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## Biological Engineering and its Possibilities for You

**"We Bring Engineering to Life, and Life to  
Engineering"**

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## Contents

There are many outlets to which a student can apply their Biological Engineering education. The purpose of these pages is to introduce current or prospective Biological Engineering students to various career options that are available and to provide broad descriptions of the areas. Related resources at Cornell and elsewhere are also referenced as needed. A quick look at the most recent survey of our graduates can be obtained at the following link.

<http://www.engineering.cornell.edu/student-services/engineering-coop-career-services/statistics/Post-Graduate-Reports.cfm>

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# How to Get Started in Biological Engineering

## What is Biological Engineering?

Biological engineering is engineering applied to living systems on a range of scales from molecules to whole organisms to complex biological systems. 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 are used as sensors. Nucleic acid is engineered to make molecular structures for drug delivery and nanobarcodes 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. Miniaturized biosensors and biochips enable in-field and point-of-care diagnostics. 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.

# How to Get Started in Biological Engineering:

## Mentorship

The Department of Biological and Environmental Engineering (BEE) [website](#) has information about courses, graduation requirements, faculty and their research areas in biological engineering and perhaps should be the initial source of information. Additional sources of information and networking are provided below.

- **Faculty Advisors**

Each student at Cornell University is assigned a faculty advisor. This faculty advisor advises and mentors the student throughout their undergraduate career; guiding them both academically and socially. If admitted through the College of Agriculture, the student is assigned a faculty advisor for the entire duration of the undergraduate degree. If admitted through the College of Engineering, a student will have 2 faculty advisors during their undergraduate years--the initial faculty advisor teaches the ENGRG 1050, helps the student acclimate to Cornell's Engineering, and assists with class schedule planning. Once a student affiliates with their major, he or she will receive an advisor from within their own department.

- **Peer Advisors**

All freshmen admitted through the College of Engineering are assigned a peer advisor for their first year in college. The peer advisors are there to help select classes, answer questions about academics or student life, and give advice and tips about life at Cornell. For more information, visit <http://www.engineering.cornell.edu/student-services/academic-advising/peer-advising/index.cfm> .

- **Pre-medical, Pre-vet and Pre-dental Advisors**

The Health Careers Program at Cornell (<http://www.career.cornell.edu/HealthCareers/>) provides a wide range of services, including advising, programs, information resources, and a Health Careers Evaluation Committee (HCEC). They should be the first point of contact for those aspiring to go these professional schools.

- **BEE 1200 and ENGRG 1050s**

All BEE freshmen in the College of Agriculture are required to take BEE 1200 as part of their curriculum. The course is a forum covering the career opportunities 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.

All freshmen in the College of Engineering are enrolled in ENGRG 1050 their first semester at Cornell. The course is designed to help students transition into college life and the demand of engineering academics. The course's website describes it as "a one-credit, created-to-be-fun, get-to-know-Cornell class where you will meet us, your very own peer advisors! The class will be led by your faculty advisor, whom you will consult before enrolling in classes every semester until you affiliate with a major (which you will do during your sophomore year). It's an S/U class with no homework or exams, and we will make it fun!" Freshmen in ENGRG 1050, who are interested in Biological Engineering, are encouraged to contact Biological Engineering faculty or Peer Advisors from the *Institute of Biological Engineering* (see below).

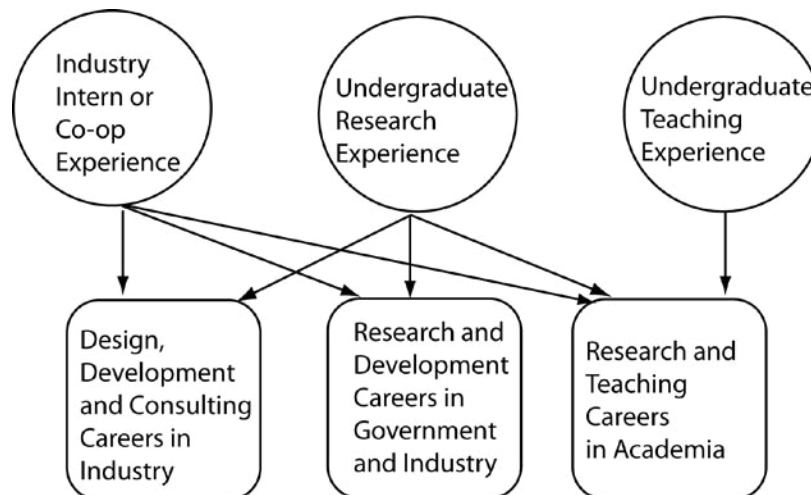
- **Institute of Biological Engineers (IBE) Mentorship Program**

