROGRESS FORM

Applies to students matriculating in the Fall Semester of 2012 or later.

Name: _____
 E-mail: _____
 Minor: _____
 Concentration: _____

Empl ID: _____
 Advisor: _____
 Anticipated Graduation Date: _____
 Double Major: _____

Course Title and Required Credits	Course (Credits)	Semester	Credits	Grade
1. Mathematics: 16 credits				
Calculus for Engineers I*	MATH 1910 (4)	_____	_____	_____
Calculus for Engineers II*	MATH 1920 (4)	_____	_____	_____
Engineering Math* (Differential Equations)	MATH 2930 (4)	_____	_____	_____
Engineering Math* (Linear Algebra)	MATH 2940 (4)	_____	_____	_____
*Must earn at least a C- or repeat course				
2. Physics: 8 credits				
Mechanics	PHYS 1112 (4)	_____	_____	_____
Electromagnetism	PHYS 2213 (4)	_____	_____	_____
3. Chemistry: 7 credits				
General Chemistry	CHEM 2070 or 2090 (4)	_____	_____	_____
Organic Chemistry	CHEM 1570 or 3570 (3)	_____	_____	_____
4. Biological Sciences: 15 credits				
Introductory Biological Science	_____	_____	_____	_____
Introductory Biological Science	_____	_____	_____	_____
Introductory Bio Lab	_____	_____	_____	_____
Biochemistry or	_____	_____	_____	_____
BIOMG 3300 (4) or 3330 (4) or 3310+3320 (5) 3350 (4)				
Microbiology	_____	_____	_____	_____
BIOMI 2900 (3) or CEE 4510 (3)				
Students following the Bioenvironmental Engineering Concentration are encouraged to include Microbiology				
Advanced Bio Sci Elective (to complete 15 credits)	_____	_____	_____	_____
5. Written Expression (First Year Writing Seminars): 6 credits				
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
6. Liberal Studies: 18 credits (Minimum of six courses in at least three of the seven groups; at least two of six courses at or above 2000 level.)				
Cultural Analysis (CA)	Knowledge, Cognition, and Moral Reasoning (KCM)			
Historical Analysis (HA)	Social Behavior and Analysis (SBA)			
Literature and the Arts (LA)	Foreign Language (FL, not literature)			
Communications in Engineering (CE)				
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Course Title and Required Credits	Course (Credits)	Semester	Credits	Grade
7. Computer Programming: 4 credits				
Intro to Computer Programming	BEE 1510 or CS 1112 (4)	_____	_____	_____
8. Engineering Distribution and Field Courses: 46 credits				
<i>(a) Required Courses</i>				
Mechanics of Solids	ENGRD 2020 ^a (4)	_____	_____	_____
Engineering Statistics and Probability	ENGRD 2700 (3) or CEE 3040 (4)	_____	_____	_____
<i>(b) Biological Engineering Core Courses</i>				
The BEE Experience	BEE 1200 (1) ^b or ENGRI (3) ^c	_____	_____	_____
Engineering Distribution**	BEE 2600 or BEE 2510 (3)	_____	_____	_____
Students following the Bioenvironmental Engineering concentration should include BEE 2510 and CEE 3510				
Biological and Bioenv. Transport Processes	BEE 3500 (3)	_____	_____	_____
Bio-Fluid Mechanics/Fluid Mechanics	BEE 3310 or CEE 3310 (4)	_____	_____	_____
Thermodynamics	BEE 2220 or ENGRD 2210 (3)	_____	_____	_____
<i>(c) Biological Engineering Concentration</i>				
Three courses from one concentration (minimum of 9 credits)				
Concentration Elective I	_____	_____	_____	_____
Concentration Elective II	_____	_____	_____	_____
Concentration Elective III	_____	_____	_____	_____
<i>(d) Major-approved electives to complete 46 engineering credits</i>				
BEE and other Engineering courses at 2000 level or above				
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
9. Approved Electives: 6 credits				
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Minimum Credits Required: 126

_____ Technical Writing Course _____
 _____ Capstone Design Course _____
 _____ Laboratory Course _____

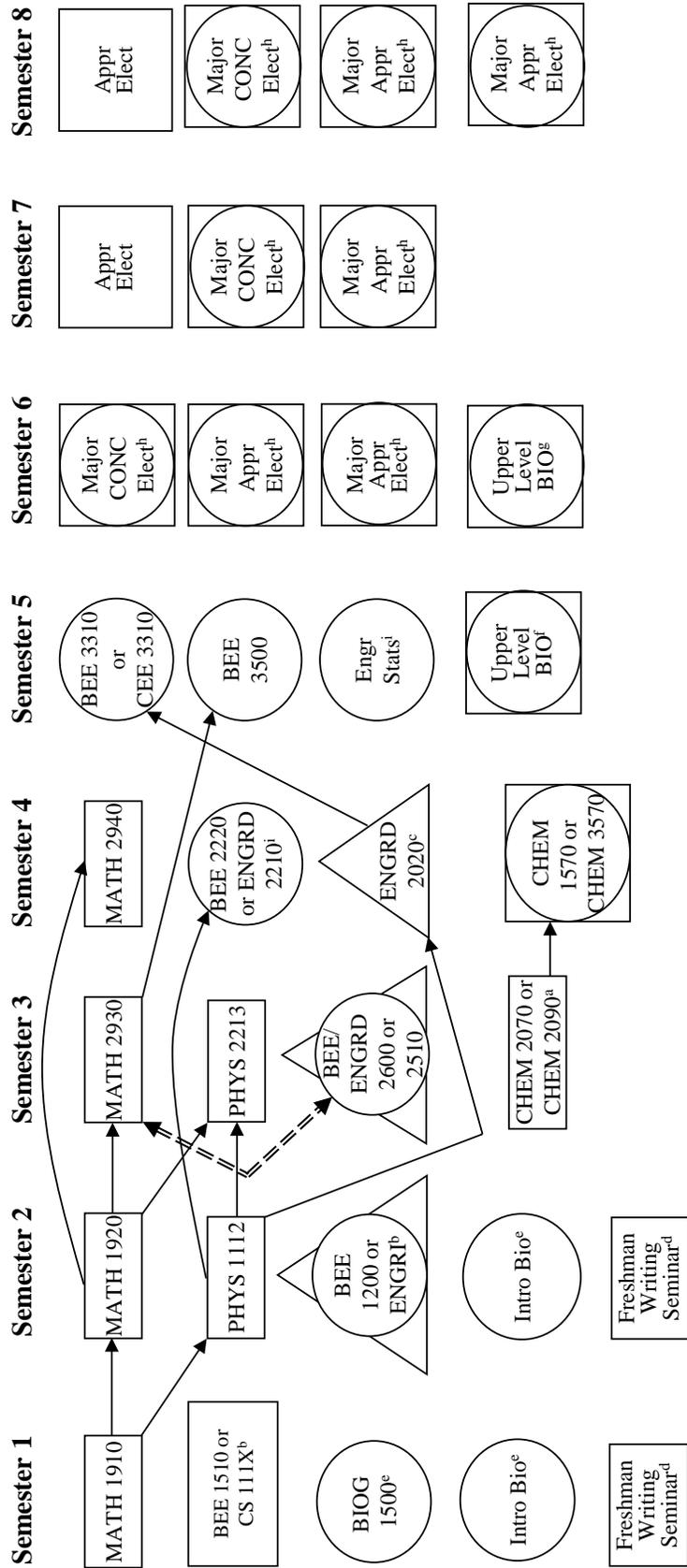
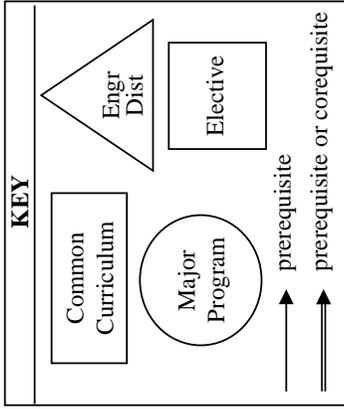
_____ PE
 _____ PE

^aEngineering distribution requirement is satisfied by ENGRD 2020 and ENGRD 2510 or ENGRD 2600

^bStudents matriculating in CALS

^cStudents matriculating in the College of Engineering

Biological Engineering Major (BE) Roadmap



^aCALS matriculates must enroll in CHEM 2070 (fall); CoE matriculates must enroll in CHEM 2090 (fall, spring). Students in either college may also substitute CHEM 2150 for either CHEM 2070 or 2090.

^bBEE 1510 and BEE 1200 required of CALS matriculates. CS 111X and ENGRI required of CoE matriculates.

^cThe major program includes nine (9) credits of courses outside the major. These are satisfied by ENGRD 2020, CEE 3040, or ENGRD 2700, and a non-BEE major approved elective.

^dIn addition to the Freshman Writing seminars, a technical writing course must be taken as an engineering distribution, liberal studies, approved elective or major course.

^eChoose two of the three following: BIOMG 1350, BIOG 1440 or BIOEE 1610; plus BIOG 1500. May substitute BIOG 1105/1106. All BIO courses must be taken for letter grade.

^fEither biochemistry or microbiology is required: BIOMG 3300 or BIOMG 3330 or BIOMG 3310 and BIOMG 3320, or BIOMI 2900, or CEE 4510.

^gUpper level BIO: any biology course that has a biology pre-requisite.

^hEngineering electives must include a BE capstone design course and a BE lab experience course. See department web page for a current list of approved courses.

ⁱBEE 2220 or ENGRD 2210 and Engineering Statistics preferably before Semester 6.

CONCENTRATIONS WITHIN THE BIOLOGICAL ENGINEERING PROGRAM

*A concentration is a graduation requirement. Students are required to complete one of the three Biological Engineering Concentrations: **Biomedical Engineering, Bioprocess Engineering, Bioenvironmental Engineering.*** Concentrations are intended to be used as an introduction to areas in biological engineering that relate to individual interests and preparation for careers or graduate study. They are also intended to help students select electives while planning an individual curriculum. You are encouraged to work closely with your faculty advisor to select concentration electives that meet your academic objectives.

BIOMEDICAL ENGINEERING CONCENTRATION

Although biological engineering is broader than any one application area such as biomedical engineering, human system applications obviously form a critical part of the biological engineering program. Many of the biological engineering courses, especially at the junior and senior level, have been designed with human systems as the major emphasis. Thus, the *core biological engineering courses* in molecular and cellular biological engineering, bio-thermodynamics, bio-fluid mechanics and bio-transport all include biomedical applications.

The objective of the concentration in biomedical engineering is to relate the broader biological engineering program to the individual's interest in preparing for an industrial career or graduate study in areas related to human medicine, veterinary medicine and dentistry. The concentration should guide the individual in choosing elective subjects that they will use in their life after graduation.

The table below is a list of elective courses in biomedical engineering (beyond the *core* discussed earlier) grouped into topical areas of upper level subject matter and applications.

To further enhance the concentration and the curriculum in general, undergraduate research or independent study is encouraged. Such work could be with faculty members within Cornell (Engineering departments, Veterinary Medicine, Weill Medical College in New York City) or outside of Cornell University, in academia or industry.

Select one course from 3 different topic areas (9 credits minimum required)

Topical Areas	Courses that cover this area		
Quantitative Physiology	S	BEE 3600	Molecular and Cellular Bioengineering (BME 3600)
	F	BEE 4600	Deterministic and Stochastic Modeling in Biological Engineering
	F	BME 4010	Biomedical Engineering Analysis (MAE 4660)
	S	BME 4020	Electrical and Chemical Physiology
	F	BME 4110	Science and Technology Approaches to Problems in Human Health
	S	BME 4910	Principles of Neurophysiology (BIONB/ECE 4910)
	S	BME 5600	Biotransport and Drug Delivery
	S	CHEME 4810	Biomedical Engineering (BME 4810)
Instrumentation	S	BEE 4500	Bioinstrumentation
	F	BEE 4550	Biologically Inspired Microsystems Engineering
	F	BEE 4590	Biosensors and Bioanalytical Techniques
	F	BME 3300	Introduction to Computational Neuroscience (BIONB/PSYCH/COGST 3300)
Materials	F	AEP 4700	Biophysical Methods (BIONB/VETMM 4700; BME 5700)
	F	BME 5850	Current Practice in Tissue Engineering
	F, S	BEE 3650	Properties of Biological Materials
	S	MSE 4610	Biomedical Materials and their Applications
	S	BME 5390	Biomedical Materials and Devices for Human Body Repair (FSAD 4390)
Mechanics	S	MAE 4640	Orthopaedic Tissue Mechanics (BME 4640)
	F	MAE 5680	Soft Tissue Biomechanics (BME 5810)
	S	MAE 5690	Clinical Biomechanics of Musculoskeletal Tissue (BME 5690)
Analysis/Modeling of Biomedical Systems	S	BEE 3600	Molecular and Cellular Bioengineering (BME 3600)
	S	BEE 4530	CAE: Applications to Biomedical Processes (MAE 4530)
	F	BEE 4550	Biologically Inspired Microsystems Engineering
	F	BEE 4600	Deterministic and Stochastic Modeling in Biological Engineering
	F	BME 3300	Introduction to Computational Neuroscience (BIONB/PSYCH/COGST 3300)
	F	BME 4010	Biomedical Engineering Analysis (MAE 4660)
	F	BME 6670	Nanobiotechnology (AEP 6630/MSE 5630)
	S	ECE 3530	Introduction to Systems and Synthetic Biology (BME 4980)
S	ECE 5780	Computer Analysis of Biomedical Images (BME 5780)	

-Some of these courses have prerequisites not included in the Biological Engineering curriculum.

