Renewable Chemical Platforms Building the Biobased Economy

Bio Biotechnology Innovation Organization

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Bio World Congress on Industrial Biotechnology

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Renewable Chemicals & Biobased Products

Growing Global Biobased Markets

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Algae Production Technologies (**New!**)

Synthetic Biology & Gene Editing

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Renewable Chemical Platforms Building the Biobased Economy

1201 Maryland Ave. SW
Suite 900
Washington, DC 20024

Renewable Chemical Platforms Building the Biobased Economy

The biobased economy is a value chain of sustainable manufacturing that uses biological processes to convert renewable, low-cost or waste feedstocks into everyday products. It creates new markets for agricultural crops, crop residues and waste streams as well as opportunities for innovation in producing consumer goods. Renewable chemicals and biobased manufacturing provide a cost-competitive alternative to petroleum's value chain that generates added value through environmental, economic and other benefits.

Companies around the globe – both those profiled in this report and many others, including dozens of emerging companies – are building the biobased economy as they commercialize renewable chemical processes and biobased products. Collectively, their progress has reached a tipping point for accelerated growth in the 21st century. Governments and policy makers can unleash this growth by supporting all companies and sectors that contribute to building the value chain.

BIO estimates that the global economic value of industrial biotechnology, renewable chemicals and polymers, biofuels, enzymes and biobased materials is $355.28 billion. The United States generates 58 percent of the value, or more than $205 billion.

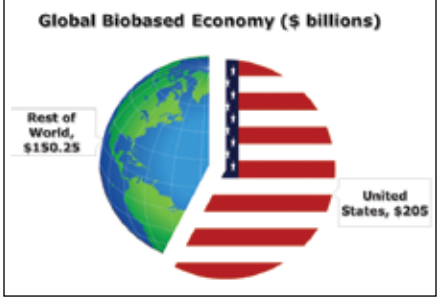


Figure 1: The Biobased Economy

Industrial biotechnology is at the heart of this manufacturing revolution, serving as a catalyst for growth, new economic opportunities and employment in:

- agriculture and forestry, especially through development of new crops and new uses for crop residues;
- industrial manufacturing, through use of offgases and waste streams;
- feed ingredients for animal nutrition;
- nutritional ingredients, flavors and fragrances for grocery manufacturing;
- enzymes, for household cleaners, laundry detergents, and food and fabric processing;
- renewable chemical production for cosmetics, personal care and other consumer product sectors;
- biobased polymer production for packaging and textiles; and
- biofuels.

Measuring the Biobased Economy

Several studies and market analyses have aimed to calculate the economic value of the biobased economy. It is difficult to capture economic impacts across the entire value chain, though, because the biobased economy is characterized by rapid innovation. Industrial biotechnology continually creates potential for use of new feedstocks, new tools such as genomics, gene editing and microbial engineering, as well as new products and materials.

Bioeconomy Capital estimates that the U.S. industrial biotechnology sector generated more than $140 billion in business-to-business revenue in 2016.[1] The group's estimate is drawn from reported revenues for the renewable chemicals, biofuels, human and animal nutrition ingredients, and biotech research and development industries, controlling for the costs of the non-biotech sectors. The group also notes that the consumer level economic impact is likely to be 10 to 30 percent larger than the direct business-to-business revenues. The group notes significant growth in the renewable chemicals, pharmaceutical and nutrition ingredients sectors since a previous report of 2012 revenues. In 2012, total revenue for industrial biotechnology was $105 billion, with renewable chemicals representing $66 billion of that total.

The U.S. Department of Agriculture (USDA) also commissioned a study of the economic impact associated with

the 97 categories of products recognized by the federal BioPreferred® program. Looking specifically at that sector, USDA found that between 2013 and 2014, direct revenue from renewable chemicals and biobased products grew from $125.75 billion to $127 billion, providing direct employment to 1.53 million U.S. workers. The industry also creates employment in other industries, such as transportation and feedstock supply; every direct job in the biobased product industry creates 1.76 jobs in other industries. The total economic impact of U.S. biobased production grew from $369 billion to $393 billion from 2013 to 2014.[2]

This study incorporates the economic and employment impact on agriculture, but does not incorporate the industrial biotech component.

In a separate study specifically of the biotech industry, TEConomy calculates that every direct bioscience industry job creates 5.5 additional jobs elsewhere in the economy. For workers in the agricultural feedstock and chemicals sector of the biotech industry, which includes biofuel producers, the multiplier is as high as 18.4 additional jobs for every direct job.[3]

According to Lux Research, investors pumped nearly $9.2 billion into the industrial biotechnology sector, primarily in renewable chemicals and biobased polymers between 2010 and 2015. The funding came from a variety of sources, including private equity and some public investment. But the majority of the investment and financing – $5.3 billion (57 percent) – came from venture capital.[4] Venture capital investments primarily target research and development of new technologies, and synthetic biology startups have garnered the largest share in recent years.

Another significant source of investment came from partnerships and private equity investments to launch new commercial-scale industrial biotech processes. The commercial success of pioneer renewable chemical producers encouraged these additional equity investments.

Building the Value Chain

Similar to assessments of the chemical industry, projections of future growth in industrial biotechnology, renewable chemicals and biobased manufacturing are built on the abundance and favorable costs of renewable feedstocks, the successful commercialization of pioneer products, and new investments in production capacity. In contrast to traditional industries, though, expectations for industrial biotechnology's future potential are heightened by the diversity and exponential growth in discovery of biological or other processes that convert sustainable, renewable resources to high-value products. The intensifying pace of research and development in biotechnology, new developments in synthetic biology and gene editing, and recent experience in engineering commercial-scale industrial biotech processes augment projections for accelerated economic growth in the field.

The profiles of companies, technology and products in this study documents some of this emerging potential. It also provides a snapshot of mature, commercialized biobased products and processes across various industries and subsectors – renewable chemicals, enzymes, biofuels, and biobased polymers. Taken together, the profiles create a tapestry of a global biobased economy poised for accelerated growth during the first half of the 21st century.

Continued growth of the biobased economy will benefit countries, states and clusters that implement effective policy to support continued investment and commercialization. Several companies profiled in this study have partnered with governments around the world in a variety of ways – research and development grants, business incubators, and market building programs. Many other companies have grown through private partnerships, including mergers and joint ventures. Governments and regions that support the emergence of the biobased economy are poised to reap the job creation and economic growth benefits. And the public will reap environmental and other benefits.

NOTES

1. Bioeconomy Capital. (2018) Bioeconomy Dashboard: Economic Metrics. http://www.bioeconomycapital.com/bioeconomy-dashboard/.
2. Golden, J.S., Handfield, R.B., Daystar, J., and McConnell, T.E. An Economic Impact Analysis of the U.S. Biobased Products Industry. Washington, DC: USDA BioPreferred Program, 2016.
3. TEConomy/BIO. The Value of Bioscience Innovation in Growing Jobs and Improving Quality of Life. Washington, DC: Biotechnology Innovation Organization, 2016.
4. Oh, V. "Show Me the Money: Where is Venture Capital Placing Bets in Biobased?" Boston: Lux Research, Dec. 5, 2016.

ADVANCED ENZYME TECHNOLOGIES, LTD.

Mumbai, India

Number of employees: 500

ADVANCED ENZYMES PRODUCES ENZYMES AND PROBIOTICS.

BIOREFINERY CLASSIFICATION: COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Pitampur Special Economic Zone, Indore, Madhya Pradesh, India
+ Sinnar, District Nashik, Maharashtra, India
+ Vashind, District Thane, Maharashtra, India
+ Satpur, District Nashik, Maharashtra, India
+ District Prakasam, Andhra Pradesh, India
+ Chino, CA
+ Capacity: 420 metric tons.

PARTNERSHIPS AND FINANCING

Advanced Enzymes completed the acquisition of Advanced Enzymes (Malaysia) Sdn. Bhd. (formerly Palm Techno Ventures Enzyme Sdn. Bhd.) in July 2017.

On July 11, 2017, Advanced Enzymes incorporated a wholly owned subsidiary, Advanced Enzyme Europe B.V. in Amsterdam. On July 26, Advanced Enzymes Europe B.V. entered a binding agreement to acquire evoxx technologies GmbH.

About: Advanced Enzymes is a research-driven company with global leadership in manufacturing enzymes and probiotics. We are the largest Indian enzyme company engaged in the research and development, manufacturing and marketing of 400-plus proprietary products developed from over 65 indigenous enzymes and probiotics. Our aim is to help consumers access side-effect free health care, help farmers enhance nutrition for animals, and also to help the industry replace traditional thermal-chemical-mechanical processes into enzyme-passed processes.

Having pioneered the production of enzymes in India, we continue to set trends with the research and development of new applications for the use of enzymes across various industries. We pride ourselves in being one of the very few manufacturers in the world who possess great depth and expertise in fermented enzymes manufacturing. In collaboration with evoxx technologies GmbH, Advanced Enzymes has ventured into directed evolution technology.

Today, Advanced Enzymes with three wholly owned subsidiaries, three joint ventures and five stepdown subsidiaries is able to service 700 customers across 45 countries worldwide.

Product applications: Human health care and nutrition, animal nutrition, food and grain processing, textile processing, paper and pulp processing, biofuels, and biocatalysis.

Technology: Enzymes are considered potent biocatalysts for a large number of reactions. Advanced Enzymes offers eco-safe solutions for variety of industries, which are used in the manufacture of a wide range of products. The biological solutions of Advanced Enzymes improve the efficiency of industrial processes by saving energy, water and other raw materials, while reducing waste and effluent load, thereby helping to comply with the pollution norms reducing overall process cost.

AEQUOR, INC.

San Diego, CA
Number of employees: ~ 2

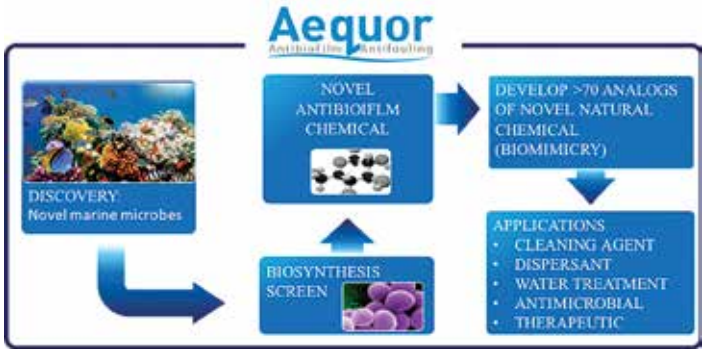
AEQUOR OFFERS A PORTFOLIO OF OVER 30 PROPRIETARY SMALL MOLECULES THAT ARE NONTOXIC, "GREEN," ECO-FRIENDLY AND SUSTAINABLE. AEQUOR ALSO DISCOVERED OVER 40 NEW USES FOR KNOWN CHEMICALS.

About: Aequor, Inc. is an early-stage for-profit company whose mission is to develop nontoxic solutions to biofilm infections and marine fouling. Aequor conducts biofilm testing services for third party product formulators and device manufacturers. Aequor is a Woman Owned Small Business and has won many awards.

Product applications: Dispersants, surfactants, and cleaning agents, some of which are available for immediate sale; antimicrobial biocides and antifouling agents; and human and veterinary drugs, therapeutics and device coatings.

Technology: Discovery and synthesis of a large portfolio of small molecules that remove pre-formed biofilm and fouling and prevent the ability of a broad spectrum of bacteria and fungi to form biofilm, microfouling and macrofouling.

Aequor discovered novel molecules in the ocean that combat bacteria and fungi in a new way: they prevent biofilm formation and remove biofilm. Aequor has now synthesized over 30 novel small molecules that are nontoxic and highly effective but do not trigger a resistance response. Aequor's molecules can be used alone and in combination with existing antimicrobials or antibiotics.



KEY FACTS

+ Aequor is a resident company of Johnson & Johnson Innovation JLABS in San Diego.
+ Aequor is a "C" corporation established in Delaware and California.
+ Aequor Ltd. is a subsidiary located at 72 Great Suffolk St, London, SE1 0BL, United Kingdom.

PARTNERSHIPS AND FINANCING

Aequor has won cooperative research and development grants and awards for pilot studies with:

+ DOE for reducing fouling and increasing yields in algae/biofuel production;
+ NASA for antibiofilm treatment of the water recycling system on the International Space Station; and
+ USDA for antimicrobial activity against gram-negative bacteria and fungi.

Aequor is undertaking pilot testing with companies in the "green" consumer sector.

Aequor was selected for the NIH/NIAID and USAMRIID accelerator programs.

Aequor Ltd. won a Horizon 2020 Phase I grant in the BioMed category.

TECHNOLOGY CLASSIFICATION: PILOT
COMMERCIAL
DEMONSTRATION
PILOT

AGRIVIDA

Medford, MA

Number of employees: 30

AGRIVIDA IS DELIVERING THE NEXT GENERATION OF ANIMAL HEALTH AND NUTRITION SOLUTIONS.

TECHNOLOGY CLASSIFICATION: COMMERCIAL | PILOT | DEMONSTRATION | COMMERCIAL

KEY FACTS

+ Feedstock: Grain, lignocellulosic biomass and sugar.

PARTNERSHIPS AND FINANCING

In 2016, Agrivida completed a $20.4 million Series E financing led by the University of Texas Investment Management Company and joined by ARCH Venture Partners, Cultivian Sandbox, Middleland Capital, Kleiner Perkins Caufield & Byers, Northgate Capital, and private investors.

About: Agrivida, Inc. is developing and commercializing solutions that are the next evolutionary step in animal health and nutrition, using the plant as a factory to provide highly differentiated agricultural and nutritional products.

Product applications: Animal health and nutrition; grain, food and feed processing; first- and second-generation biofuels and biobased chemicals; industrial enzymes for a variety of industries.

Technology: Agrivida's INzyme® technology is a biological platform for producing enzymes, polypeptides and proteins in plants as an integrated product ready for animal production and agricultural processing. Agrivida-delivered molecules help improve the yield, efficiency and overall costs of animal production by delivering higher performance ingredients that are ready for use by producers.

Agrivida's GraINzyme® technology is an expression platform for making recombinant or synthetic proteins in grain and other plant tissues. Using GraINzyme® technology, Agrivida is commercializing a series of enzyme and protein products that are produced and delivered in grain. These initial products target the animal health and nutrition industries to improve feed conversion, yields, and the efficiency of food production.

AKZONOBEL

Amsterdam, Netherlands
Number of employees: ~ 46,000

AKZONOBEL IS A PAINTS AND COATINGS MANUFACTURER AND A PRODUCER OF SPECIALTY CHEMICALS.

About: AkzoNobel is a leading global paints and coatings company and a major producer of specialty chemicals. We create everyday essentials to make people's lives more livable and inspiring.

Product applications: AkzoNobel produces paints and coatings for application in a wide range of end use segments: buildings and infrastructure, industrial, consumer goods and transportation.

AkzoNobel Specialty Chemicals provides polymer chemistry, ethylene and sulfur derivatives, bleaching and oxidizing chemicals, surface chemistry, and salt-chlorine products, among others.

Sustainability: Sustainability is at the heart of everything we do at AkzoNobel and our Planet Possible sustainability strategy is our commitment to doing more with less and creating more value from fewer resources.

Biobased raw materials make an important contribution to our sustainability strategy as we proactively integrate selected, relevant biobased materials in our core markets and applications.

In partnership with EY and ABT, we have developed a new online tool to track the use of biobased material in products for end customers. The new system is intended for use by the whole value chain to drive the proactive procurement of biobased materials.

KEY FACTS

+ Operate in more than 80 countries.
+ In 2016, 12 percent of all of our organic raw materials came from biobased sources, which include natural oils, fatty acids, alkyd resins, solvents, base chemicals, intermediates and rheology agents.

PARTNERSHIPS AND FINANCING

AkzoNobel are working with Enerkem, Air Liquide, and Port of Rotterdam on the initial engineering and to develop the business case for a waste-to-chemistry facility in Rotterdam, with support of the City of Rotterdam, the Province of Zuid Holland and InnovationQuarter. The consortium partners are working together to secure all necessary permits to begin construction of the waste to methanol plant in 2018.

In 2017, AkzoNobel entered into a Joint Development Agreement with Itaconix under which Itaconix will supply its proprietary polymers of itaconic acid, which are obtained from sugars through fermentation, and AkzoNobel will develop products for a range of applications from coatings to construction to detergents.

AMERICAN PROCESS

Atlanta, GA

Number of employees: 100

AMERICAN PROCESS IS COMMERCIALIZING GREENPOWER+ FOR ETHANOL.

BIOREFINERY CLASSIFICATION: PRE-COMMERCIAL | PILOT | DEMONSTRATION | COMMERCIAL

KEY FACTS

- Thomaston, GA
- Integrated demonstration plant for GP+, GP++, GP3+ and AVAP technologies.
- BIOPLUS Nanocellulose production plant.
- Alpena, MI
- Demonstration pre-commercial GreenPower+ plant – successfully completed demonstration – currently producing molasses.
- Feedstock: Any woody or agricultural residue biomass.

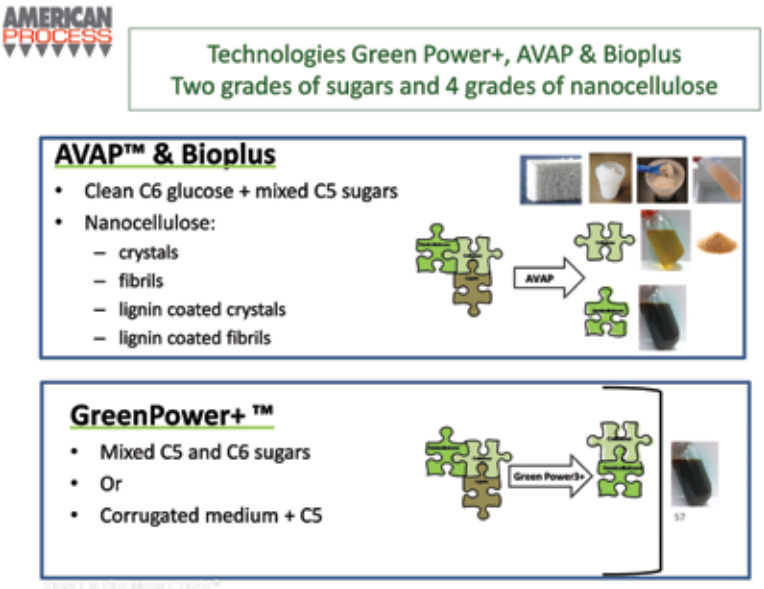
PARTNERSHIPS AND FINANCING

American Process is a privately joint venture of GranBio and TRLLC. API has partnership and joint development agreements with several companies.

