



**BIOINDUSTRIAL
MANUFACTURING
MADE IN THE
USA**



STEM connector



BioMADE

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Funded by BioMADE

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NATURE INSPIRES SCIENCE

For thousands of years, the study of nature has inspired scientific innovation. Today, advancements in biotechnology and bioindustrial manufacturing are driving improvements in manufacturing efficiency and reducing the use and reliance of petrochemicals for producing fuel and consumer products.

Modern biotechnology is creating breakthrough products and technologies to reduce our environmental footprint, feed the hungry, use less and cleaner energy, and have cleaner and more efficient industrial manufacturing processes. Bioindustrial manufacturing is growing rapidly in response to the innovation generated from the biotech sector.

The bioeconomy is poised for enormous growth over the coming decades, driving increased demand for a diverse STEM-skilled workforce. Career opportunities abound in bioindustrial manufacturing to create new products that will reduce our carbon footprint, expand U.S. manufacturing, and accelerate our economy. In this ebook we explore the pathways and opportunities available in bioindustrial manufacturing as well as the people and companies driving innovations with the potential to feed, fuel and build a more sustainable eco-friendly world.

“BIOTECHNOLOGY WILL SOON PROVIDE US WITH THE ABILITY TO PROGRAM OUR OWN CELLS TO CURE DISEASE, HARVEST MEAT WITHOUT THE WORRIES OF CLIMATE IMPACT, ENGINEER MICROBES TO BREAK DOWN PLASTIC IN LANDFILLS, AND USE BIOMASS—IN PLACE OF PETROCHEMICALS—TO MAKE THE MATERIALS AND CHEMICALS WE USE IN OUR DAILY LIVES.”

The President’s Council of Advisors on Science and Technology (PCAST)



BIOINDUSTRIAL AT A GLANCE

ANIMAL CELLS

Animal cells can be used for bioindustrial uses such as recombinant protein expression, virus production, pathogen detection, and toxicity screening.

MICROBES

Microbes are found in nearly every environment and make up much of the biomass on Earth. The use of microbes in biotechnology has provided a wide range of products and services to a diverse number of industries.

PLANT CELLS

Plant biotechnology is the use of plant culture and genetic engineering techniques to produce genetically modified plants that exhibit new or improved desirable characteristics.

DNA TECHNOLOGIES

BIOINDUSTRIAL MANUFACTURING

The production of biomaterials or biomolecules at scale to create bio-based products.

BIOINDUSTRIAL MANUFACTURING USES BIOLOGICAL SYSTEMS—INCLUDING MICROBES SUCH AS BACTERIA, YEAST, AND ALGAE—TO CREATE NEW MATERIALS OR SUSTAINABLE ALTERNATIVES TO EXISTING PETROLEUM-BASED MATERIALS.

MATERIALS

Geno plant-based nylon is transforming an industry that has relied on fossil fuel-based nylon.

COSMETICS

Amyris uses sugarcane fermentation to convert basic plant sugars into rare bioidentical molecules, essential ingredients and clean, effective everyday products. Their bioproduct Squalane is an ethical and sustainable alternative to shark-derived squalene that is used for beauty products.

FOOD & BEVERAGE

California Cultured is producing chocolate and coffee using plant cell cultures that grow into cacao and coffee beans inside of large tanks. No rainforest needed.

INDUSTRIAL PRODUCTS

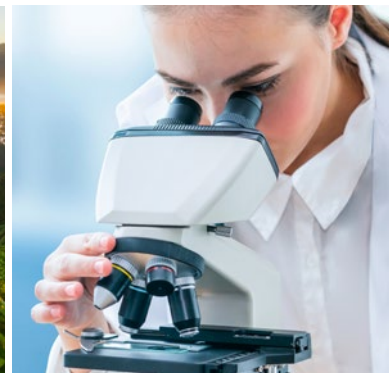
Biomason uses natural microorganisms to grow structural Biocement® in ambient temperatures, harnessing the power of biotechnology to reinvent traditional cement and offer a more planet-friendly alternative.

AGRICULTURE

Bio-based solutions promote sustainable production of renewable resources from land and sea including crops, forests, fish, animals and micro-organisms for use in the production of food, fiber, bio-based products and bioenergy.



BIOTECHNOLOGY



Biotechnology, bioengineering, and synthetic biology all rely on biological processes that are found in the natural world, such as bacteria, plant and animal cells, that can be applied to manufacturing, resulting in more efficient process and products with less impact to the environment. Using biological systems found in organisms or the use of the living organisms themselves, biotechnology develops solutions that help improve our lives and the health of the planet.

Recent advances in biotechnology are helping us prepare for and meet society's most pressing challenges. According to the Biotechnology Innovation Organization (BIO), There are More than 13.3 million farmers around the world using agricultural biotechnology to increase yields, prevent damage from insects and pests and reduce farming's

impact on the environment. Biotech crop need fewer applications of pesticides and allow farmers to reduce the tilling of farmland. There are more than 50 biorefineries being built across North America to test and refine technologies to produce biofuels and chemicals from renewable biomass, which can help reduce greenhouse gas emissions.

BIOINDUSTRIAL MANUFACTURING



Biomanufacturing is the use of live organisms or active biomolecules to produce goods at scale. Using these biological systems like bacteria, yeast, and algae, we can create new materials or sustainable alternatives to petroleum-based products and materials. Bioindustrial manufacturing creates more environmentally sustainable products and increases our ability to be a more self-sufficient society less reliant on petrochemicals such as natural gas and crude oil.

A quickly expanding field of manufacturing, bioindustrial manufacturing uses renewable biological resources to produce food, energy, and other goods. Key biomanufacturing sectors include consumer products, food and beverage, industrial and environmental.



BIOINDUSTRIAL MANUFACTURED PRODUCTS

Although the major use of petroleum is fuel, there are thousands of other products made from petroleum. For example, all plastic is made from petroleum as well as fertilizer, pesticides, herbicides, detergents, photographic film, furniture, packaging materials, surfboards, paints, and artificial fibers used in clothing, upholstery, and carpet backing. Bioindustrial products are an earth friendly alternative for many products and materials. More bioindustrial manufacturing results in less reliance on fossil fuels and lower greenhouse emissions.



BIOMADE

BioMADE is a Manufacturing Innovation Institute (MII) sponsored by the U.S. Department of Defense. Its purpose is to harness the power of biology to help create and domestically source the manufactured goods that people use every day. By supporting the development of biomanufacturing technologies, BioMADE and its members are strengthening American competitiveness, creating a more robust and resilient supply chain, and making the U.S. more self-sufficient.