-Courses listed in more than one area may be used to satisfy one area only. F = Fall, S = Spring

BIOPROCESS ENGINEERING CONCENTRATION

Increasingly, manufacturers are finding that the fastest, most environmentally sound, and most economical route to a product is through a biological system. From pharmaceuticals to foods to industrial enzymes, biological systems are being harnessed to increase product yield, purity, and efficacy. Bioprocess engineering is the use of cell cultures, bacteria, enzymes, plants and even farm animals (in short, any biological system) for the synthesis of industrially-relevant product, such as drugs, foods, and detergent additives. There are typically many steps to a bioprocess and, hence, many opportunities for biological engineers to get involved. The three main areas of interest are process development, product recovery, and process validation and modeling. Courses that have a particular focus in these areas are noted below. Much like chemical engineers, bioprocess engineers need a strong background in kinetics, thermodynamics, statistics, and chemistry (especially biochemistry). In addition, courses in food science, microbiology, cell biology, and physiology can be essential depending on where the student wants to work.

The educational objective for the concentration in bioprocess engineering is to relate the broader biological engineering program to the individual's interest in preparing for an industrial career or graduate study in areas related to bioprocess development, product recovery, or process validation and modeling. The concentration should guide the individual in choosing elective subjects that they will use in their life after graduation.

To further enhance the concentration and the curriculum in general, undergraduate research and independent study are encouraged. Such work could be with faculty members within Cornell (Engineering departments, Microbiology, Food Science) or outside of Cornell University, in academia or industry.

Select three courses from the list below (9 credits minimum required)

S	BEE 3600	Molecular and Cellular Bioengineering (BME 3600) ^{a, c}
S	BEE 4500	Bioinstrumentation ^a
S	BEE 4530	Computer aided Engineering ^c
F	BEE 4550	Biologically Inspired Microsystems Engineering ^{a, c}
F	BEE 4590	Biosensors and Bioanalytical Techniques ^{a, b, c}
F	BEE 4600	Deterministic and Stochastic Modeling in Biological Engineering
F	BEE 4640	Bioseparation Processes ^b
S	BEE 4840	Metabolic Engineering ^a
F	BEE 4870	Sustainable Bioenergy Systems ^a
S	CHEME 3320	Analysis of Separation Processes ^b
S	CHEME 3720	Introduction to Process Dynamics and Control ^a
S	CHEME 4700	Process Control Strategies ^a
F	CHEME 5430	Biomolecular Engineering of Bioprocesses ^a
F	ORIE 5100	Design of Manufacturing Systems ^a
S	ORIE 4710	Applied Linear Statistical Models ^c

Some of these courses have pre-requisites not included in the Biological Engineering curriculum.

Topic Areas

^aResearch and Bioprocess Development

^bProduct Recovery

^cValidation/Modeling

F = Fall

S = Spring

BIOENVIRONMENTAL ENGINEERING CONCENTRATION

The bioenvironmental engineering concentration is for students who want to apply their interest in biological systems to the environment. The natural environment is influenced to a great extent by the consortium of organisms that inhabit it. In order to understand the natural environment or to mitigate the negative impact of human activities we must understand not only fundamental biological processes (material covered in the core program), but we must also understand how the natural environment works (for example how water cycles in the environment—hydrology) and how organisms interact with their environment. Courses suggested for this concentration include those that focus on the natural environment as well as courses on engineered systems which rely on biology to remediate contamination.

The educational objective of the concentration in bioenvironmental engineering is to relate the broader biological engineering program to the individual's interest in preparing for an industrial career or graduate study in areas related to environmental engineering, environmental sustainability, or environmental management. To further enhance the concentration and the curriculum in general, undergraduate research or project team participation is encouraged.

Select three courses from the list below (9 credits minimum required)

S	BEE 3710	Physical Hydrology for Ecosystems
S	BEE 4010	Renewable Energy Systems
S	BEE 4360	Engineering Design of Aquacultural Systems
S	BEE 4550	Biologically Inspired Microsystems Engineering
S	BEE 4710	Introduction to Groundwater (EAS 4710)
F	BEE 4730	Watershed Engineering
S	BEE 4740	Water and Landscape Engineering Applications
F	BEE 4750	Environmental Systems Analysis
S	BEE 4760	Solid Waste Engineering
S	BEE 4860	Industrial Ecology of Agriculturally Based Bioindustries
F	BEE 4870	Sustainable Bioenergy Systems
S	BEE 4880	Applied Modeling and Simulation for Renewable Energy Systems
S	CEE 3510	Environmental Quality Engineering
S	CEE 4320	Hydrology
S	CEE 4360	Case Studies in Environmental Fluid Mechanics
F	CEE 4510	Microbiology for Environmental Engineering
F	CEE 4540	Sustainable Municipal Drinking Water Treatment
S	CEE 4650	Transportation, Energy, and Environmental Systems for Sustainable Development
S	CEE 5970	Risk Analysis and Management (TOX 5970)
F	CEE 6530	Water Chemistry for Environmental Engineering
F	CEE 6550	Transport, Mixing, and Transformation in the Environment
F	EAS 4570	Atmospheric Air Pollution
F	MAE 5010	Future Energy Systems

Some of these courses have pre-requisites not included in the Biological Engineering curriculum.

F = Fall

S = Spring

HONORS PROGRAM

“With Honors” Designation

The Bachelor of Science degree with honors will be granted to engineering students who, in addition to having completed the requirements for a bachelor’s degree, have satisfactorily completed the honors program in the Department of Biological & Environmental Engineering and have been recommended for the degree by the honors committee of the department. To be eligible for field honors, a student must enter the program with and maintain a cumulative GPA ≥ 3.50 .

A BEE honors program shall consist of at least nine (9) credits beyond the 126 minimum required for graduation in BEE. These nine (9) credits shall be drawn from one (1) or more of the following categories with at least six (6) credit hours in category A:

- A. A significant research experience or honors project under the direct supervision of a BEE faculty member using BEE 4991-4992 -- BEE Honors Research. A written senior honors thesis must be submitted as part of this component. A minimum grade of A- is required for successful completion of the honors requirement.
- B. A significant teaching experience under the direct supervision of a faculty member or as part of a regularly recognized course in the department under BEE 4980 - Undergraduate Teaching.
- C. Advanced or graduate courses. These additional courses must be technical in nature and related to the student’s research area (i.e., engineering, mathematics, biology, chemistry and physics at the 4000 and graduate level).

A written proposal of the honors project must be accepted by the student’s research advisor. Advisor-approved proposals are **due by October 22nd** for review by the BEE Committee on Academic Programs. A preliminary draft of your thesis is due to your honors research advisor **by March 18th**. A final spiral bound copy of the honors thesis is due **by May 13th**.

Timing: All eligible students must complete a written application no later than the end of the third week of the first semester of the senior year, but are encouraged to make arrangements with a faculty member during the second semester of their junior year. A student must be in the program for two (2) semesters during their senior year.

Procedures: Each applicant to the BEE honors program must have a BEE faculty advisor to supervise the honors program. Written approval of the faculty member who will direct the research is required. After the department verifies the student's GPA, the student will be officially enrolled in the honors program.

Latin Honors Designation

Cum laude is awarded to all engineering students with an overall GPA >3.50 . Cum laude is also awarded to all engineering students who received a semester GPA >3.50 in each of the last four semesters of attendance at Cornell; in each of these semesters, at least 12 letter-grade credits must be taken with no failing, unsatisfactory, missing, or incomplete grades. If the student is an Engineering Co-op student, then the Engineering Co-op summer term will count as one of the last four. Students who were approved for prorated tuition in their final semester will be awarded cum laude if they received a semester GPA >3.50 in their last semester and meet the conditions above in the prior four semesters. Magna cum laude is awarded to all engineering students with a GPA >3.75 (based on all credits taken at Cornell). Summa cum laude is awarded to all engineering students with a GPA >4.0 (based on all credits taken at Cornell). All GPA calculations are minimums and are not rounded.

MINORS AND PRE-MED STUDY

Biological Engineering majors may choose to complete one or more of the minors offered in any college. There are over 70 to choose from. Most students can complete a minor within their Biological Engineering program in 8 semesters provided they work closely with their faculty advisor to carefully plan and schedule their courses. Completion of a minor is noted on the final Cornell transcript as official recognition of academic achievement above and beyond the Bachelor of Science degree requirements. Students may participate in either the Biological Engineering minor or the Biomedical Engineering minor, but not both. Note that the Minor in Biological Engineering offered by BEE is NOT available to Biological Engineering majors.

Minors are listed on this web site: <http://www.cornell.edu/academics/minors.cfm>

An example program shown on the next page meets the requirements of the Biological Engineering major and Biomedical Engineering minor.

Pre-Medical Study

Biological engineers in the pre-med program often complete the Biomedical Engineering minor. A sample curriculum plan which identifies the minor and pre-med courses is shown on the following page. Consult the Health Careers Advising office, 103 Barnes Hall for detailed information on Pre-Medical study. The Health Careers website is: <http://www.career.cornell.edu/HealthCareers/>

BIOLOGICAL ENGINEERING

Sample Program for Biological Engineering which meets requirements for the **Biomedical Engineering Minor** and **pre-medical study**

Course Title and Required Credits	Course Number	Credit Hours	Total Credits
1. Mathematics: 16 credits			
Calculus for Engineers I	MATH 1910 ^a	4	
Calculus for Engineers II	MATH 1920 ^a	4	
Engineering Math (Differential Equations)	MATH 2930	4	
Engineering Math (Linear Algebra)	MATH 2940	4	16
2. Physics: 8 credits			
Mechanics	PHYS 1112	4	
Electromagnetism	PHYS 2213	4	8
Pre-medical students may petition the College of Engineering to substitute PHYS 2208.			
3. Chemistry: 7 credits			
General Chemistry I (Chem II counted in Area 9)	CHEM 2070 or 2090 ^a	4	
Organic Chemistry I (O-Chem II counted in Area 9)	CHEM 3570 ^a	3	7
4. Biological Sciences: 15 credits			
Introduction to Biological Science I	BIOG 1XXX ^{a,b,d}	3-4	
Introduction to Biological Science II	BIOG 1XXX ^{a,b,d}	3-4	
Biological Science: 2000 level or above, 3 credits (Select 1-2 courses)			
Biochemistry (BIOBM 3300 recommended)	BIOMG 3300 or 3330 or BIOMG 3310+3320	4/5	
Microbiology/Micro Lab (Both recommended)	BIOMI 2900/2910 ^{a,b}	5	
Behavior/Neurobiology	BIONB 2210 ^a /2220 ^{a,b}		
Physiology/Histology	BIOAP 3110 ^{a,b} /4130 ^a		17-18
5. Written Expression (First Year Writing Seminars): 6 credits			
_____	_____	3	
_____	_____	3	6
6. Liberal Studies: 18 credits (minimum of 6 courses)			
Minimum of six courses in at least three of the seven groups; at least two of six courses at or above 2000 level.			
Cultural Analysis (CA)	Knowledge, Cognition, and Moral Reasoning (KCM)		
Historical Analysis (HA)	Social Behavior and Analysis (SBA)		
Literature and the Arts (LA)	Foreign Language (FL, not literature)		
Communications in Engineering (CE)			
_____	_____	3	
_____	_____	3	
_____	_____	3	
_____	_____	3	
_____	_____	3	
_____	_____	3	18

Course Title and Required Credits	Course Number	Credit Hours	Total Credits
7. Computer Programming: 4 credits Intro to Computer Programming	BEE 1510 or CS 1112	4	4
8. Engineering Distribution and Field Courses: 46 credits			
<i>(a) Required Courses</i>			
Mechanics of Solids	ENGRD 2020 ^c	4	
Engineering Probability and Statistics	ENGRD 2700 or CEE 3040	3/4	
<i>(b) Biological Engineering Core Courses</i>			
The BEE Experience	BEE 1200 or ENGRI	1/3	
Engineering Distribution	BEE/ENGRD 2600	3	
Biological & Bioenvironmental Transport	BEE 3500	3	
Bio-Fluid Mechanics	BEE 3310	4	
Thermodynamics & Biokinetics	BEE 2220	3	
<i>(c) Biological Engineering Concentration</i>			
Three courses in concentration (minimum of 9 credits)			
Com-Aided Engineering	BEE 4530 ^b	3	
Deterministic and Stochastic Modeling in BE	BEE 4600 ^b	3	
Biosensors and Bioanalytical Techniques	BEE 4590 ^b	3	
<i>(d) Major-approved electives to complete 46 engineering credits</i>			
BEE and other Engineering courses at 2000 level or above			
Properties of Biological Materials	BEE 3650 ^b	3	
Bioinstrumentation	BEE 4500 ^b	4	
Molecular Principles of Biomedical Engineering	BME 3010 ^b	3	
Bioengineering Seminar	BME 5010 ^b	1	
Biomedical Engineering	BME 4810 ^b	3	
Biomed Eng Analysis of Metabolic & Structural	BME 4010 ^b	3	46-48
9. Approved Electives: 6 credits			
General Chemistry II	CHEM 2080 ^a	4	
Organic Chemistry II, O Chem	CHEM 3580 ^a /2510 ^a	5	9
TOTAL: 132-135			
(Minimum required: 126)			

^aCourses satisfying pre-medical requirements.