About: American Process Inc. (API) specializes in the development, demonstration and commercialization of GreenPower+, AVAP and Bioplus technologies for the commercial production of cellulosic ethanol, cellulosic sugars and nanocellulose from biomass.

Product applications: Cellulosic ethanol, cellulosic sugars, nanocellulose.

Technology: GreenPower+® (GP+) is a patented technology suite for producing low-cost mixed cellulosic sugars from biomass hemicelluloses and cellulose in co-production mode. These sugars are fermented to ethanol. AVAP® technology produces low-cost clean cellulosic sugars from biomass cellulose – and ethanol from the hemicelluloses – in a stand-alone facility. Bioplus® technology produces highly functional, hydrophilic and hydrophobic nanocellulose fibrils or crystals, in gel or dried form.



AMSILK GMBH

Planegg/München, Germany
Number of employees: 34

AMSILK PRODUCES HIGH-PERFORMANCE SILK BIOPOLYMERS.

About: AMSilk GmbH is the world's leading industrial supplier of synthetic silk biopolymers. Sustainably produced using a patented biotechnological process, AMSilk high-performance biopolymers have the unique functional properties of the natural product – spider silk – on which they're based. The organic high-performance material can be used across industries and applications, ranging from medical or technical products to cosmetic ingredients. AMSilk high-performance biopolymers give everyday products unique properties, as the polymers are biocompatible, breathable and especially robust.

Product applications: AMSilk high-performance biopolymers are distributed in the form of Silkbeads (microparticles), Silkgel (hydrogel) or Biosteel® fibers. They are currently used in biocompatible coatings for medical technology products, in the textile industry and as an ingredient in cosmetic products.

Technology: AMSilk was founded in Munich based on technology developed in the lab of Prof. Thomas Scheibel (a co-founder of the company) at the Technische Universität München. AMSilk reprograms *E. coli* bacteria to produce silk proteins.

KEY FACTS

+ AMSilk currently produces and distributes increasing volumes of high-quality silk biopolymers for use in textile products, medical devices and cosmetics.

PARTNERSHIPS AND FINANCING

In October 2017, AMSilk and Interpolymer, a Germany-based global polymer manufacturer, announced a partnership to produce SILKTRAN®5621, a combination of Silkgel, the transparent hydrogel developed by AMSilk, and the polymer emulsion SYNTRAN®5620CG, produced by Interpolymer. It is a completely new hybrid polymer emulsion, ideal for breathable and water-based nail polishes.

In April 2017, AMSilk strengthened its strategic partnership with Gruschwitz Textilwerke AG to commercialize Biosteel® fiber yarns.

In November 2016, Adidas unveiled the Futurecraft Biofabric prototype shoe, the world's first performance shoe made using AMSilk's Biosteel® fiber.

AMYRIS

Emeryville, CA

Number of employees: 470

AMYRIS IS PRODUCING NUMEROUS PRODUCTS SERVING LARGE GLOBAL MARKETS.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Brotas, São Paulo, Brazil
+ Capacity: 1.2 million liters.
+ Feedstock: Sugarcane juice.

PARTNERSHIPS AND FINANCING

Amyris has executed several partnerships with some of the leading institutions and corporations in the world, including, among others, the Bill & Melinda Gates Foundation, Department of Energy, Defense Advanced Research Projects Agency, Royal DSM, Firmenich, Givaudan, Biogen, and Roche.

BUSINESS MODEL:

+ Covers direct research and development costs.
+ High investment returns from funded development.
+ Long-term annuity from product profit share.

About: Amyris, Inc. (Nasdaq:AMRS) delivers high-performance renewable products across a wide range of consumer and industry segments. Our products offer customers a way to reduce environmental impact with No Compromise® in performance or availability.

Product applications: Flavors and fragrances, cosmetics, detergents, fuels, lubricants, performance materials, nutraceuticals, and biopharmaceuticals.

The personal care and health and nutrition areas of Amyris's business are experiencing rapid growth driven by the consumer trend for natural, high-performing, sustainably sourced ingredients. This has led to an expansion in the number of partnerships the company has executed with global leaders in their respective markets to support their product innovation and supply security needs.

Technology: Amyris is the only company that has scaled and manufactures new products powered by unique ingredients made accessible by highly engineered organisms that are cost-advantaged and are delivering high-performance products for our customers, their consumers and our planet. Today, Amyris is one of the fastest-growing industrial biotechnology companies in its space and is delivering products that are disrupting markets for its customers in several of the world's largest and rapidly growing industries.

ANELLOTECH

Pearl River, NY

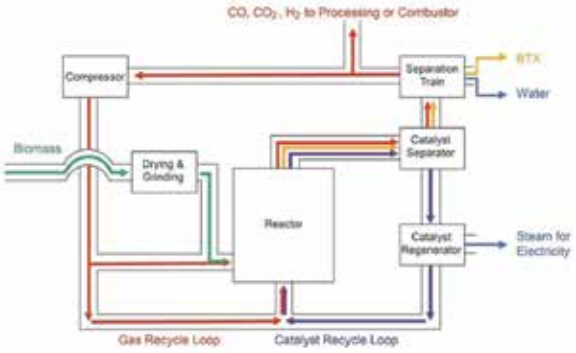
Number of employees: 23

ANELLOTECH IS PRODUCING BENZENE, TOLUENE AND XYLENES (BTX).

About: Anellotech is a sustainable technology company pioneering the production of cost-competitive renewable aromatic chemicals and fuels from non-food biomass. Anellotech is developing the Bio-TCat™ process to produce cost-competitive renewable aromatic chemicals – benzene, toluene and xylenes (BTX) – from non-food biomass. Bio-TCat's cost-competitive advantage results from the use of non-food biomass such as wood or agricultural residues and an efficient and economical catalyst as the only significant inputs.

Product applications: Polyester, polyethylene terephthalate (PET), polystyrene, polyurethane, nylon, styrene butyl rubber (SBR), acrylonitrile butadiene styrene (ABS) and other polymers, which are used to produce beverage bottles, clothing, carpeting, automotive components, and a broad range of other household and industrial products. Renewable transportation fuels are an end market as well.

Technology: Through Bio-TCat™ technology, non-food biomass is rapidly heated in a fluid-bed reactor and the resulting gases are immediately converted into hydrocarbons by a proprietary, recirculating zeolite catalyst. Biobased BTX, which is identical to petroleum-derived counterparts, can be further purified, separated and converted into a broad range of plastics using existing commercial technologies and industry infrastructure.



KEY FACTS

+ Pearl River, NY
+ Feedstock: Biomass (wood, corn stover, sugarcane bagasse) and other non-food agricultural products.

Anellotech has completed commissioning its 25-meter tall TCat-8® pilot plant and announced commencement of its research and development (R&D) program. An integrated team of Anellotech and IFP Energies nouvelles (IFPEN) research engineers and technicians will optimize process variables and generate data for process development and scale-up. Commercial Bio-TCat™ plant design and process licensing will be carried out by Axens. The R&D program will generate biobased BTX samples for use in making prototype samples of PET polymer for biobased bottles and biobenzene-based polymers, such as ABS, polycarbonate and polyurethane for other strategic investors.

STRATEGIC PARTNERS

Axens IFP Group Technologies

IFP Energies nouvelles

JM Johnson Matthey Inspiring science, enhancing life

SUNTORY

TOYOTA TSUSHO

BIOREFINERY CLASSIFICATION: RESEARCH & DEVELOPMENT

COMMERCIAL

DEMONSTRATION

R&D

ARBIOM

Durham, NC

Number of employees: 45

ARBIOM PRODUCES C5 AND C6 SUGARS AND LIGNIN.

BIOREFINERY CLASSIFICATION: COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS:

- Biotechnology Center: Evry, France
- Process Operations Center: Norton, VA
- HQ & Applications Center: Durham, NC
- Feedstock: Lignocellulosic biomass.

PARTNERSHIPS AND FINANCING:

In 2017, Arbiom announced the SYLFEED project in partnership with:

- Norske Skog Golbey: a leading newsprint producer in Europe;
- Prayon: global leader in phosphoric acid;
- RISE Processum: Advanced expertise in microbial protein production;
- Matis: fish feed formulation and trials;
- Østfoldforskning: Cradle-to-cradle lifecycle analysis; and
- Skretting Aquaculture Center AS and LAXA: global leaders in fish feed production.

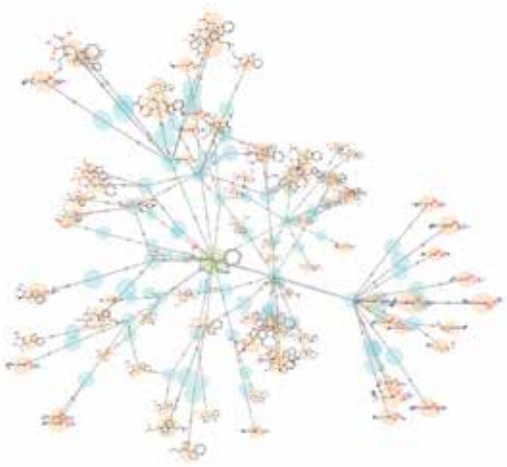
Arbiom has been funded by private investors and grants from the State of Virginia ($10 million), France Ademe (€4 million) and the EU Bio-Based Joint Undertaking (BBI-JU) (€10.9 million).

About: Arbiom is a biotechnology company developing solutions to convert the most sustainable and readily available carbon source in the world – wood – into food and biobased materials. Arbiom's patented bioconversion processing technology converts renewable lignocellulosic (non-food) material to biocompatible sugars and high-grade lignin for a variety of applications, notably as an ideal substrate for microbial protein production for feed and food. Virginia-based OptaFuel US, Inc. and France-based Biométhodes, SA announced the formation of Arbiom, Inc. in July 2015.

Product applications: Food/ feed and biobased materials.

Technology: For the past 10 years, Arbiom has been developing technologies to process lignocellulose and maximize the potential use of each of its components. Arbiom has developed a low-temperature, phosphoric-acid-based process, allowing the recovery of each fraction of the biomass (C6, C5, lignin) in a state compatibile with a variety of downstream processes. Use of phosphoric acid in pretreatment increases the efficacy of enzymatic hydrolysis, which lowers processing costs. Arbiom then uses the core products from its process, notably C5 and C6 sugars, as a highly fermentable and digestible substrate for microbial protein production.

Arbiom SylPro (enhanced Torula) is an antibiotic-free, non-GMO protein concentrate (62 percent) that has an optimal amino acid profile and digestibility for improved nutritional quality over alternative protein sources, first targeting salmon and piglet feed.



ARZEDA

Seattle, WA

Number of employees: 24

ARZEDA COMBINES COMPUTATIONAL PROTEIN DESIGN AND SYNTHETIC BIOLOGY TO PRODUCE NEW PROTEINS AND DESIGNER PROCESSES FOR FINE AND SPECIALTY CHEMICALS.

About: Since 2008 Arzeda, The Protein Design Company™, has been harnessing the power of computational and synthetic biology to create new enzymes and chemical products that can compete on performance, cost and sustainability. In partnership with Fortune 500 companies and industrial leaders, the company has developed a portfolio of enzymes and specialty chemicals for polymers, advanced materials and health and nutrition products. Arzeda's proprietary platform and validation process rapidly create "cell factories" that can be used at industrial scale to solve problems and create products that otherwise would be impossible.

Product applications: Arzeda's protein design platform has applications in industrial enzymes, specialty chemicals, agricultural biotech, advanced polymers and materials, food and feed as well as flavors and fragrances.

Technology: Arzeda's proprietary technology combines computational protein design and optimization with state-of-the-art metabolic engineering to create biological production pathways for valuable chemicals and materials, including many that have previously been impossible to produce.

The company has already successfully developed proteins for global manufacturers, such as DuPont, Mitsubishi Chemical, INVISTA and others to improve crop yields; increase the performance and sustainability of advanced polymers; reduce the cost of producing food ingredients; and more.

Arzeda's advanced computational tools build complex biological pathways required to produce almost any target molecule by combining natural enzymes with the ability to design new enzyme functions.

KEY FACTS

+ Seattle, WA
+ Leading proprietary protein design intellectual property.
+ High-throughput protein expression, purification and assay platform (>10,000/wk using MS).

PARTNERSHIPS AND FINANCING

In 2016, Mitsubishi Chemical Holdings entered into a partnership with Arzeda to develop a new process for producing a chemical building block.

In 2017, Arzeda announced the close of a Series A fundraise with a total investment of $15.2 million to expand throughput capacity of the protein design platform and product development pipeline. Lead investor OS Fund was accompanied by Bioeconomy Capital, Sustainable Conversion Ventures, Universal Materials Incubator Co., Ltd. (UMI), Casdin Capital, LLC., and Arzeda's seed investor, WRF Capital.

In 2017, Arzeda announced a partnership with TeselaGen Biotechnology, a leading provider of cutting-edge DNA design software, that will dramatically improve the efficiency and speed of Arzeda's ability to create new proteins, enzymes and chemicals.

TECHNOLOGY CLASSIFICATION: COMMERCIAL

PILOT DEMONSTRATION COMMERCIAL

ATUM

Newark, CA

Number of employees: 100

ATUM PROVIDES TOOLS AND SERVICES FOR THE DESIGN AND SYNTHESIS OF GENES, PROTEINS AND CELL LINES.

TECHNOLOGY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ 50,000 square foot facility in Newark, CA
+ ATUM is completing construction of a 7,000 square foot mammalian cell engineering laboratory at its Newark, CA headquarters. The new facility doubles ATUM's lab space dedicated to mammalian work and will include a cGMP cell bank manufacturing facility.

PARTNERSHIPS AND FINANCING

ATUM and Horizon Discovery in June 2017 announced a cross-license agreement for Horizon's CHO SOURCE platform and ATUM's vector technology to speed development of highly productive stable cell lines for drug development.

Acquired MIGS, an integrated contract research organization specializing in antibody engineering, in April 2016.

Adimab, Inc., a pioneer in antibody discovery, and ATUM have a strategic alliance to design and construct antibody libraries.

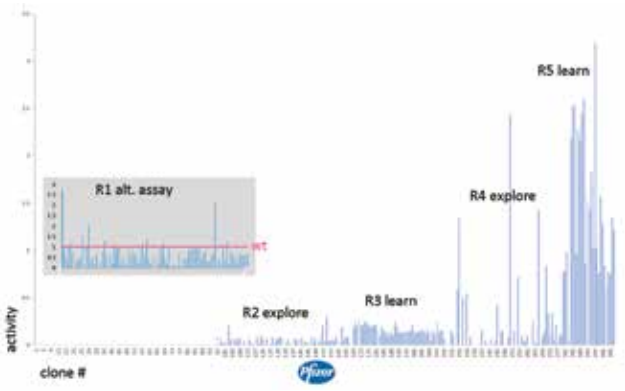
Cytovance Biologics utilizes GeneGPS® from ATUM as part of their Keystone Expression System™ for microbial strain development.

ADM, a global food processing and commodities trading company, in 2014 entered into a protein engineering technology access agreement with ATUM.

About: Founded in 2003 (as DNA2.0), ATUM has developed a platform that combines Machine Learning, Synthetic Biology and Design of Experiment to rapidly and efficiently design and build improved biological products for our partners. These biological products include biocatalysts, antibodies, vaccines, herbicide resistant traits, food additives, metabolic pathways and much more.

Product applications: ATUM offers an integrated pipeline of bioengineering services for the pharmaceutical, industrial, agricultural and chemical industries, as well as academia and governments.

Technology: ATUM has developed a unique bioengineering platform based on Machine Learning, Synthetic Biology and Design of Experiment. The ProteinGPS® proprietary protein engineering technology uses megadimensional, empirical optimization processes to calculate a set of nodes that are maximally information-rich in the relevant space, gene synthesis to make those exact sequences, and machine learning to extract the sequence-function space to find the preferred solution. The platform relies on *in silico* calculations to map out the sequence-function space and wet lab experiments to link each node to experimental data. The result: precise engineering of any measurable property in any protein so that it fulfills the exact functional criteria needed for commercialization.



AVANTIUM

Amsterdam, Netherlands
Number of employees: ~140

AVANTIUM RENEWABLE CHEMISTRIES PRODUCES FURANICS AND LEVULINICS.

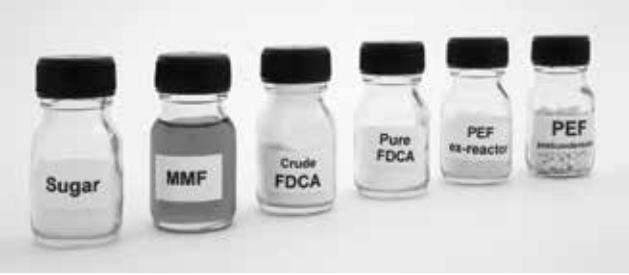
About: Avantium is a leading chemical technology company and a forerunner in renewable chemistry. Together with its partners around the world, Avantium develops efficient processes and sustainable products made from biobased materials. Avantium offers a breeding ground for revolutionary renewable chemistry solutions.

Product applications: Biobased plastics, such as in bottles, textiles, packaging, solvents and cosmetics.