BioMADE's mission is to enable domestic bioindustrial manufacturing at all scales, develop technologies to enhance U.S. bioindustrial competitiveness, de-risk investment in relevant infrastructure, and expand the biomanufacturing workforce to realize the economic promise of industrial biotechnology. BioMADE officially launched in April 2021 and has a national network of over

175 members spanning industry, academia, and non-profit organizations.

TECHNOLOGY & INNOVATION

BioMADE is moving the bioindustrial manufacturing industry forward by funding innovative research, reducing barriers to scaling-up and commercialization, and de-risking investment

in relevant infrastructure. Through technical innovation, strike improved domestic infrastructure availability, and maintaining robust connectivity among sectors, BioMADE de-risks the process of bringing new products to market and stimulates investment in biomanufacturing. The direct outcome of these research and development efforts will be to develop and expand industrial and defense-related biomanufacturing in the United States.

EDUCATION & WORKFORCE DEVELOPMENT

The bioindustrial manufacturing sector is poised for significant growth in

the coming decade and will need a trained and prepared workforce. BioMADE is building the workforce of the future by pairing industry-driven competencies with program development through K-12 schools, community colleges, universities, and professional development organizations.

WHAT CAN BE CREATED WITH BIOINDUSTRIAL MANUFACTURING?

Check Out These Bio-based Products!

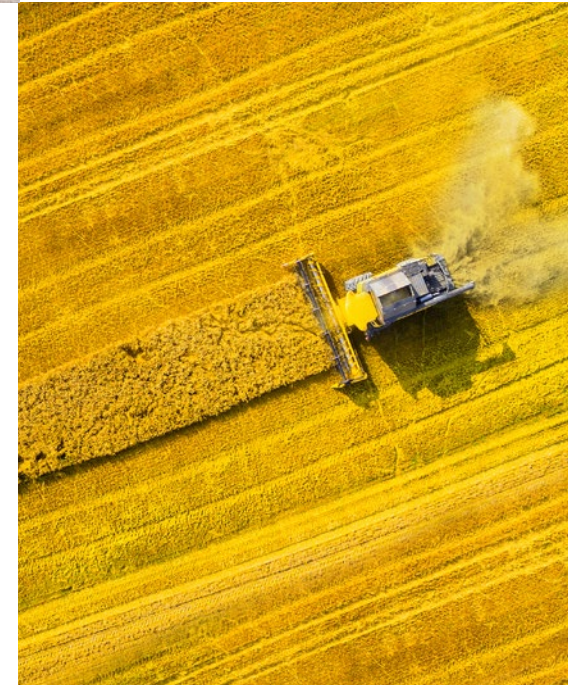
- Bio-based cement, from member organization Biomason
- Bio-based fire-resistant composite materials, from member organization Cambium

- Bio-butanediol (BDO) used to make compostable tote bags, coffee capsules, and food packaging, from member organization Geno
- Carbon-negative chemicals that can be used for water treatments, concrete, fertilizers, detergents, and more, from member organization Solugen
- Plant-based nylon for use in leggings, a partnership from Lululemon and member organization Geno
- Protein made from anaerobically fermented microbes that can be used to create cheeses, milks, protein bars, ice cream, and more, from member organization Superbrewed Food
- Squalane, a plant-based skincare ingredient that is bioidentical to Squalene, a product traditionally derived from shark livers, from member organization Amyris

- Synthetic spider silk, one of the strongest natural materials in the world, from member organization Technology Holding
- Urethane foam for backcountry alpine skis, from member organization Checkerspot



“BY SUPPORTING THE DEVELOPMENT OF BIOMANUFACTURING TECHNOLOGIES, BIOMADE AND ITS MEMBERS WILL STRENGTHEN AMERICAN COMPETITIVENESS, CREATE A MORE ROBUST AND RESILIENT SUPPLY CHAIN, AND HELP THE U.S. BECOME MORE SELF-SUFFICIENT.”
— BioMADE





IT'S IN THEIR DNA

TWIST BIOSCIENCE CORPORATION



SILICON-POWERED DNA SYNTHESIS

Twist Bioscience developed a proprietary semiconductor-based synthetic DNA manufacturing process that miniaturized the chemistry necessary for DNA synthesis. This miniaturization reduces the reaction volumes by a factor of up to 1,000,000 while increasing throughput by a factor of 1,000, enabling

the synthesis of 9,600 genes on a single silicon chip at full scale compared to traditional synthesis methods which produce a single gene in the same physical space.

FUELED BY STEM

Twist Bioscience strives to continuously push the boundaries of what's possible. The fuel for continuous improvement and innovation comes from the diverse, skilled, and

talented "Twisters" whose experience, dedication and persistence advance their product offerings. Continuing to source top talent and building a skilled workforce is critical to the innovation and the success of the company.

Many career paths exist for individuals interested in pursuing a career in biomanufacturing. Post-secondary educational opportunities including career technical education programs, biomanufacturing

certificates and degrees, as well as the more traditional educational pathway of completing a bachelor's degree program in a related STEM field are entry points to a career at Twist Bioscience. In addition, many high schools are incorporating career technical education into their curriculum which is an avenue for exposure to hands-on technical experience prior to entering a post-secondary degree or certificate program.



“ HERE AT TWIST, WE MAKE SYNTHETIC DNA TO ENABLE OUR CUSTOMERS TO HELP IMPROVE THE HEALTH AND SUSTAINABILITY OF THE PLANET. OUR CUSTOMERS ARE DEVELOPING A WIDE RANGE OF PRODUCTS INCLUDING SIMPLE BLOOD TESTS FOR THE DETECTION OF MULTIPLE CANCERS, INNOVATIVE THERAPEUTICS FOR A WIDE RANGE OF DISEASES, IMPROVED FLAVORS AND FRAGRANCES, ENGINEERED MICROBES TO DELIVER NITROGEN AT THE ROOT OF PLANTS AND SO MUCH MORE.”
—Emily Leproust

Many industries rely on DNA as the building blocks of biology. Twist Bioscience manufactures synthetic DNA and tools to support the scientists who are changing the world for the better in fields such as medicine, agriculture, industrial chemicals, and data storage.

By using Twist Bioscience's synthetic DNA tools, customers are developing ways to improve lives and the sustainability of the planet. By harnessing the highly scalable production and processing infrastructure of the semiconductor industry, Twist Bioscience has achieved precision in manufacturing DNA at scale.



FOR THE LOVE OF BEER

HOW BERKELEY YEAST USES SYNTHETIC BIOLOGY FOR BETTER BREWS

Berkeley Yeast uses synthetic DNA from Twist Bioscience to engineer unique yeast strains for use in craft brewing. The people at Berkeley Yeast love good beer, and they are focusing their talents towards developing yeast strains that make brewing more sustainable and add delicious new aromas and flavors to craft beers. To get

there, they need a steady supply of quality synthetic DNA from Twist Bioscience.