^bCourses may be used in Biomedical Engineering Minor (See Engineering Handbook).

^cEngineering distribution requirement is satisfied by ENGRD 2020 and ENGRD 2510 or ENGRD 2600.

^dChoose BIOG 1440, BIOMG 1350, BIOG 1500 or BIOG 1105/1106.

COURSE OFFERINGS

1200 The BEE Experience

Spring

1 credit

J.B. Hunter

Letter grade only. Requirement for CALS BEE freshman. Not required for students who have completed an ENGR1 course. Prerequisite: BEE majors or permission of instructor. Lec T 3:35-4:25.

Forum covering the career opportunities for engineering students and the activities and curricula that lead to these opportunities. A series of seminars are given by practicing engineers, Cornell faculty members, alumni, staff from the Cornell Career Services offices, and students. Students develop their undergraduate course plans; complete a web search assignment to locate jobs and internships, and select future courses to meet their academic objectives and career goals.

1510 Introduction to Computer Programming

Fall

4 credits

C. L. Anderson

Letter grade only. Limited to 18 students per lab and rec. No previous programming experience is assumed. Pre-or co-requisite: MATH 1910 or equivalent. Lec M W 10:10-11:25; Lab W R 12:20-2:15, 2:30-4:25.

Introduction to computer programming and concepts of problem analysis, algorithm development and data structure in an engineering context. The structured programming language MATLAB is used, implemented on interactive personal computers, and applied to problems of interest in biological and environmental engineering.

2220 Bioengineering Thermodynamics and Kinetics

Spring

3 credits

J. B. Hunter

Letter grade only. Prerequisites: MATH 1920, PHYS 2213 and chemistry course completed or concurrent. Lec M W F 10:10-11:00.

Living systems rely on chemical and phase equilibria, precise coordination of biochemical pathways, and the

release of chemical energy as heat, all of which are governed by the laws of thermodynamics and the rates of chemical reactions. The course covers concepts and laws of thermodynamics as applied to phase transformations, work, heat, and chemical reactions; and reaction kinetics applied to industrial processes and living systems, all with a focus on biological examples.

2510 Engineering for a Sustainable Society (ENGRD 2510)

Fall

3 credits

B. A. Ahner

Letter grade only. Pre- or co-requisite: MATH 2930. Lec T R 10:10-11:25.

Case studies of contemporary environmental issues including pollutant distribution in natural systems, air quality, hazardous waste management and sustainable development. Emphasis is on the application of math, physics and engineering sciences to solve energy and mass balances in environmental sciences. Introduces students to the basic chemistry, ecology, biology, ethics and environmental legislation relevant to the particular environmental problem. BEE students must complete either BEE 2510 or BEE 2600 according to their academic plan. BEE students who complete both BEE 2510 and BEE 2600 receive engineering credit for only one of these courses.

2600 Principles of Biological Engineering (ENGRD 2600)

Fall

3 credits

A. J. Baeumner

Letter grade only. Pre-or co-requisite: MATH 2930, 2 semesters of core biology major classes and the investigative lab or BIOG 1105/1106. Lec T R 10:10-11:25.

Focuses on the integration of biological principles with engineering, math and physical principles. Students learn how to formulate equations for biological systems in class and practice in homework sets. Topics range from molecular principles of reaction kinetics and molecular binding events to macroscopic applications such as energy and mass balances of bioprocessing and engineering design of implantable sensors. Students will also experience scientific literature searches as related to the biological engineering topics, and critical analysis and evaluation of relevant information sources. BEE students must complete either BEE 2510 or BEE 2600 according to their academic plan. BEE students who complete both BEE 2510 and BEE 2600 receive engineering credit for only one of these courses.

3299 Sustainable Development

Spring, Summer 3 credits

M. F. Walter

S/U or Letter grade. Prerequisite: at least sophomore standing. Course is web based.

Sustainable development is the dominant economic, environmental and social issue of the 21st century. This course develops the concepts of sustainable development as an evolutionary process, demanding the integration of the physical sciences and engineering with the biological and social sciences for design of systems. Topics include the nature of ecosystems, global processes, sustainable communities, and industrial ecology, renewable energy and life cycle analysis.

3310 Bio-Fluid Mechanics

Fall, Summer 4 credits

K. G. Gebremedhin

Letter grade only. Prerequisites: ENGRD 2020 and Engineering math sequence. Lec M W F 10:10-11:00, Disc R 2:55-3:45; two evening prelims and a final exam.

Properties of Newtonian and non-Newtonian fluids; hydrostatic and dynamic forces; principles of continuity, conservations of mass, energy and momentum and their applications; laminar and turbulent flows and boundary layer, introduction to Navier Stokes; dimensional analysis and similarity; blood flow in the cardiovascular system; gas exchange in the pulmonary system; blood flow and sodium transport in the kidney. The major concepts are covered by case studies.

3500 Biological and Bioenvironmental Transport Processes

Fall, Summer 3 credits

A. K. Datta

Letter grade only. Pre- or co-requisites: MATH 2930 and fluid mechanics course. Lec M W F 11:15-12:05; Disc W 1:25-2:15, two evening prelims.

Focuses on understanding the principles of heat and mass transfer in the context of biological (biomedical/bioprocessing/bioenvironmental) systems. Emphasizes physical understanding of transport processes and simple reaction rates with application examples from plant, animal and human biology, in the bioenvironment (soil/water/air), and industrial processing of food and biomaterials.

3600 Molecular and Cellular Bioengineering (BME 3600)

Spring 3 credits

J. C. March

Letter grade only. Prerequisites: BEE 2600, biochemistry, linear algebra, ordinary differential equations, or permission of instructor. Lec T R 2:55-4:10

Biotechnology viewed at the cellular and molecular level. Advances in biotechnology will be broken down to their functional parts using the tools of biological engineering (thermodynamics, transport, kinetics, etc.) to understand how and why they work with an emphasis on design. Particular attention paid to gene therapy, synthetic biology, protein engineering and nucleic acid engineering. Case studies in biomedical, bioprocess, and bioenvironmental engineering.

3650 Properties of Biological Materials

Fall, Spring 3 credits

J. A. Bartsch

Letter grade only. Satisfies the BE laboratory experience requirement. Pre- or co-requisite: ENGRD 2020. Lec T R 12:20-1:10; Lab W or F 2:30-4:25 or W 7:30-9:25 PM.

Mechanics and structural properties of biological materials; mechanical testing of animal, plant, and food products. Laboratory exercises involve quasistatic and dynamic testing of materials and interpretation of test results. Uses experimental techniques to determine engineering properties of these materials.

3710 Physical Hydrology for Ecosystems (Offered alternate years)

Spring 3 credits

M. T. Walter

Letter grade only. Prerequisite: MATH 1920 or permission of instructor. Lec T R 9:05-9:55; Lab R 2:30-4:25.

This is an introduction to physical hydrology with an emphasis on roles and interactions between hydrological processes and ecological, biogeochemical, and human systems. <http://www.hydrology.bee.cornell.edu/BEE371Index.htm>

4010 Renewable Energy Systems

Spring 3 credits

M. B. Timmons

Letter grade only. Prerequisite: college physics and chemistry. Lec T R 10:10-11:25.

Introduces energy systems with emphasis on quantifying costs and designing/optimizing renewable energy systems to convert environmental inputs into useful forms of energy. Covers solar energy, small scale hydropower, wind, bio-conversion processes, house energy balances, and psychrometric principles as applied to biomass drying... Focuses on the technologies and small-scale system design, not policy issues. Use of spreadsheets is extensive. Personal laptop computers are required for each class. Class time is often focused on solving weekly homework problems. Required term project that student selects a client and develops a project proposal on a self-selected renewable energy project.

4270 Water Measurement and Analysis Methods

Fall 3 credits

L. D. Geohring, T. S. Steenhuis

Letter grade only. Satisfies BE and EnvE laboratory experience requirement. Prerequisites: CEE 3310 or hydrology course. Lec T 9:05-9:55; Lab T 1:25-4:25.

Get wet and muddy learning how to monitor and characterize water and soil management problems in the natural environment. This is a field based lab course that integrates science and engineering technologies, using various measurement equipment and analytical techniques to quantify water flow and quality parameters in surface and subsurface environments. Measurement accuracy, water sampling quality assurance protocols, and interpretation of watershed contaminants are addressed.

4350 Principles of Aquaculture

Spring 3 credits

M. B. Timmons

Letter grade only. Prerequisite: at least junior standing in a non-engineering discipline and one semester of physics and chemistry. No-one is allowed to add the course after the 2nd lecture. Two required field trips require class to return to campus at approximately 7 p.m. on Wednesday's. Lectures are web based with required reading from course text, "Recirculating Aquaculture", Timmons and Ebeling (2nd Ed., 2010, Cayuga AquaVentures, LLC. Ithaca, NY). Lec W 1:25-2:15

An in-depth treatment of the principles of aquacultural engineering: mass balances, waste treatment design, gas conditioning, production economics, & system design.

Some coverage of fish processing, nutrition and fish health in context of global and local demand is presented, all in the context of engineering analysis and design. Course intended to build upon previous coursework. Course includes "hands on" experiences and field trips and weekly audio-tutorial lectures.

4360 Engineering Design of Aquacultural Systems

Spring 3 credits

M. B. Timmons

Letter grade only. Satisfies BE and EnvE Capstone design requirement Prerequisite: at least junior standing in the College of Engineering. No-one is allowed to add the course after the 2nd lecture. Two required field trips require class to return to campus at approximately 7 p.m on Wednesday's. Lectures are web based with required reading from course text, "Recirculating Aquaculture", Timmons and Ebeling (2nd Ed., 2010, Cayuga AquaVentures, LLC. Ithaca, NY). Lec W 1:25-2:15.

An in-depth treatment of the principles of aquacultural engineering: mass balances, waste treatment design, gas conditioning, production economics, & system design. Some coverage of fish processing, nutrition and fish health in context of global and local demand is presented, all in the context of engineering analysis and design. Course intended to build upon previous coursework. Course includes "hands on" experiences and field trips. The Capstone Design project, done in teams as an open ended project, is constructed as a consulting engineering report to a client and addresses issues of: environmental sustainability, manufacturing design and layout, economic analysis, and health & safety aspects of production. The capstone projects are presented to the class at the end of the course.

4500 Bioinstrumentation

Spring 4 credits

D. J. Aneshansley

Letter grade only. Satisfies both BE laboratory experience and BE capstone design requirement. Prerequisites: MATH 2940, introductory computing, two semesters of physics, statistics, or permission of instructor. Lec T R 8:40-9:55; Lab: one 2 hour lab per week, TBA.

Bioinstrumentation applications are emphasized in this laboratory-based course. Electronic instruments from sensor to computer are considered. Static and dynamic characteristics of components and systems are examined theoretically and empirically. General analog and digital signal condition circuits are designed, constructed, and tested. A variety of biological applications of instrumentation are discussed.

4530 Computer-Aided Engineering: Applications to Biomedical Processes (MAE 4530)

Spring 3 credits

A. K. Datta

Letter grade only. Satisfies BE capstone design requirement. Satisfies College of Engineering technical writing requirement. Prerequisite: heat and mass transfer (BEE 3500 or equivalent). Lec M W F 10:10-11:00.

Introduction to simulation-based design as an alternative to prototype-based design; analysis and optimization of complex real-life processes for design and research, using industry-standard physics-based computational software. Emphasis is on problem formulation, starting from a real process and developing its computer model. Covers biomedical processes in thermal therapy and drug delivery that involve heat transfer, mass transfer and fluid flow. Computational topics introduce the finite-element method, pre- and post-processing, and pitfalls of using computational software. Students choose their own semester-long biomedical project, which is the major part of the course (no final exam).

BEE 4550 Biologically Inspired Microsystems Engineering

Fall 2-3 credits

M. Wu

Letter grade only. Satisfies BE laboratory experience requirement. Prerequisites: one year of biology, BEE 2220 or an equivalent thermodynamics course, co-registration in BEE 3500 and BEE 3310. Lec W F 8:40-9:55. Lab M 1:25-4:25.

