A return to biomanufacturing

ASSOCIATE PROFESSOR JOY DORAN-PETERSON

As the impacts of a petroleum-based economy become more prevalent than ever, experts including **Associate Professor Joy Doran-Peterson** of the University of Georgia are beginning to consider shifting to a bio-based system. Here, she outlines how the biomanufacturing industry is coming full circle, and how educators are preparing biomanufacturing students to bring about this change

In what capacity is the University of Georgia's (UGA) Master's Program benefiting from the expertise from industry leaders?

The Master of Biomanufacturing and Bioprocessing (MBB) Program is industry-led from the start, with respected companies combining forces with an experienced faculty to develop curricula and non-traditional learning experiences that prepare students for a challenging but highly rewarding workplace.The MBB Program provides hard science, technology, engineering and mathematical (STEM) training to motivated science students. They are also prepared for immediate engagement in an industry short of leaders equipped with these necessary STEM skills coupled with business and project management knowledge. Companies that will potentially hire graduates are involved alongside those that produce biomanufacturing tools to guide faculty and to train, set challenges for, and provide internships to students. Numerous companies fully support this vision and the UGA faculty and administration are committed to developing the MBB as a landmark Program at UGA.

Since the Master's Program began, what would you consider your greatest accomplishments thus far?

The 'total package' manifested in our graduates is our greatest accomplishment thus far because they exemplify those traits desired by biomanufacturing and bioprocessing industries. We were fortunate to receive funding from the National Science Foundation to launch this Program in 2010. Our Industrial Advisory Board is instrumental in helping to shape our 38 credit, 18-24 month curriculum, so that we are providing relevant training to our students that will equip them for today's ever-changing work environment. We have built fluidity into the curriculum in order to be responsive to industry needs and cutting-edge technological advances. Students evolve in our curriculum as they are exposed to industry, business perspectives, skills development, and technical training. Our first graduates all had multiple job offers within a month of graduating. Our challenge is to keep up that track record.

Which areas of the biomanufacturing industry will be the focus of expansion over the coming years?

There is a strong and increasing demand for professional biomanufacturing specialists for disciplines as diverse as biopharmaceuticals, biofuels and energy, bio-based chemicals, and agricultural biotechnology. One specific area poised for exponential growth is bio-based industrial products, using renewable plant resources to make a wide-variety of industrial products. Bio-based industrial products are starting to come full circle, replacing those petroleum-derived products that once displaced them, only now with the benefit of a new toolbox accelerating the process and new applications for the biochemicals.

You require students to become competent in the regulatory framework and laws currently governing biomanufacturing. Do you consider these to be barriers to progress?

I do not consider these barriers to progress because many laws and regulations are in place to help protect people and the environment. Knowing how to navigate within the regulatory environment, however, is very important for individuals working in the biotechnology/biomanufacturing space. It is very frustrating for everyone if time and energy is spent on a project, only to find out that it will likely never meet regulatory compliance. Equally important is the ability to estimate the costs, supplies, manpower and environmental impact of implementing a project. Our students possess these skills.

What are your hopes for the future of biomanufacturing and bioprocessing?

I believe we must pay attention to all of the drivers now pushing us in the direction of bio-based fuels, chemicals, and power: political, environmental and economic. Some of these ideas are certainly not new; bio-based chemicals and fuels were the original ones but were displaced when petroleum became cheaper to use. As we face the true costs of being so dependent on petroleum in terms of environmental quality, national security, and sustainability, I hope we will accelerate the transition to a more bio-based economy. We must make this transition in a responsible, sustainable, and economically viable fashion. We are resourceful and creative and can meet this challenge together as an interwoven network of academia, industry, agencies, government and an educated public.