Yeast and bacteria have been evolving new flavors for eons—consider bread, chocolate, and cheese, all of which gain their flavor profile through these organisms. Berkeley Yeast seeks to accelerate the process of flavor enhancement, adding flavors nature has already invented.

Because it's relatively easy to manipulate, brewer's yeast offers tremendous opportunities to enhance sustainability and add natural flavors to beer. Companies have gone to the ends of the Earth to capture novel yeast strains that will impart unique flavor profiles into beer. But those explorations are expensive and don't always translate

into better brews.

Berkeley Yeast is taking a different approach. Rather than looking for yeasts and hoping they might find useful traits, they identify natural traits and use molecular biology expertise to bring these traits to yeast. As a result, beer makers can produce hoppy beers with fewer hops and fruity beers with less fruit. The result is a more sustainable, differentiated product that tastes great.

This innovative approach requires a steady supply of high-quality synthetic DNA—high fidelity clonal genes and gene fragments— which are provided by Twist Bioscience. These raw materials produce an ideal cycle: better DNA, better yeast, better beer.



INDIVIDUAL SPOTLIGHT



Gamze Hooker
*Manufacturing Associate,
Twist Bioscience*

Q Tell us about your pathway to the biomanufacturing industry.

A My pathway to biomanufacturing is unique. I did not have a background in bioscience and my exposure to manufacturing was in a limited capacity. I immigrated to the US in 1999 as a student. I initially lived in New York, where I worked as a graphic web designer and extended my education at Pratt. After a few years filled with dedication and hard work, I found success in managing high-end small businesses in a variety of different industries.

After relocating to Oregon to be closer to family, I refocused my career and started looking into other opportunities where I could be part of making a difference in

the sustainability of the planet. I began looking into coursework at local colleges when I heard about Twist, and that they were building the “Factory of the Future” in my area. Twist is a company that is creating a better future and investing in its employees, so I submitted my resume and interviewed for a position in the Reagents Lab. At first, I was worried that my skill set was not applicable to the role. I'm not a scientist, however, I have been pleasantly surprised that my abilities directly relate to what I'm doing today in the lab.

Q What has been the biggest challenge for you professionally?

A I'd say the biggest challenge was wrapping my head around learning something new. I had done in-person and online training before, so I felt confident in my ability to learn. I know how to follow directions and have common sense. At Twist, I have new challenges. It's been a pivotal point in my career as I've been able to put my strengths into practice. Being trainable, having good decision-making skills, and having the ability to communicate serve me well and are what I relied upon. Overall, what makes great work is a

great team! We have that at Twist Bioscience, in every department. I appreciate all my colleagues and my managers. It's one giant, high-end cutting-edge facility with extraordinary minds contributing to bioscience every day.

Q What do you like most about the biomanufacturing industry?

A I love that you can contribute to science and the cause at all levels in the organization. I've realized that the complexity of what we are doing at Twist is endless. We are working on many ideas and areas where we can improve the world. The tiniest of ingredients can make a huge difference. I'm not a scientist. I'm an individual that cares and thinks about how to make a positive impact on our future. At Twist Bioscience, as a sole contributor, I feel the support to move forward with Twist to accomplish our business goals. It is what we all care about. This is something exceptional!

Q What do you like most about your current role?

A I like that there are formulas and complex mathematical equations. Seeing the results makes me proud that I have extended myself. I'm using a different part of my brain

that was not being used daily in previous jobs.

Q What impact will biomanufacturing have on the future?

A At Twist, we create products that can contribute to a promising future that will improve health, help our planet, and educate future generations. The duty to pass on the flag is real for me.

Q What is your advice for someone wanting to pursue a career in biomanufacturing?

A Don't be afraid to try something new. At Twist, there is a structured training program. You have access to different training platforms. My hiring manager shared a training sheet that helped me a lot. Initially, I was scared to transition to another field. With some research and after meeting the people at Twist, I feel like I have been set up for success even though I did not have a science background. The environment here encourages you to take responsibility for your mistakes, learn, and grow. If you are collaborative, can follow directions, and want to learn something new I feel confident to encourage all candidates to apply to Twist's open positions. If you are looking to work with a company that can be an inspiration, Twist Bioscience is the place to be!

SCIENTIFIC BIOPROCESSING, INC



Scientific Bioprocessing (SBI) is dedicated to developing cutting-edge digital technologies such as sensors, actuators and software that simplify bioprocessing activities.

Like all good stories, this one began when Dr. Govind Rao pursued his fascination to connect the environment of the cell with its metabolic behavior — and share his research with experts and practitioners in the biotech industry.

Whenever Dr. Rao gave a seminar to industry audiences, he would hear the woes of bioprocessing engineers. They would share their respective challenges in trying to effectively use conventional

pH and oxygen electrodes in experiments. The electrodes were bulky, expensive, subject to drift and not sensitive enough at physiological ranges.

To solve these problems, SBI pioneered a new category of Digitally Simplified Bioprocessing tools that enable researchers to move from the current era in research of trial and error to one amplified and accelerated by digital twins and computational tools. Digitally

Simplified Bioprocessing enables a year of trial-and-error research to be completed in hours.

SBI's tools are the building blocks for the first life science internet of things consisting of networks of proprietary tiny optical sensors that collect environmental and process parameters, soft sensors, powerful data analytics, visualization tools, and digital twins. These tools allow biologists, bioprocessing engineers,

and data scientists to collaborate and bring biology-based products to market faster and more affordable than ever.

PUTTING SBI INNOVATIONS TO WORK: BOND PET FOODS

Bond Pet Foods is a Boulder, Colorado-based company using biotechnology to create meat proteins that are nutritionally comparable to their conventional counterparts but without all the bad stuff—so people, pets, farm animals and the planet all win. Using some

of the same processes that are employed in craft brewing, Bond produces high-quality animal proteins through fermentation, harvests them to better meet the nutritional requirements of companion animals, and supplies the ingredients to manufacturers for pet food, treat and supplement applications.

An important part of bioprocess development is selecting the right growth medium that best supports the metabolic needs of your microbial organisms. Not all organisms require the same type or amount

of nutrients. The process of manual sampling involves a multitude of operations and each touchpoint leaves room for contamination and potential human error.