Covers fundamental mechanisms that nature uses to build and control living systems at micro- and nano-meter length

scales; engineering principles for fabricating micro/nano-meter scale devices; examples of solving contemporary problems in health sector and environment. The lab sessions will provide students with hands on experiences in cell culture, microfluidic device and live cell imaging techniques.

4590 Biosensors and Bioanalytical Techniques

Fall 3 credits

A. J. Baeumner

Letter grade only. Satisfies BE capstone design requirement. Satisfies College of Engineering technical writing requirement. Prerequisites: biochemistry course and permission of instructor. Lec T R 1:25-2:40.

Provides students with an understanding of the scientific and engineering principles of biosensors and bioanalytical techniques. Addresses selected topics from simple home-pregnancy-style tests to nanofabricated lab-on-a-chip devices. Biosensor and lab-on-a-chip device applications in environmental analysis, food safety, and medical diagnostic are explored. The class is designed to be highly interactive, seeks student participation via frequent discussion sessions. Students also give oral presentations, practice in-depth literature source evaluations analyze biosensors published in literature and theoretically design a biosensor based on criteria discussed in class. Undergraduate students work together in teams of two to three. Meets concurrently with BEE 6590.

4600 Deterministic and Stochastic Modeling in Biological Engineering

Fall 3 credits

J. C. March

S/U or Letter grade. Satisfies BE capstone design requirement. Prerequisites: MATLAB, MATH 2930, MATH 2940, BEE 3500 or equivalent, Mass and Energy Balances, or permission of instructor. Lec T R 10:10-11:25.

This course covers modeling biological systems from an engineering standpoint. Starting with deterministic approaches, the class will functionally decompose and mathematically model systems important to biological engineers (including bioprocessing, biomedicine, and microbial ecology). Mechanistic aspects of biology will be handled using stochastic (probabilistic) approaches in the second half of the semester.

4640 Bioseparation Processes (Offered alternate years)

Fall 3 credits

J. B. Hunter

S/U or Letter grade. Prerequisites: introductory biochemistry, physics, calculus, BEE 2600 or equivalent, or permission of instructor. Lec M W F 12:20-1:10.

Separation methods used in the biotechnology industry, governing principles and applications, and scale-up. Key topics (centrifugation, filtration, extraction, membrane methods, chromatography) supplemented with student presentations.

4710 Introduction to Groundwater (EAS 4710) (Offered alternate years)

Spring 3 credits

T. S. Steenhuis, L.M. Cathles, M. T. Walter,

S/U or Letter grade. Prerequisites: fluid mechanics or hydrology course. Lec F 1:25-4:25, Field Trip.

Intermediate-level study of aquifer geology, and water and contaminant transport in the groundwater and unsaturated zone. Includes description and properties of natural aquifers, groundwater hydraulics, soil water, and solute transport. The class is taught as a special problem course in which readings and problem sets are assigned and then discussed once a week.

4730 Watershed Engineering

Fall 4 credits

M. T. Walter

Letter grade only. Satisfies BE and EnvE capstone design requirement. Satisfies College of Engineering technical writing requirement. Prerequisite: CEE 3310 or hydrology course. Lec T R 10:10-11:00; Disc R 1:25-4:25.

This course teaches basic design and analysis as practiced for water control and nonpoint source pollution prevention. We will discuss the origins of design approaches including their theoretical bases but this is not a theory course. Most of the course is dedicated to practicing applied design. Assignments are generally representative of real-life engineering problems and will involve as much hands-on experience as possible. Some example topics include risk analysis, water conveyance, nonpoint source pollution control, stream restoration, stormwater management, and erosion control.

4740 Water and Landscape Engineering Applications

Spring 3 credits

L. D. Geohring, T. S. Steenhuis

Letter grade only. Satisfies BE and EnvE capstone design requirement. Prerequisites: CEE 3310 or hydrology course or permission of instructor. Lec M W F 12:20-1:10.

This course will focus on how water moves in soil and the implications for design of drainage and irrigation systems in the landscape. The course addresses aspects of soil physics, flow in porous media, water quality and water supply or disposal in regard to drainage and irrigation applications. Emphasis is on problem solving of actual situations, and a major site-design project is required.

4750 Environmental Systems Analysis

Fall 3 credits

D. A. Haith

Letter grade only. Prerequisites: BEE 2510 or BEE 2600 or permission of instructor. Lec T R 11:40-12:55.

Applications of mathematical modeling, simulation, and optimization to environmental-quality management. Fate and transport models for contaminants in air, water, and soil. Optimization methods (search techniques, linear programming) to evaluate alternatives for solid-waste management and water and air pollution control. Introduction to hydrologic simulation (runoff and streamflow). Software packages for watershed analyses of point and nonpoint source water pollution.

4760 Solid Waste Engineering

Spring 3 credits

D. A. Haith

Letter grade only. Prerequisites: BEE 3500 or CEE 3510 or permission of instructor. Lec T R 11:40-12:55.

Planning and design of processes and facilities for management of municipal solid wastes. Source characterization and reduction; collection and transport systems; waste-to-energy combustion; sanitary landfills; composting; recycling and materials recovery facilities; and hazardous waste management. Emphasizes quantitative analyses

4800 Our Changing Atmosphere: Global Change and Atmospheric Chemistry (EAS 4800)

Fall 3 credits

P. G. Hess

S/U or letter grade. Prerequisites: CHEM 2070 or 2090, MATH 1920, PHYS 1112 or equivalent, or permission of instructor. Lec T R 1:25-2:40.

This course investigates the science behind changes in our atmospheres composition and its relation to global change. We will examine the chemistry and physics that determines atmospheric composition on global scales including the effects of biogeochemistry and atmospheric photochemistry.

4810 LRFD-Based Engineering of Wood Structures (CEE 4810)

Spring 3 credits

K. G. Gebremedhin

Letter grade only. Satisfies BE capstone design requirement when co-registered in BEE 4960. Prerequisite: ENGRD 2020. Lec M W F 12:20-1:10 (Hollister Hall), two evening prelims and a final exam.

Computer-aided and manual computation procedures of Load and Resistance Factor Design (LRFD)-based engineering of wood structures. National design codes and standards; estimation of factored design loads and load combinations; mechanical properties of wood and wood products; designs of beams, columns, trusses, frames, arches, bridges, diaphragms, connections, and wood structural systems. Also discussion engineering design as an integral component of the quantitative design procedure.

4840 Metabolic Engineering

Spring 3 credits

R. M. Spanswick

Letter grade only. Prerequisite: biochemistry course or permission of instructor. Lec T R 10:10-11:25.

The principles of metabolic engineering as they relate to the regulation of metabolic pathways, including membrane transport, are considered in terms of enzyme kinetics and metabolic control analysis. Case studies, reflecting the interests of the instructor, include examples involving higher plants in addition to those on microorganisms. Each student is expected to investigate one topic in depth and make a short class presentation.

4860 Industrial Ecology of Agriculturally Based Bioindustries

Spring 3 credits

L. P. Walker

Letter grade only. Prerequisites: one year of calculus, some knowledge of MATLAB. Lec T R 1:25-2:40.

Agricultural-based biofuels and bioproducts systems are very complex and highly integrated. Each of these subsystems are composed of a number of biological, chemical, and physical processes that can be interconnected to a multitude of ways to generate the essential material and energy flows for the production of biofuels and bioproducts. For this course an input/output modeling methodology is employed to develop and manipulate the structure of complex agriculturally-based bio-industries and to generate the material, energy and monetary flows. Students will use linear algebra and state space tools in the MATLAB toolbox to simulate static and dynamic behavior of these complex webs of connected processes and to conduct lifecycle analysis of these complex webs.

4870 Sustainable Bioenergy Systems

Fall 3 credits

L. Angenent

Letter grade only. Satisfies BE and EnvE capstone design requirement. Intended for upper-level undergraduates and graduate students. Prerequisites: BEE 2220 or an equivalent thermodynamics course. Lec T R 9:05-9:55; Lab W 1:25-4:25.

Offers a systems approach to understanding renewable bioenergy systems (biomass) and their conversion processes, from various aspects of biology, engineering, environmental impacts, economics, and sustainable development. A large part of the course will deepen your understanding of bioprocessing with undefined mixed cultures of microbes.

4880 Applied Modeling and Simulation for Renewable Energy Systems

Spring 3 credits

C. L. Anderson

Letter grade only. Prerequisite: senior in engineering, graduate standing or permission of instructor. Lec M W 10:10–11:25.

This course will provide an applied introduction to modeling, simulation and optimization techniques for various renewable energy systems. The course will be modular in nature. Each module will focus on a particular renewable energy application and relevant modeling/simulation tools. Some modules are independent and some will build on previous modules. The instructional format of the course will include lectures, scientific paper reviews, and some MATLAB™ programming. Students will have an opportunity to apply new techniques to a relevant modeling project. The course will culminate with a modeling project relevant to renewable energy. Undergraduates will work in teams of 2-3 students to complete the team project.

4890 Entrepreneurial Management for Engineers

Fall 4 credits

M. B. Timmons

Letter grade only. Satisfies College of Engineering technical writing requirement. Prerequisite: junior standing or higher. No one is allowed to add the course after 2nd week. Lecture M W 2:30-3:20 and 3:35-4:25.

The course focuses on how to start a new company centered on engineering or biological technologies. Course objectives include coverage of: entrepreneurship principles, fund raising, negotiation, financial calculations (internal rate of return, time value of money, proforma statements); legal structures of businesses; project management; and technical writing and communication. Majority of work done in teams including a complete business plan that is presented to angel investors. Business plans should represent an opportunity one member of the group is willing to pursue upon leaving Cornell. Intention is to make the team project as real-world as possible, meaning that the Phase I start up funds are < \$100,000. The Wednesday lab time is devoted to working on business plan components. The engineering economics coverage is in the context of entrepreneurship but covers all topics that are included in the Fundamentals of Engineering Exam (FE), which is the first step towards professional licensing. The overall goal of the course is to move the student towards being prepared to function in a professional work world.

4940 Special Topics in Biological and Environmental Engineering

Fall, Spring 4 credits maximum

Staff

S/U or Letter grade.

The department teaches “trial” courses under this number. Offerings vary by semester and will be advertised by the department. Courses offered under this number will be approved by the department curriculum committee and the same course will not be offered twice under this number. Each 4940 has a unique course ID for enrollment.

[BEE 4940 Terrestrial Hydrology in a Changing Climate (offered alternate years)

Spring 3 credits

P. G. Hess, M. T. Walter

S-U or Letter grade. Prerequisite: one hydrology course (e.g., BEE 3710) or climate course (e.g., EAS 3050) at the 2000 level or higher. Lec T R 11:40-12:55. Next offered 2013-2014.

Explore the impact of climate change on hydrology and the resulting impacts and uncertainty in future water management practices. Course activities will include lectures, seminars, readings, and student lead presentations, discussions and project related to climate change and hydrology.]

BEE 4940 Cross Scales Biogeochemical Modeling

Spring 3 credits

P. G. Hess, N. Mahowald, L. Derry

S-U or Letter grade. Prerequisite: graduate student standing; undergraduate junior or senior with math 2930 and physics 1112; or permission of instructor. Lec T R, TBD

The course will teach the basic principles of biogeochemical modeling from the process level to the global earth system and will include hands-on computer programming.

4960 Capstone Design in Biological and Environmental Engineering

Spring 1 credit

Staff

Letter grade only. Co-requisite: Students must co-register in BEE 4810.

Involves capstone design experience, including a team project incorporating analysis, design, evaluation, synthesis, and a written and oral report of the end-product.

4970 Individual Study in Biological and Environmental Engineering

Fall, Spring 1-4 Credits
Staff

Letter grade only. Prerequisites: written permission of instructor and adequate ability and training for work proposed; normally reserved for seniors in upper two-fifths of their class. Students from all colleges must register with an Independent Study Form (available on line at: <https://dust.cals.cornell.edu/IndStudyPolicy.aspx>).

Special work in any area of biological and environmental engineering on problems under investigation by the department or of special interest to the student, provided, in the latter case, that adequate facilities can be obtained.

4971 Engineers Without Borders Independent Study

Fall, Spring, Summer 1-4 credits
M. F. Walter

S/U or letter grade. Prerequisites: students need to be members of Engineers Without Borders.

The course content must relate directly to goals of Engineers Without Borders (EWB) and can be taken for 1 to 4 credits under supervision of a College of Engineering faculty member with approval of the EWB faculty advisor (Currently M.F. Walter). Internships can consist of on- or off-campus research or work experiences. The independent study should be purposeful, provide opportunities for reflection, present a continual challenge to the student, and incorporate active learning. The student is expected to be an active participant in all stages of the experience from planning to evaluation. Students taking this course must be members of Cornell EWB.