DR DORAN-PETERSON EXAMINING AN ASSAY IN HER LABORATORY

Biomanufacturing: back in the spotlight

Bio-based industrial products were swept aside when petroleum started being offered as a cheaper alternative. However, as the problems associated with petroleum dependency grow ever greater, the training of a new generation of bio-manufacturing leaders is underway at the **University of Georgia**

BIOMANUFACTURING IS THE fundamental process that unites the various market sectors of the global biotechnology industry. Its scale is eclectic, with the production of liquid biofuels on one side, and the pharmaceutical industry on the other. Between them, there are commercial sectors, including the biochemical industry, agriculture, environmental technology, biodefense, biomaterials, domestic and leisure goods, each using biotechnology products. Though each sector can be defined by its own requirements and characteristics, there is one factor that unites them all: biological entities need to be turned into a product; they need to be 'biomanufactured'.

There are few programmes that address biomanufacturing specifically. The University of Georgia programme is unique, dedicating its Master of Biomanufacturing and Bioprocessing (MBB) Program to the entire biomanufacturing experience, including practical hand's on training and access to first-rate, industrially relevant equipment. 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 curriculum also exposes students to lessons in science and business, as well as internships with leading companies in the market. Biomanufacturing projects carried out at the university are coordinated through the interdisciplinary Biomedical Health Sciences Institute and may occur in departments or schools of microbiology, engineering, biochemistry, genetics, pharmacy, infectious disease, veterinary medicine, or forestry and natural resources.

MBB STUDENT CHECKING THE PERFORMANCE OF A FERMENTATION

For example, one project examines insect systems for degrading lignocellulosic biomass or plant material. The researchers examine industrial processes and look to Nature to guide them in improving their overall development. Doran-Peterson, MBB Director, elaborates further: "In some cases, the insect synergises the activities of the microbial community by producing enzymes itself. In other cases, the insect is more of a natural bioreactor or vessel, providing the right environment, but relying on the associated microorganisms to do the bulk of the plant cell wall deconstruction". The environments are then analysed for microorganisms, enzymes, and other attributes, which are subsequently translated into practical solutions for industrial processes, such as fermentation or bioprocessing. "As more products are produced using plant matter as the starting material instead of petroleum, the possible applications of this work are multiplied," reflects Doran-Peterson. "We have created the new Professional Science Master's Program to help meet the increasing demand for technically trained scientists in manufacturing for bio-based products with business skills and the ability to navigate a regulatory environment."

TRAINING FOR THE FUTURE

Indeed, the University of Georgia's MBB Program trains students to take leadership positions in the ever-increasing and important field of biomanufacturing, which in turn has positive effects on such areas as biofuel production, green chemical manufacturing and biopharmaceuticals. The course intends to prepare students to join an industry that is currently lacking leaders who are adept in crucial areas, such as science, technology and engineering, coupled with a strong business and management ethic. The long lead-time to commercialisation for biotechnology products is such that to date, the industry focus has been R&D. However, the industry is now ripe to move into production, and a perfect storm of growth in the biofuels, biochemicals, pharmaceutical, and other sectors creates a high demand for well-trained biomanufacturing leaders.

The course also grants students access to pioneering tools and equipment, including opportunities to train virtually, fully preparing them for the industry ahead. The hope is that students will graduate with a unique understanding of the biology, biochemistry, chemical engineering, process control and regulatory issues that are entwined with fermentation, cell culture and product

PROFESSIONAL SCIENCE MASTER'S PROGRAM: FROM SCIENCE TO BUSINESS IN BIOMANUFACTURING: THE MISSING LINK FOR THE US BIOTECHNOLOGY INDUSTRY

OBJECTIVES

The University of Georgia's Professional Science Master's Program in Biomanufacturing and Bioprocessing trains science and technology graduates for leadership roles in the rapidly expanding and vitally important biomanufacturing field. It prepares students for immediate engagement in an industry that is short of leaders equipped with the necessary science, technology and engineering skills combined with proven business and project management training.