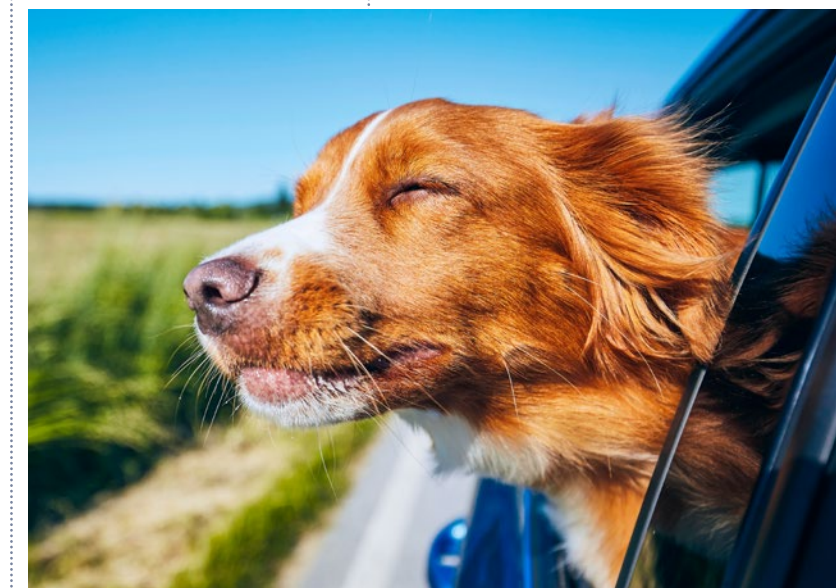
For each sample point, researchers at Bond Pet Foods must interrupt their shake flask experiment. Each flask must be removed, opened under a hood in a sterile environment, and sampled. The data is then manually collected.

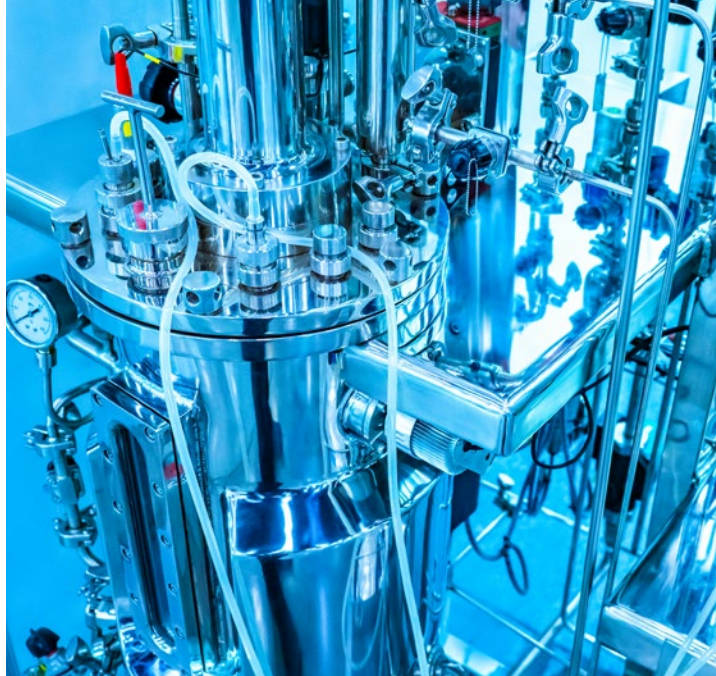
Even with qualified technicians performing the right experiments, manual sampling provides low-resolution data. To fully

understand the growth behavior of your organism, one would need 24-hour coverage, with sampling intervals of every one to two hours which can still result in rough growth curve estimations. This means that lab technicians would have to sample at times outside of the traditional workday, including nights and weekends, putting a substantial strain on staff.

With the implementation of SBI's products, Bond

Pet Foods was able to identify significant savings in both money and time. Incorporating an automated, non-invasive technology for biomass monitoring gave researchers at Bond unprecedented insights into the growth behavior of their organisms. Access to high-resolution, continuous growth curves provided critical information and helped to enhance process development.





SCIENTIFIC BIOPROCESSING, INC.

INDIVIDUAL SPOTLIGHT



Tayler Britt
Academic Application
Scientist, Scientific
Bioprocessing Inc.

Q What was your path to the biomanufacturing industry?

A I pursued my passion for biology and received a bachelor's degree in the field. I then went on to complete a master's degree in Microbiology. I have been a science educator for the last decade for all age

levels, with the last four at the university level. I wanted to pivot into the industry to gain more professional skills when I had an opportunity to join Scientific Bioprocessing Inc (SBI).

Q What has been the biggest challenge for you professionally?

A The biggest challenge is literally the science. There is always more to learn. I can never know everything there is to know

about microbiology and that keeps the work alive and exciting for me.

Q What do you like most about the biomanufacturing industry?

A I love that biomanufacturing is a field that is inextricably linked to saving the planet and a better tomorrow. I feel great about the work I get to do.

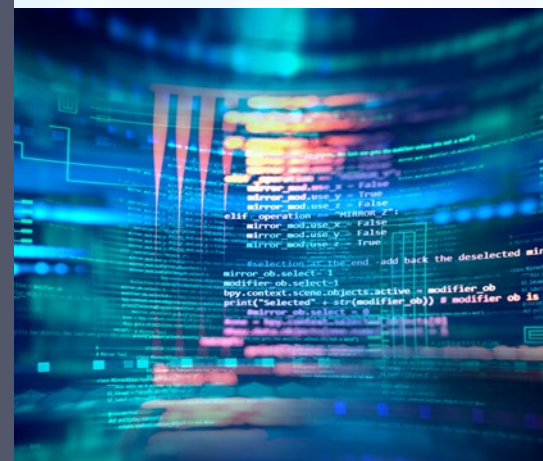
Q What impact do you think biomanufacturing will have on the future?

A Biomanufacturing is involved in the production of sustainable foods, biofuels, vaccines, and

better technologies for controlling and monitoring experiments. The biomanufacturing industry will also be producing many more employment opportunities as we move into the future.

Q What is your advice for someone wanting to pursue a career in biomanufacturing?

A If you are a student that has a zeal for nature, humanity, biology, and/or future technologies, don't be scared to pursue the field. A career in biomanufacturing is a way to have a lifetime of exploring these passions while simultaneously contributing to a cleaner, healthier world.



MICRO-CREDENTIALS

BIOSCIENCE CORE SKILLS INSTITUTE



“IMAGINE HAVING A DIGITAL WALLET WITH EVERY SKILL YOU’VE LEARNED DOCUMENTED INSIDE? DIGITAL CREDENTIALS CONNECT SKILLED WORKERS TO JOBS AND COMPANIES. THEY HAVE THE POTENTIAL TO CREATE EQUITABLE AND FAIR PATHWAYS FROM TRAINING OF ALL TYPES INTO EXCELLENT JOBS WITH UPWARD MOBILITY. THIS TECHNOLOGY WILL IMPROVE THE WAY WE DESIGN CURRICULUM AND TRAINING PROGRAMS, MANAGE WORKFORCE AND HIRING, AND SUPPORT INDIVIDUALS AS THEY NAVIGATE THE TRAINING AND WORK PATHWAYS THROUGHOUT THEIR CAREERS.”

