

Science Careers

From the journal *Science*



## Career Advice

# Melding Talents With a Career in Bioprocessing

By Emma Hitt  
July 15, 2011



Credit: Photograph by Izabela Gierach

David Wood (left) and graduate student Michael Coolbaugh prepare a small fermentation vessel for growing recombinant *E. coli* cells.

Bioprocessing is an expanding field encompassing any process that uses living cells or their components (e.g., bacteria, enzymes, or chloroplasts) to obtain desired products, such as biofuels and therapeutics. As with other fields considered under the broader scope of biotechnology, bioprocessing

draws upon multiple areas of knowledge, but especially molecular biology, chemical engineering, and manufacturing. With advances in biotechnology and an ongoing need for pharmaceuticals and sustainable forms of fuel as well as cheaper, more effective ways to make them, the opportunities in bioprocessing, at both the undergraduate and graduate level, are looking promising. **By Emma Hitt**

---

---

*"I've found that one thing that binds many people who work in this industry is the satisfaction that the work that you're doing is going to making someone's life better."*

*—Michael Fino*

---

---

## THE SPECTRUM OF BIOPROCESSING

Bioprocessing, in its broadest sense, is the conversion of raw materials into products using biological processes. According to **David Wood**, professor in the Department of Chemical and Biomolecular Engineering at the Ohio State University, bioprocessing can be loosely divided into four major and somewhat diverse areas, namely: (1) large-scale food processing, (2) the manufacture of fine chemicals and small-molecule pharmaceuticals, (3) the production of recombinant protein therapeutics (biologics), and (4) the generation of renewable energy.

"Bioprocessing is generally distinguished from farming or agriculture in that it usually refers to methods that include the use of isolated cells or enzymes in an artificial environment," explains Wood. However, he points out that bioprocessing is a highly diverse field of study that can range from the large-scale manufacture of fermented foods or biofuels to smaller-scale, high-value therapeutic protein production. Although all of these processes are tied together by their reliance on a biological component, the scale, technologies involved, and economic drivers exhibit enormous diversity, says Wood.

"The bioprocessing field spans processes yielding a few grams of product worth millions of dollars



Lee Rybeck Lynd

per gram (e.g., some pharmaceuticals), to processes yielding millions of tons of products worth a few cents per pound (e.g., some biofuels)," says **Lee Rybeck Lynd**, professor in environmental engineering design, at the Thayer School of Engineering at Dartmouth College in New Hampshire.

**Suwan N. Jayasinghe**, principal investigator for the biophysics group in the Department of Mechanical Engineering at University College London (UCL), United Kingdom, explains that the term bioprocessing is expanding to include a greater variety of disciplines including biophysics, biotechnology, and biomaterials. "In essence there are several ways to define the field and wide variations exist," he says.

Considering the diversity of bioprocessing research and the increasing demand for products such as biofuels and pharmaceuticals, career opportunities are likely to grow. "This is an ever-expanding industry," says UCL's Jayasinghe. "Our need for tackling and understanding our evolving health

care problems are constantly challenging conventional biology and medicine and thus requires the constant need for new minds."

Wood points out that although bioprocessing as a whole is a fairly mature field, some areas continue to grow and still others are emerging. "Certainly the development of renewable energy is a rapidly expanding area, with many opportunities for growth," he says.

### TRAINING OPPORTUNITIES IN BIOPROCESSING

One area in the United States particularly ripe with opportunity and growth is the research triangle area in North Carolina. According to the North Carolina Community Colleges BioNetwork, the state has over 525 bioscience-related companies that employ about 58,000 people—making it one of the top biotech hubs in the United States.

"We've worked closely with the state and the North Carolina Biotechnology Center to attract more industry to the area, and having a pipeline of well-trained students is one of the lures that attract those companies here," says **Chris Daubert**, professor and interim head of the Department of Food, Bioprocessing, and Nutrition Sciences at North Carolina State University (NCSU). According to Daubert, NCSU offers one of the first undergraduate degree-granting programs specifically directed towards a career in bioprocessing. The program recently graduated their first crop of students in spring 2010.