IBE has developed a Peer Advising program that is designed to be a support system for the freshman and sophomore classes, with advice from upperclassmen about topics such as course scheduling, engineering classes, graduation requirements, career decisions and life as a Cornell Engineering student. About three to four underclassmen are paired with an upperclassmen mentor who guides their mentees as they map out their next 8 semesters at Cornell and can help answer any questions that freshman may have as they transition into college life and into the biological and environmental engineering department. This program is a great way for underclassmen to learn about the major and connect with upperclassmen.

- Networking...

# How to Get Started in Biological Engineering:

## Getting Experience While at Cornell



### Interns in industry or government

If you are thinking in terms of a career in industry or in government (see detailed descriptions later of the various possibilities), experience through internship or the co-op program can be an important step. The engineering career office at <http://www.engineering.cornell.edu/student-services/engineering-coop-career-services> has relevant information.

### Undergraduate Research

Undergraduate research at Cornell University is strongly encouraged. Not only will undergraduate research allow you to actively apply your education to solve scientific problems, and make medical discoveries, but it also helps solidify your career goals. If you enjoy undergraduate research, would a PhD or some kind of graduate school be the correct place for you? Would you want to become a professor, and do research while teaching? Do you want to go directly into industry or to a national research lab? Experience helps finalize your career goals.

For information regarding undergraduate research, see <http://www.research.cornell.edu/undergrad/>. It is strongly encouraged for you to browse through faculty biographies on the web since they often describe the research topics the professor is involved in as well as list their publications and/or group website. You can find Cornell's faculty database at each respective college's website, and the office of undergraduate biology has a very useful faculty research search function cutting across all colleges, see <http://biology.cornell.edu/research/rfindex.php>. Also, don't forget to check out the Cornell's Veterinary School's website.

**Undergraduate Teaching**

Experience as an undergraduate teaching assistant in one of many courses in BEE (or outside BEE) can sharpen communication, leadership and technical skills. Teaching skills are of particular value when applying to graduate school. Interested persons should contact individual faculty members responsible for the course.

# Careers in Industry

Approximately 30% of BEE students go into industry upon graduation. The remaining students take the Higher Education route, whether it be graduate school (MS, PhD) or Professional School (MPS, MEng, MD, DVM)

## **Biotechnology**

Biotechnology is a very broad term and includes topics such as synthetic biology, plant genetics and gene therapy. A popular field of biotechnology is medicine and pharmaceuticals. Using molecular and cellular biology, companies delve deeper into drug discovery and biosensing and investigate not only new drugs but also alternate methods of drug delivery. Concentrations in bioprocess engineering under BEE can be of additional help in preparing for careers in Biotechnology companies. Examples of Biotech companies where BE graduates have been hired recently are Genentech, DNANO Systems, Integrated Plant Genetics, Monsanto, Medigene and Amgen.

## **Bioprocess Industries**

Bioprocess Engineering at Cornell applies engineering fundamentals to the exciting area of biological processes used for industrial production of goods. The curriculum prepares bioprocess engineers for work with firms such as Genentech, Pfizer, Merck and Novazyme. With specializations in Metabolic Engineering, Synthetic Biology and Biomaterial Design, the faculty in BEE are well suited to educate students for a career harnessing biocomplexity and multifunctionality for synthesis of pharmaceuticals, industrial enzymes, biomaterials and other biologically-derived products. Engineers with training in biology are also employed by the food processing industry. The biofuels industry is growing rapidly to meet America's demand for clean, renewable and domestic energy, and biological engineers have the right training for jobs in this industry as well.