—Angela Consani
BCSI CEO and co-founder

What are Micro-credentials?

In bioscience, the details matter. Higher education credentials are largely awarded for content knowledge leaving graduates with degrees that lack detail about the lab skills acquired. Micro-credentials are digital credentials that add detail to the traditional degree, allowing students to document skills mastered during their educational journey. These skills include things like lab safety, hazard management, standard operating procedures and mastering small volume metrology (liquid transfer from 1 microliter to 25 milliliters).

BIOSCIENCE CORE SKILLS INSTITUTE (BCSI)

BCSI is a non-profit organization that has made it their mission to use practical skills testing to document the skills of newly trained individuals. Their vision is a future where students, trainees, and employees can accurately and reliably document the

skills they acquire.

In biotechnology, biopharma, and other bioscience sectors, there is no single credential or certificate that trainees can acquire to show mastery of laboratory skills and practices. To address this problem, BCSI has designed a series of task-based tests that individuals can use to show they have

mastered the skills and abilities desperately needed by companies in this specialized and technical workforce sector.

BCSI uses digital archiving to maintain the credentials and display them to potential employers. As the credentials are lines of code, they are portable to all electronic documents

once awarded to the recipient. The credentials display as digital badges with embedded hotlinks to the BCSI site where the viewer is provided with contact information for the organization, criteria by which the skill was assessed, and other pertinent information such as the assessor’s name and date of testing.



BIOINDUSTRIAL MANUFACTURING

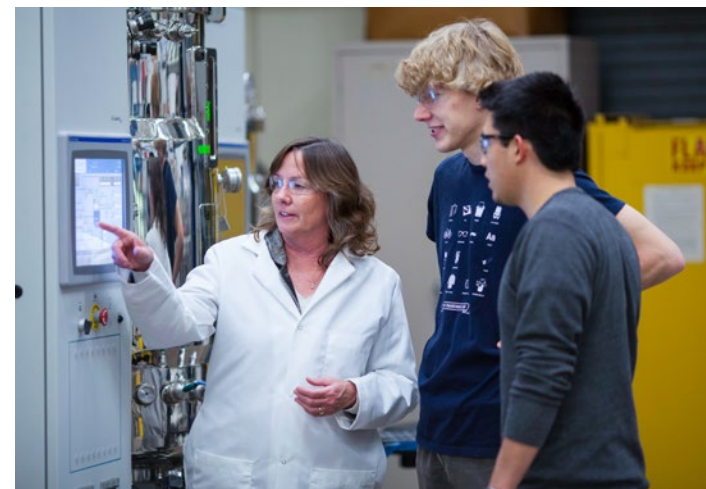
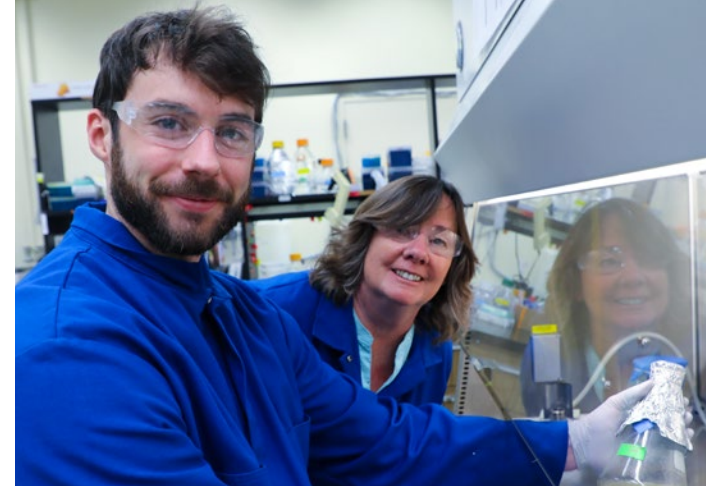
AT UC DAVIS

UC Davis is a large, research-intensive university situated in the greater Sacramento Valley just north of the San Francisco Bay Area. Known for strong STEM programs, especially those related to agriculture and the environment, UC Davis is also considered a “comprehensive campus” with expertise in key disciplines needed to support the development of bioindustrial manufacturing.

UNDERGRADUATE MAJOR IN BIOCHEMICAL ENGINEERING

The undergraduate major in Biochemical Engineering is a four-year program that culminates in students receiving a Bachelor of Sciences Degree (BSc). This program is one of the few in the country that is an [ABET](#) (Accreditation Board of Engineering and Technology) accredited undergraduate engineering degree in Biochemical Engineering. In the first two years, students take foundational courses in chemistry, biology, microbiology, mathematics and physics and in the

upper division they take courses in process engineering (material balances, fluid mechanics, heat transfer, mass transfer, thermodynamics, kinetics and reaction engineering, process modelling and control, and engineering economics) along with specialized courses in bioprocess engineering (bioreactor design and analysis, bioseparations, bioprocess engineering laboratory, biotech facility design and regulatory compliance) culminating in a capstone design project focused on design and techno-economic modelling and analysis of a biomanufacturing facility in collaboration with industrial or academic partners.



UNDERGRADUATE MAJOR IN BIOTECHNOLOGY

The undergraduate major in Biotechnology is a four-year program that culminates in students receiving a Bachelor of Sciences Degree (BSc). In the first two years, students develop a strong and general background in the biological sciences with an emphasis on the basic principles of genetics, molecular biology, cell biology and recombinant DNA. In their third and fourth year, students focus their studies into one of four general areas for more in depth studies: microbial biotechnology, animal biotechnology, plant biotechnology, or bioinformatics.

COMMITMENT TO SUSTAINABILITY AND THE BIOECONOMY

Developing new life science and engineering technologies that promote environmental sustainability and boost the regional, national and global bioeconomy is an important part of UC Davis’ land grant mission as a public university. Since 2014, UC Davis has ranked in the top five most “green” or sustainable universities in the world by UI GreenMetric and has an on-going focus on improving the sustainability of campus infrastructure and operations. [Learn more](#)

BIOINDUSTRIAL COURSEWORK

EACH OF THE ACADEMIC MAJORS LISTED BELOW HAS MANY OPPORTUNITIES FOR UNDERGRADUATE STUDENTS TO ENGAGE IN COURSEWORK AND RESEARCH PROJECTS FOUNDATIONAL FOR BIOINDUSTRIAL MANUFACTURING:

- Applied Chemistry
- Biochemical Engineering
- Biological Systems Engineering
- Biotechnology
- Cell Biology
- Chemical Engineering
- Chemistry
- Food Science and Technology
- Genetics and Genomics
- Materials Science and Engineering
- Microbiology and Molecular Genetics
- Molecular and Cellular Biology

[Learn More](#)



LANEY COLLEGE



Laney College is a public community college in Oakland, California. Laney is the largest of the four colleges of the Peralta Community College District which serves northern Alameda County and approximately 17,000 students annually. As the flagship college for the Peralta District, Laney College stretches across sixty acres in downtown Oakland, California, one of the most ethnically and economically diverse cities in America.