4980 Undergraduate Teaching

Fall, Spring 1-4 credits
Staff

Letter grade only. Prerequisite: written permission of instructor. Students from all colleges must register with an Independent Study Form (available on line at: <https://dust.cals.cornell.edu/IndStudyPolicy.aspx>).

The student assists in teaching a biological and environmental engineering course appropriate to his/her previous training. The student meets with a discussion or laboratory section, prepares course materials, grades assignments, and regularly discusses objectives and techniques with the faculty member in charge of the course.

4990 Undergraduate Research

Fall, Spring 1-4 credits
Staff

Letter grade only. Prerequisites: normally reserved for seniors in upper two-fifths of their class; adequate training for work proposed; written permission of instructor. Students from all colleges must register with an Independent Study Form (available on line at: <https://dust.cals.cornell.edu/IndStudyPolicy.aspx>).

Research in any area of biological and environmental engineering on problems under investigation by the department or of special interest to the student, provided that adequate facilities can be obtained. The student must review pertinent literature, prepare a project outline, carry out an approved plan, and submit a formal final report.

4991-4992 BEE Honors Research

Fall and Spring 1-6 credits
Staff

Letter grade only. Prerequisite: enrollment in the BEE research honors program. Students must be eligible for Latin honors and complete the honors program application by the 3rd week of the fall semester, senior year.

Intended for students pursuing the research honors program in BEE.

5010 Bioengineering Seminar (BME 5010)

Fall, Spring 1 credit
D. Lipson and J. Black

S/U grades only. Prerequisite: junior, senior, or graduate standing.

Students attend self-selected seminars in the fields of engineering, biology, veterinary and human medicine. Eligible seminars include the Biomedical Engineering Seminar, listings in the "Biophysics Colloquia" or those with biological engineering or biological sciences content.

5330 Engineering Professionalism

Spring 1 credit

M. B. Timmons, J. R. Stedinger, other Engineering Faculty
S/U or Letter grade. Prerequisite: graduate student with an accredited engineering degree or senior who will graduate with an accredited engineering degree. Students enrolling in the FE 1-credit review portion must register to take the Fundamentals of Engineering Exam**. Three required lectures (weeks 1, 2, and 11). The other weeks are Wednesday evening working sessions where a professor is present along with two TA's who work primarily one-on-one with students on the weekly homework assignments. Group interaction and teaching is encouraged. Lectures

and Section W 7:30-8:45 final exam required that mimics the real FE 8-hour exam held in mid-April on the Cornell campus.

Course prepares the student for the general national FE Examination taught in a team-based format. FE review homework addresses FE exam preparation, and students complete the formal comprehensive review of engineering subjects associated with the Fundamentals of Engineering Exam. The NY FE exam is valid in any state and does not expire.

** Students must file their NY FE Exam application by either November 1 of the previous year or by May 1 of the spring semester to be enrolled in BEE 5330. The FE exam registration and sitting fees total \$205 and are paid to the NY State Education Department and the testing service, not to Cornell. The NY FE Exam is offered in April and October. The April exam may be taken at Cornell and other NY locations. The October exam is not offered at Cornell. Once the nationally conducted FE exam is passed, it is valid forever and is valid in any state for Professional Engineering registration (requires an additional 4 years of experience under another registered engineer).

5901-5902 M.P.S Project

Fall and Spring 1-6 credits

BEE Graduate Faculty

Letter grade only. Prerequisite: requirement of each M.P.S. candidate in the field.

Comprehensive project emphasizing the application of agricultural technology to the solution of a real problem.

5951-5952 Master of Engineering Design Project

Fall and Spring 3-6 credits

BEE Graduate Faculty

Letter grade only. Prerequisite: admission to the M.Eng. degree program.

Comprehensive engineering design projects relating to the candidate's area of specialization. Projects are supervised by BEE faculty members on an individual basis. A formal project report and oral presentation of the design project are required for completion of the course(s). A minimum of 3 to a maximum of 9 credits of 5951-5952 is required for the M.Eng. degree.

6200 Approaches to Analytical Characterization of Biological Macromolecules

Spring 1 credit

K. A. Edwards

Letter grade only. Prerequisites: permission of instructor. Lec T R 11:15-12:05, 1st 8 weeks of semester.

Survey of modern biological macromolecule characterization techniques (surface plasmon resonance, light scattering, calorimetry, and separation methods). Emphasis on applications for protein analysis and their integration, along with theory, instrumental design, and quantitative analysis. Intended for practical understanding of these techniques in a research setting for upper level undergraduates and graduate students without a strong background in analytical chemistry.

6430 Veterinary Perspectives on Pathogen Control in Animal Manure (VTMED/BIOMI 6430)

Spring 2 credits

D. D. Bowman

Prerequisite: third and fourth year veterinary students. Lec M T W R 3:00-4:00, March 24-May 16.

In-depth look at the management of pathogens in animal manures. Reviews the pathogens involved, the role of governing agencies, the survival of pathogens in the field, and methods of pathogen destruction. Discusses commercial methods of manure processing for the control of these pathogens for the protection of other animals and the human population. Concludes with class discussions with major stakeholders representing the dairy, beef, pork, and poultry industries and their understanding of the problem as it relates to veterinary students.

[6470 Water Transport in Plants (BIOPL 6510) (Offered alternate years)

Fall 2 credits

R. M. Spanswick

Letter grade only. Lec T R 10:10-11:00. Next offered 2013-2014.

Topics include: water relations of plant cells and tissues using water potential terminology; permeability of plant cells to water and the role of aquaporins; transport of water through whole plants, including transpiration, stomatal physiology, and the modifications due to plant communities; water status and plant growth in relation to water stress.]

6490 Solute Transport in Plants (BIOPL 6490) (Offered alternate years)

Fall 3 credits

R. M. Spanswick

Letter grade only. Lec TR 10:10-11:25.

A fundamental treatment of the transport of ions and small organic molecules in plants.

[6570 Mixed-Culture Engineered Systems: Bioenergy and Microbial Ecology (Offered alternate years)

Spring 3 credits

L. Angenent

Letter grade only. Prerequisite: graduate standing only. Lec T R 10:10-11:25. Next offered 2013-2014.

We will perform an in-depth analysis of the latest publications that describe undefined mixed cultures of microbes in engineered systems for bioenergy production. We will especially discuss different organic waste treatment options, such as anaerobic digestion, aerobic digestion, composting, bioelectrochemical systems (such as microbial fuel cells), and carboxylic-acid fermentation systems. The latest and most powerful molecular biology techniques (e.g., 16S rRNA gene surveys, metagenomics, proteomics, metatranscriptomics) will be discussed in the context of undefined mixed culture engineered systems. Some bioinformatic and microbial ecology tools will also be used in a hands-on project module. After completing this course, you should be able to critically read and evaluate scientific papers that show results obtained with molecular techniques from engineered systems. More specifically, you should be able to know the limitations of the utilized techniques and be able to give other techniques that may complement or improve the knowledge gained from the study.]

6580 Biofuels Topics (Offered alternate years)

Spring 3 credits

L. Angenent

S/U or letter grade. Prerequisites: graduate standing. Lec T R 10:10-11:25.

The specific topic changes each year, and will be chosen with the input from graduate students at the beginning of the course, but will be within the area of biofuels or bioenergy generation. This class is highly participation-oriented and each student is expected to actively participate. During each lecture we will review a single paper selected by a student and go in depth. Within the biofuels topic, we will not only discuss the research and science, but also the application and evaluation. For

example, we will examine the economic analysis and the life cycle assessment. The student choosing the paper will be expected to lead the discussion after a small lecture. The others will provide a summary of each paper possibly with additional sources.

6590 Biosensors and Bioanalytical Techniques

Fall 3 credits

A. J. Baeumner

Letter grade only. Prerequisites: biochemistry course and permission of instructor. Lec T R 1:25-2:40.

Provides students with an understanding of the scientific and engineering principles of biosensors and bioanalytical techniques. Addresses selected topics from simple home-pregnancy-style tests to nanofabricated lab-on-a-chip devices. Biosensor and lab-on-a-chip device applications in environmental analysis, food safety, and medical diagnostic are explored. The class is designed to be highly interactive, seeks student participation via frequent discussion sessions. Students also give oral presentations, practice in-depth literature source evaluations analyze biosensors published in literature and theoretically design a biosensor based on criteria discussed in class. Meets concurrently with BEE 4590. BEE 6590 students work independently on individual biosensor projects.

[6740 Ecohydrology (Offered alternate years)

Spring 3 credits

M. T. Walter

Letter grade only. Prerequisite: ecology or hydrology course. Lec T R 9:05-9:55; Sec R 2:30-4:25. Next offered 2013-2014.

The objective of this course is to investigate novel topics that involve the interactions between physical hydrological processes and ecosystem processes, including the impacts of human activities on the ecohydrological system. The course is designed to encourage teams of students from historically disparate disciplines to collaboratively combine their unique skills and insights to answer multidisciplinary ecohydrological questions. This course will consider a broad range scales from a stomate and a soil pore to a forest, watershed, and region, with emphasis placed on those scales and systems most appropriate to student interests. Through course work we will clarify the current understanding of various topics, identify knowledge gaps, develop hypotheses, and test them quantitatively by creating models and analyzing available data. The goal of this course is to identify the basic principles of ecohydrology and become familiar and

comfortable with a range of quantitative tools and approaches for answering ecohydrological questions.]

6870 The Science and Engineering Challenges to the Development of Sustainable Bio-based Industries

Fall 1 credit

L. P. Walker

Letter grade only. Prerequisite: graduate standing. Disc R 12:20-1:10; Lec R 1:25-2:15.

Environmentally sustainable alternatives for our energy and chemical needs are critical. This seminar series explores challenges facing the development of industries that use biologically derived materials to produce useful chemicals and energy for society. Topics include natural products from biological systems, conversion of biomass to fuel and other commodities, and the use of biological systems for environmental remediation.

6880 Applied Modeling and Simulation for Renewable Energy Systems

Spring 3 credits

C. L. Anderson

Letter grade only. Prerequisite: senior in engineering, graduate standing or permission of instructor. Lec M W 10:10-11:25

This course will provide an applied introduction to modeling, simulation and optimization techniques for various renewable energy systems. The course will be modular in nature. Each module will focus on a particular renewable energy application and relevant modeling/simulation tools. Some modules are independent and some will build on previous modules. The instructional format of the course will include lectures, scientific paper reviews, and some MATLAB™ programming. Students will have an opportunity to apply new techniques to a relevant modeling project. The course will culminate with a modeling project relevant to renewable energy. Graduate students will be required to complete the term project on an individual basis.

6940 Graduate Special Topics in Biological and Environmental Engineering

Fall, Spring 4 credits maximum

BEE Graduate Faculty

S/U or Letter grade.

The department teaches "trial" courses under this number. Offerings vary by semester and are advertised by the department. Courses offered under this number will be approved by the department curriculum committee and the

same course will not be offered twice under this number. Each 6940 has a unique course ID for enrollment.

6970 Graduate Individual Study in Biological and Environmental Engineering

Fall, Spring 1-6 credits

BEE Graduate Faculty

S/U or Letter grade. Prerequisite: permission of instructor.

Topics are arranged by faculty at the beginning of the semester.

7000 Orientation to Graduate Study

Fall 1 credit

A. J. Baeumner

S/U grade only. Prerequisite: new graduate students in BEE. Lec first 7 weeks, M 10:10-11:00.

Introduction to BEE research policy, programs, methodology, resources, and degree candidates' responsibilities and opportunities including those for fellowship funding.

7540 The Right to Water

Spring 2 credits

T. S. Steenhuis, G. Holst-Warhaft, et al.

S/U or Letter grade. Prerequisite: graduate standing or permission of instructors. Lec M 1:25-3:20.

The course addresses the crisis of water in the Mediterranean region, through case studies situated in watershed basins, especially the Nile. It focuses on attitudes, conflicts, and relationships of local people and nations toward water, expressed in culture, environmental laws and watershed management practices.

7600 Nucleic Acid Engineering (BME 7600)

Spring 2 credits

D. Luo

S/U or Letter grade. Prerequisite: graduate standing, seniors by permission of instructor. Lec T R 12:20-1:10.

Nucleic acid engineering focuses on manipulating nucleic acid molecules in a true engineering sense as well as in the "genetic engineering" sense by treating nucleic acids (including DNA, RNA, PNA and TNA) as both genetic and generic materials. Both biomedical and non-biomedical applications of nucleic acid engineering, including tool kits for nucleic acid engineering and current examples of DNA-based engineering, DNA nanotechnology, and DNA-based medicine are introduced.

Efficient and effective literature reading and evaluation are emphasized.

7710 Soil & Water Engineering Seminar

Fall, Spring 1 credit

T. S. Steenhuis, M. F. Walter, M. T. Walter.

S/U or letter grade. Prerequisite: graduate standing or permission of instructor. Lec M 3:30-4:25.

Study and discussion of research or design procedures related to selected topics in watershed management, erosion control, hydrology, colloid transport, and water quality.

Note to Undergraduates: the following courses are restricted to Graduate level students.

