Biomanufacturing 101

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What is biomanufacturing?

One of the most profound effects of the emerging biotechnology industry is the creation of new opportunities for bioproduction, or the use of biological systems to create clinical and commercial products. Examples of bioproduction range from the manufacturing of biologics-based therapeutic drugs to the mushroom-enabled production of plastics and polystyrene foam alternatives.[1,2] By harnessing biology, bioproduction enables new manufacturing capabilities and has unlocked the ability to create biologically-produced products as both alternatives to currently available products and novel introductions for a wide range of sectors.

Biomanufacturing is a type of bioproduction that uses fermentation to transform inputs into a range of outputs and end-products. One well-known biomanufacturing end-product is beer. Beer brewers all begin with three inputs: grain (like malt and hops), yeast (a living microorganism), and water. Brewers mash the grain in water to release starch (consisting of sugar molecules), and then add yeast. Over time, the yeast consumes the sugar molecules, and transforms it into two outputs: alcohol and carbon dioxide. Brewers then filter the output and bottle the desired end-product: beer.

Using this same fermentation process, biomanufacturers can make so much more than beer, including outputs like biomaterials, biochemicals, and biofuels. From there, producers can create a wide range of end-products from pharmaceuticals[3] and baby formula[4] to cloth and alpine skis.[5]

Why biomanufacturing matters

Like traditional manufacturing, biomanufacturing allows the United States to use what it has to make what it needs. Because of a robust agricultural sector, the United States has an abundance of feedstock (such as corn) that biomanufacturers can transform into vital end-products like materials, chemicals, and fuel. By aligning feedstock with domestic biomanufacturing, Americans can collapse supply chains and address existing supply chain vulnerabilities here in the United States. Biomanufacturing would also create new opportunities for the United States to maintain its economic leadership in the 21st century. Due to advances in bioengineering, biomanufacturing possesses immense potential in establishing new domestic supply chains and generating economic opportunities for entirely novel products with minimal environmental impacts. For example, ongoing research into the domestic bioproduction of synthetic spider silk has shown to have potential applications ranging from high-tech textiles for bulletproof vests to bone regeneration.[6]

Pilot-scale 300 L bioreactor

> ***"Advancing biomanufacturing in the United States is key to strengthening our national security. Biomanufacturing can scale up the innovations happening in laboratories across America, diversify our supply chains, and provide good paying jobs to workers with diverse skill sets throughout the country."***
>
> \- Representative Ro Khanna (CA-17)

Stage I: Inputs

Manufacturers optimize and engineer their inputs to create a specific output for use in making a commercial end-product. Careful consideration is given to the specific combination of microorganism, feedstock, water source, and equipment that will then produce the outputs effectively and efficiently. By bioengineering more efficient microorganisms, manufacturers are able to use a wide variety of feedstocks ranging from wastewater to leftover woody biomass from timber operations.[7] For example, if the desired output is bioplastic, a manufacturer may choose engineered microalgae as their primary microorganism and nutrient-rich wastewater as their feedstock to create algae-derived bioplastics.[8]