Laney College offers associate degrees in more than 20 liberal arts and science fields; a significant number of graduates go on to attend 4-year colleges and universities, including the University of California and California State University systems.

LANEY COLLEGE BIOMANUFACTURING PROGRAM

The Biomanufacturing Program at Laney College provides students with the necessary training in the basic skills of biology, biomanufacturing, chemistry and math, as well as an introduction to biomanufacturing careers to enter the workforce. Two certificates and an

Associates of Science degree are offered. Each certificate/degree prepares the student to work as an entry-level technician and other positions in the manufacturing component of the biotech/pharmaceutical industry and burgeoning synthetic biology industry.

With a certificate or degree in biomanufacturing from Laney College, students have the skills to gain employment at biotech companies.

These companies include major manufacturers and hot new food tech and biomaterial companies such as Upside Foods, Geltor, Advanced Biofuel Process Demonstration Unit (ABPDU), and Perfect Day.

The starting pay for entry-level jobs is competitive and there are opportunities to advance rapidly within the industry. The Laney College Biomanufacturing Program has placed over 320 graduates in various biotech companies in the

past eight years.

Biomanufacturing is an exciting and expanding new field. The state of California is booming with biomanufacturing opportunities. Over 95% of Laney College Biomanufacturing graduates get placed in synthetic biology companies, particularly in food tech and biomaterials. These new synthetic biology companies build sustainable food items and lessen our impact on the climate.

BUILDING A PATH TO COLLEGE AND CAREER

BIOBUILDER



BioBuilder offers innovative science and engineering programs to open pathways to biology and successful careers. BioBuilder offers in-person training in synthetic biology at Learning Labs for students and teachers, online resources for teachers and students and in-person training for professionals seeking to advance their synthetic biology skills. Created by an award-winning team from MIT and founded in 2011, BioBuilder empowers teachers and schools to better serve students and employers by elevating the skills that students are taught.

BioBuilder has grown to partner with schools in almost every state and around the world to help students access tools and programs that unlock their potential as life science innovators, acquire skills to be able to build with biology, and invent/imagine ways synthetic biology can make the world better. [Learn more here.](#)

BIOBUILDER HIGH SCHOOL APPRENTICESHIP PROGRAM

The BioBuilder Apprenticeship Challenge is an eight-week program that provides lab readiness training for low-income students from diverse backgrounds and under-resourced schools in the Boston metro area. Through this training, students learn laboratory and professional skills

that will prepare them for competitive, summer internship opportunities and careers in local academic labs and/or life science companies.

Since 2016, over 100 students have been able to benefit from the program, with 80-90% of graduating Apprentices being offered and accepting summer internships each year. To date, all the Apprentices surveyed at the end of the program said they plan to attend college and major or work in life sciences.

“IT WASN'T UNTIL THE BIOBUILDER APPRENTICESHIP PROGRAM THAT I STARTED DEVELOPING AND UNDERSTANDING ABOUT HOW TO USE SCIENCE AND TECHNOLOGY TO DIVE DEEP IN SYNTHETIC BIOLOGY. A HUGE PART OF IT IS USING YOUR PEERS TO HELP REVISE YOUR LAB NOTEBOOK TECHNIQUES WHICH HELPS YOU UNDERSTAND HOW TO WORK IN AN ACTUAL RESEARCH LAB.”

— Angela Girodier
Biotechnology Teacher and Coach at Brockton High School
& BioBuilder Student Ambassador

REAL LIFE IMPACT

Angela Girodier graduated from Emmanuel College in May of 2022, majoring in biology and secondary education. She went through the BioBuilder Apprenticeship Program in 2017 after a high school teacher encouraged her to apply. She says the BioBuilder Apprenticeship taught her lab math and techniques which she describes as vital to her success in college. The apprenticeship's emphasis on teamwork and networking helped her build her resume and make the most of her summer internships at MassBiologics and at Merck during her college experience. Now she is transferring her knowledge and experiences as a high school teacher to inspire students, especially those in low-income communities, to explore STEM related fields.



BIOINDUSTRIAL PATHWAYS & RESOURCES

K-12 BIOINDUSTRIAL PROGRAMS

ENGINEERING IS ELEMENTARY (EIE)

Prepare the workforce of tomorrow. Encourage critical thinking and problem solving to inspire young learners to think like engineers. Engineering is Elementary, 2nd Edition presents real world challenges that encourage students to explore multiple ways to solve a problem. Following the Engineering Design Process and using scientific inquiry, students make connections to the real world.

[Learn More](#)

ARMY EDUCATIONAL OUTREACH PROGRAM

The Army Educational Outreach Program STEM Enrichment activities spark student interest in STEM from the earliest grades through high school. They also provide experiential learning opportunities for educators. These programs are great for students and teachers from all backgrounds and interests, and are designed to complement classroom learning and teaching by providing exciting, engaging, hands-on experiences.

[Learn More](#)

PROJECT LEAD THE WAY (PLTW)

PLTW Gateway (6-8) opens paths that create meaningful futures. Students begin to lead their own learning and explore

computer science, engineering, and biomedical science, boosting classroom engagement and excitement, supporting teamwork, and inspiring deep comprehension.

[Learn More](#)

BIOBUILDER

BioBuilder offers in-person training in synthetic biology at Learning Labs for students and teachers; provides online resources for teachers and hands-on kits for students; and provides in-person training for professionals seeking to advance their synthetic biology skills.

[Learn More](#)

BAY AREA BIOSCIENCE EDUCATION COMMUNITY

BABEC is dedicated to providing teachers with the support, resources and networking opportunities they need to educate students in biotech and prepare the next generation of scientists.

[Learn More](#)

BOSTON UNIVERSITY RISE PROGRAM

RISE offers two tracks for students in their junior year of high school. For the Internship track, students spend 40 hours each week working on research projects designed by their mentor. For the Practicum track, students conduct group research in a university setting.

[Learn More](#)

K-12 OUTREACH AND TEACHER TRAINING RESOURCES

BIOBITS

BioBits labs and accompanying curriculum are developed to meet standards for K-12 STEM education. BioBits take advantage of cutting-edge freeze-dried cell-free technology to make it possible to run biological experiments without living cells. Learn about DNA and how it makes proteins by making your own fluorescent proteins and more! BioBits are portable, user-friendly, and inexpensive, making it possible to teach molecular biology outside of the lab.