8900 Master's-Level Thesis Research

Fall, Spring 1-15 credits

BEE Graduate Faculty

S/U grade only. Prerequisite: permission of advisor.

Variable credit for M.S. research.

9900 Doctoral-Level Thesis Research

Fall, Spring 1-15 credits

BEE Graduate Faculty

S/U grade only. Prerequisite: permission of advisor.

Variable credit for Ph.D. research.

BEE FACULTY AND INSTRUCTORS

BETH A. AHNER, 104 Riley-Robb Hall, 607.255.2270, baa7@cornell.edu

In general, my research in environmental biotechnology explores how organisms adapt to environmental stress and how organisms can be harnessed to produce raw materials in a sustainable manner. I am particularly interested in trace metal stress in the environment— for example how plants solubilize, take up, detoxify and sequester toxic or nutrient metals. My laboratory group focuses on research questions involving intracellular detoxification mechanisms and how biological processes affect the biogeochemical cycling of metals in the natural environment and in engineered systems. One application of this research is to phytoremediation, the use of plants to remove metals from contaminated soils. I am also working in the area of biofuels both through biomolecular farming or the production of specialty enzymes and proteins in transgenic plants and algae and through projects that specifically focus on algae biomass as a biofuel source.

Teaching

BEE 2510 Engineering for a Sustainable Society

LOUIS D. ALBRIGHT, 304 Riley-Robb Hall, 607.255.2483, lda1@cornell.edu

My interests concern environmental control and energy management in agricultural buildings, particularly commercial greenhouses. Recent emphasis has been on energy conservation, microclimate, and computer control of Controlled Environment Agriculture (CEA) facilities for vegetable production in cold and cloudy climates. Development of fault-detection methods, and a systems approach to greenhouse production, are related concerns also part of the research effort. Mathematical modeling of the thermal environment of greenhouses and animal housing continues to be of interest as is the use of energy-efficient microclimate control to enhance the production of pharmaceuticals and other high-value chemicals from plants, both natural and genetically modified.

C. LINDSAY ANDERSON, 332 Riley-Robb Hall, 607.255.2474, cla28@cornell.edu

My research interests are in the area of systems analysis, particularly the modeling, simulation and optimization of energy systems. Much of my research deals with the interactions between market forces and environmental issues in deregulated electricity markets. Currently I am examining ways to moderate the uncertainty associated with wind energy, so that wind farms can participate more fully in the US energy markets. I am also interested in the development of a framework for the design of effective biofuels industry in North America.

Teaching

BEE 1510 Introduction to Computer Programming

BEE 4880/6880 Applied Modeling and Simulation for Renewable Energy Systems

DANIEL J. ANESHANSLEY, 318 Riley-Robb Hall, 607.255.3069, dja4@cornell.edu

I have always been an experimenter and have spent most of my teaching and research career experimenting with biological and electrical systems. My courses are laboratory based in which I try to share the variety of tools I have accumulated as an engineer and through associations with biologists, animal scientists, veterinarians and physicians. I have studied biological systems to see how they solve engineering problems, designed engineering interfaces to biological systems, designed and constructed nondestructive testing or inspection systems for food products and modeled biological and agricultural systems. Most of this activity is related to bioinstrumentation, but has connections to bioinspection (apples, beef, swine), biomimetics (insect defense and communication system), cellular transport (mosquito kidneys), electrophysiology (affects of electricity on dairy cows) and aspects of energy (biomass and reduced usage).

Teaching

BEE 4500 Bioinstrumentation

LARGUS ANGENENT, 214 Riley-Robb Hall, 607.255.2480, la249@cornell.edu

I am interested in converting organic materials into useful products, and have worked mainly in the area of energy generation. The members in my lab (The Angenent Lab) optimize biological anaerobic fermentation processes to foster undefined mixed cultures or pure cultures to generate the energy carriers - methane, electrical current, hydrogen, and alcohols. In this area, my lab focuses on improving the performance and stability of anaerobic digesters, on novel microbial fuel cell configurations, and on the optimization of anaerobic fermentation. When necessary, molecular biology techniques are used in conjunction with long-term bioreactor studies. We use PCR assays, hybridization assays, functional genomic approaches, and highly parallel sequencing technologies, to ascertain the biological mechanisms of substrate conversion. We are, thus, working on the interface between biology and engineering to produce bioenergy from lignocellulosic materials or industrial, agricultural, and municipal waste (water).

Teaching

BEE 4870 Sustainable Bioenergy Systems
BEE 6570 Mixed-Culture Engineered Systems: Bioenergy and Microbial Ecology
BEE 6580 Biofuels Topics

LUDMILLA ARISTILDE, 312 Riley-Robb Hall, 607.255.6845, la31@cornell.edu

The research efforts in my group are aimed towards understanding of the "why" and "how" of the environmental behavior of biologically-active organic molecules and contaminants with implications for ecosystem health. We are particularly interested in the fate and effects of emerging contaminants including pharmaceuticals, antibiotics, hormones, and natural toxins in soils and surface waters and in the reactivity and fate of important macromolecules including proteins, enzymes, and genetic fragments in soils. Our approach is to employ a combination of experimental and computational techniques to elucidate the mechanisms of the chemical and biochemical interactions relevant to the environmental chemistry and toxicology of these molecules. The long-term goal of our research is to contribute to the evaluation of the potential risk or implications of these bioactive molecules for environmental fate and exposure, ecosystem health, and environmental toxicology.

ANTJE J. BAEUMNER, 202 Riley-Robb Hall, 607.255.5433, ajb23@cornell.edu

My research focuses on the development of biosensors and bioanalytical microsystems (micro-TAS) for the detection of viable pathogenic organisms in food, the environment and in clinical diagnostic. Pathogens of interest range from *Cryptosporidium parvum* to Dengue virus to *B. anthracis*. Molecular biological recognition of the pathogenic organisms is integrated with micro- and nanofabricated devices in order to develop portable analytical systems for field use. A group of postdocs, graduate students and several undergraduate students is working on projects investigating highly specific mRNA sequences of pathogens and how to amplify their presence using molecular biological techniques, modeling and designing micromixers, developing micropotentiostats, developing novel cell lysis systems based on lasers, and combining all of this for the development of a micro-TAS. Testing the biosensors in a variety of matrices such as apple cider, environmental water samples, blood etc. is in progress for a couple of pathogen analytes. Most recently, sensor systems for the use in the Third World have become a design focus in part of the research group. Challenges such as stability of the biological systems under high temperature tolerance and simplicity of use are being addressed. Examples of analytes here include CD4+ T-lymphocytes for AIDS/HIV related diagnostics.

Teaching

BEE 2600 Principles of Biological Engineering
BEE 4590/6590 Biosensors and Bioanalytical Techniques
BEE 7000 Orientation to Graduate Study

JAMES A. BARTSCH, 314 Riley-Robb Hall, 607.255.2800, jab35@cornell.edu

My primary interest is working with students in a teaching and advising capacity. The BEE undergraduate program and all of the people associated with it is the single most enjoyable part of my job at Cornell.

I teach a course (BEE 3650) on the engineering properties of food products and biological materials, along with two freshmen introductory courses.

My research includes work in Material Properties and Postharvest Systems Engineering for Horticultural Crops. Part of my time is devoted to outreach in the postharvest systems area and in International development and appropriate technology.

Teaching

BEE 3650 Properties of Biological Materials

ASHIM K. DATTA, 208 Riley-Robb Hall, 607.255.2482, akd1@cornell.edu

My research and teaching programs are built around the application of transport phenomena (e.g., energy and water transport, fluid flow) in biological processes in an effort to better understand their complexities. We have been active in two broad application areas industrial food processing and medicine. From a fundamental engineering standpoint, these two areas have a lot in common that become particularly evident as we approach from a transport phenomena viewpoint. In food process engineering, we develop quantitative models for complex processes such as frying and meat cooking under various heating modes (such as microwave and infrared) and their combinations, with a goal to improve their safety and quality in industrial processing. From time to time we have ongoing biomedical projects, jointly with College of Veterinary Medicine at Cornell or with Albert Einstein College of Medicine, in the areas of modeling physiological flows or drug delivery, respectively. My teaching program provides the knowledge base in transport processes-- the first course deals with the basics of energy and mass transport and the second one builds on the first one through class projects involving real-life biomedical processes.

Teaching

BEE 3500 Biological and Bioenvironmental Transport Processes

BEE 4530 Computer-aided Engineering: Applications to Biomedical Processes

KATIE A. EDWARDS, 145 Riley-Robb Hall, 607.254.6435, kae24@cornell.edu

My research is centered on the development and characterization of biosensors and bioanalytical methodologies. Techniques employed for characterization include fluorescence spectroscopy, isothermal titration calorimetry, resonant waveguide grating biosensors, and high performance liquid chromatography. These techniques are used to understand and improve the specificity and sensitivity of portable assays similar to home pregnancy tests and high-throughput assays commonly found in laboratory environments for analytes of environmental, national security, and clinical interest.

Teaching

BEE 6200 Approaches to Analytical Characterization of Biological Macromolecules

KIFLE G. GEBREMEDHIN, 322 Riley-Robb Hall, 607.255.2499, kgg1@cornell.edu

The thrust of my research program is in two areas: The first area is on structural mechanics and timber engineering. The focuses on this area has been on efficient use of wood and wood products in structural applications through advanced testing, modeling, and development of analysis techniques to design efficient and safe wood structures. This includes theoretical studies, and experimental testing of joints, scaled-down-structural assemblies (diaphragms) and full-scale post-frame buildings. The second area is on engineering livestock thermal environments to maximize production and reproduction potential; stress factors of livestock; and modeling from bio-energetics to population dynamics of single or multiple species of animals for sustainable ecosystem.

Teaching

BEE 3310 Bio-Fluid Mechanics

BEE 4810 LRFD- Based Engineering of Wood Structures

BEE 4960 Capstone Design in Biological and Environmental Engineering (with BEE 4810)

LARRY D. GEOHRING, 212 Riley-Robb Hall, 607.255.2481, ldg5@cornell.edu

I joined Cornell in 1977 to coordinate an interdisciplinary project dealing with water management on agricultural and rural lands in New York State. Having a farm background and prior drainage and irrigation experience working in the Colorado River Basin, my interests in applied research and technology transfer in hydrology and soil and water management complement those of other faculty in the Department of Biological and Environmental Engineering. My engineering and construction skills have also facilitated several drainage and irrigation infrastructure improvements on various Cornell University research farms, providing experiential learning opportunities for students in engineering design classes and benefiting researchers in other Departments. Research interests include managing water quantity and quality for the benefit of agricultural production, society, and the environment; and encompass aspects of soil-water-plant relationships and the fate and transport processes of nutrients and other potential pollutants. My interests in technology transfer and teaching is in identifying, developing, applying, and facilitating natural or engineered solutions to address various soil and water resource management concerns and environmental policy issues, and in encouraging students to broaden their education and horizons to do the same.

Teaching

BEE 4270 Water Measurement and Analysis Methods
BEE 4740 Water and Landscape Engineering Applications

DOUGLAS A. HAITH, 308 Riley-Robb Hall, 607.255.2802, dah13@cornell.edu

My work is in environmental systems analysis, or the application of mathematical modeling and optimization to environmental problems. Much of my research deals with nonpoint source pollution, risk assessment, and toxicology. Current research includes watershed modeling, environmental and human health impacts of pesticides applied to turf, and climate change implications of solid waste management.

Teaching

BEE 4750 Environmental Systems Analysis
BEE 4760 Solid Waste Engineering

PETER G. HESS, 228 Riley-Robb Hall, 607.255.2495, pgh25@cornell.edu

My research is geared towards understanding how anthropogenic and natural processes affect the chemical composition of the atmosphere. The composition of the atmosphere affects air quality and the response of the climate system to global change. I am particularly interested in the coupling between atmospheric chemistry and climate and in predicting future changes. My research primarily makes use of large three dimension computer simulations of the atmosphere and its chemistry.

Teaching

BEE 4800 Our Changing Atmosphere: Global Change and Atmospheric Chemistry
BEE 4940 Cross Scales Biogeochemical Modeling
BEE 4940 Terrestrial Hydrology in a Changing Climate

JEAN B. HUNTER, 207 Riley-Robb Hall, 607.255.2297, jbh5@cornell.edu

Currently my main research interest is in the engineering design and optimization of space life support technology, particularly the food and water subsystems. Recent projects have dealt with water recovery from challenging waste streams such as ISRU condensates and water reprocessing brines, drying and stabilization of astronaut cabin waste (space trash), design and cost analysis of food systems based on bulk packaged ingredients and crops grown on planetary surfaces. I also retain an interest in the use of fermentation, enzyme technology, and bioseparation processes for manufacturing value-added products from agricultural and food processing residues.