Technology: Avantium's YXY process begins with the catalytic dehydration of the carbohydrate feedstock in an alcohol to make methoxymethyl furfural (MMF) and levulinics, like methyl levulinate. The next step is the catalytic oxidation of MMF in acetic acid to make furandicarboxylic acid (FDCA). To make the biobased polymer polyethylene furanoate (PEF), a third catalytic step brings together FDCA and monoethylene glycol (MEG).

Avantium's Zambezi process uses concentrated hydrochloric acid (HCL) at low temperatures to hydrolyze glucose from wood chips. The process uses a simulated moving bed to create countercurrent flows of the HCL to effectively fractionate the cellulose, hemicellulose and lignin in wood and sequentially hydrolyze each component.

Avantium is piloting the Mekong process to produce biobased monoethylene glycol.



KEY FACTS

- Pilot plant opened in 2011 in Geleen, Netherlands.
- Feedstock: Glucose.
- In July 2017, Avantium announced a contract with AkzoNobel to construct a pilot plant for the Zambezi process at Chemie Park Delfzijl, Netherlands.

PARTNERSHIPS AND FINANCING

In October 2016, BASF and Avantium formed a new joint venture, Synvina, for the production and marketing of renewable furandicarboxylic acid (FDCA) as well as the marketing of polyethylene furanoate (PEF).

In January 2017, Avantium acquired Liquid Light, Inc., and will combine technologies to commercialize a process using CO_2 as a feedstock.

BASF CORPORATION

Florham Park, NJ

Number of employees: 17,471 in North America

BIOREFINERY CLASSIFICATION: COMMERCIAL | DEMONSTRATION | PILOT | COMMERCIAL

KEY FACTS

+ In addition to its own manufacturing facilities, BASF secures contract manufacturing relationships with qualified third parties possessing sufficient fermentation capacity to meet commercial production requirements.

  For example, BASF has an important partnership with Fermic, which operates a U.S. Food and Drug Administration-registered fermentation facility in a suburb of Mexico City.

About: BASF Enzymes LLC, located in San Diego, is a wholly owned subsidiary of BASF Corporation. It is a recognized pioneer in the development and commercialization of high-performance enzymes for use in industrial processes.

Our interdisciplinary, international research and development teams work at several BASF sites: Ludwigshafen, Germany; Tarrytown, New York; and San Diego, California.

Product applications: BASF sells enzymes developed using its unique patented research and development capabilities, harnessing the power of nature to satisfy the needs of the global market. Key markets are: human and animal health and nutrition, home care, grain processing, oilfield solutions, and pulp and paper.

Technology: Genetic expression libraries are constructed and quickly screened using automated and high-throughput robotic technologies. BASF uses patented, state-of-the-art gene evolution capabilities – suite of DirectEvolution® technologies — that make possible rapid optimization of proteins at the DNA level.

White biotechnology develops and refines methods to use microorganisms, enzymes and cells to produce chemical and biochemical products. For thousands of years, people have been harnessing natural chemical processes to produce food, medicines and other products. Today, rapid technological progress in the life sciences is leading to innovative ways to use nature's variety for completely new applications.

BASF White Biotechnology uses natural synthesis techniques to develop products such as vitamins, food and feed supplements, chiral compounds, and pharmaceutical and agricultural intermediates. These techniques can increase efficiency and reduce raw materials, energy requirements and carbon emissions.

BIOAMBER SARNIA

Sarnia, Ontario, Canada
Number of employees: 60

BIOAMBER SARNIA PRODUCES BIOBASED SUCCINIC ACID.

About: BioAmber (parent company) uses industrial biotechnology to convert renewable feedstocks into building-block chemicals. Its process has lower emissions and lower energy consumption than the equivalent petroleum chemicals process, without compromising on performance and quality.

Product applications: Plastics, resins, paints, textiles, food and flavors, lubricants, and personal care products.

Technology: BioAmber uses sugars, instead of fossil fuels, and applies industrial biotechnology (fermentation) using its proprietary yeast, which consumes the sugar and CO_2 to produce succinic acid in a crystalline form similar to table salt. BioAmber then recovers and purifies the succinic acid and uses conventional chemistry to convert the succinic acid into 1,4-butanediol and disodium succinate.

KEY FACTS

+ Sarnia, Ontario, Canada
+ Nameplate capacity: 30,000 metric tons.
+ Feedstock: Glucose.

PARTNERSHIPS AND FINANCING:

BioAmber Sarnia is 100 percent owned by BioAmber.

BioAmber Sarnia is operating and selling product in Asia, Europe and the United States. BioAmber Sarnia's Bio-SA™ has been qualified by over 200 customers. We are producing several grades of product, including FDA-approved, pharma grade succinic acid. Our certifications include ISO 9001, ISO 14001, OHSAS 18001, and FSSC 22000.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL
DEMONSTRATION
PILOT

BIOBLEND RENEWABLE RESOURCES LLC

Elk Grove Village, IL
Number of employees: 8

BIOBLEND PRODUCES ENGINE OIL, HYDRAULIC FLUIDS, GREASES AND LUBRICANTS.

BIOREFINERY CLASSIFICATION: COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ All BioBlend products are made in the USA in ISO certified facilities. Our state of the art manufacturing facilities are capable of producing a full spectrum of biodegradable and food grade lubricants for a variety of industries and applications.

PARTNERSHIPS AND FINANCING

In April 2016, the Defense Logistics Agency in partnership with the Air Force Research Laboratory announced testing and validation of "biobased" synthetic oil from BioBlend and others in government vehicles at four U.S. Air Force bases and a Department of Homeland Security installation:

+ DHS Federal Law Enforcement Training Center in Georgia;
+ Seymour Johnson Air Force Base [AFB] in North Carolina;
+ Luke AFB in Arizona;
+ Fairchild AFB in Washington; and
+ Malmstrom AFB in Montana.

About: BioBlend is a leading manufacturer and marketer of biobased industrial lubricants. We provide environmentally responsible products and solutions to a variety of customers and industries around the world.

Product applications: Automotive, mining, marine, dredging, drilling, metalworking and industrial lubricants.

Technology: BioBlend has been in the business of making high-performance biodegradable lubricants and greases since 2001, and that's been our primary focus all along. We started out blending natural ester base stocks and have expanded into synthetic esters, which offer additional performance benefits without sacrificing favorable biodegradability and minimal toxicity characteristics. By offering a full range of technology solutions in a range of price points, we can satisfy virtually every industrial need. Technology continues to evolve in base oils as well as the complex additives that go into our lubricants. Greater performance specifications, increased renewability, enhanced sustainability and decreasing costs have been our goals throughout history and continue to be primary goals.

BIOBTX B.V.

Groningen, Netherlands

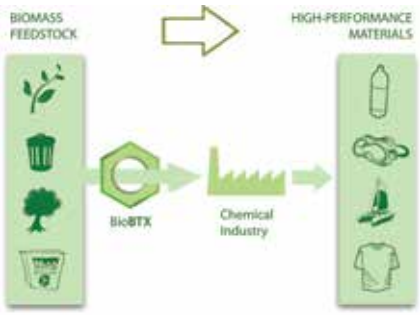
Number of employees: 7

BIOBTX B.V. HAS DEVELOPED TECHNOLOGY TO PRODUCE AROMATICS, LIKE BENZENE, TOLUENE AND XYLENES, FROM BIOMASS AND OTHER HYDROCARBON-RICH FEEDSTOCKS.

About: BioBTX B.V. is an innovative technology company that develops and employs efficient and effective technologies for the production of biobased aromatics, including BTX and bio-oil (benzene, toluene, xylene, and higher branched aromatics). The proprietary Integrated Cascading Catalytic Pyrolysis (ICCP) technology combines high feedstock flexibility and improved catalyst stability and selectivity to maximize yields of aromatic, high-volume chemical building blocks. By shifting to biobased and hydrocarbon-rich feedstocks, BioBTX will contribute considerably to making the chemical and plastics industry more sustainable.

Product applications: High-volume polymers derived from BTX include: PET, PBAT, other polyesters, aramid, PUR, ABS, epoxy resins, polycarbonate, and nylon, which are used in a variety of industrial and consumer products, like bottles, fibers, carpeting, clothing and automotive components. Any aromatic derivative of BTX for other applications (PTA, IPA, Styrene, etc.) also could be produced.

Technology: BioBTX's ICCP technology has a two-stage reactor system for sequential pyrolysis and catalytic conversion. In the ICCP process, there is no direct contact between the biomass and the zeolite catalyst. This protects the selective catalyst against poisoning by minerals and other impurities from the biomass, thereby significantly increasing its lifespan. Moreover, ICCP allows processing of contaminated feedstocks such as crude glycerin, waste streams, and composites. The ICCP process gives higher yields than direct, *in situ*, catalytic pyrolysis. The high conversion efficiency makes ICCP the most favorable process to prepare aromatics from biomass.



KEY FACTS

+ Zernike Campus, University of Groningen, Groningen, Netherlands.
+ Feedstocks: wood, crude glycerin, lignin, black liquor, used cooking oil, jatropha oil, agricultural products, waste, plastics, and cellulose.

PARTNERSHIPS AND FINANCING

BioBTX B.V. was founded in 2013 by KNN Groep and Syncom. In January 2017, Carduso Capital joined as an investor.

BioBTX has received contributions from European Union, SNN, Provinces of Groningen and Drenthe as well as the city of Emmen.

BioBTX's ICCP pilot plant was jointly engineered by BioBTX and Tebodin, Bilfinger and is currently under construction by ZETON. It will be operational in 2018.

BioBTX has partnerships with University of Groningen, Sunoil, Cumapol and Syncom to accelerate commercialization of the first fully biobased PET cosmetic container.

The next step will be the construction of a plant with partners Cumapol and Sunoil to produce aromatic building blocks out of glycerin.

BIO-CAT/BIO-CAT MICROBIALS

Troy, VA; Shakopee, MN

Number of employees: 52 BIO-CAT employees in Troy, VA; 15 BIO-CAT Microbials employees in Shakopee, MN

BIO-CAT AND BIO-CAT MICROBIALS PRODUCE ENZYMES AND BACILLUS MICROBES.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ BIO-CAT is an FSSC 22000 certified company.
+ BIO-CAT Microbials is GMP certified.
+ Kosher and Halal Certified.
+ Multiple Patents.

About: BIO-CAT and BIO-CAT Microbials are the industry leaders in enzymes, microbials and custom formulations for nutritional food processing, animal nutrition and agriculture. The companies run an FSSC 22000 certified enzyme facility in Virginia and a GMP certified facility manufacturing microbials in Minnesota. With 30 years in business, we provide customized tailored solutions for your product ideas. We are best in class in research and development, regulatory, quality and product development in our state-of-the-art facilities.

Product applications: Dietary supplements, food, beverage and ingredients, animal nutrition, agriculture, aquaculture, cleaning, septic and drain care, and waste treatment.

Technology: BIO-CAT has an established application based research and development (R&D) group for enzymes and bacillus technology. With over 30 years' experience in enzymes and 15 years in bacillus, you can count on BIO-CAT for your customized solutions. With patents covering a range of applications from food probiotics to bioremediation, our technology, history, and customer service can help you find solutions to your challenging problems.

+ Single to multi-enzyme custom blends; bacillus manufacturing, formulating and large-capacity blending;
+ Research & Development (R&D) team provides custom solutions in our applications lab for scientific research and product development;
+ Quality Control (QC) lab conducts testing, assuring strict quality standards are met and testing to ensure the potency and overall quality;
+ Powder and liquid packaging;
+ Refrigerated storage and warehouse.

BIOCATALYSTS

Chicago, IL; Cardiff, United Kingdom
Number of employees: 60+

BIOCATALYSTS PRODUCES SPECIALTY ENZYMES FOR MULTIPLE CHEMISTRIES.

BIOCATALYSTS
exceeding enzyme expectations

About: Biocatalysts is a global industrial biotech company that produces specialty enzymes at all scales, from grams to tons. Biocatalysts offers both off-the-shelf enzyme products, as well as customized enzyme discovery and manufacturing services. The latter is where the company excels, covering the identification of an enzyme (e.g., from databases or proprietary metagenomic data) all the way through to large-scale commercial production of stable enzymes suitable for global shipment. This business is built around reducing the costs and timelines associated with finding, sampling, developing, and supplying new enzymes.

Product applications: The company provides enzyme products to multiple markets, including food ingredient processing, flavor and fragrance, life science, diagnostics, pharmaceutical, and fine/specialty chemicals.

Technology: Biocatalysts has built a wealth of enzyme knowledge and experience in its 30+ years of business. The company has invested heavily in new technology and capabilities to ensure enzyme solutions are delivered quickly, cost-effectively, and at the lowest risk.

Amongst Biocatalysts' many capabilities is their own metagenomic library, protein synthesis technologies, bioinformatics and cloning expertise, downstream processing, and enzyme stabilization technologies. As a primary manufacturer, there are over 80 different capabilities that are utilized, depending on the type of project being undertaken.

Biocatalysts utilizes its "Design for Manufacture" approach for all projects, taking into consideration all the potential limitations (including regulatory, technical, and cost-in-use) at the outset, enabling the company to reduce risk and exceed its customers' enzyme expectations.

KEY FACTS

+ Cardiff, United Kingdom
+ North American distribution and warehousing out of the U.S. Midwest.
+ Proprietary technology platforms for enzyme discovery (e.g., MetXra™ - unique metagenomic database with smart screening).
+ Specific technology and expertise in enzyme product development and supply at all scales.
+ Molecular microbiologists and fermentation specialists under the same roof to de-risk projects.

PARTNERSHIPS AND FINANCING

+ Privately owned.
+ Multiple confidential collaborations for the supply of unique enzymes to several different markets.

TECHNOLOGY CLASSIFICATION: COMMERCIAL
COMMERCIAL | DEMONSTRATION | PILOT

bio-on
turn off pollution

BIO-ON, S.P.A.

Bologna, Italy
Number of employees: 50

BIO-ON PRODUCES POLYHYDROXYALKANOATES AND LICENSES ITS TECHNOLOGIES WORLWIDE.

BIOREFINERY CLASSIFICATION: COMMERCIAL
PILOT | DEMONSTRATION | COMMERCIAL

KEY FACTS

- 1st Industrial biopolymer PHA Plant under finalisation in Castel San Pietro Terme, Bologna, Italy.
- Feedstock: wastes, co- and by-products from many agro-industrial sectors, including sugar beet, sugar cane, glycerol from biodiesel, potatoes, animal fat, fruit, vegetables, wood, domestic wet, wine production.
- Capacity: 1,000 tons per year (TPY), expandable to 3,000 TPY.

PARTNERSHIPS AND FINANCING

In December 2017, AkzoNobel and Bio-on announced ongoing collaboration in developing new biobased paints, beyond the activities of the SEAFRONT project.

In September 2017, Bio-on announced a partnership with Kering Eyewear to develop new products based on MinervPHA™.

In May 2017, Bio-on spearheaded project BioBarr, development of the food packaging of tomorrow, funded by the European Union Horizon 2020 program.

In March 2017, Bio-on and Sadam Group launched a levulinic acid project in San Quirico (Parma), using sugar industry by-products. It will also include an industrial plant to produce PHAs from crude glycerol, co-products of bio-diesel production.

About: Bio-on S.p.A., an Italian Intellectual Property Company (IPC), conducts applied research and development of modern biofermentation technologies in the field of eco-sustainable and completely, naturally biodegradable materials. Since February 2015, Bio-On S.p.A. has also been operating in the development of natural and sustainable chemicals for the future.

Bio-on supplies technologies to produce or use polyhydroxyalkanoates (PHAs) through licenses that restrict rights to a particular territory or to a specific business area. The technology developed over the last 10 years by Bio-on is therefore feasible on industrial scale, with production capacity of up to 20 thousand tons of PHA per year.

Product applications: Bio-on grants licenses for the production of MinervPHA™ for: cosmetics, biomedical, automotive, design, paintings, consumer electronics, food packaging, others.

Technology: Bio-on PHAs are linear polyesters produced by bacterial fermentation of sugar. The fermentation process is based on the ability of a *Ralstonia eutropha* species to metabolize carbon sources and convert them to PHA. At the end of the process, the microorganism has a biomass of up to 80 percent PHA, contained within the bacteria cell. Polyhydroxyalkanoates are recovered and separated from the rest of the organic material of the bacterial cell without using any chemical solvents, reducing both the production costs and the environmental impact of the process streams.

BIOPETROLIA

Göteborg, Sweden

Number of employees: 5

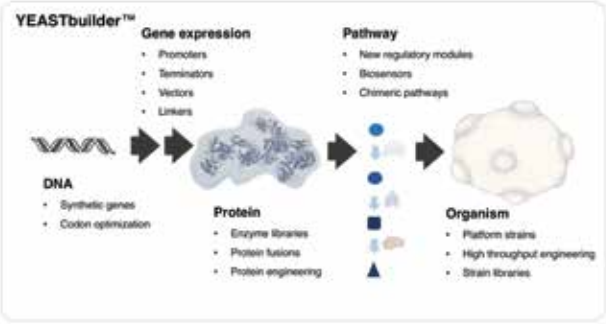
BIOPETROLIA DESIGNS, BUILDS AND TESTS YEAST CELL FACTORIES.

Biopetrolia®

About: Biopetrolia was founded to explore the synergy between science, engineering and entrepreneurship as a way to provide solutions to some of today's sustainability problems. From a group known for its in-depth knowledge in synthetic biology and metabolic engineering of yeast cell factories, the company was created as a vehicle to transfer evolving technologies to the market and industry.

Product applications: Lipids, fatty acids, and amino acids for cosmetics, fragrances, flavors, lubricants, pharmaceuticals and food ingredients. Recombinant proteins for pharmaceuticals.

Technology: Biopetrolia's YEASTbuilder™ pipeline enables rapid construction of yeast cell factories for production of target compounds. Biopetrolia continuously generates and maintains collections of genetic parts and strategies to precisely engineer yeast metabolism. The company's YeastSense™ platform allows for high-throughput screening and development of many different yeast cell variants. Biopetrolia currently uses several biosensors for important precursors and end products and constantly works on developing new biosensors to further accelerate yeast cell factory design. In addition, Biopetrolia possesses a series of "platform strains" that are engineered for high-level production of important precursors for different products.