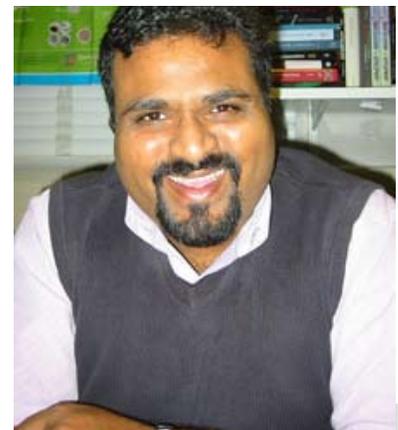
MiraCosta College in Oceanside, North San Diego County, California is also located in one of the larger hubs of life science activity in the United States and offers certificate programs that focus on laboratory skills, bioprocess technology, and the production and analysis of biofuels, says **Michael Fino**, lead instructor in the Bioprocess Technology Program at MiraCosta.

"There's little doubt that the future of medicine, including diagnosis and treatment, will be founded in biotechnology," he says. "In addition, biotechnology is expected to play a critical role in our future energy independence—there's tremendous growth potential." However, Fino points out that the growth rate, as with other areas of scientific development, will be heavily dependent on private and government funding, making it susceptible to economic changes.

NCSU's bioprocessing science program lists quality assurance, process development, and product development as potential career paths for graduates of their program.

"People who hold certificates or Bachelor's-level degrees are more likely to be involved in actually carrying out the bioprocessing techniques, whereas those with graduate-level backgrounds are more likely to be involved in the development and understanding of bioprocessing techniques," Fino says.

There are many suitable graduate degrees for students interested in bioprocessing, including Professional Master's programs in microbial microbiology or biomanufacturing and M.S. programs



Credit: BioPhysics Group-UCL

Suwan N. Jayasinghe



Credit: Photo: Jessica Fino

Michael Fino

in microbiology, food science, biochemistry, or engineering, says NCSU's Daubert. "There are all sorts of avenues for these students to pursue," he explains, and adds that these types of degrees allow students to keep their career options open since the curriculum also prepares them for professional school, medical school, or pharmacy school.

According to **Hans Blaschek**, director for the Center for Advanced BioEnergy Research (CABER) at the University of Illinois, there are considerable opportunities in bioprocessing for students with both the undergraduate and graduate degrees, especially those with an expertise in scaling up and translating protocols from the lab bench to production. The biofuels, bioenergy, and pharmaceutical industries in particular are likely to need graduates with such expertise. To help train students, CABER offers a bioenergy-focused curriculum via their Professional Science Master's program. Now in its third year, the program also offers students an opportunity to gain professional business experience through

coursework and an internship.

### CAREER DIRECTIONS

Key to the future of bioprocessing, says Dartmouth's Lynd, will be personnel who are qualified to run all phases of operations for bioprocessing facilities and equipment, at the research, pilot, and commercial scale as well as process-related aspects of research and development. "Bioprocessing needs engineers of various kinds [including chemical, biochemical, mechanical, process control, and instrumentation engineers], chemists, and life scientists," he says. He adds that most jobs in bioprocessing are more focused on process development and operation than early-stage research and development.

In industry, there are ample opportunities for people with backgrounds in both life sciences and engineering. **Beth Junker**, senior scientific director in the bioprocess development group at Merck Research Laboratories, explains that Merck is focusing on using bioprocessing techniques to develop biologics and vaccine candidates for their pipeline. She adds that "green chemistry" is being highly leveraged in the form of biocatalytic conversions for several synthetically derived product candidates.

According to Junker, the company's needs include people who are skilled in manufacturing using bioprocessing techniques as well as the analysis and development of new bioprocessing methods. "We typically hire biochemical and chemical engineers, biochemists, microbiologists, and analytical and physical chemists," she says, for "opportunities that largely focus on advancing product candidates through our pipeline and transferring their production to manufacturing."

At Incell—a small company in San Antonio, Texas, that provides contract services for various biomedical applications in the areas of regenerative medicine, cancer, vaccines, and infectious diseases—people with bioprocessing knowledge in areas such as product development, research, testing, and quality assurance and control are typically hired, says **Mary Pat Moyer**, chief executive officer and chief science officer. However, she points out that "everyone is expected to do multiple jobs in a small company and to support the overall team effort."