## **Biomedical Industries**

Biomedical jobs can relate to biomedical device manufacturing, imaging, diagnostics and other medical instrumentation, design of artificial tissues, organs, joints, blood vessels, or dental implants, pharmaceuticals, and research and development. The concentration in biomedical engineering in the BE program can be of help in preparing for careers in biomedical companies. You can also consider a minor in biomedical engineering at Cornell offered by the Department of Biomedical Engineering. Places where our recent graduates have been hired include Mayo Clinic, Cleveland Clinic and Bethesda Medical Center, in research and development. In biomedical devices and biomaterials, our graduates have been hired by Becton Dickinson, Johnson & Johnson, Siemens Medical Systems and Abbott.

### **Consumer Products Industries**

A career in the consumer products industry provides students with the opportunity to touch and improve people's lives every day by designing and engineering products ranging from everyday household items to the most prestigious beauty and health care products. Consumer products is a dynamic industry which must meet the ever evolving needs of people by applying cutting edge technology and cultural understanding and awareness. Students will leverage a wide range of knowledge and skills to solve the most challenging problems. Job functions typically range from using holistic consumer and market understanding to drive new business initiatives, to integrating core science fundamentals (fluid dynamics, chemistry, biology) to develop and conceptualize new products at the lab bench, to developing new processes that drive execution at the pilot and manufacturing scales, all with the goal of ultimately delivering novel and reliable products across the globe every day.

### **Bioenvironmental Careers**

Cornell has two primary environmental engineering programs. The bioenvironmental concentration in the BE program provides students a broad understanding of environmental systems with a unique emphasis on the biological aspects including ecosystem processes, microbiology, agro-ecology, and biogeochemistry. The curriculum is designed so students gain the expertise required to engineer sustainable solutions to problems associated with our water, soil, energy and climate systems. Graduates have been hired by a wide range of employers: environmental engineering firms (e.g., Malcolm Pirnie, Greeley and Hansen), federal agencies (e.g., Natural Resources Conservation Service, US Geological Survey, National Science Foundation), state and county agencies, (e.g., AK Dept. of Environmental Conservation, Soil and Water Conservation Districts), local planning departments and programs (e.g., the New York City Watershed Agricultural Council), various research institutes and agencies (e.g., Woods Hole Oceanographic Inst., US Agricultural Research Service), international relief and development agencies (e.g., OXFAM, IOM - Sri Lanka, Peace Corps), and large companies (e.g., the Louis Berger Group, inc). It is not uncommon for students to form their own engineering firms (e.g., JESS Engineering, Transform Consulting) or other businesses (e.g., agriculture). Many graduates pursue advanced degrees, typically in environmental engineering or related disciplines. However, it is also common for them to build upon their strong foundation in environmental sciences, engineering, and biology to pursue careers as teachers, lawyers, businessmen, and policy makers among others.

# Careers in Government

Our graduates have been hired by the regulatory or research agencies such as the Food and Drug Administration (FDA), National Institute of Health (NIH), US Patent Office, US Department of Agriculture (USDA), and the US Geological Survey. Examples of positions within these agencies include Solar Engineer, Engineer I and Patent Examiner.

The Food and Drug Administration (FDA) is one of the many agencies that are a part of the Department of Health and Human Services (HHS). Other agencies within the department include the Center for Disease Control (CDC), the National Institutes of Health (NIH), and the Indian Health Service (IHS). BEEs have the opportunity to work on issues involving food, drugs, medical devices, vaccines, blood, biologics, animals, cosmetics, combination products, radiation-emitting products, and tobacco. There are many different centers within the FDA such as the Center for Devices and Radiological Health, or the Center for Drug Evaluation and Research. Further descriptions of the offices can be found at <http://www.fda.gov/AboutFDA/CentersOffices> . BEEs who work at the FDA can be involved in a variety of different tasks such as reviewing 510(k)s, PMAs, classifying recalls, and writing warning letters. A typical assignment could entail work on a specific set of devices such as orthopedic devices or neurology devices. There are also a variety of research-based positions available at the FDA.