KEY FACTS

+ Göteborg, Sweden
+ Systems and Synthetic Biology Department of Biology and Biological Engineering.
+ Chalmers University of Technology.

PARTNERSHIPS AND FINANCING

In June 2017, Biopetrolia and other collaborators participating in Cell Nova, a center for development and production of biological drugs, received SEK40 million from Vinnova.

In December 2016, Biopetrolia began work in the EU Horizon 2020 project CHASSY, a consortium to build and optimize a versatile yeast chassis for producing lipids and aromatics.

TECHNOLOGY CLASSIFICATION: LABORATORY | DEMONSTRATION | COMMERCIAL

BIOSYNTHETIC TECHNOLOGIES

Irvine, CA

Number of employees: 20

BIOSYNTHETIC TECHNOLOGIES IS PRODUCING BIOSYNTHETIC BASE OIL.

BIOREFINERY CLASSIFICATION: DEMONSTRATION

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Baton Rouge, LA
+ Feedstock: Organic fatty acids found in plant oils.

PARTNERSHIPS AND FINANCING

In December 2017, BT received final approval from the U.S. Department of Agriculture for a $132 million loan guarantee to fund their first commercial plant, being built inside the BP Chemicals complex in Houston, Texas.

BT's largest shareholders are BP, Monsanto, Evonik and Sime Darby, who have contributed $60 million in funding.

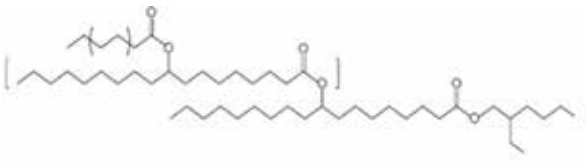
For info, visit Biosynthetic.com.

About: Biosynthetic Technologies (BT) manufactures several renewable, high-performance chemicals used as base oils in lubricants and in multiple other industrial applications. The technical performance of these biosynthetic oils exceeds that of most other petroleum-based synthetic chemicals in the market. In addition to their excellent performance specifications, these synthetic products are biodegradable, nontoxic and biobased. BT is working with most of the largest lubricant companies in North America and the European Union, who are formulating and selling finished lubricants containing these biosynthetic oils. BT has also received American Petroleum Institute (API) International Lubricants Standardization and Approval Committee (ILSAC) GF-5 certification on both SAE 5W-20 and 5W-30 grade passenger car motor oil formulations made from biosynthetic base oil.

Product applications: Passenger car motor oil; marine lubricants; hydraulic fluid; wind turbine gear oils; agricultural chemicals; plasticizers; refrigeration/compressor oil; food-grade lubricants; greases; dielectric (transformer) fluid; metalworking fluid; gear oil; rubber process oils; personal care ingredients.

Technology: Biosynthetic Technologies (BT) manufactures a revolutionary new class of biobased synthetic molecules that are made from organic fatty acids found in plant oils.

BT holds over 90 issued patents and has an additional 65 pending.



BLUE MARBLE BIOMATERIALS

Missoula, MT

Number of employees: 21

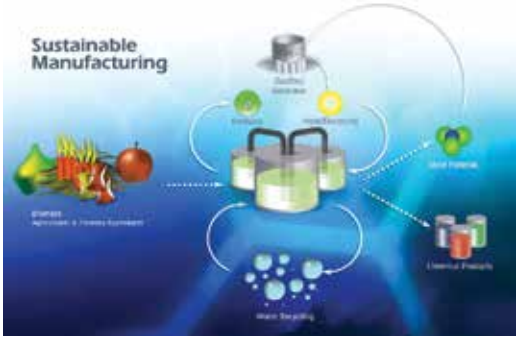
BLUE MARBLE BIOMATERIALS IS PRODUCING NATURAL SPECIALTY CHEMICALS – SULFUR COMPOUNDS, THIOESTERS, ESTERS, SPECIALTY OFFERINGS, EXTRACTS AND OILS.

About: Blue Marble harnesses nature's solutions from plant-based, non-GMO starting materials, using traditional methods to provide desirable consumer alternatives.

Product applications: Natural flavors and fragrances.

Technology: Blue Marble's core capabilities include analytical capabilities, green chemistry pathways, and fermentation technology. Patented processes utilize plant material and managed ecosystems of bacteria to produce complex natural compounds. The company refines compounds using green chemistry processes.

Blue Marble's proprietary AGATE system uses cellulosic, lignin, and protein-based biomass to produce target products. AGATE uses non-genetically modified (non-GMO), polyculture fermentation and extraction.



KEY FACTS

+ Missoula Valley, MT
+ Feedstock: Organic material (biomass): food co-products, spent brewery grain, spent coffee and tea, algae, milfoil, agricultural silage, wood chips.

PARTNERSHIPS AND FINANCING

In 2016, Blue Marble partnered with Welch's to assist them in valorizing their fruit by-products, such as grape and apple pomaces.

Further, Blue Marble is working with researchers at the University of Montana to develop natural algal products, using patent-pending algae strains, growth systems, and extraction technologies.

Blue Marble is also collaborating with another Missoula company, CLEARAS Water Recovery, to target downstream applications of algae utilzed in waste water clean up.

BIOREFINERY CLASSIFICATION: PILOT

COMMERCIAL | DEMONSTRATION | PILOT

BORREGAARD

Sarpsborg, Norway
Number of employees: 1,010

BORREGAARD PRODUCES LIGNIN, SPECIALTY CELLULOSE, BIOETHANOL, VANILLIN AND CELLULOSE FIBRILS.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Sarpsborg, Norway.
+ Feedstock: Wood.
+ The Borregaard Group has production plants in Norway, the UK, Germany, Spain, the Czech Republic, South Africa and the USA.
+ Borregaard has a large-scale pilot plant in Rothschild, WI for the production of SenseFi, a cellulose-based advanced texture system for food products.

PARTNERSHIPS AND FINANCING

In 2015, Borregaard formed a venture with Rayonier Advanced Materials. Borregaard and RYAM are building a new lignin plant adjacent to RYAM's pulp mill in Fernandina Beach, FL. Phase one of the project is expected to be completed mid-2018 and will represent a capacity of 100,000 metric tons dry solids lignin. Phase two will add another 50,000 tons.

LignoTech South Africa is a 50:50 joint venture between Borregaard and Sappi. LTSA is a supplier of lignin products based on raw material from Sappi Saiccor's adjacent pulp mill, in Umkomaas, South Africa.

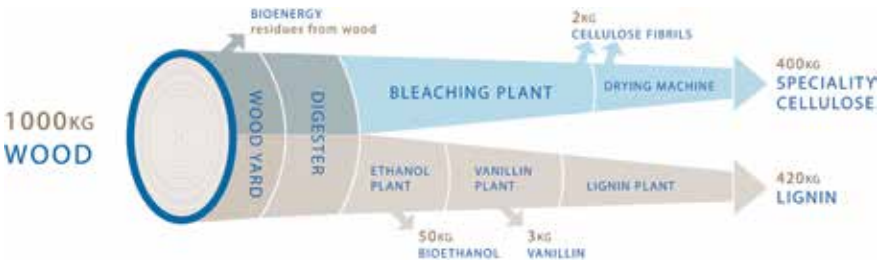
About: Borregaard operates one of the world's most advanced bio-refineries. By using natural, sustainable raw materials, the Borregaard Group produces advanced and environmentally friendly biochemicals that can replace oil-based products. Borregaard's activities focus on performance chemicals, specialty cellulose, ingredients, fine chemicals and cellulose fibrils.

Product applications: By using the different components of wood, Borregaard produces lignin products, specialty cellulose, vanillin, bioethanol and cellulose fibrils for a variety of applications in sectors such as agriculture and fisheries, construction, pharmaceuticals and cosmetics, foodstuffs, batteries and biofuels.

Technology: Calcium based sulfite pulping.

Borregaard has developed the patented Borregaard Advanced Lignin (BALI) concept, allowing the extraction of lignin-based products from various biomasses through sulphite pretreatment. BALI has its own pilot plant in Sarpsborg.

Through its proprietary Exilva technology, Borregaard is now able to provide high-quality Microfibrillated Cellulose (MFC) from its production plant in Sarpsborg. A new plant built specifically for the production of Cellulose Fibrils began production in Q3 2016.



CALYSTA

Menlo Park, CA

Number of employees: 50

CALYSTA IS DEVELOPING FEEDKIND® PROTEIN AND OTHER PRODUCTS FOR THE NUTRITION AND CHEMICAL INDUSTRIES.

CALYSTA

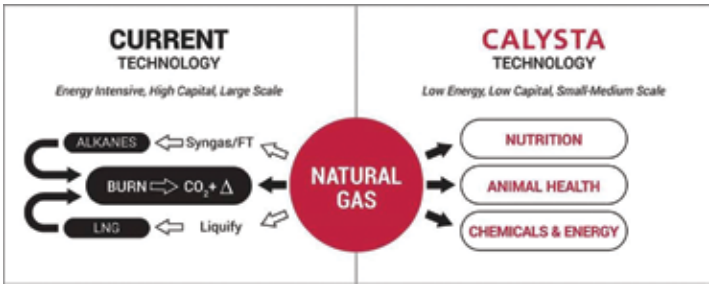
Above: FeedKind®

About: Calysta creates high-value nutrition products and industrial materials by converting energy-rich methane into sustainable building blocks for life.

Product applications: Fish and livestock nutrition products, industrial materials and consumer products. FeedKind® protein is a natural, safe, non-GMO, sustainable fish feed ingredient to reduce the global aquaculture industry's use of fishmeal.

Technology: Calysta is converting novel feedstocks to high-value sustainable products using synthetic biology. Calysta is developing Biological Gas-to-Chemicals® and Biological Gas-to-Liquids® platforms and Biological Gas to Feed™ and Biological Gas to Fuel™ fermentation platforms. Calysta's products are produced using methanotrophs, natural organisms that consume methane from multiple sources, including anaerobic digestion and municipal solid waste, as their energy source.

In January 2016, Calysta received a conditional £2.8 million Exceptional Regional Growth Fund grant from the UK Government to develop a Market Introduction Facility in northern England for FeedKind® protein. In June 2014, Calysta announced successful methane fermentation into lactic acid, under a research collaboration with NatureWorks. Lactic acid is the building block for NatureWorks Ingeo lactide intermediates and polymers.



KEY FACTS

+ Menlo Park, CA
+ Feedstock: Methane
+ In April 2017, Calysta and Cargill broke ground on NouriTech, a commercial-scale FeedKind® protein production plant in Memphis, TN.

PARTNERSHIPS AND FINANCING

In May 2017, Calysta announced $40 million in Series D funding, in a financing round led by Mitsui & Co. Ltd., Tokyo, Japan. Also participating were Temasek, a Singapore-based investment company, and current investors Cargill, the Municipal Employee Retirement System (MERS) of Michigan, Walden Riverwood Ventures, Aqua-Spark and Pangaea Ventures. In February 2016, Calysta announced $30 million in Series C funding with Cargill, MERS, and Old Westbury Global Real Assets Fund LLC. In January 2015, Calysta completed a Series B financing round totaling $10 million, led by Walden Riverwood Ventures, a venture firm focused on investing in core technology companies globally, and Aqua-Spark, a Netherlands-based firm focused on sustainable aquaculture investments.

CARGILL

Wayzata, MN
Number of employees: 155,000

CARGILL PRODUCES BIOINDUSTRIAL VEGETABLE OILS AND WAXES, STARCHES, POLYOLS, HYDROCOLLOIDS, COALESCING AGENTS, DIELECTRIC FLUIDS, EPOXY ADDITIVES AND CURING AGENTS.

BIOREFINERY CLASSIFICATION: COMMERCIAL | DEMONSTRATION | PILOT | COMMERCIAL

PRODUCTION FACILITIES

+ Bergen op Zoom, Netherlands
+ Blair, NE
+ Chicago, IL
+ Dalton, GA
+ Eddyville, IA
+ Efremov, Russia
+ Fort Dodge, IA
+ Haryana, India
+ Istanbul, Turkey
+ Mairinque, Brazil
+ Memphis, TN
+ Ponta Rossa, Brazil
+ Uberlandia, Brazil

PARTNERSHIPS AND FINANCING

In May 2017, Cargill purchased the Agrol® line of vegetable-based polyol and other assets from Rogers, AR-based BioBased Technologies.

In April 2017, NouriTech™ and its lead investors, Cargill and Calysta, broke ground on a natural gas fermentation facility in Memphis, TN, to produce Calysta's FeedKind® protein.

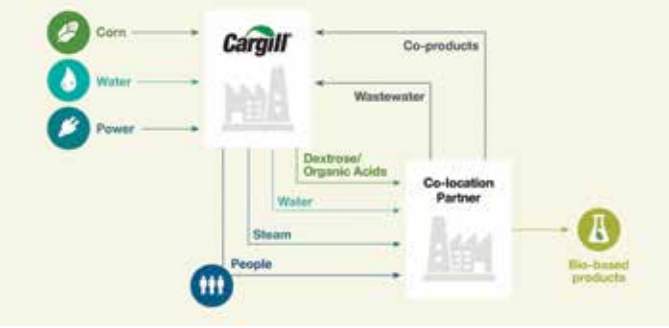
About: Cargill provides food, agriculture, financial and industrial products and services to the world. Together with farmers, customers, governments and communities, we help people thrive by applying our insights and over 150 years of experience. We have 155,000 employees in 70 countries who are committed to feeding the world in a responsible way, reducing environmental impact and improving the communities where we live and work.

Product applications: Adhesives and binders, asphalt solutions, construction, drilling/oilfield, lubricants, foams and flooring, home care, paper making, paints, coatings and inks, soaps and surfactants, and personal and beauty care products.

Technology: We draw on the whole Cargill portfolio of products and services to create solutions to help our customers increase performance, and lower costs – all in a responsible, sustainable manner.

We provide base chemistries, specialized products, and fully customized solutions for customer needs across a broad spectrum of applications and industries.

We also offer a wide array of services and resources through our co-location partnerships for companies seeking to scale-up commercialization more quickly and affordably long-term.



CELLANA, LLC

Kailua-Kona, HI
Number of employees: 20+

CELLANA IS PRODUCING ALGAE OILS, PROTEINS/ CARBOHYDRATES AND BIOMASS.

About: Cellana, LLC is a leading developer of algae-based bioproducts for sustainable nutrition and energy applications.

Product applications: Algae-based bioproducts such as Omega-3 nutritional oils, aquaculture/animal feeds, human foods and fuels.

Technology: Cellana's patented production system, called ALDUO™, is unique in that it couples large-scale photobioreactors (PBRs) with open ponds in a two-stage process. Open ponds, which are very cost-effective, have historically been limited by contamination from undesirable algae strains (weeds) or grazer organisms (pests). PBRs are generally unable to produce algae at an acceptable cost for commodity applications. ALDUO™ minimizes the footprint of PBRs and maximizes the footprint of the open ponds, in order to minimize overall cost & minimize risk of contamination. By operating the PBRs in semi-continuous mode to provide inoculum for the open ponds, which are operated in batch mode, Cellana has successfully grown more than 10 strains of algae at commercial yields wthout pesticides or herbicides.

KEY FACTS

+ Kailua-Kona, HI
+ 12+ tons per year, current capacity.
+ Feedstock: Algae.

PARTNERSHIPS AND FINANCING

Cellana has recieved multiple large grants from the U.S. Departments of Energy (DOE) and Agriculture (USDA). Cellana has entered into a commercial-scale off-take agreement with Neste, the world's leading supplier of renewable diesel and jet fuel, for Cellana's ReNew™ Fuel biocrude oil for fuel applications.

BIOREFINERY CLASSIFICATION: DEMONSTRATION

COMMERCIAL | DEMONSTRATION | PILOT

CELLUCOMP

Burntisland, Fife, Scotland
Number of employees: 16

CELLUCOMP PRODUCES CURRAN® CELLULOSE NANO-FIBERS.

Above: CelluComp CEO Christian Kemp-Griffin (left), and founders Dr. Eric Whale and Dr. David Hepworth (right).

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ In March 2015, CelluComp completed the construction of its state of the art manufacturing facility based in Glenrothes, Fife, Scotland.
+ Feedstock: Sugar beet pulp

PARTNERSHIPS AND FINANCING

In 2016, CelluComp closed £3.7 million in funding. The funding was led by FPCI CapAgro Innovation, with follow-on investments from Sofinnova Partners and Scottish Enterprise through its investment arm, the Scottish Investment Bank (SIB), as well as a syndicate of angel investors.

About: CelluComp is a Scottish-based materials start-up company that manufactures and markets sustainable products produced from the waste streams of the food industry. CelluComp launched its business in 2004 with the research and development of Curran®, a material derived from nano-cellulose (also known as microfibrilated cellulose) of sugar beets.

Product applications: Paints and coatings, paper, food, concrete, home and personal care, oil drilling and composites.

Technology: CelluComp uses a proprietary technology to extract nano-cellulose fibers from root vegetables to produce a unique product called Curran®. Curran® is produced through green chemistry processes, including water-based reactions at low temperatures and pressures, which maximize the energy efficiency of the manufacturing process. Curran® provides a high-performing, environmentally sound and economically viable solution for reinforcement and rheology (thickening) in multiple industries, such as paints and coatings, paper, food, home and personal care, concrete, oil drilling and composites.

CHEMISTRIA

Pertuis, France

Number of employees: 85

CHEMISTRIA PRODUCES SEPARATION AND PURIFICATION TECHNOLOGY FOR SECOND-GENERATION SUGARS OR ORGANIC ACIDS, INCLUDING ACETIC, GLUCONIC, LACTIC, AND SUCCINIC.

About: Chemistria is the "green chemistry" division of Eurodia Industrie SA, one of the world's leading specialists in membrane treatment for the food industry. Eurodia also is involved in the winemaking industry and leads the field in the sugar and dairy industries. Now, its innovative methods for developing new chemicals from renewable resources (green chemistry) are available under the name of Chemistria.