[Learn More](#)

NAVAL STEM CENTER

STEM development begins with Naval STEM outreach programs at the Pre-K through 12th grade levels, continues through undergraduate and graduate school, supports student advancement into post-doctoral work, and continues through all stages of their STEM professions.

[Learn More](#)

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[Learn More](#)

BIOTECH SYSTEM

BioTech SYSTEM is a K-14 STEM education consortium administered by the UC Davis Biotechnology Program in collaboration with regional colleges and universities, community organizations, local governments, school districts and industry partners. The overarching goal of BioTech SYSTEM is raising awareness of biotech career paths, supporting students and teachers in experiential learning opportunities and improving public science literacy. Flagship activities of the BioTech SYSTEM are Train-the-Trainer Workshops for biotech educators, the Teen Biotech Challenge poster competition for middle and high school students and the SPARK Summer Research Program.

[Learn More](#)

SCIENCE COMPETITIONS

INTERNATIONAL GENETICALLY ENGINEERED MACHINE COMPETITION (IGEM)

The iGEM Competition is an annual,

worldwide synthetic biology event aimed at undergraduate university students, as well as high school and graduate students. The iGEM Competition gives students the opportunity to push the boundaries of synthetic biology by tackling everyday issues facing the world. Multidisciplinary teams work together to design, build, test, and measure a system of their own design using interchangeable biological parts and standard molecular biology techniques.

[Learn More](#)

TEEN BIOTECH CHALLENGE

The Teen Biotech Challenge 2023 is an online poster design competition for Grades 6-12 that allows students to demonstrate research skills, scientific communication skills, and creativity. Participating students will be asked to submit a poster (.pdf) for judging in one of the following biotech-related research categories: Agricultural Biotechnology; Biomanufacturing; Computational Biology and Genomics; Environmental Biotechnology and Planetary Health; Molecular Tools; Nanobiotechnology, Synthetic Biology and Genetic Engineering; and, Regenerative Medicine and Biomedical Engineering.

[Learn More](#)

JUNIOR SCIENCE AND HUMANITIES SYMPOSIUM

JSHS is an annual symposium, competition, and year-round digital programming funded by the Department of Defense (DoD), and administered by the National Science Teaching Association (NSTA). It provides mentoring, scholarship, and career pathways for young minds from everywhere to

find success, growth, and connection in STEM.

[Learn More](#)

THE REGENERON INTERNATIONAL SCIENCE AND ENGINEERING FAIR (REGENERON ISEF)

The Regeneron International Science and Engineering Fair (ISEF) is the world's largest international pre-college science competition. It is owned and administered by the Society for Science.

[Learn More](#)

USA SCIENCE AND ENGINEERING FESTIVAL

The mission of the USA Science & Engineering Festival is to stimulate and sustain the interest of our nation's youth in STEM by producing and presenting compelling, exciting, and educational STEM events and programs.

[Learn More](#)

HIGH SCHOOL/ COMMUNITY COLLEGE

AUSTIN COMMUNITY COLLEGE

The Biotechnology Program offers a variety of cutting-edge certificates and degrees tailored for people wanting to enter into the bioscience and biotechnology workplace. The program offers Entry-Level Certificates, an Associate Degree, and Post-Baccalaureate Certificate training. Biotechnology degrees focus on a "hands-on" training approach spanning topics from basic laboratory skills such as micropipetting and solution preparation to more advanced

skills such as quantitative PCR, HPLC and cell culture. In addition, the program also provides specialized training in bioinformatics, regulatory affairs, and biomanufacturing.

[Learn More](#)

SKYLINE COLLEGE

Skyline College's Biotechnology Manufacturing Technician Associate in Science Degree Program prepares graduates with the skills and experience to work in the biotechnology industry as a production technician. Students will culture and maintain bacteria, yeast, and mammalian cells as well as gain experience in the recovery of proteins that the cultures produce. Students will develop skills in good manufacturing practices (GMP) by maintaining records and following standard operating procedures.

[Learn More](#)

SOLANO COMMUNITY COLLEGE

Solano Community College offers a Bachelors of Science degree in Bioindustrial Manufacturing.

[Learn More](#)

DES MOINES AREA COMMUNITY COLLEGE

A DMACC Biotechnology Certificate as a part of the DMACC AS plus Certificate degree or as an addition to previous coursework and experience will assist students in finding a career in cutting edge research in this fast growing and exciting scientific frontier.

[Learn More](#)

LANEY COLLEGE

Laney College offers certificate programs and an Associate in Science in biomanufacturing.

[Learn More](#)

OHLONI'S COLLEGE

Ohlone's Biotechnology program provides students with excellent preparation in the hands-on skills and protocols used in local companies.

[Learn More](#)

SHORELINE COMMUNITY COLLEGE

Shoreline Community College allows students to gain access to jobs in the rapidly expanding field of biotechnology with real-world training in essential skills and knowledge sought by local industry employers.

[Learn More](#)

MIRACOSTA COLLEGE

MiraCosta College is one of only 15 California community colleges authorized to offer a bachelor's degree program. Upper degree coursework for the biomanufacturing bachelor's degree began in fall 2017.

The degree program prepares students for work within the biotechnology industry in the unique environment of biological production where science thrives in partnership with quality and compliance.

[Learn More](#)

BIOSCIENCE CORE SKILLS INSTITUTE (BCSI)

Bioscience Core Skills Institute (BCSI) provides workforce skills assessment and digital micro-credentialing that are valid, reliable, and trusted by the bioscience industry. Working with educational and industry partners, BCSI provides assessment opportunities and documentation of skills.

[Learn More](#)

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BIOINDUSTRIAL PATHWAYS & RESOURCES

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INTERNSHIPS/ APPRENTICE PROGRAMS

NAVY SCIENCE AND ENGINEERING APPRENTICE PROGRAM

SEAP is an 8-week high school apprenticeship opportunity at one of nearly 25 naval laboratories or warfare centers. Accepted students gain real-world, hands-on experience and research skills while being introduced to the Navy and Marine Corps science and technology environment.

[Learn More](#)

SCIENCE UNDERGRADUATE LABORATORY INTERNSHIP AT NATIONAL LABS

Science Undergraduate Laboratory Internship at National Labs encourages undergraduate students and recent graduates to pursue STEM careers by providing research experiences at the Department of Energy (DOE) laboratories. Selected students participate as interns appointed at one of 17 participating DOE laboratories/facilities. They perform research, under the guidance of laboratory staff scientists or engineers, on projects supporting the DOE mission.