Teaching

BEE 1200 The BEE Experience
BEE 2220 Bioengineering Thermodynamics and Kinetics
BEE 4640 Bioseparation Processes

LYNNE H. IRWIN, 422 Riley-Robb Hall, 607.255.2805, lhi1@cornell.edu

My general area of research and extension interest is low-volume, farm-to-market roads. My research is focused on the structural evaluation of roads using the falling weight deflectometer (FWD). We have developed computer programs for determining the properties of pavement layers from the FWD data. We have also developed instrumentation and software for calibrating FWDs.

In the past we have investigated ways to understand how soil stabilization improves highway materials through a study of the basic strength properties of stabilized soils. Several recent graduate student theses describe our progress in this area.

A related research interest is in the investigation of seasonal variations of pavement strength. This project is directed at understanding the impact of freeze-thaw and other environmental parameters on the weight of vehicles that can safely use farm-to-market roads. The FWD is used in our field research program.

In the highway drainage area I am interested in developing improved methods for runoff estimation and drainage design. I am also interested in erosion control, particularly by comparing some of the newer synthetic products with the traditional methods for erosion control.

My extension activities are directed primarily at the city and village public works officials and the town and county highway superintendents in New York State. Each year we conduct two statewide conferences on road and bridge issues, we teach 50 to 60 one-day workshops around the state, and periodically I speak at meetings of local associations of highway officials.

DAN LUO, 226 Riley-Robb Hall, 607.255.8193, dl79@cornell.edu

My general research and teaching interests focus on bioengineering at the molecular and cellular level. In particular, my group has been engaged in engineering nucleic acids including DNA and RNA. In addition to the critical role nucleic acids play in living organisms as the carriers of genetic information, nucleic acid can also be employed as a generic material. My group has been employing DNA/RNA as true polymers for novel, generic materials, from which we are exploring real-world applications in diagnostics, pharmaceuticals, protein production, drug delivery, cell culture and optoelectronics.

Teaching

BEE 7600 Nucleic Acid Engineering

JOHN C. MARCH, 220 Riley-Robb Hall, 607.254.5471, jcm224@cornell.edu

Work in my laboratory is focused on reconfiguring biological systems for improved performance in the areas of biomedicine and sustainability. We attempt to change bacterial or eukaryotic signal transduction to make cells that are more responsive to their environment and more efficient as technological tools. By rewiring cellular signaling circuitry, we tailor highly specific responses to a wide array of process inputs.

Most of the work in our laboratory is centered in three major areas: 1) signal transduction, 2) metabolism and 3) eukaryotic-prokaryotic interactions. Into each of these disciplines we take the tools of biological engineering. While we are primarily concerned with events occurring at a subcellular level, sometimes the best solution can be found by focusing on the environment immediately around a cellular population. To that end we are working with collaborators to develop platforms that can house cells in a way that facilitates high throughput screening of various environments. Currently there are three specific areas that are of interest:

- Engineering eukaryotic cells for recombinant cell culture,
- Ingestible Microorganisms for Adjustive Gene Expression, and
- Microfluidic platforms for exploring waste product conversion.

Teaching

BEE 3600 Molecular and Cellular BioEngineering

BEE 4600 Deterministic and Stochastic Modeling in Biological Engineering

GERALD E. REHKUGLER, 326 Riley-Robb Hall, 607.255.0052, ger1@cornell.edu

I am an Emeritus Professor volunteering for advising undergraduate students and enjoy providing assistance to aspiring biological and environmental engineers. I continue to be interested in design of machinery in the context of biological systems. Energy demand of the food system as a function of dietary needs also intrigues me. My most active current project is preparing the Rau Model plow collection to be available on line for those interested in the history of the development of the plow.

NORMAN R. SCOTT, 216 Riley-Robb Hall, 607.255.4473, nrs5@cornell.edu

I have been involved in bioengineering research and teaching throughout my academic career. Research has focused on thermoregulation in poultry, biomechanics of machine milking of dairy cows and electronic applications in agriculture, with particular attention to automatic identification and estrus detection of livestock. A principal theme of this research is biothermal engineering for plants, animals and humans.

I have now redirected my research and teaching interests to sustainable development. I believe “sustainable development” is the dominant economic, environmental and social issue for the 21st century. To meet this challenge requires an entrepreneurship, which combines energy, environmental, industrial, and agricultural knowledge and innovation. The objective is to combine science, engineering, technology, economics, and social principles to “engineer” new ecologically sustainable communities. The concept represents the epitome of systems analysis— a challenge combining the insight from the physical sciences with those of the biological and social sciences. Characteristics of a sustainable community will be based in biologically-derived fuels, renewable energy, recycling, energy conservation, reduced transportation, managed ecosystems, advanced housing systems and sustainable agriculture.

ROGER M. SPANSWICK, 316 Riley-Robb Hall, 607.351.2813, rms6@cornell.edu

My research program aims to relate basic studies of transport and metabolism to the flows of carbon, nitrogen and mineral nutrients that determine (a) the quantity and quality of the economic yield of crop plants, particularly in relation to the production of biofuels, and (b) the capacity of the plants to function in bioremediation of sites contaminated by heavy metals while yielding products suitable for industrial use.

Teaching

BEE 4840	Metabolic Engineering
BEE 6470	Water Transport in Plants
BEE 6490	Solute Transport in Plants

TAMMO S. STEENHUIS, 206 Riley-Robb Hall, 607.255.2489, tss1@cornell.edu

The primary focus of my research is on the management of soil and water resources as they relate to agricultural processes. This requires an understanding of the complex interrelations between morphology, water flow, plant growth, and fertility. The research proceeds, therefore, from basic processes governing these relationships, and leads to fundamental and universally applicable solutions to engineering design problems in water management.

The research program currently emphasizes the fate of agricultural toxics and nutrients applied to the land. Conditions allowing the occurrence of wetting-front instability for layered soils such as are found in areas that overlie major aquifers are being studied, as well as the water quality of tile drain effluents in nonhomogeneous soils. The outcome of these studies will lead to mathematical models that realistically describe the movement of toxics and water under field conditions. Currently we are also adapting these models to describe movement of nonaqueous phase liquids through soils.

Another area of research is the application of computer graphics in water management design. Among the procedures that have been developed is one for the design of subsurface drainage systems, another for the hydraulic loading of land treatment sites, and yet another to track pesticides through the vadose and saturated zones. Other computerbased design tools are under development.

Teaching

BEE 4270	Water Measurement and Analysis Methods
BEE 4710	Introduction to Groundwater
BEE 4740	Water and Landscape Engineering Applications
BEE 7540	The Right to Water
BEE 7710	Soil and Water Engineering Seminar

MICHAEL B. TIMMONS, 302 Riley-Robb Hall, 607.255.1630, mbt3@cornell.edu

Optimization of animal environments to maximize economic return is a primary focus of my research programs. Aquacultural engineering activities are currently being addressed with emphasis on water quality and management systems. My research focuses on the broad area of aquaculture with particular emphasis on water recycle systems. Recent research has addressed biological filtration, gas transfer processes, bi-valves used for filtration, and use of growth hormone. Species of interests include various salmonids, tilapia, oysters and clams and salt-water shrimp. An Extension program related to the above topics is also being conducted.

Emphasis on computer modeling in developing user software is being emphasized to answer a producer's questions of, "what if ...", i.e., the economic ramifications of a change in management.

Named by President and Board of Trustees in 2000 as a J. Thomas Clark Professor of Entrepreneurship & Personal Enterprise Program (Multi-university Program).

Teaching

BEE 4010	Renewable Energy Systems
BEE 4350	Principles of Aquaculture
BEE 4360	Engineering Design of Aquacultural Systems
BEE 4890	Entrepreneurial Management for Engineers
BEE 5330	Engineering Professionalism

LARRY P. WALKER, 232 Riley-Robb Hall, 607.255.2478, lpw1@cornell.edu

The use of enzymes, microorganisms and plants as active components of industrial processes is a rapidly expanding and challenging area of study. What makes this area so fascinating is the numerous opportunities for integrating biological and engineering concepts to develop new products and processes. Many of the new developments in modern agriculture are products of this synthesis. My research activities are focused on developing processes and methods for the industrial utilization of enzymes, microorganisms, and plants. Currently, my research activities are focused in two areas: enzymatic hydrolysis of polysaccharides, and high-solids aerobic decomposition. My enzymatic research has focused on understanding the molecular mechanisms of synergism between cellulases -- the cooperative interactions of cellulases on insoluble cellulose; and how cellulose morphological features, such as pore size distribution and crystalline structure, influence the binding and catalytic activity of native enzymes and their respective catalytic (CDs) and binding domains (CBDs). My aerobic decomposition research has focused on understanding and manipulating coupled mass and energy transport mechanisms and microbial kinetics in solid-state microbial processes. In addition, I am also interested in studying changes in the microbial ecology due to changes in environmental conditions and to changes in the type and distribution of carbon sources. A relatively new area of research is the use of plants for bioremediation of sites contaminated with toxic metals. Once again, the focus is on identifying and modeling the mechanisms responsible for ion uptake and active transport in plants, and coupling this knowledge with the science of mass transport to design and manipulate plant based bioremediation systems.

Teaching

BEE 4860	Industrial Ecology of Agriculturally Based Bioindustries
BEE 6870	The Science and Engineering Challenges to the Development of Sustainable Bio-based Industries

MICHAEL F. WALTER, 218 Riley-Robb Hall, 607.255.3161, mfw2@cornell.edu

My program is focused primarily on international and sustainable development. I am particularly interested in working on interdisciplinary programs with my expertise in irrigation, soil and water conservation, and rural development. The nexus of water and energy is a particular interest.

Teaching

BEE 3299	Sustainable Development
BEE 4971	Engineers Without Borders Independent Study
BEE 7710	Soil and Water Engineering Seminar

M. TODD WALTER, 222 Riley-Robb Hall, 607.255.2488, mtw5@cornell.edu

My primary interests are in the linkages between hydrology and ecosystems and as such my research is generally interdisciplinary, collaborative, and broad in scope. Much of my research is focused on the transport and fate of nutrients, organisms, sediments, and other substances in the environment. My work is typically mechanistic, or physically based, and considers a wide span of spatial scales from bacteria and raindrops to watershed-wide ecohydrological processes. Two of my current focus areas are: (1) linking hydrology with biogeochemical hotspots and (2) developing nanobiotechnology to study landscape scale processes. Other interests include water quality protection, environmental fluid mechanics, cold-regions hydrology, watershed and hydro-meteorological modeling, environmental biophysics, and climate change impacts on water resources.

Teaching

BEE 3710	Physical Hydrology for Ecosystems
BEE 4710	Introduction to Groundwater
BEE 4730	Watershed Engineering
BEE 4940	Terrestrial Hydrology in a Changing Climate
BEE 6740	Ecohydrology
BEE 7710	Soil and Water Engineering Seminar

MINGMING WU, 306 Riley-Robb Hall, 607.255.9410, mw272@cornell.edu

My research and teaching interests are in the field of cellular bioengineering - an emerging field that aims at a quantitative understanding of cell functions using engineering principles and applies this understanding to develop cell-based biotechnologies. More specifically, my lab is working on a range of problems that elucidate how prokaryotic and eukaryotic cells proliferate, adhere and move in respond to physical (*e.g.* fluid flow or mechanical stress) and chemical (chemokine/growth factor gradient) cues within their microenvironment, using an integrated method of Microsystems engineering, cellular engineering, advanced imaging methods and theoretical modelling. Currently, one research project is to develop high throughput microfluidic devices to model 3D cancer cell microenvironment, to learn how physical and chemical microenvironment of cancer cells play a role in cancer cells' ability to metastasize. Cancer metastasis is a leading cause of all cancer death. This work can potentially improve current diagnostic tools for cancer patients. A second research project is to develop novel micro-scale 4D imaging techniques to track cellular dynamics, as well as to map mechanical stresses around the cells in space and time. We are using this tool to learn how mechanical environment of cancer cells influences cancer progression. A third project investigates the fluid mechanics of a living fluid – bacterial suspension. We are particularly interested in how cell-cell, cell-fluid interactions as well as chemotactic cell migration mediate the transport of cells within this new fluid. Undergraduate research has always been an integrate part my research program, as they often bring in new ideas and expand the ranges of things we do in the lab. Many of the undergraduate students in my lab have published in peer reviewed journals as a result of their work in the lab.

Teaching

BEE 4550	Biologically Inspired Microsystems Engineering
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YOUR FACULTY ADVISOR

Each Biological Engineering student is assigned a faculty advisor. The primary role of the advisor is to guide you through your academic program and to assist with questions or problems you may have along the way. You will pre-register for each semester's classes in the middle of the previous semester using CoursEnroll. You should plan on meeting with your faculty advisor early in the pre-enrollment process to discuss your progress and course selections. Advisors do not select your courses for you and you are ultimately responsible for meeting all graduation requirements. However, we do track your progress and alert you of your progress toward graduation in each semester of the junior and senior year.