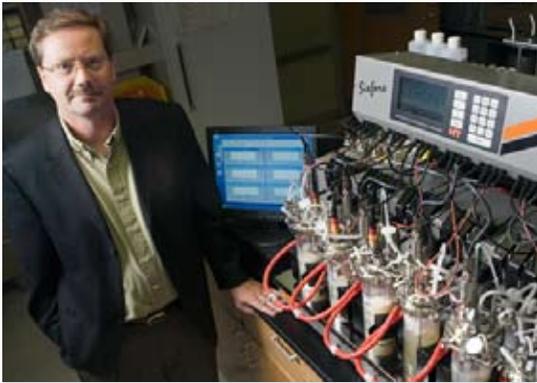
### TRENDS IN BIOPROCESSING

Bioprocessing depends on ever-advancing technology and will continue to evolve as new methods are developed. Wood believes that synthetic organisms specifically designed for efficient biofuel production will become increasingly important in the future. "The development of these organisms is only beginning. Although their likely capabilities are still unclear, this is an area where highly creative and well-trained individuals



Credit: (c) Merck & Co. Inc. 2011

Beth Junker



Credit: H. Blaschek

Hans Blaschek

will find exciting careers,” Wood explains. “Once created, these organisms would enable completely new approaches for energy production, and the processes to effectively utilize these microbes would also require development,” he says.

In the biopharmaceutical area, “the focus on recombinant human antibody therapeutics, along with the development of extremely efficient platform processes for their manufacture, has accelerated the maturation of the industry,” he says. However, the biopharmaceutical industry is being affected by expiring patents and overseas migration of manufacturing facilities, as well as various acquisitions and consolidation among existing companies, and these factors have led to uncertainty about job growth in this sector.

“My feeling is that the [biopharmaceutical] industry is in transition, and job creation will grow with the

development of personalized medicines and the discovery of new classes of therapeutic proteins,” says Wood, noting that the development of high throughput genome sequencing as well as efficient and reliable manufacturing processes has set the stage for an explosion in targeted therapeutics based on the genetic makeup of patient populations. Although the discovery of these products will be driven by basic science, their development and manufacture will require bioprocess engineers skilled in the different facets of manufacturing, he adds.

### **ADVICE FOR BIOPROCESSING CAREER SEEKERS**

Students seeking a career in bioprocessing should begin thinking about how their background applies or can be tailored to meet the growing needs of the field. “My primary advice to anyone considering this field is to take as many courses in engineering and biology as possible,” says Wood. “The new era of bioprocessing will be driven by basic biological science in harmony with conventional engineering approaches, and those who can move easily between those two worlds will have the greatest opportunities and impacts in this area,” he says. “This fact is becoming increasingly clear to hiring managers and companies, and many universities have now specifically increased their teaching and research efforts in biological and biomolecular engineering.”

Junker notes that careers in bioprocessing are largely interdisciplinary in nature so “some knowledge and appreciation of the challenges outside one’s own area of expertise is highly valued,” she says. “Teamwork and written and oral communication skills also are essential, especially for effective and efficient problem-solving,” she adds.

Moyer agrees that practical skills for operations, problem-solving, and teamwork are important, as are strong communication skills—both written and verbal. “Prior job experience, preferably in a job outside of academic training, is required for all employment levels at Incell,” she adds.

According to Robinson, people seeking a career in bioprocessing should get plenty of experience in molecular biology and chemical engineering at the graduate and postdoctoral level and should seek to develop a mixture of technical skills in these areas.

By all accounts, a career in bioprocessing can be highly rewarding. “I’ve found that one thing that binds many people who work in this industry is the satisfaction that the work that you’re doing is going to making someone’s life better,” says Fino.

*Emma Hitt is a freelance medical and science writer residing in Marietta, Georgia.*

10.1126/science.opms.r1100105



Credit: Photo Provided by INCELL Corporation LLC

Mary Pat Moyer

As a sign of the field's infancy and growth, the International Society for BioProcess Technology was launched only last year. We interviewed the organization's Executive Director Keith L. Carson, ChE, MBA, about the bioprocessing industry and potential careers in the field.