Product applications: Biodegradable plastics, biobased chemicals and biochemicals, second-generation sugars.

Technology: Capitalizing on 30 years of experience in providing industrial processes for the purification of liquids, Eurodia has established Chemistria as its division to provide process solutions specifically targeted to the biobased chemicals industry. Chemistria provides a wide range of process solutions, combining electrodialysis, ion exchange, chromatography and membrane filtration specifically dedicated to the challenges of sustainable chemistry.

KEY FACTS

+ U.S. Division: Ameridia in Somerset, NJ.
+ Purification and separation expertise.
+ Develops complete process lines and provides turnkey systems.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

CHR. HANSEN

Hørsholm, Denmark
Number of employees: 3,050

CHR. HANSEN PRODUCES FOOD CULTURES, ENZYMES, PROBIOTICS AND NATURAL COLORS.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL
DEMONSTRATION
PILOT

KEY FACTS

+ Copenhagen, Denmark
+ Chr. Hansen has employees in 32 countries, including five main production sites: two in Denmark, and one each in France, Germany and the United States.

PARTNERSHIPS AND FINANCING

In September 2016, Chr. Hansen acquired from Valio OY the *Lactobacillus rhamnosus GG* (protected under the trademark LGG®), the best documented probiotic strain in the world, along with a collection of 3,200 strains and a small production site in Tikkurila, Finland.

About: Chr. Hansen is a leading, global bioscience company that develops natural ingredient solutions for the food, nutritional, pharmaceutical and agricultural industries. We develop and produce cultures, enzymes, probiotics and natural colors for a rich variety of foods, confectionery, beverages, dietary supplements and even animal feed and plant protection. We are the owners of one of the world's largest commercial collections of bacteria, numbering almost 30,000 strains. We like to refer to them as "good bacteria." From this collection, bacteria are screened, selected and improved to meet specific requirements. Our natural solutions enable food manufacturers to produce more with less – while also reducing the use of chemicals and other synthetic additives – which makes our products highly relevant in today's world. We have been delivering value to our partners – and, ultimately, end consumers worldwide – for over 140 years. We are proud that more than one billion people consume products containing our natural ingredients every day.

Product applications: Food and beverages, dietary supplements, infant formula, animal feed, plant protection. Chr. Hansen is the global market leader in dairy ingredients; every second cheese in the world contains a Chr. Hansen ingredient.

Technology: Our library of nearly 30,000 microbial strains allows for extensive screening and selection of the best available combinations of strains for new, improved products and solutions. Know-how in fundamental bioprocess engineering is used to develop products that optimize customers' production efficiency, with higher yields and improved stability. Scientific knowledge of bacterial strain properties and technical application knowledge are the key platforms enabling development of healthy and tasty new product solutions.

C-LECTA

Leipzig, Germany
Number of employees: 50

C-LECTA DEVELOPS AND PRODUCES ENZYMES AND INGREDIENTS.

About: c-LEcta is a fully integrated industrial biotechnology company.

Product applications: Enzymes and ingredients for personal care, food, feed and pharma. Biocatalysts for the chiral synthesis of chemical active pharmaceutical ingredients. Food ingredients, like sweeteners, prebiotics and functional sugars. Food and feed enzymes for industrial use.

Technology: c-LEcta possesses a unique and growing collection of prequalified, dereplicated, cultivable microorganisms from different habitats plus metagenome libraries. The company works mainly with three different production platforms, *Escherichia coli*, *Pichia pastoris* and *Bacillus sp.* The company has built up a unique genetic engineering toolbox to optimize their production strains for the direct fermentative production of small-molecule products, like carbohydrates, food and cosmetic ingredients or flavors. A key technology of the company is enzyme engineering. c-LEcta is leading in using cell-free synthetic biology for the enzymatic production of valuable ingredient products for different markets.

Products: DENARASE is a genetically engineered endonuclease from *Serratia marcescens* able to cleave all forms of DNA and RNA very efficiently. The full-GMP product is used in pharmaceutical production processes of vaccines and biopharmaceuticals. c-LEcta has developed a patent-protected production technology for this enzyme, based on recombinant expression in a *Bacillus sp.* production host.

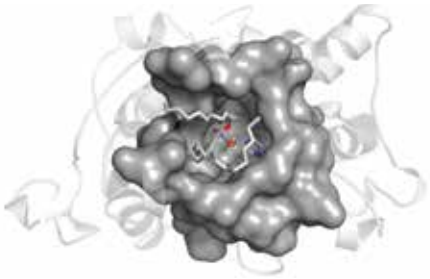
Lipase B from *Candida antarctica (CalB)* has proven an exceptional catalyst for production of drug substances as well as ingredients for personal care and food applications. CalB Immo Plus has been developed through a joint development and manufacturing collaboration between c-LEcta GmbH and Purolite Corporation.

KEY FACTS

+ Leipzig, Germany
+ c-LEcta operates an ISO 9001-certified, state-of-the-art pilot scale (100 – 400 liters) facility to supply enzymes or other biotechnological products and to scale up bioprocesses in food and pharma quality.
+ Large-scale production is realized through partnerships with European contract manufacturing organizations (CMOs).
+ Capacity: 10 -100 cubic meters fermentation capacity, including downstream processing equipment.

PARTNERSHIPS AND FINANCING

c-LEcta is an established technology partner and supplier of biotech products for the industry and cooperates with partners like BASF, Evonik or Roche. C-LEcta is a profitable, self-sustained company.



TECHNOLOGY CLASSIFICATION: COMMERCIAL

PILOT DEMONSTRATION COMMERCIAL

CODEXIS®
PROTEIN ENGINEERING EXPERTS™

CODEXIS

Redwood City, CA
Number of employees: 115

UNLOCK THE POWER OF PROTEINS™.

TECHNOLOGY CLASSIFICATION: COMMERCIAL | PILOT | DEMONSTRATION | COMMERCIAL

KEY FACTS

- Redwood City, CA
- 107,200 square feet of office and laboratory space.
- Over 175 issued patents and pending patent applications worldwide.

PARTNERSHIPS AND FINANCING

In 2015 and 2016, Codexis completed a technology transfer and non-exclusive license agreement with Merck and GSK to use Codexis' proprietary CodeEvolver® platform to develop novel enzymes for use in the manufacture of Merck's and GSK's pharmaceutical products.

In December 2016 and March 2017, Codexis announced an exclusive multi-year development agreement with Tate & Lyle, a global provider of ingredients and solutions, to research and supply novel enzymes for new food ingredients.

In October 2017, Codexis and Nestlé Health Science announced a strategic collaboration for multiple projects accessing Codexis' CodeEvolver® platform, including an option for the global development of Codexis' novel enzyme, CDX-6114, to treat phenylketonuria (PKU).

About: Codexis, Inc. is a leading protein engineering company applying innovative technologies to *unlock the power of proteins*™. We work collaboratively with our clients to advance protein optimization and production, enabling breakthrough developments in pharmaceuticals and fine chemicals, biotherapeutics, food and beverage, agriculture and other industries. Codexis' proven technology enables implementation of protein engineering solutions to meet customer needs for rapid, cost-effective and sustainable manufacturing.

Product applications: Pharmaceuticals (active pharmaceutical ingredients), biotherapeutics, food and beverage and industrial enzymes (fine chemicals, animal health, food and nutrition, flavors and fragrances, agrochemicals).

Technology: Codexis' proprietary CodeEvolver® technology enables the rapid development and production of highly optimized proteins, custom-designed for a client's application. Our revolutionary approach starts with an understanding of the desired performance specifications and optimizes a protein specifically to fit these requirements. CodeEvolver® combines DNA library synthesis and sequencing, advanced high-throughput screening and machine learning with the expertise of our scientific team.

Services: Screening (screen protein libraries), protein engineering (generate *de novo* protein libraries on which to direct evolution), scale-up and supply (from gram to multi-metric ton quantities) and off-the-shelf screening kits.

THE COCA-COLA COMPANY

Atlanta, GA

Number of system employees: >700,000

THE COCA-COLA COMPANY PRODUCES PLANTBOTTLE™ PACKAGING, THE FIRST-EVER FULLY RECYCLABLE PET PLASTIC BEVERAGE BOTTLE MADE PARTIALLY FROM PLANTS.

plantbottle

About: The Coca-Cola Company is the world's largest beverage company, refreshing consumers with more than 500 sparkling and still brands and more than 3,800 beverage choices.

Product applications: PET packaging and materials. PlantBottle™ packaging accounts for 30 percent of the company's packaging volume in North America and 8 percent globally.

Technology: Coca-Cola introduced PlantBottle™ technology in 2009 as the first recyclable PET plastic bottle made partially from plants. This year, The Company set a global sustainable packaging goal to collect and recycle a bottle or can for every one it sells by 2030. To achieve this collection goal, The Coca-Cola Company is continuing to work toward making all of its packaging 100 percent recyclable and it is working to build better bottles, whether through more recycled content, by using plant-based resins, or by reducing the amount of plastic in each container.

KEY FACTS

+ Feedstock: Sugarcane.

PARTNERSHIPS AND FINANCING

Coca-Cola intends to continue partnering with NGOs, industry and governments to accomplish its packaging goals. Past partnerships included the formation of the Plant PET Technology Collaborative with Ford, Heinz, Nike and Procter & Gamble in 2012. The PlantBottle™ technology has also been applied beyond beverage bottles. Coca-Cola developed partnerships with the Ford Motor Company to use the PlantBottle™ technology for polyester car interiors and with SeaWorld® Parks & Entertainment (as well as other theme parks and zoos) to introduce a refillable souvenir cup made with PlantBottle™ technology.

COOL PLANET

Greenwood Village, CO

Number of employees: 40

COOL PLANET MANUFACTURES BIOCARBON PRODUCTS.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Production facilities: Camarillo, CA and Alexandria, LA.
+ Feedstock: Non-food biomass.
+ Cool Terra® Organic is a USDA Certified 100 percent Biobased Product.

PARTNERSHIPS AND FINANCING

In March 2017, Cool Planet closed a $19.3 million series A financing and note conversion, led by Agustín Coppel and North Bridge Venture Partners.

Nationwide, the Cool Terra® distributrion network includes approximately 3,000 retail locations. Cool Planet recently added Crop Production Services and Helena Chemical Company to its existing distribution network for Cool Terra® soil health products.

Cool Planet's distribution network for Cool Terra® also includes J.R. Simplot Company, Triangle Chemical Company, AgRx, as well as turf, nursery, and ornamental market distributors such as: Fisher & Son, Innovative Turf Solutions, Sierra Pacific Turf and Supply, and Sigma Organics.

About: Cool Planet was founded in 2009 to commercialize a groundbreaking technology that produces Engineered Biocarbon™ from biomass. The company is currently focused on deploying its proprietary Cool Terra® featuring Engineered Biocarbon™ products into a variety of markets. Cool Terra® works to improve soil quality by having a good ionic exchange capacity, increasing water and nutrient retention, and providing a positive environment for microbial growth. It has been shown to improve plant establishment through quicker germination and increased root development. It also benefits the environment by integrating fixed carbon back into the soil.

Product applications: Cool Terra® delivers both sustainability and profitability for agriculture, landscape, turf, nursery and ornamental markets.

Technology: Cool Terra® begins by heating renewably sourced, non-food biomass in low oxygen conditions, creating "raw biochar." This material is then adjusted through Cool Planet's proprietary upgrading technology to:

+ Adjust and balance pH to ensure consistent performance without side effects;
+ Enhance the surface chemistry of the material to optimize microbial growth in the pores and on the surfaces as well as enhancing nutrient exchange in the soil;
+ Condition pores to better retain water and nutrients and to host beneficial microbes; and
+ Remove dust, improve flowability and create consistent particle sizes for easy, predictable application.

CORBION

Amsterdam, Netherlands
Number of employees: 1,700

CORBION IS PRODUCING LACTIC ACID, 2,5-FURANDICARBOXYLIC ACID, AND SUCCINIC ACID.

About: Corbion is the global market leader in lactic acid, lactic acid derivatives, and a leading company in emulsifiers, functional enzyme blends, minerals, vitamins and algae ingredients.

Product applications: The company delivers high-performance biobased products made from renewable resources and applied in global markets such as bakery, meat, home and personal care, packaging, pharmaceuticals and medical devices, automotive, coatings and adhesives. Its products have a differentiating functionality in all kinds of consumer products worldwide.

Technology: Corbion has an established technology platform based on over 80 years of fermentation experience. Corbion leads the way in lactic acid as well as in cutting-edge emulsification technology and functional blending capability. Drawing on the deep-rooted application and market knowledge that has been built up over decades, we work side-by-side with our customers to make our technology work for them.

In 2016, Total and Corbion announced they are joining forces to develop bioplastics by creating a 50/50 joint venture to produce and market polylactic (PLA) polymers. With the construction of a 75 kiloton per year PLA plant in Rayong, Thailand, the Total Corbion PLA joint venture is moving one step in the value chain.

PRODUCTION FACILITIES

+ Blair, NE
+ Dolton, IL
+ East Rutherford, NJ
+ Grandview, MO
+ Peoria, IL
+ Totowa, NJ
+ Tucker, GA

PARTNERSHIPS AND FINANCING

In 2017, Corbion acquired TerraVia and its broad and diverse platform centered on innovative food and specialty ingredients derived from microalgae. This acquisition includes an R&D center and pilot facility in San Francisco, a demonstration plant in Peoria and an industrial scale plant in Brazil, in a joint venture (50.1 percent owned by Corbion) with Bunge.

In 2015, Corbion and MedinCell established a 50/50 joint venture, CM Biomaterials, to supply polyethylene glycol and polylactic acid co-polymers for use in controlled release drug delivery.

In 2013, Corbion and BASF established the 50/50 joint venture Succinity GmbH, dedicated to the production and commercialization of high-quality succinic acid based on renewable resources.

BIOREFINERY CLASSIFICATION: COMMERCIAL | DEMONSTRATION | PILOT | COMMERCIAL

CRODA

Snaith, Yorkshire, United Kingdom
Number of employees: 4,273

CRODA PRODUCES SURFACTANTS FROM BIOETHYLENE OXIDE AND OTHER SPECIALTY AND OLEOCHEMICALS.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Atlas Point, New Castle, DE
+ Feedstock: Ethanol.
+ Croda has 18 manufacturing sites globally; 62 percent of its raw materials were from renewable sources in 2016. Twelve Croda manufacturing sites are now certified to handle Certified Sustainable Palm Oil (CSPO).

PARTNERSHIPS AND FINANCING

In December 2017, Croda acquired IonPhasE, an innovative technology supplier of static electricity protection products headquartered in Tampere, Finland.

In September 2017, Croda announced a research project with Liverpool University and Scanwell Ltd. to optimise MyCroFence™ antimicrobial and anti-biofilm technology.

In July 2017, Croda acquired Enza Biotech AB, a research enterprise established as a spin-out company from Lund University in Sweden to develop renewable surfactants using carbohydrate-based chemistry.

About: Established in 1925, Croda is the name behind high-performance ingredients and technologies in some of the world's biggest and most successful brands: creating, making and selling specialty chemicals that are relied on by industries and consumers everywhere. They have a network of over 4,200 passionate and committed employees, working together as one global team across manufacturing sites and offices in 36 countries.

Product applications: Croda focuses on developing and delivering innovative, sustainable ingredients that their customers can build on in: personal care, health care, crop care, polymer additives, lubricants, coatings and polymers, geo tech, home care and industrial specialties.

Technology: "Turning the World Green Through Innovation." Croda once again revolutionizes the industry with its latest investment in sustainability. The first of its type in the United States, Croda's new Atlas Point plant in New Castle, DE, is capable of producing 100 percent renewable, 100 percent biobased non-ionic surfactants, which are active emulsifying agents used in a wide range of consumer products. This expansion of the Atlas Point facility enables Croda to use bioethanol derived from natural feedstocks for the manufacture of its 100 percent renewable surfactants, significantly increasing the biobased content of ethoxylated products and reducing reliance on fossil fuels. This marks a turning point in the industry, as companies traditionally use petrochemical ingredients over sustainable ones when seeking high performance non-ionic surfactants for the formulation of consumer products. Now, Croda has implemented a way to use renewable ingredients without sacrificing product performance. Moreover, the ingredients will be manufactured with renewable energy.

To learn more about the ECO range of products, contact us at: ATPP Marketing.US@croda.com or visit us at www.croda.com

DANIMER SCIENTIFIC

Bainbridge, GA

Number of employees: 70

DANIMER SCIENTIFIC IS PRODUCING NODAX™ MEDIUM-CHAIN-LENGTH POLYHYDROXYALKANOATES (MCL-PHA).

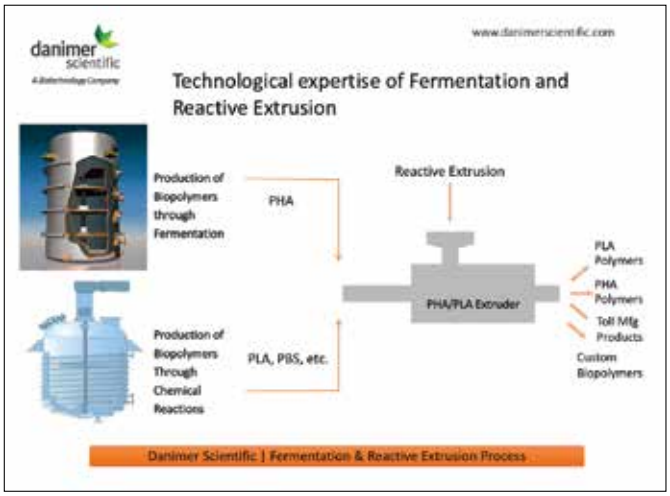
danimer scientific

A Biotechnology Company

About: Danimer Scientific makes commercial-grade PHA using world-class production systems, offering a scalable, durable, and cost-effective material that reduces manufacturing dependence on non-renewable, diminishing resources.