KEY PARTNERS

Biomedical Health Sciences Institute (www.biomed.uga.edu) • **Bioexpression and Fermentation Facility at University of Georgia** (http://bff.uga.edu) • **College of Pharmacy Regulatory Affairs Program at UGA** (www.ra.rx.uga.edu) • **Franklin College of Arts and Sciences UGA** (www.franklin.uga.edu) • **College of Engineering** (www.engr.uga.edu) • **Warnell School of Forestry and Natural Resources** (www.warnell.uga.edu) • **Novozymes** (www.novozymes.com) • **Merial, Ltd.** (www.merial.com) • **Meredian Bioplastics** (www.DaniMer.com) • **Terrapin Beer Company** (www.terrapinbeer.com) • **Baxter** (www.baxter.com) • **Synageva** (www.synageva.com)

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purification. Furthermore, unlike many of today's traditional university graduates, they will emerge with the skill to use their knowledge and acumen in corporate spheres, supporting the increase in environmentally sustainable manufacturing, which will have advantageous knock-on effects on the economy, healthcare and even national security.

BIO LIMITATIONS

Bio-based product production has not been without its limitations, though, as Doran-Peterson explains: "Any time we take a microorganism out of its natural environment and ask it to perform a specific process for us, there will be limitations and challenges. Techniques such as directed evolution, metabolic pathway engineering, synthetic biology, and various 'omics' approaches all have advanced the productivity and stability of biocatalysts for bio-based fuels and chemicals production. We have used all of these new tools under various conditions for developing robust, industry-ready biocatalysts for specific products". Some of these tools have also been applied to the pharmaceutical industry for vaccine and drug development.

The future of biomanufacturing and bioprocessing is quite promising, as several powerful drivers: political, environmental, and economic are now aligned to loosen the grip of petroleum on the world's economies. Indeed, this will come as no surprise: bio-based chemicals and fuels may have been the original products on offer, but they were soon usurped by petroleum, when it became cheaper to use. As the true results of petroleum dependence (in terms of air quality, national security and sustainability) become ever more apparent, Doran-Peterson hopes to speed up the change to a more bio-based economy. However, this will only be achieved when there is a clear balance between the type of material used and the cost of its implementation. "Every choice has a consequence and an impact on our environment and we need to be willing to use the same magnifying lens used on bio-based chemicals and fuels with the current fossil fuel processes," she underlines.

BACK TO BIO

Global corporations are starting to embrace the idea that there can be economic benefit in using microorganisms, enzymes and cells to manufacture their goods. And as more and more businesses choose to adopt biomanufacturing and bioprocessing, Doran-Peterson plans to spread the idea of introducing technical science, engineering and mathematical methods to students, preparing for their instant involvement in an industry that lacks leaders with the crucial science, business and management talents and acumen. "We work very closely with our industrial advisory board to prepare students for the workforce of tomorrow," she notes. "Students receive advanced training in hard sciences while developing workplace skills highly valued by employers. Written and verbal communications skills, leadership, and team-building are emphasised throughout our Program. Leveraging excellent facilities of an internationally recognised biomanufacturing pilot plant adds to the quality of the experience for our students."

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The biomanufacturing industry has plenty of room for expansion in the coming years. Indeed, there is a strong and growing demand for biomanufacturing professionals and experts in sectors as eclectic as biopharmaceuticals, biofuels, energy, bio-based chemicals and agricultural biotechnology. "Microorganisms live in virtually every environment on our planet, including those with high temperature, extreme pH and high salinity," Doran-Peterson points out. "As we continue to develop new tools to examine these environments and to dissect the interactions, enzymes, small molecules, and other components involved in transformation of one form of carbon to a desired product, more of these discoveries lend themselves to improving industrial processes." According to Doran-Peterson, there is cause for optimism that bio-based industrial products are set to witness exponential growth in the future.

DORAN-PETERSON AND MBB STUDENTS AT THE BIOEXPRESSION AND FERMENTATION FACILTY AT UGA.