**Q: How does The International Society for BioProcess Technology serve its members?**

A: The International Society for BioProcess Technology is dedicated to the scientists and engineers who have day-to-day responsibility for creating and managing scalable and reproducible processes as well as the assays needed to ensure indisputable quality. Through networking events and the society's web-based resources, biotech professionals can access and share the techniques and best practices needed for safe, effective, and consistent products.

We also provide resources to help companies find the right individuals, and help individuals find the right jobs.

**Q: What are some of the undergraduate and graduate career options available in this field and what are the job prospects like?**

A: There is a continual need for both undergraduate and graduate qualifications holders throughout the bioprocessing industry for positions in research, process development, production, quality control, quality assurance, validation, and other functions. There is a fairly constant demand for degrees from all the biological sciences including biochemistry, microbiology, cell biology, and molecular biology. In addition, good chemists can always provide significant value in a number of areas including protein and analytical chemistry. Then there is a strong need for engineers who can interface effectively with the scientists, plus design and operate the systems and facilities needed to make the products. The field is dominated by chemical engineers, but biochemical and mechanical engineers also occupy important positions, and it is certainly possible for an electrical engineer to find a role on the facility and instrumentation side of the larger companies.

While it does help to have an advanced degree, a Bachelor-level degree is sufficient for the engineering disciplines and many of the scientific fields of study. Then an MBA is always a plus for those who want to move up into management.

While many of the larger companies have been cutting staff over the last two years, I have been seeing growth in the smaller firms, and especially the contract service companies [that perform testing, development, and production]. However, for career advancement, it tends to work best if someone can first get a few years under his or her belt at a big company.

**Q: What advice would you have for someone who might be interested in a career in this field?**

A: I highly recommend that individuals do all they can to intern with a large biopharmaceutical company while in undergraduate school, plus take advantage of programs that many universities offer and allow undergraduates to work alternating semesters in very meaningful jobs.

Then if someone wants an advanced degree, he or she should consider doing this part-time while working for a large firm, who might even pay for the courses. And finally, it makes little sense to me for someone to do postdoctoral work in an academic institution where pay may be low and the learning experience doesn't compare to what can be obtained in industry. Typically, the big firms have all the latest technology available and there is often no shortage of money or supplies.

Finally, there are many good positions that are constantly becoming available in various government agencies, including the U.S. Food and Drug Administration. Starting salaries may range between \$80K and \$100K for individuals with Ph.D.s. Then with this type of experience, a regulatory affairs job in industry will be easily attainable.

## Additional Resources

**North Carolina Community Colleges BioNetwork**

**Biotech Job Descriptions** - [www.ncbionetwork.org/careers/biotech-job-examples](http://www.ncbionetwork.org/careers/biotech-job-examples)

**U.S. Bureau of Labor Statistics Career Guide to Industries:**

**Pharmaceutical and Medicine Manufacturing** - [www.bls.gov/oco/cg/cgs009.htm](http://www.bls.gov/oco/cg/cgs009.htm)

## Featured Participants

**Dartmouth College** - [www.dartmouth.edu](http://www.dartmouth.edu)

**Incell Corporation** - [www.incell.com](http://www.incell.com)

**International Society for BioProcess Technology** - [www.ISBiotech.org](http://www.ISBiotech.org)

**Merck & Co.** - [www.merck.com](http://www.merck.com)

**MiraCosta College** - [www.miracosta.edu](http://www.miracosta.edu)

**North Carolina State University** - [www.ncsu.edu](http://www.ncsu.edu)

**The Ohio State University** - [www.osu.edu](http://www.osu.edu)

**University College London** - [www.ucl.ac.uk](http://www.ucl.ac.uk)

**University of Illinois** - [www.illinois.edu](http://www.illinois.edu)

## Upcoming Features

Annual Postdoc Survey - July 15

Focus on Japan - September 2

Faculty: Financial Planning for Scientists - September 9