Besides applying for jobs with the government by going to [www.usajobs.gov](http://www.usajobs.gov) , you can also apply for special programs such as the Presidential Management Fellow Program or the Medical Device Fellow Program. More information can be found here: <http://www.hhs.gov/careers/internships/index.html>

# Higher Education

## Graduate Schools

Upon graduation, many Biological Engineering Graduates have chosen to take a path other than industry -- Graduate School. Approximately 40% of the graduating class of BE's decide to attend one of the Graduate School options or Medical School. Graduate school programs include, but aren't limited to the following

- Masters of Engineering - The Masters of Engineering degree (commonly referred to as the M.Eng. degree) is a 1-year degree in which the student develops technical expertise in his or her field of choice. The student will also take additional classes, with a course credit requirement ranging from 24-30 credits (if a student's program is for 24 course credits it also includes a 6-9 credit design project). Many BEE students choose this degree to advance their professional career.
- Masters of Science - The Masters of Science degree (referred to as the M.S. degree) is generally a two-year degree in which the student partakes in a research-based project.
- Masters of Engineering & MBA - The Masters of Engineering & MBA is a dual graduate degree in which a student earns not only an M.Eng. degree, but also a business degree known as an M.B.A.
- The Doctor of Philosophy - The Doctor of Philosophy (commonly referred to as a Ph.D.) is a research intensive graduate program that lasts between 5-7 years (3-5 years beyond an M.S. degree).

Graduate Schools attended by BEE alumni include, but aren't limited to, Caltech, Carnegie Mellon, Cornell University, Duke University, Harvard, KAUST, New York University, MIT, Stanford University, SUNY Stony Brook and University of Rochester.

For more information concerning Graduate School, please contact the Office of Research and Graduate Studies. Their campus office is 222 Carpenter Hall, and their telephone is (607) 255-7413. Feel free to visit their website at <http://www.engineering.cornell.edu/student-services/rgs/index.cfm>.

# Higher Education:

## Professional Schools

Upon graduation, many Biological Engineering graduates have chosen to go for a professional degree. A number of paths are available from engineering to law and medicine.

### **M.P.S**

Worldwide, the growing complexity and diversity of systems and issues in the agricultural, life, social, and environmental sciences offer challenging opportunities for persons with appropriate skills, experience, and educational backgrounds. The Master of Professional Studies (M.P.S.) program is designed especially for persons who want to prepare for these opportunities but are not interested in research careers. Persons already embarked on professional careers, those who plan to continue in their current fields or related ones, or those who will be working primarily as educators often select this program. The M.P.S. program emphasizes breadth of training via course work rather than research experience. M.P.S. degree candidates take the same courses as other graduate students and then complete a problem-solving or applied project. (<http://www.cals.cornell.edu/cals/prospective/mps/index.cfm>)

### **M.ENG.**

Expand your knowledge, your connections, and your career opportunities—with a Cornell M.Eng. degree. Gain real-world experience by working on an M.Eng. project—hands-on application and design. Customize the program around your specific goals and interests. Become part of the vast Cornell alumni network ... giving you invaluable connections and references. This one-year program will prepare you to hit the ground running and stand out in the career of your choice.

(<http://meng.engineering.cornell.edu/>)

### **Medical School**

Gaining admission into medical is a daunting task. However, majoring in biological engineering can make a world of difference for a student who is also an aspiring doctor. As a biological engineer, you enroll in courses identical to those of a normal pre-medical student, yet the supplemental insight that you acquire can provide a valuable edge. Engineering classes such as biofluid mechanics and the biomedical lab courses will provide you with an enhanced understanding of how all the biological systems work and how innovative technology can be incorporated into the solutions of medical problems. Technology is increasingly integrated into all aspects of medicine, and with a background in how the surgical tools are designed, or how to model blood flow throughout the body, you are better equipped to relate the causes of diseases and problems with their solutions. The best physician is one who understands all aspects of medicine, and with a major in biological engineering, you will not only become well versed in all aspects of biology and chemistry, but also in how the devices and tools you use are designed in order to achieve their purpose.