Product applications: In March 2014, NODAX™ received FDA approval for food contact applications. The PHA produced at Danimer Scientific is also Vinçotte certified to biodegrade within 12 to 18 weeks in 6 different mediums, including anaerobic, soil, freshwater, marine, industrial and home composting. Danimer Scientific also produces many compostable polymers for use in varying applications such as extrusion coating, thermoforming, injection molding, films (blown and cast), and many other areas. We can custom-make biopolymers designed to be run on existing equipment with comparable processing conditions.

Technology: Danimer Scientific purchased the intellectual property that forms the basis of its bioplastic technology from Procter & Gamble in 2007 and has continued to improve the patent portfolio with key international and North American patents.



KEY FACTS

+ Bainbridge, GA
+ Capacity: 130,000 liters.
+ Feedstock: Fatty acid feedstocks.

PARTNERSHIPS AND FINANCING

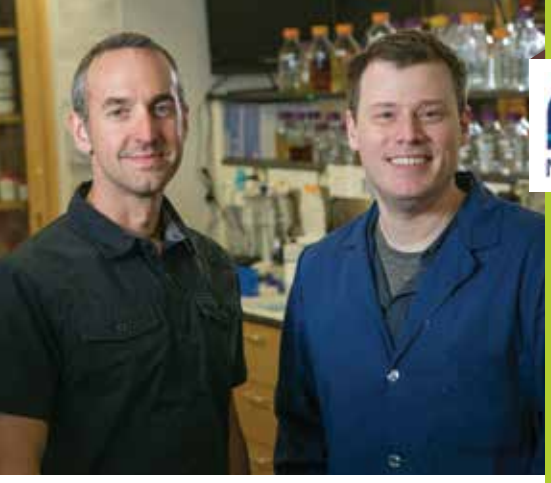
In February 2017, Danimer Scientific recently entered into partnership with PepsiCo to develop biodegradable packaging resins. The agreement builds on a long-standing relationship that has included the development of biobased compostable packaging for PepsiCo's snack brands and will facilitate the expansion of Danimer Scientifics' Nodax™ PHA plant.

U.S. government loan programs for businesses, such as those offered by the USDA Rural Development and the U.S. Department of Treasury New Market Tax Credit programs.

In late March 2014, Tate & Lyle validated the replication of the proprietary process.

BIOREFINERY CLASSIFICATION: DEMONSTRATION

COMMERCIAL | DEMONSTRATION | PILOT



DMC

Boulder, CO

Number of employees: 5

DMC IS DEVELOPING BIOPROCESSES TO PRODUCE SPECIALTY AMINO ACIDS, ORGANIC ACIDS, ESTERS, AND TERPENOIDS.

TECHNOLOGY CLASSIFICATION: PILOT

COMMERCIAL | DEMONSTRATION | PILOT

Above: DMC founders CEO Matt Lipscomb, Ph.D. and CTO Mike Lynch, M.D. (left-to-right).

KEY FACTS

+ Boulder, CO
+ Durham, NC

PARTNERSHIPS AND FINANCING

In December 2017, DMC raised a Series Seed equity investment round.

In December 2017, DMC executed a collaborative development agreement with a global partner.

In August 2017, DMC was awarded a National Science Foundation Small Business Innovation Research (SBIR) Phase II grant to commercialize Dynamic Metabolic Control technology.

In June 2017, DMC received a USDA National Institute of Food and Agriculture SBIR Phase I grant to study the feasibility of producing d-limonene.

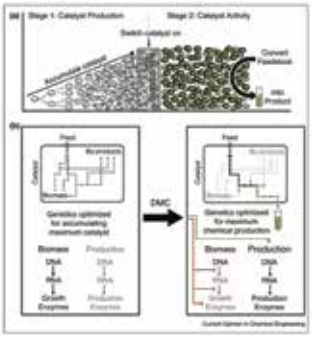
In March 2017, Maine's Born Global Challenge named DMC as one of 11 companies to prequalify for the competition.

In June 2016, Duke University and DMC received a Department of Energy Biotechnology Incubator 2 Award to develop novel process intensification technology.

About: We are a metabolic engineering startup company with a mission to unleash the manufacturing power of biology by reducing biological complexity. Our goal is to produce high-value products using enhanced microbial fermentation. Our key enabler is a proprietary technology exclusively licensed from Duke University for the dynamic metabolic control of microbial metabolism.

Product applications: Our novel, patent-pending technology for rapid engineering of robust microbial hosts enables the production of a broad diversity of specialty chemicals, flavors, fragrances, neutraceuticals, natural products, and pharmaceuticals.

Technology: Our Dynamic Metabolic Control technology was successfully developed to utilize a universal, standardized two-stage bioprocess. This approach enables the dynamic minimization of metabolism to only those components necessary for product formation. The approach has been engineered using inducible enzyme degradation in addition to gene silencing techniques, such as CRISPRi. We have demonstrated development for multiple products in parallel to commercially relevant metrics at cost and timeline that is >50x improved compared to the state of the art.



< Stage 1: Growth
- Strains optimized for maximum growth and yield
- Dynamic Transition
- Strains "pre-programmed" to switch to production phase in response to an environmental trigger

< Stage 2: Production
- Metabolism reduced to minimum network
- Strains optimized for maximum production efficiency
- Strain ability to respond to environmental factors is curtailed – resulting in robustness to the process environment and predictability across scale

DUPONT INDUSTRIAL BIOSCIENCES

Wilmington, DE

DUPONT IS DEVELOPING PLATFORMS FOR BIOMATERIALS, FOOD INGREDIENTS, MATERIALS AND CHEMICALS.

About: DuPont Industrial Biosciences has been bringing world-class science and engineering to the global marketplace in the form of innovative products, materials and services since 1802.

Product applications: Animal nutrition, food, detergents, monomers, polymers, textiles, carpets, personal care, biobased materials and biofuel enzymes.

Technology: DuPont Industrial Biosciences works with customers across a wide range of industries to make products and industrial processes more efficient and sustainable. Through a unique combination of agriculture, biotechnology, chemistry and material science capabilities, the company advances market-driven, biobased solutions that offer high performance with less impact on the environment. As an industry leader, the company has shown both commercial and pre-commercial success in developing new biomaterials that meet the needs of customers and consumers worldwide.

KEY FACTS

- FDME Demonstration Facility, Decatur, IL.
- Capacity: 60 tons per year.
- Feedstock: Corn-based.

PARTNERSHIPS AND FINANCING

ADM and DuPont are bringing furan dicarboxylic methyl ester (FDME) to market by moving forward on the scale-up phase of the project. The two companies are in the process of scaling up an integrated 60-ton-per-year demonstration plant in Decatur, IL. The facility will provide potential customers with sufficient product quantities for testing and research as well as the required basic data for a planned commercial-scale plant.

BIOREFINERY CLASSIFICATION: DEMONSTRATION

COMMERCIAL | DEMONSTRATION | PILOT

DUPONT TATE & LYLE BIO PRODUCTS

Loudon, TN

DUPONT TATE & LYLE BIO PRODUCTS IS PRODUCING 1,3-PROPANEDIOL.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ The global headquarters and production facility for DuPont Tate & Lyle Bio Products is located in Loudon, TN.
+ The plant started production in 2006 and has a current capacity of 140 million pounds per year.
+ Feedstock: Glucose from corn wet milling operation.

PARTNERSHIPS AND FINANCING

DuPont Tate & Lyle Bio Products is a joint venture between DuPont, a global science company, and Tate & Lyle, a world-leading renewable food and industrial ingredients company. DuPont and Tate & Lyle jointly funded the plant with total investment of $100 million.

AWARDS

2003 EPA Presidential Green Chemistry

2007 ACS Heroes of Chemistry

2009 ACS-BIOT Industrial Biotechnology

2010 State of Tennessee Governor's Award for Trade Excellence

About: DuPont Tate & Lyle Bio Products provides natural and renewably sourced ingredients that enhance product performance.

Product applications: 100 percent biobased 1,3-propanediol is used to produce fiber-grade polyester polymer for residential and commercial carpets, apparel, and automotive mats and carpets. In addition, the Zemea™ brand of 1,3-propanediol is found in cosmetics, personal care, food, flavors, laundry, cleaning and pharmaceutical products. The Susterra™ brand is targeted for industrial applications, such as heat transfer fluids, deicing, polyurethanes, paints, coatings, and inks.

Technology: Under exact temperatures and conditions, a patented microorganism functions as a biocatalyst, converting sugar into 1,3-propanediol. The deactivated microorganism is separated from the broth, along with unfermented sugars, salts and water. The material is then refined to remove any trace quantities of water and other by-products. The resulting product is highly purified 1,3-propanediol ready for commercial use.

EARTH ENERGY RENEWABLES

Bryan, TX

Number of employees: 10

EARTH ENERGY RENEWABLES PRESENTLY FOCUSES ON PRODUCING SHORT- AND MEDIUM-CHAIN FATTY ACIDS.

About: Earth Energy Renewables is a company focused on commercializing biobased chemicals and fuels. The company has demonstrated success in creating high-margin green alternatives to petroleum-based products. With a robust technology that can process any biodegradable material, dry or wet, Earth Energy is able to deliver superior returns with lower risk.

Product applications: Flavors, fragrances, animal health and nutrition, biocides and antifungals, lubricants.

Technology: Earth Energy's technology is a hybrid biological/chemical process. The biological step is the same process that occurs in the rumen of cattle, termite guts, or methanogenic anaerobic digesters, where a mixed culture of naturally occurring microorganisms converts biomass into carboxylic acids (i.e., short- and medium-chain fatty acids such as acetic, propionic, butyric, valeric, caproic, heptanoic and octanoic acids). These carboxylic acids are recovered using patented and proprietary technologies and may then be chemically converted into other desired products.

Short-and medium-chain fatty acids, valuable in their own right, also represent the backbone for a very rich chemical platform that can produce hundreds of different chemicals, such as esters, ketones, di-carboxylic acids, and biofuels, such as alcohols and drop-in biofuels.

KEY FACTS

+ Bryan, TX
+ Feedstock: Any organic material.
+ Capacity: Pilot and demo scale.

PARTNERSHIPS AND FINANCING

In December 2016, the Department of Energy announced $70 million in funding for the Iowa State University-based Rapid Advancement in Process Intensification Deployment Institute. The grant included funds to build on technology developed by Mark Holtzapple of Texas A&M University to efficiently ferment biomass for production of carboxylic acids.

The company has also completed its Series A raise from investors from the United States and Asia, which will allow it to convert its present pilot plant into a fully integrated pilot plant process. These same partners have agreed to fund commercial plants once pilot testing and engineering is completed.

BIOREFINERY CLASSIFICATION: COMMERCIAL | DEMONSTRATION | PILOT

ECOSYNTHETIX

Burlington, Ontario, Canada

Number of employees: 50

ECOSYNTHETIX PRODUCES ECOSPHERE® BIOLATEX™ BINDERS AND DURABIND™ ENGINEERED BIOPOLYMERS.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Centre of Innovation, Burlington, Ontario, Canada.
+ Production sites in Dyersburg, TN and Oosterhout, Netherlands.

PARTNERSHIPS AND FINANCING

The company has established a number of academic and government funding partnerships to support its research and development activities. EcoSynthetix is a public company trading on the Toronto Stock Exchange (TSX: ECO). For further details, visit us at ecosynthetix.com.

About: EcoSynthetix is a renewable chemicals company offering a range of sustainable engineered biopolymers that allow customers to reduce their use of harmful materials, such as formaldehyde and styrene-based chemicals. Our flagship products, DuraBind™ and EcoSphere®, are used to manufacture wood composites, paper and packaging, and enable performace improvements, economic benefits and sustainability.

Product applications: Binders and modifiers for key global markets, including: paper and paperboard, building and construction, personal care, and others.

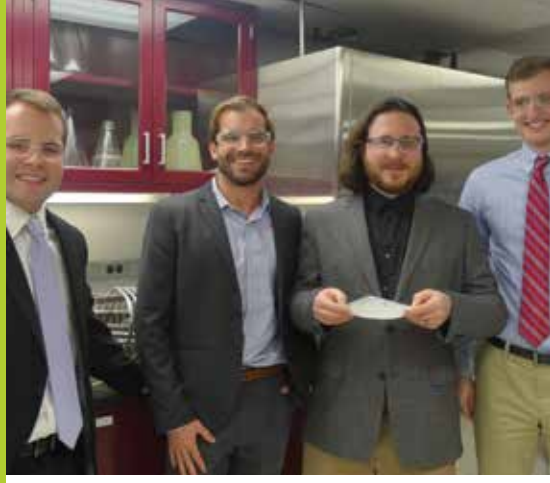
Technology: EcoSphere biolatex binders are used by many of the paper and paperboard industry's largest manufacturers. DuraBind engineered biopolymers enable manufacturers of particle board, MDF and oriented strand board to decrease the amount of highly regulated chemicals, such as formaldehyde-based chemistries, in their products.

ECOVIA RENEWABLES

Ann Arbor, MI

Number of employees: 5

ECOVIA RENEWABLES IS DEVELOPING ECOVIA™ BIOPOLYMERS.



Above: Samuel Kohley, CBO Drew Hertig, President & CEO Jeremy Minty, Ph.D., and Ian Graves (left-to-right) of Ecovia Renewables.

About: Ecovia Renewables, Inc. is a privately held company focused on the development of high-performing biobased materials and fuels. It was founded in 2014 by Dr. Jeremy Minty and Dr. Nina Lin to commercialize their EcoSynth™ platform, spun out from the Department of Chemical Engineering at the University of Michigan.

Product applications: Agricultural soil amendments for water retention and erosion control; personal care products, including cosmetic ingredients and superabsorbents for hygiene; dispersants and flocculants.

Technology: Ecovia's EcoSynth™ platform utilizes teams of different microbial species, each specialized in performing a different biosynthesis step, to convert biomass to a specified biochemical product. This approach of consolidating multi-step biosynthesis pathways into a single bioreactor tank yields dramatic reductions in processing and capital costs by reducing the number of unit operations required for biochemical or biofuel fermentation processes. The system is designed to use lower-cost biomass feedstocks like waste glycerol. The modularity of the EcoSynth™ platform enables Ecovia to readily adapt co-cultures to different feedstocks and biochemical products.

KEY FACTS

+ Headquartered in Ann Arbor, MI.

PARTNERSHIPS AND FINANCING

In June 2017, Ecovia Renewables was selected as the grand prize winner of the 2017 Imagine Chemistry Challenge, hosted by AkzoNobel.

In March 2017, Ecovia Renewables was awarded a Small Business Innovation Research (SBIR) Phase II grant from the National Science Foundation to develop eco-friendly, superabsorbent biopolymers for hygiene applications.

In July 2016, Ecovia Renewables received a DOE Small Business Technology Transfer (STTR) Phase I grant to investigate the production of medium-chain-length (C11 to C15) methyl ketones via single-step fermentation of renewable biomass with mixed microbial cultures.

In May 2015, Ecovia Renewables was awarded a USDA SBIR Phase I grant to engineer microbial co-cultures to produce high-value biopolymers from bioprocessing by-products of industrial crops.

Bio Member

ELEVANCE RENEWABLE SCIENCES

Woodridge, IL

Number of employees: <100

ELEVANCE IS PRODUCING ETHYLENE.

BIOREFINERY CLASSIFICATION: COMMERCIAL | PILOT | DEMONSTRATION | COMMERCIAL

KEY FACTS

- Woodridge, IL
- Feedstock: Plant-based oils like soybean, canola, palm, mustard and jatropha or algae.
- Elevance and Wilmar International Limited formed a joint venture that operates a world-scale biorefinery in Gresik, Indonesia, based on Elevance's technology. The commercial-scale manufacturing facility capacity is 180,000 metric tons per year.

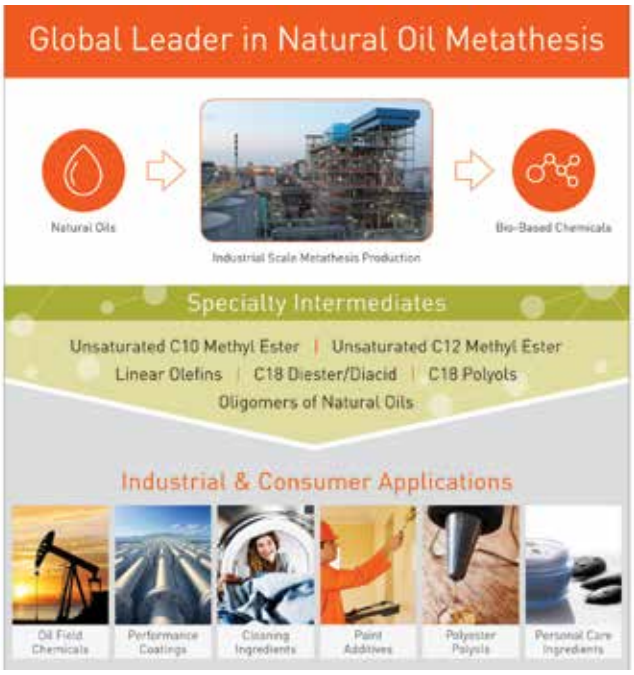
PARTNERSHIPS AND FINANCING

The company is privately held with strategic investors, including TPG, Genting, Naxos, Total and Materia. Elevance has active collaborations with various leading chemical organizations and continues to seek new strategic partnerships with companies looking to differentiate their product portfolio by leveraging its unique, biobased products and intermediates.

About: Elevance Renewable Sciences, Inc. creates novel, high-performing specialty chemicals from renewable feedstocks, using a proprietary Nobel Prize-winning olefin metathesis technology. Elevance uses a collaborative business model, exploring opportunities to engage with industry leaders, accelerating time to market and leveraging market expertise while enabling its partners to achieve growth through sustainable and higher performing solutions.

Product applications: Detergents, coatings, personal care, oil field, agricultural chemicals and engineered polymers.