We also enjoy getting to know you and we appreciate hearing about your successes in academics and in life. We will talk with you about career plans, provide letters of recommendation and assist you with applying to graduate or professional schools if this is what you want to do next. Faculty advisors help students applying for internships, study abroad, and they provide advice as you look for summer jobs and undergraduate research. Therefore, you are encouraged to make opportunities to visit with us at times other than during the scramble of pre-enrollment.

Everyone (especially students) at Cornell is busy and juggling a number of responsibilities and activities. The following suggestions will allow you to maximize the help your advisor can offer with regard to your academics. If you follow them, you will get the most out of your relationship with your advisor.

- **Plan ahead!** Schedule routine appointments ahead of time.
- When you need **to see your Biological Engineering advisor**, use E-mail to **schedule an appointment in advance** and indicate why you wish to meet. If your advisor is unavailable or **if you are experiencing an emergency**, contact Brenda Marchewka (607.255.2173; bls19@cornell.edu) or Professor Jean Hunter (607.255.2297; jbh5@cornell.edu). They will work with you and bring your advisor into the loop as quickly as possible.
- **Be prepared to think about the big picture.** One place you will do this is in BEE 1200 in your second semester of study. Your future plans may change, but it helps both you and your advisor to see in the beginning where you think you are headed.
- **Always have a copy of your schedule** or a list of courses with you when you meet with your advisor to pre-enroll.
- Make a **list of questions and concerns** that you want to raise with your advisor before you meet so you don't forget anything important.
- **Share good news and personal accomplishments** with your advisor. This helps us get to know you and gives you another good reason to dialog with us.

If you have questions about your academic focus or decide to make some changes in the direction of your education, you may change faculty advisors (or majors) if your interests do shift. To change advisors in Biological Engineering, contact Professor Jean Hunter to discuss your situation. Contact the Counseling and Advising Office in Roberts Hall at 607.255.2257 if you are seeking a new major in CALS. Contact the College of Engineering Advising Office in Olin Hall at 607.255.7414 if you are seeking to transfer to a different Engineering major. Biological Engineering Advisors are knowledgeable about other majors in both colleges, and will talk with you even if you feel you might want to change majors. Our interest is in your education and what is best for you!

ACADEMIC SUPPORT SERVICES

Having problems managing your workload or your time? Have you been sleeping more but still feel tired all the time? Having problems getting out of bed and getting motivated? Each year, many students in the College and the University find that they are having problems academically, socially, and/or personally. Deciding how you respond to these obstacles can profoundly affect your level of success at Cornell.

Cornell offers several resources to help students with their academic work. The best time to visit is as soon as you identify a problem – don't wait until it's overwhelming.

Biology Advising Center

8am-4:30pm Monday-Thursday and 8am-4pm on Friday; 216 Stimson Hall

Tel: 607.255.5233; Fax: 607.255.0470; Email: bioadvising@cornell.edu

<http://biology.cornell.edu/index.php/oub-advising-services>

Engineering Advising Office

8am-4:30pm Monday-Friday; 167 Olin Hall

Tel: 607.255.7414; Fax: 607.255.9297; Email: adv_engineering@cornell.edu

<http://www.engineering.cornell.edu/resources/advising/index.cfm>

Learning Strategies Center

8:30am-4:30pm Monday-Thursday, 8:30am-4pm Friday; 420 Computing and Communications Center (CCC)

Tel: 607.255.6310; Email: jcb13@cornell.edu

<http://lsc.sas.cornell.edu/>

Math Support Center

Open during Academic Year – see web site for specific hours; 256 Malott Hall

Tel: 607.255.4658; Email: mst1@cornell.edu

<http://www.math.cornell.edu/Courses/FSM/>

<http://www.math.cornell.edu/twiki/bin/view/MSC/>

Writing Workshop

8:30am-5pm Monday-Friday –see web site to schedule an appointment; 174 Rockefeller Hall

Tel: 607.255.6349; Fax: 607.255.4010; Email: thc33@cornell.edu

http://www.arts.cornell.edu/knight_institute/walkin/walkin.htm

Minority & Women's Programs in Engineering

8am-4:30pm; 146 Olin Hall

Tel: 607.255.6403; Fax: 607.255.2834; Email: dpeng@cornell.edu

<http://www.engineering.cornell.edu/diversity/>

Tau Beta Pi (<http://www.rso.cornell.edu/tbp/tutoring.html>) and Ho-Nun-De-Kah

(<http://www.rso.cornell.edu/hndk/request.html>)

Both offer a match-up service for free tutoring.

MENTAL WELLNESS SUPPORT

Sometimes obstacles aren't rooted in study habits but in medical or psychological problems. These range from low iron or blood sugar to depression or anxiety. For many students this is the first time they are living away from home and are responsible for their own well-being. Although many people see you each day and may genuinely care about you, no one is making sure that you are eating well, getting regular exercise, and are healthy. Indeed, it is less likely that people will recognize if you're facing some minor or major emotional problem, especially if you are living off-campus. It is important that you care for yourself, and ask for help and direction from your Resident Advisor, faculty advisor, or other campus or community office/agency.

Cornell offers mental wellness support to students through the following services, among others:

CAPS (Counseling and Psychological Services) at Gannett: Cornell University Health Services; Tel: 607.255.5155; Email: gannett@cornell.edu
<http://www.gannett.cornell.edu/services/counseling/caps/index.cfm>

CAPS has noted a trend that engineering students tend to wait a long time before they seek assistance. This behavior results from the—usually mistaken—belief that the problem solving skills of engineers extend to emotional and psychological issues. Failure to seek help usually ends up putting the student in more academic and personal risk. If you are really stressed, tired all the time, having trouble getting yourself to class, not able to complete assignments on time, confused about life in general, sad, anxious, or just want someone to talk to so you can decompress, contact CAPS. Oftentimes just talking with a trained professional can help you feel better. Note: each student is limited to 12 individual counseling sessions per year, this is not long-term counseling. Let's Talk:

<http://www.gannett.cornell.edu/cms/services/counseling/caps/talk/index.cfm>

EARS (Empathy, Assistance, and Referral Service); Tel: 607.255.3277
<http://ears.dos.cornell.edu/>
Free and confidential.

General Medical Problems

Gannett Health Center; Tel: 607.255.5155; Email: gannett@cornell.edu
<http://www.gannett.cornell.edu>

If you've had a lingering health concern, please have it checked out. Even minor illnesses can detract from your overall enjoyment of 'the college experience'.

PROFESSIONAL REGISTRATION

Engineers are licensed (after examination and if they also have suitable experience) to practice engineering in each state of the U.S. While not required for all Environmental Engineering jobs, registration is important for environmental engineers because they are responsible for public safety in much of their work. Most states and communities require that a registered engineer give final approval to all plans and specifications for engineering projects. Students can take the first step toward getting a Professional Engineering (PE) license while still a senior at Cornell. Students are eligible during their last term to take Part A of the nationwide examination, the "Fundamentals of Engineering (FE) Examination." Successful completion earns the title "Intern Engineer" (often also called "Engineer-in-Training"). Because Part A emphasizes fundamental knowledge gained in engineering distribution courses and core courses, there is a comparative advantage in taking this exam during your last term. **Please be sure to have BEE or CEE notified of your exam results so we receive the feedback we need to document the success of our graduates.** Success or failure in this examination has no bearing on your academic standing at Cornell.

The Part A exam is held at Cornell University in the Spring and at other locations in New York for the Fall exam. Application forms to apply for the Part A exam are available on-line at: <http://www.op.nysed.gov/prof/pels/> and in 116 Riley-Robb Hall or in 221 Hollister Hall. In 1999, the State of New York Education Department contracted with an independent examination vendor to administer the exam and handle related activities. Because of this you are required to first apply for licensure and then you will be sent information regarding testing including application deadlines. Historically application deadlines have been November 1st for the April exam, and May 1st for the October exam. There is a \$70.00 licensing fee for Part A of the exam plus a \$135 scheduling fee.

Part B of the examination may be taken after four years for engineering students who have suitable engineering experience after passing Part A. Successful completion of Part B will give you the title "Professional Engineer" in the state where you took the Part B exam. With some exceptions registration in other states may usually be obtained by reciprocity rather than taking another exam.

BEE 5330, Engineering Professionalism, prepares the student for the general national FE Examination taught in a team-based format. FE review homework addresses FE exam preparation, and students complete the formal comprehensive review of engineering subjects associated with the Fundamentals of Engineering Exam.

GRADUATE EDUCATION

It's not too early to consider additional study beyond your bachelor's degree. B.S. degree holders in engineering from Cornell who have a grade point average of 2.7 are generally eligible for admission to either option of the Master of Engineering program outlined below. However, each application is evaluated individually, and BEE and CEE reserve the right to make all admission decisions. To apply visit: <http://www.gradschool.cornell.edu/>

MASTER OF ENGINEERING (BIOLOGICAL AND ENVIRONMENTAL ENGINEERING) PROGRAM

The Master of Engineering (MEng) degree builds on the foundation of the engineering BS degree to prepare candidates for a professional career. The program integrates technical engineering with the biological and life sciences, enabling graduates to solve technical problems on a scale ranging from molecular to whole organism to eco system depending on their interests. Graduates assume positions in production companies, consulting firms, government and agencies, and in the public service sector. The degree may also be used as a pathway to advanced study in science and engineering or professional study in business, law and medicine.

Curriculum Requirements

A total of 30 credits* is required for the master of engineering degree, and the program is usually completed in two semesters. Cornell Engineering undergraduates may apply early and be accepted into the program in their last undergraduate semester if they have 8 or fewer credits remaining in their bachelor's program. All MEng students must complete the following:

- BEE 5951-5952, Master of Engineering Design Project, 3 to 9 credits
- Biological and Environmental Engineering focus courses, 9 credits minimum
- A total of 30 credits* approved by their MEng Faculty Advisor

Students work with their graduate faculty advisor to develop their design project and complete appropriate courses in one of the following major concentrations:

- Bioenergy and Integrated Energy Systems
- Bioenvironmental Engineering
- Biological Engineering
- Bioprocess Engineering
- Ecohydrology
- Environmental Engineering
- Environmental Management (M.P.S. (A.L.S.) only)
- Food Engineering
- Industrial Biotechnology
- Nanobiotechnology
- Sustainable Systems
- Synthetic Biology

*Detailed requirements are shown on the department web site.

Applicants to the program need to apply directly to the Cornell Grad School at www.gradschool.cornell.edu/

MASTER OF SCIENCE AND PH.D. PROGRAMS

Some students pursue a research-oriented Master of Science (M.S.) program either here or elsewhere, and an increasing percentage of students continue on to the Ph.D. for careers in research, teaching, or consulting. Some students prefer to take a job immediately after receiving the B.S. and then return for graduate study a few years later. Ask your advisor, professors, or the BEE Director of Graduate Studies for information about graduate study.

ACADEMIC INTEGRITY AND PLAGIARISM

Absolute integrity is expected of every Cornell student in all academic undertakings. Integrity entails a firm adherence to values most essential to an academic community, including honesty with respect to the intellectual efforts of oneself and others. Both students and faculty at Cornell assume the responsibility of maintaining and furthering these values. A Cornell student's submission of work for academic credit implies that the work is the student's own. Outside assistance should be acknowledged, and the student's academic position truthfully reported. In addition, Cornell students have the right to expect academic integrity from each of their peers. It is plagiarism for anyone to represent another person's work as his or her own. As stated in the University Code of Academic Integrity, "The maintenance of an atmosphere of academic honor . . . is the responsibility of the student and faculty. . ." Gray areas sometimes exist when students study and work together. It is important that faculty state clearly what is expected, and that students understand what authorship citations an instructor expects. To become better acquainted with academic integrity responsibilities, each student should read the Code of Academic Integrity. A copy may be obtained from the Engineering Advising Office, 167 Olin Hall, or from the Dean of the Faculty, 315 Day Hall. Also available on the web at: <http://cuinfo.cornell.edu/Academic/AIC.html> with an explanation at <http://www.theuniversityfaculty.cornell.edu/AcadInteg/>

FREEDOM FROM SEXUAL HARASSMENT

The College feels it is essential for the well being of the University community that every individual be treated with respect. Sexual harassment and sexist comments are incompatible with this goal.

Unwelcome sexual advances, requests for sexual favors, or other verbal or physical contact or written communication of a sexual nature is sexual harassment when any of the following occurs:

1. Submission to such conduct is made either explicitly or implicitly a term or condition of employment or academic standing; or
2. Submission to or rejection of such conduct is used as the basis for employment or academic decisions affecting the individual; or
3. Such conduct has the purpose or effect of unreasonably interfering with an individual's work, academic performance, or participation in extracurricular activities; or creating an intimidating, hostile, or offensive working or learning environment.

Any student, staff employee, or faculty member who believes she/he has been victimized by sexual harassment is encouraged to promptly contact a title IX coordinator via the Office of Workforce Policy and Labor Relations at 607.254.7232 or equalopportunity@cornell.edu. Individuals may also contact the University Ombudsman at 607.255.4321 in 118 Stimson Hall, 8:30am-4:30pm Monday-Friday or other times by appointment.

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