Stage II: Production

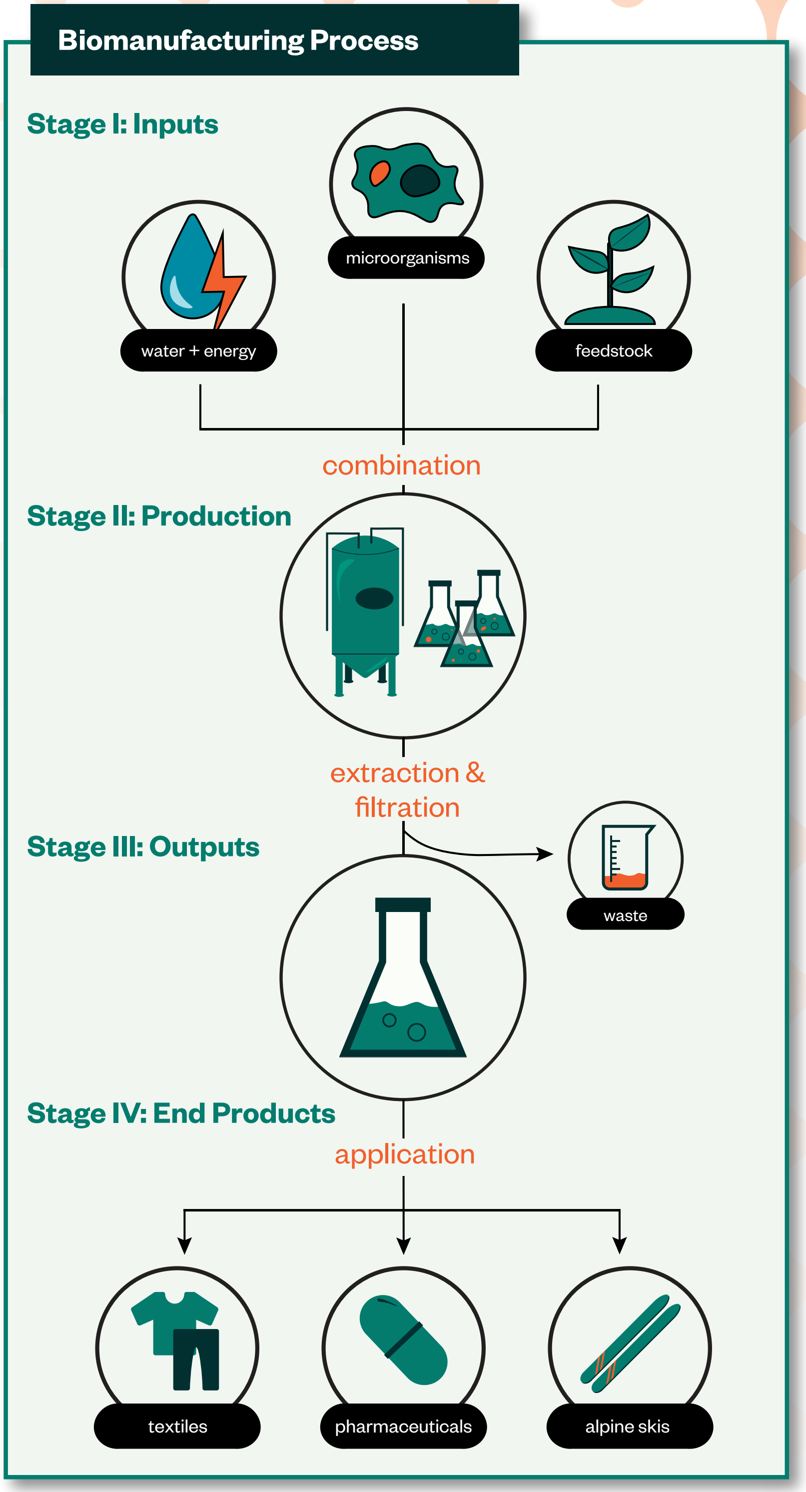
Once manufacturers have selected the right inputs, outlined the bioprocess, and obtained access to the necessary infrastructure, they can begin production. During production, manufacturers prepare and combine the inputs into a bioreactor (a large, specialized tank), which possesses a controlled environment with the ideal conditions for the bioprocess to occur. There, the microorganism transforms the feedstock through bioprocesses such as fermentation to produce unrefined chemical and biological outputs.

Stage III: Outputs

At this stage, the microorganism has transformed the inputs into a mixture that includes both the target output and waste products. Manufacturers process and filter the output mixture to isolate the desired output from the waste products. This extraction process could include filtration, isolation, introduction of solvents, and other methods to prepare the desired output for the next stage.

Stage IV: End Products

In this final stage, manufacturers purify and refine the target output for use in the end-product. Manufacturers then package and transfer the end-product to consumers who will use it as-is or as an ingredient for other products.



Sources

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For any questions about this white paper, or related work at the National Security Commission on Emerging Biotechnology, please contact us at ideas@biotech.senate.gov.

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