Technology: Olefin metathesis chemistry, a groundbreaking catalyst technology, allows carbon atoms in natural oils to "swap" places, enabling new chemical compounds and manufacturing processes.



ENERKEM

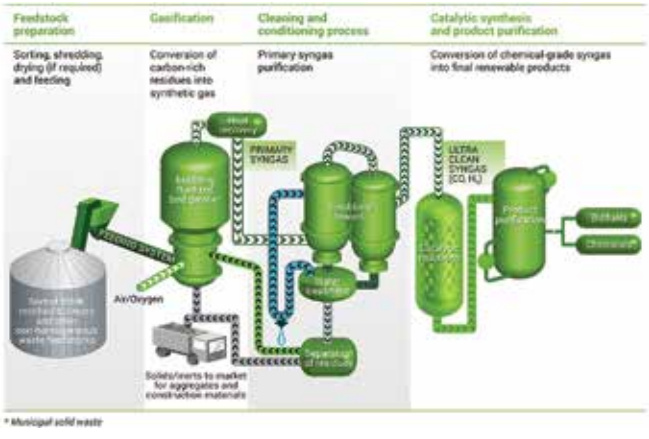
Montréal, Québec, Canada
Number of employees: 200

ENERKEM PRODUCES ETHANOL AND METHANOL.

About: Enerkem produces biofuels and renewable chemicals from waste. Its proprietary technology converts non-recyclable, non-compostable municipal solid waste into methanol, ethanol and other widely used chemical intermediates.

Product applications: Biofuels and renewable chemicals. Methanol is a chemical building block for the production of secondary chemicals, such as ethanol, acrylic acid, *n*-propanol, olefins, acetic anhydride and *n*-butanol, which are then used to form thousands of everyday products.

Technology: In less than five minutes, Enerkem's process first converts carbon contained in non-recyclable waste (i.e., garbage) into a pure synthesis gas (also called syngas), which is then turned into biofuels and chemicals, using commercially available catalysts.



KEY FACTS

+ Enerkem Alberta Biofuels LP. Edmonton, Alberta, Canada.
+ Capacity: 100,000 metric tons of waste. 38 million litres (10 million gallons) per year ethanol and methanol.
+ Feedstock: post-sorted municipal solid waste (after recycling and composting).
+ Enerkem Westbury, Westbury, Québec, Canada (Innovation Centre).
+ Capacity: 5 million litres (1.3 million gallons) per year of syngas, methanol, ethanol.
+ Feedstock: decommissioned telephone poles and sorted municipal solid waste.

NEW DEVELOPMENTS

+ Varennes, Québec, Canada
+ The future facility will produce methanol and ethanol by converting non-recyclable residual materials from the institutional, commercial and industrial sectors, as well as construction and demolition debris. Construction is scheduled to start in 2018.

ENEVOLV

Boston, MA

Number of employees: <20

ENEVOLV ENGINEERS MICROBES TO MAKE BIOBASED PRODUCTS.

TECHNOLOGY CLASSIFICATION: BETA COMMERCIAL PHASE

PILOT | DEMONSTRATION | COMMERCIAL

KEY FACTS

+ Boston based organization with centralized technology development and commercialization center.
+ Core technology developed at Harvard Medical School.

DEVELOPMENT PARTNERSHIPS AND FINANCING

+ Venture Capital financed business.
+ Lead investor: Cultivian Sandbox Venture Partners.
+ Technology development supported through five additional Small Business Innovation Research (SBIR) grants, totaling approximately $3 million.
+ Includes recent SBIR Phase I award from the National Science Foundation.

COMMERCIALIZATION

enEvolv has had commercial revenue since opening in 2013 and is commercializing its first organism product in 2018 in conjunction with a confidential commercial partner.

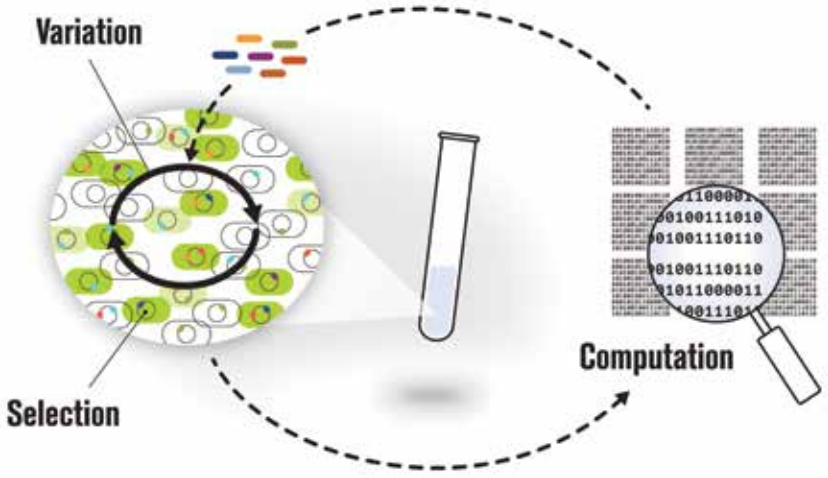
About: enEvolv, Inc. was founded in 2013 to engineer microbes to produce biobased chemicals. They partner with pharmaceutical, nutrition, energy and specialty chemical companies to develop novel strains and improve existing ones.

Product applications: Specialty chemicals, food, pharmaceuticals, energy products.

Technology: enEvolv's platform consists of *in vivo* variation and selection technologies, driven by computational design and learning.

enEvolv's variation technology introduces synthetic DNA at targeted locations in the genome – directly in living cells. By repeatedly introducing designed mutations at multiple locations simultaneously, enEvolv can generate billions of combinatorial genomic designs.

enEvolv's selection technology allows them to screen strains more quickly than they can build them. Their proprietary sensor engineering platform builds custom sensors, which directly respond to the amount of the desired target molecule produced by each clonal variant.



ENMEX

Tlalnepantla, Mexico State, Mexico
Number of employees: >100

ENMEX PRODUCES FOOD, FEED AND INDUSTRIAL ENZYMES.

About: ENMEX is one of the pioneers in the field of biotechnology. In 1974, we started the production in Mexico of food and industrial grade enzymes. Today we offer reliable alternatives to optimize food, feed and industrial processes, contributing to the care of our environment.

Through our commercial and technological network, we cover Europe, North America, Latin America and South Asia.

Product applications: Biosolutions based on individual enzymes and tailor-made blends for brewery, protein hydrolysis, cheese manufacturing, lactose-free products, animal nutrition, pet food, detergents, and textiles.

Technology: Enmex proprietary microorganisms are a safe source for the production of food-grade microbial enzymes. We produce enzymes through state of the art manufacturing processes, which enables us to deliver world-class liquid, powder, granular and micro-granular enzymes.

KEY FACTS

- FSSC 22000-certified plant with most recent expansion in 2013.
- Distribution center in Europe.
- Main application laboratories for protein hydrolysis, dairy, brewery and detergents.
- Successful record of scaling up and fermentation development projects in our submerged fermentation bioreactors.

PARTNERSHIPS AND FINANCING

ENMEX was born as a joint venture between Arancia Industrial and Miles Laboratories back in the early 1970s. Since 1993, Enmex is 100 percent a Mexican firm, part of Grupo Arancia (www.arancia.com.mx).

EVOLVA

Reinach, Switzerland
Number of employees: 116

EVOLVA IS PRODUCING HIGH-VALUE SPECIALTY INGREDIENTS.

BIOREFINERY CLASSIFICATION: COMMERCIAL
COMMERCIAL | DEMONSTRATION | PILOT

KEY FACT

+ Feedstock: Baker's yeast.

PARTNERSHIPS AND FINANCING

The partners in the BioPreDyn project are developing software tools to facilitate metabolic engineering by the use of computer-based cell models. The PROMYS project has a duration of four years and a total EU funding of € 7.2 million (CHF 8.9 million), of which Evolva's share is 9.8 percent. The PROMYS project is part of the European Commission's 7th Framework Programme for Research ("FP7"). Evolva's role in the project will be to construct a yeast that is able to produce high yields of a taste modulating ingredient.

About: Evolva is a pioneer and global leader in sustainable, fermentation-based approaches to ingredients for health, wellness and nutrition.

Product applications: Evolva's products include stevia, resveratrol, vanillin, nootkatone and valencene.

Technology: We have an array of technologies that allow us to rapidly insert and express tens to hundreds of genes in billions of individual yeast cells in a highly combinatorial fashion. This allows us to explore large numbers of gene combinations and hence find those gene combinations that are necessary to biosynthesize a given ingredient. Funded by the Innovative Medicines Initiative, the CHEM 21 project (Chemical Manufacturing Methods for the 21st Century Pharmaceutical Industries) brings together six pharmaceutical companies, five small- to medium enterprises and research groups, and eight other universities from the United Kingdom and Europe.

GENOMATICA

San Diego, CA

Number of employees: 100

GENOMATICA'S TECHNOLOGY IS PRODUCING 1,4-BUTANEDIOL AT COMMERCIAL SCALE, WITH A SECOND PROCESS FOR BIO-1,3-BUTYLENE GLYCOL IN EARLY COMMERCIALIZATION. TECHNOLOGIES TO PRODUCE BUTADIENE, HEXAMETHYLENEDIAMINE, CAPROLACTAM AND ADIPIC ACID ARE UNDER DEVELOPMENT.

About: Genomatica delivers new manufacturing processes that enable its partners to produce the world's most widely used chemicals from alternative feedstocks, with better economics and greater sustainability than petroleum-based processes.

Product applications: 1,4-Butanediol (BDO) is used in plastics, solvents, electronic chemicals and elastic fibers for the packaging, automotive, textile, and sports and leisure industries. Butylene glycol is used as an ingredient in personal care and cosmetics. Hexamethylenediamine, caprolactam and adipic acid are used to make nylon and polyurethanes. Butadiene is a key raw material for tires, engineering polymers and latex products.

Technology: Genomatica uses its bioengineering platform and extensive intellectual property (~700 patents and applications) to develop highly optimized microorganisms and complete processes for multiple target chemicals.

Genomatica's BIO-BG™ produced in 85,000 liter fermentation tanks

KEY FACTS

- Novamont's plant in Adria, Italy.
- Capacity: 30 kilotons per year.
- Feedstock: Relationships with Cargill, Tate & Lyle and M&G for dextrose sugars and sugars from cellulosic biomass.
- Novamont, a Genomatica licensee, started operation of a 30,000 ton per year Bio-BDO™ plant in Q4 2016. Genomatica has additional licensees for its BDO and other process technologies.

PARTNERSHIPS AND FINANCING

Genomatica has multiple partnerships, including with Novamont, BASF, Cargill, ENI Versalis, Ginkgo Bioworks, plus five new ones signed in the first nine months of 2017 and not yet disclosed. Novamont and BASF have licensed Genomatica's BDO process, and Novamont has had a "notably smooth" startup of its 30,000 ton per year Bio-BDO™ plant.

BIOREFINERY CLASSIFICATION: COMMERCIAL | DEMONSTRATION | PILOT

GFBIOCHEMICALS

Geleen, Netherlands

GFBIOCHEMICALS FOCUSES ON THE PRODUCTION, MARKETING AND COMMERCIALIZATION OF LEVULINATES AND LEVULINATE KETALS.

BIOREFINERY CLASSIFICATION: DEMONSTRATION

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Pilot plant, Process & Application Development, Minneapolis, MN.
+ Capacity: 3 million pounds per year.
+ GFBiochemicals levulinic acid demonstration plant in Caserta, Italy.

PARTNERSHIPS AND FINANCING

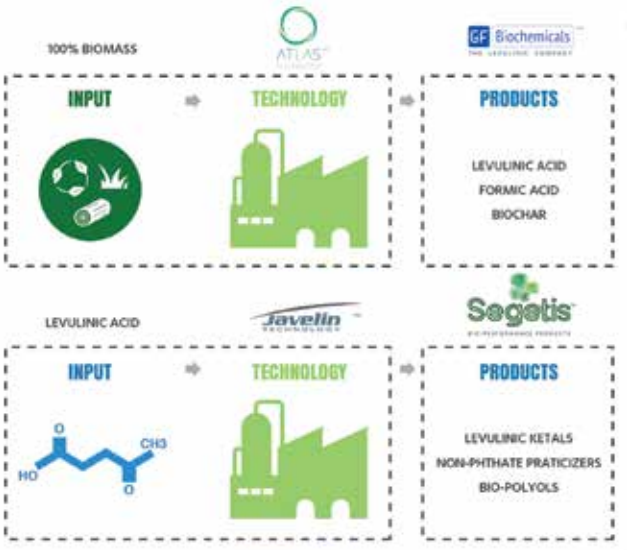
+ GFBiochemicals is owned by private investors.

About: GFBiochemicals is the owner and developer of the process for producing levulinic acid directly from biomass.

Technology: GFBiochemicals developed and proved the ATLAS™ technology to produce levulinic acid through a one-step process directly from cellulosic feedstock.

The JAVELIN™ technology allows the production of biosolvents and formulations aids, such as levulinate ketals and esters, that are highly appreciated in several markets and applications, ranging from metal cleaning, to metal remanufacturing, industrial plants cleaning, industrial and institutional cleaning and personal care.

The main drive for the adoption of these biobased solvents, degreasers and carriers is regulatory pressure on incumbents, as well as the need for non-harmful alternatives for human health and the environment.



GINKGO BIOWORKS

Boston, MA

Number of employees: ~180

GINKGO BIOWORKS DESIGNS CUSTOM MICROBES AND ENZYMES.

GINKGO BIOWORKS™ THE ORGANISM COMPANY

About: Headquartered in Boston, Ginkgo Bioworks uses the most advanced technology on the planet – biology – to grow products instead of manufacturing them. The company's technology platform is bringing biotechnology into consumer goods markets, enabling fragrance, cosmetic, nutrition, agriculture, pharmaceutical and food companies and more to make better products.

Product applications: Fragrances, foods, flavors, agriculture, pharmaceuticals, and more.

Technology: Ginkgo has developed a high-throughput, automated platform to engineer organisms that create products for use in a number of industries.

Ginkgo's facilities span over 70,000 square feet. Its first foundry, Bioworks1, opened in 2015, followed by Bioworks2 in 2016 and Bioworks in 2017. Engineers use software and a database of thousands of enzymes to design and rapidly prototype new strains. With over 500,000 automated operations per month, Ginkgo's foundries accelerate the bioengineering process and enable economies of scale. At present the company is the world's leading designer of synthetic DNA.

KEY FACTS

- Boston, MA
- Capacity: 70,000 square feet of facilities.
- 1.7 billion base pairs of designed DNA contracted to order.

PARTNERSHIPS AND FINANCING

In May 2017, Ginkgo and Robertet USA announced the successful commercial-scale fermentation of a key flavor and fragrance ingredient.

In January 2017, Ginkgo Bioworks announced the acquisition of Gen9, a pioneer in the synthesis and assembly of DNA.

Announced its Series D in December 2017. Ginkgo has raised $429 million in funding from investors, including Cascade Investment, Bill Gates' investing group, General Atlantic, Viking, and Baillie Gifford.

Formed a $100 million joint venture with Bayer focused on sustainable agriculture.

Has a contract with the Defense Advanced Research Projects Agency (DARPA), the Department of Defense's tech research arm, to develop probiotics to treat antibiotic-resistant microorganisms .

Has partnerships with companies like Cargill, Kerry, Ajinomoto, and Archer Daniels Midland.

TECHNOLOGY CLASSIFICATION: COMMERCIAL

PILOT DEMONSTRATION COMMERCIAL

GRAIN PROCESSING CORPORATION

Muscatine, IA

GRAIN PROCESSING CORPORATION PRODUCES CORN-BASED PRODUCTS, LIKE MALTODEXTRINS, STARCHES, ETHYL ALCOHOL AND CORN SYRUP.

BIOREFINERY CLASSIFICATION: COMMERCIAL | PILOT | DEMONSTRATION | COMMERCIAL

KEY FACTS

- GPC has manufacturing facilities in Muscatine, IA and Washington, IN.
- Feedstock: Corn.
- GPC has offices in Hong Kong, China; Muensingen, Switzerland; The Hague, Netherlands; and Mexico City, Mexico.

PARTNERSHIPS AND FINANCING

GPC is a wholly owned subsidiary of Kent Corporation, a private, family-owned corporation based in Muscatine, IA.

In May 2015, GPC announced a $48 million expansion project to increase alcohol production at their Muscatine, IA, corn wet milling plant.

About: Grain Processing Corporation (GPC) is a privately owned company with a solid history of innovation and a vision for continued success in the future. Our chosen mission is to manufacture, distribute and market customer-specified food, nutraceutical and industrial-grade products of uncompromising quality.

Product applications: Beverages, food products, nutraceuticals, pharmaceuticals, personal care, paper and textiles, animal nutrition.

Technology: GPC utilizes a wet-milling process to efficiently separate corn into its various components: starch, protein, fiber and germ. The starch fraction is used to produce primary products that serve a wide variety of industries, including food, ethyl alcohol, nutraceutical, personal care and industrial starch. The remaining protein and fiber fractions are used to produce coproducts or animal feed. The co-products are used as a nutrition source in the livestock and pet food industries. GPC utilizes the entire corn kernel to produce its ingredients; any remaining streams are converted to biogas, which is substituted for natural gas to provide process heat and lower energy costs.

MALTRIN® is the registered trademark for maltodextrins and corn syrup solids produced by GPC. The production process of MALTRIN® maltodextrins and corn syrup solids begins with corn starch slurry from the wet-milling operation. The starch in water slurry is hydrolyzed with food-grade acids and/or enzymes. The hydrolysis is controlled to achieve the desired endpoint. The resulting syrup is then refined by filtering and carbon treatment prior to spray drying. The spray-dried powder is packaged or agglomerated and packaged.