### **Veterinary School**

The Biological Engineering degree can be a strong starting point for practice and research in veterinary medicine (D.V.M., Ph.D.). The course material in veterinary school builds on the molecular techniques, tissue mechanics, and basic mechanical engineering that you will get in the BE program. If interested in this career route, it is important to choose schools you are interested in early to ensure you take all the required courses. You will also need to spend many hours working with practicing veterinarians to qualify. For Ph.D. programs, they like to see that you have done research, and combined Ph.D./D.V.M. programs will be looking for projects that have some hands-on animal aspects to them.

### **Business School**

The graduate field of Applied Economics and Management (AEM) awards 3 degrees: the research-based Ph.D. and Master of Science (M.S.) degrees, and the Master of Professional Studies (M.P.S.) degree, which emphasizes training through coursework and a problem-solving project. ( <http://aem.cornell.edu/grad/index.htm> )

The M.B.A. adds knowledge and skill in all the business functions along with a general management perspective. The combination of M.Eng. and M.B.A. degrees prepares engineers to advance through product development and engineering management roles to higher levels of business leadership.

( <http://www.johnson.cornell.edu/prospectivestudents/dualdegree/meng.html> )

Earning a Masters of Business Administration (M.B.A.) degree can provide you with management skills and business expertise that open new career opportunities to you. If you are working in business and are looking to move up the ladder or to move from your current area of expertise to a new one, an M.B.A. program can help you achieve your goals. An M.B.A. program will also launch you into the much higher pay range that upper level managers and executives enjoy.

Furthermore, in the high-level positions an M.B.A. degree will allow you to hold, your work will often be more interesting and rewarding.

( <http://www.mbaprograms.org/> )

### **Law Schools**

The analytical skills from the engineering coursework can greatly contribute to success in law school. Law school focuses on many of the skills central to the engineering field, such as the ability to approach a problem from multiple perspectives and to analyze issues in a methodical manner. A law degree provides BEE students with many career opportunities, including work in patent law and the Food and Drug Administration (FDA) regulatory law. One of our recent alumni is currently working at a large law firm in Washington, D.C. with a focus on patent litigation. Other alumni have gone into environmental law.

# Career Resources

## Career Offices and Websites

Cornell has many career resources. We encourage you to utilize these resources since they have been created and developed to fit you and your needs. Be sure to attend the company information sessions many engineering organizations hold, or the workshops organized by some of the offices below:

- ENGRG 2350: Career Development for Engineering
- Engineering Cooperative Education and Career Services  
201 Carpenter Hall, 255.5006, [www.engineering.cornell.edu/careerservices](http://www.engineering.cornell.edu/careerservices)
- Cornell Career Services  
103 and 203 Barnes Hall, 255.5221, [www.career.cornell.edu](http://www.career.cornell.edu)
- Research & Graduate Studies  
<http://engr.cornell.edu/student-services/rgs/>
- Professional Engineering Licensing  
222 Carpenter Hall, [www.op.nysed.gov/pe.htm](http://www.op.nysed.gov/pe.htm)
- Cornell's Career Net  
<http://cornell-students.experience.com/er/security/login.jsp>

## Career Resources:

### Professional Societies

#### **Institute of Biological Engineers**

The Institute of Biological Engineers at Cornell University is a student chapter of the professional society open to any students who are interesting in biological, environmental, or biomedical engineering. The focus of IBE is to encourage students interested in these disciplines to grow both professionally and socially by attending events and networking with peers, professors, and industry professionals. These professional events include company information sessions, graduate school panels, lectures given by faculty, and many others. Students are encouraged to network with their peers through a peer mentorship program and social events including happy hours. The largest event hosted by IBE is the BioExpo held each spring. This event is a research symposium where student researchers in all aspects of biological engineering display posters, and presentations are made by faculty and industry professionals, along with a company showcase.

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