[Learn More](#)

UT AUSTIN FRESHMEN RESEARCH INITIATIVE

The pioneering Freshman

Research Initiative (FRI) gives first-year students the opportunity to initiate and engage in real-world research experience with faculty and graduate students. The companion Accelerated Research Initiative (ARI) offers a parallel experience for students not in their first year in college. In FRI, undergraduate students explore unanswered questions in science, math, and technology. Over 1000 College of Natural Sciences (CNS) students each year uncover new knowledge and develop innovative technologies in 35 faculty-led research laboratories.

[Learn More](#)

UNIVERSITY PROGRAMS

UNIVERSITY OF CALIFORNIA DAVIS

Biotechnology offers new ways of production using biological materials, organisms, and systems. Leading research in this area enables the synthesis of pharmaceuticals, biodegradable polymers, renewable fuels, and other bio-based products from diverse feedstocks. UC Davis faculty are developing new crops for improved disease and pest resistance and adaptation to changing climate and conditions.

[Learn More](#)

UC DAVIS BIOCHEMICAL ENGINEERING MAJOR

As a biochemical engineering major, you will begin your study with an extensive series of foundation courses in

biology, chemistry, physics and mathematics. At the upper division level, you will take advanced courses in specific topics in biochemical and chemical engineering. These courses will include fundamental process engineering courses (transport phenomena, thermodynamics, kinetics, process control, engineering economics) as well as specific courses in bioreactors, bioseparations, biotechnology facility design, regulatory compliance, technoeconomic analysis and biochemical engineering laboratory.

[Learn More](#)

UC DAVIS DESIGNATED EMPHASIS IN BIOTECHNOLOGY

The DEB is an inter-graduate group program that allows Ph.D. students to receive and be credited for training in the area of biotechnology. The program brings together students and faculty from across 29 STEM disciplines to create an educational ecosystem that promotes collaborative team science, effective science communication for diverse audiences, and an entrepreneurial mindset for tackling complex global challenges across human health, agriculture and the environment. Through required coursework and seminars, DEB students are introduced to a range of biotechnology research areas with focus on the intersection of molecular biology and engineering in the development of biomanufacturing platforms for industrial enzymes, therapeutics, biofuels and

other high value products. The cornerstone of the DEB training environment is a required 3–6-month professional internship, which usually takes place in a biotechnology industry setting.

[Learn More](#)

UC DAVIS BIOTECHNOLOGY MAJOR

In the first two years students will develop a strong and general background in biological sciences with an emphasis on fundamental concepts and basic principles of genetics, molecular biology, cell biology and recombinant DNA technology. Students will do a more in-depth study at the upper division level and will focus on an animal, plant or microbial or bioinformatics option. The options in this major provide training to individuals seeking specialized knowledge in one or more aspects of biotechnology. In addition, the core requirements in each of these options have a strong laboratory component to further reinforce the theoretical concepts.

[Learn More](#)

UNIVERSITY OF GEORGIA'S BIOEXPRESSION AND FERMENTATION FACILITY

The Bioexpression and Fermentation Facility (BFF) in the Department of Biochemistry and Molecular Biology at the University of Georgia provides state-of-the-art equipment and wide-ranging expertise in

biotechnological applications to academic and industry clients. The BFF has broad range capabilities in fermentation, cell culture, monoclonal antibody generation and protein purification.

[Learn More](#)

UC BERKELEY'S MASTER OF BIOPROCESS ENGINEERING

UC Berkeley's Master of Bioprocess Engineering (MBPE) degree program is driven by the increasingly important role of the bioprocessing field in the world economy. It is designed for the incoming student who possesses the interest and aptitude but not yet the hands-on experience to step into a bioprocessing role. The MBPE program bridges this expertise and experience gap for those who wish to pursue careers as Associate Scientists or Bioprocess Engineers in the bioprocessing field to design, develop, and implement real-time solutions and strategies.

[Learn More](#)

BOSTON UNIVERSITY STEM PATHWAYS

The main objective of STEM Pathways is to inspire, mentor, train, and empower current and future generations of students, with a focus on underrepresented groups. Through STEM Pathways, students will be able to: obtain academic and research experiences in the growing field of Synthetic Biology; pursue rewarding careers in computer and biomedical engineering; and influence innovations and impacts in STEM, community education, and outreach.

[Learn More](#)

OTHER RESOURCES

INNOVATEBIO

The InnovATEBIO National Biotechnology Education Center is working to advance the education of highly skilled technicians for the nation's biotechnology workforce. Toward this goal, InnovATEBIO is providing leadership in biotechnology technician education, including support for development and sharing of best practices and emerging technologies in biotechnology workforce development.

[Learn More](#)

THE GOLDEN LEAF BIOMANUFACTURING TRAINING AND EDUCATION CENTER (BTEC)

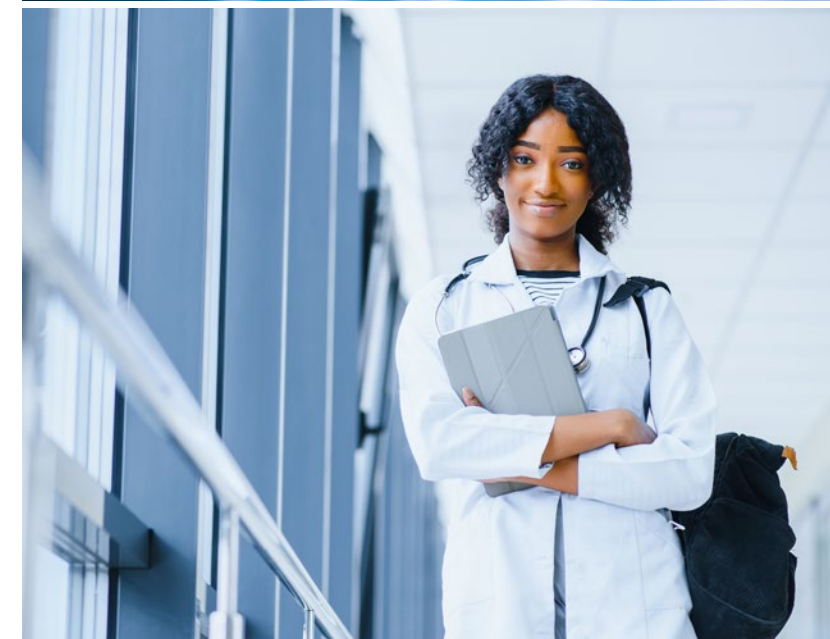
BTEC works with industry to design and develop a number of open-enrollment courses that enhance the knowledge and skills of biotechnology and biomanufacturing professionals. BTEC offers several options to expand the process expertise of individuals and the industry, including professional development courses, seminars, and customized courses.

[Learn More](#)

DOD SMART PROGRAM

The Science, Mathematics, and Research for Transformation (SMART) Scholarship-for-Service Program, funded by the Department of Defense (DoD), is a combined educational and workforce development opportunity for STEM students.

[Learn More](#)





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