GREEN BIOLOGICS

Medina, OH

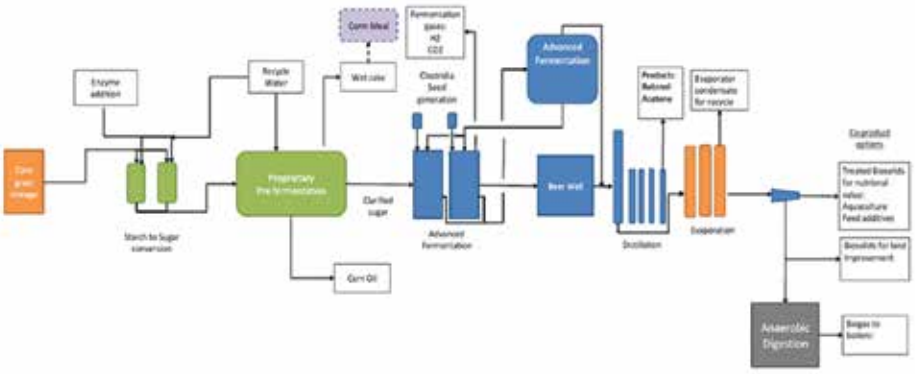
Number of employees: 61 (in U.S. operations)

GREEN BIOLOGICS IS PRODUCING 100 PERCENT BIOBASED, RENEWABLE *N*-BUTANOL, ACETONE, ISOPROPANOL AND ASSOCIATED DERIVATIVES.

About: Green Biologics, Ltd. (GBL) is developing technologies for the production of renewable specialty chemicals that reduce greenhouse gas emissions, create rural jobs and a sustainable value chain for a global green economy.

Product applications: *n*-Butanol is used in paints and coatings, consumer fuels, and as an intermediate in the production of household, institutional, and industrial products as well as plasticizers, esters and amines. Acetone is used extensively as a solvent in paints, coatings, adhesives, inks, personal care and food applications.

Technology: We use microbial engineering and synthetic biology tools to continually expand our robust library of *Clostridium* microbial strains, which are used as biocatalysts as part of our Advanced Fermentation Process (AFP)™.



KEY FACTS

+ Little Falls, MN
+ Capacity: 30,000 metric tons per year.
+ Feedstock: Corn.

PARTNERSHIPS AND FINANCING

GBL was founded in Oxford in 2003 and moved to its current location in 2005. On January 1, 2012, GBL merged with Butylfuel™ Inc. (BF), a Gahanna, OH company founded in 1991.

GBL has raised well over $100 million in equity financing from investors and venture capital firms including Sofinnova Partners, Swire Pacific Limited, Capricorn Venture Partners, Tennenbaum Capital Partners (TCP), Oxford Capital Partners, ConVergInce Holdings, the Carbon Trust and Morningside Group.

In 2014, GBL received a $500,000 grant from the Minnesota Department of Agriculture to support the engineering for repurpose of an ethanol facility in Little Falls, MN. www.greenbiologics.com.

BIOREFINERY CLASSIFICATION: COMMERCIAL | DEMONSTRATION | PILOT | COMMERCIAL

GREENLIGHT BIOSCIENCES

Medford, MA

Number of employees: <50

GREENLIGHT BIOSCIENCES MANUFACTURES RIBONUCLEIC ACIDS (RNAS) FOR AGRICULTURE AND HEALTH APPLICATIONS.

TECHNOLOGY CLASSIFICATION: LABORATORY | DEMONSTRATION | COMMERCIAL

KEY FACTS

- Boston Facility, Medford, MA – laboratory-scale RNA production and health care solutions.
- RTP Facility, Durham, NC – bioherbicide and plant disease solutions.
- Saint Louis Facility, MO – bioinsecticide solutions.

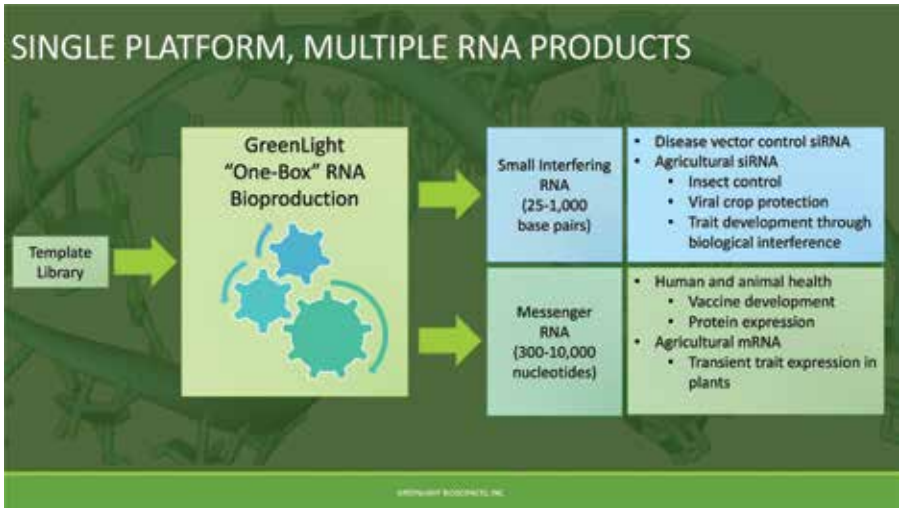
PARTNERSHIPS AND FINANCING

In September 2017, GreenLight Biosciences announced the completion of an $18 million Series D round of financing led by Fall Line Capital. Additional participants included S2G Ventures, Lewis and Clark Ventures, and Macro Capital Investments, along with the majority of GreenLight's existing investors - Kodiak Venture Partners, MLSCF and Syngenta Ventures.

About: GreenLight Biosciences' focus is on the development of RNA-based products for agriculture, public health, vaccines and human therapeutics. GreenLight's Cell-Free Bioprocessing® method for RNA production allows for a dramatic reduction in manufacturing costs and has a demonstrated scalability for a wide range of applications, placing Greenlight at the forefront of the RNA revolution.

Product applications: Biopesticide, bioinsecticide, bioherbicide, bio-fungicide, mRNA vaccine, mRNA therapeutics, and vector control.

Technology: Small interfering RNAs (siRNAs) can be used to stop disease in humans and animals; messenger RNAs (mRNAs) can be used as highly effective vaccines to control infectious disease; and double-stranded RNAs (dsRNAs) have been used in agriculture to selectively control insects.



HELIAE

Gilbert, AZ

Number of employees: 100

HELIAE IS CURRENTLY PRODUCING HIGH-VALUE PRODUCTS DERIVED FROM MICROALGAE. HELIAE PRODUCES A NUMBER OF AGRICULTURAL AND ANIMAL FEED PRODUCTS AT COMMERCIAL SCALE.

About: Heliae® is a platform technology company using sunlight and low-cost carbon feedstocks to produce a wide range of high-value products from microalgae and similar emerging biological systems, with a long term vision of producing a sustainable source of high-quality, low-cost protein, materials, and related products.

Product applications: Human and animal health, agriculture, aquaculture, materials and technology services.

Technology: While experts in phototrophic microalgae production and heterotrophic growth systems introduced in 2017, Heliae's mixotrophic algae production platform sets it apart from the industry. Mixotrophy is a hybrid of known phototrophic and heterotrophic models, which decreases capital costs, improves contamination control and increases productivity and product optionality.

Heliae offers technology and facility development services, contract research and manufacture, and maintains a robust pipeline of materials and human/animal health products.

In an effort to support the growth of algae as a sustainable resource, Heliae provides a full range of facility development services around the world. Such projects may range in scope, scale and production potential.

KEY FACTS

+ Gilbert, AZ
+ Capacity: 160 MT per year.
+ Feedstock: Microalgae and other underdeveloped biological platforms.

PARTNERSHIPS AND FINANCING

Heliae led a joint venture – named Alvita Corp. – with Japan-based Sincere Corporation, a waste management and recycling company, in the development of a commercial algae production facility in Saga City, Japan. The facility opened in October 2016. Heliae continues research partnerships with a number of universities and companies across industries and technology areas.

Heliae is privately held.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

ICM

Colwich, KS

Number of employees: 350

ICM SUPPLIES TECHNOLOGY FOR BOTH GRAIN AND CELLULOSIC ETHANOL PRODUCTION AND IS A LEADER IN THE DEVELOPMENT OF HIGH-PROTEIN ANIMAL FEEDS.

BIOREFINERY CLASSIFICATION: PILOT

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ ICM has an extensive pilot plant in St. Joseph, MO, which has capabilites to develop bio and chemical processes in grain and cellulosic ethanol along with biochemical and other materials.

PARTNERSHIPS AND FINANCING

ICM is constructing ELEMENT, a 70 million gallon per year biorefinery, in Colwich, KS, with start-up scheduled in early 2019. ELEMENT features ICM's newest technologies focused on the efficient production of low-carbon grain ethanol, including about 5 million gallons per year of cellulosic ethanol from ICM's patented Gen 1.5 technology. Most of the energy for the plant will come from the gasification of wood waste, using ICM's Advanced Gasification System technology.

In August 2017, ICM announced the start-up of FS Bioenergia, Brazil's first stand-alone dry-mill grain ethanol plant.

About: ICM, Inc. is a world leader in innovative technologies and services to sustain agriculture and advance renewable energy, including food and feed technologies that will increase the supply of world protein. By providing proprietary process technology to more than 100 facilities globally with a combined annual production capacity of approximately 8.8 billion gallons of ethanol and 25 million tons of distiller's feed products, ICM has become a world leader in biorefining technology. ICM builds new plants, retrofits existing plants and provides technological solutions to improve efficiency, cost and energy consumption and to create a suite of next-generation animal feed products.

Product applications: Fuels, animal feed, food grade corn oil.

Technology: ICM's ethanol plant design is the world leader in efficient, easy-to-operate plants.

ICM has pioneered in the production of advanced animal feed products from an ethanol plant infrastructure, starting with high-protein distillers grains and now moving on to other high-protein streams, which improves the sustainability of the ethanol plant and increases profitability.

Multiple new technologies are available that increase the productivity and efficiency and reduce costs of ethanol plants. Energy efficiency is a major focus.

Cellulosic ethanol from corn fiber is a major focus and we are starting installation of our first Generation 1.5 Grain Fiber to Cellulosic Ethanol Technology™ (Gen 1.5) in 2018.

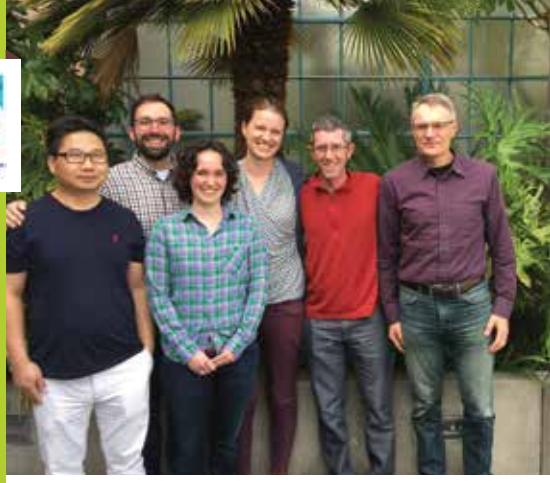
ICM has developed leading gasification technology to dramatically reduce the carbon footprint of facilities and reduce waste streams.

INDUSTRIAL MICROBES

Emeryville, CA

Number of employees: 5

INDUSTRIAL MICROBES IS ENGINEERING NEW BIOCATALYSTS FOR UPGRADING METHANE AND BIOGAS.



Above: iMicrobe team including (second from left-to-right) CEO Derek Greenfield, scientist Stephanie Jones, CTO Elizabeth Clarke, CSO Noah Helman, adviser Olivier Marie.

About: Industrial Microbes is producing a licensable technology package that will allow chemical producers to manufacture sustainable chemicals from methane, dramatically lowering feedstock costs. Methane can be sourced from natural gas or biogas and used instead of or in addition to sugars.

Product applications: Target chemicals include commodity and specialty chemicals, such as methanol, plastic monomers, amino acids, organic acids.

Technology: Industrial Microbes moves enzymes and pathways from methanotrophs into industrial organisms. The resulting strains have improved properties for converting low-cost carbon into chemicals. Demonstrated organisms include multiple species of bacteria and yeast, and our flagship products are in production at laboratory scale.

KEY FACTS

+ Synthetic biology startup, founded by ex-LS9 team, achieved breakthrough in expression of the soluble methane monooxygenase in industrial microorganisms.

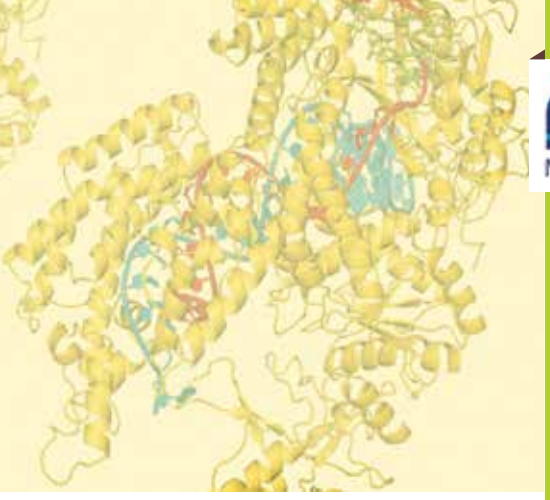
PARTNERSHIPS AND FINANCING

In June 2017, Industrial Microbes won the Imagine Chemistry Challenge to jointly develop our technology with AkzoNobel. The project goals are biobased and sustainable production of ethylene oxide using engineered biocatalysts.

Industrial Microbes is backed by Silicon Valley investors led by Y Combinator. The company was selected as a Round 1 winner in the Emissions Reduction Alberta (ERA) Grand Carbon Challenge in 2014 and has also received grants by the U.S. National Science Foundation, Environmental Protection Agency, Department of Agriculture (USDA), and Department of Energy.

TECHNOLOGY CLASSIFICATION: LABORATORY

COMMERCIAL | DEMONSTRATION | LABORATORY



INSCRIPTA

INSCRIPTA

Boulder, CO

INSCRIPTA PROVIDES GENE-EDITING TECHNOLOGY SOLUTIONS.

Below: Inscripta CEO Kevin Ness

KEY FACTS

+ Headquartered in Boulder, CO.
+ Offices also in Pleasanton, CA.

PARTNERSHIPS AND FINANCING

$23 million in Series B financing, led by Venrock and including Foresite Capital and Paladin Capital as well as Series A investors NanoDimension and Spruce/MLS.

About: Inscripta is a gene-editing technology company dedicated to creating the tools needed to revolutionize how we feed, fuel, and heal humanity. Inscripta provides full solutions (including enzymes, reagents, instrumentation and software) to academic and commercial researchers whose imagination is far outpacing the capacity of available tools for forward cell engineering. Formerly known as Muse Biotechnology, Inscripta is led by several genomic technology veterans, including CEO Kevin Ness, who co-founded QuantaLife and 10x Genomics, and John Stuelpnagel, the chair of the company's board, who was co-founder and first CEO of Illumina.

Product applications: Forward-engineered enzymes, proteins, pathways and strains for synthetic biology applications.

Technology: Inscripta is developing a family of CRISPR enzymes (called MADzymes), bespoke nucleases for researchers and commercial partners, and a full suite of gene-editing tools that will significantly increase the speed and efficiency of high-throughput precision gene editing, using a novel platform. In December 2017, Inscripta released one of its own, unique CRISPR enzymes, called MAD7, which is free for all researchers to use without up-front licensing fees or onerous "reach through" royalties. Future MADzymes will benefit from Inscripta's high-throughput, multiplexed genetic engineering platform to create enhanced enzymes for specific customer applications.

ITACONIX

Stratham, NH and Deeside, United Kingdom

Number of employees: 25

ITACONIX'S GROWING LINE OF NOVEL POLYMERS UTILIZE THE UNIQUE FUNCTIONALITY OF ITACONIC ACID TO MEET CUSTOMER NEEDS FOR SAFER CHEMICALS.

About: Itaconix Corporation (LON:ITX) is a biobased specialty chemicals company developing highly functional polymers from itaconic acid that achieve three essential objectives – safety, performance and sustainability.

In 2016, Itaconix merged into Revolymer plc (now known as Itaconix plc), a publicly traded company on the London Stock Exchange AIM market.

Product applications: Itaconix® DSP™ for hard water conditioning in consumer, agricultural, and industrial uses. Itaconix® CHT™ for spotting/filming prevention in automatic dishwashing. Itaconix® VELASOFT™ for foam and skin conditioning in skin products. Itaconix® ZINADOR™ for odor neutralization. Itaconix® XDP™ for dispersing minerals. Itaconix® TSI™ for anti-scaling. Itaconix® BIOBIND™ for binding in coatings and adhesives. RevCoat™ BOND for adhesion promotion in hybrid sealents. RevCare™ NE100S for hair styling. Itaconix® SAP for adsorption in diapers and feminine care.

Technology: Itaconix's broad intellectual property platform covers processes, compositions and applications for polymers of itaconic acid.

KEY FACTS

+ Stratham, NH
+ Deeside, United Kingdom
+ Feedstock: Corn.

PARTNERSHIPS AND FINANCING

In September 2017, Itaconix signed an application area agreement with the chelates business of AkzoNobel Specialty Chemicals.

In July 2017, Itaconix signed an application area agreement with the performance additives business of AkzoNobel Specialty Chemicals.

In January 2017, Itaconix signed a joint development agreement with AkzoNobel Specialty Chemicals to develop commercial collaborations in relevant application areas.

In January 2017, Itaconix signed a worldwide supply and joint marketing agreement with Croda for its ZINADOR odor removal product.

In 2014, Itaconix received a Phase II Small Business Innovation Research (SBIR) grant from the National Science Foundation for the development of biobased latex resins.

KALION, INC.

KALION

Milton, MA

Number of employees: 3

KALION DEVELOPS GLUCARIC ACID AND RELATED MOLECULES.

Above: Akash Narani, bioprocess engineer, ABPDU.

TECHNOLOGY CLASSIFICATION: PILOT

COMMERCIAL | DEMONSTRATION | PILOT

KEY PARTNERS

+ Berkeley, CA
+ Lawrence Berkeley National Lab, Advanced Biofuels Process Development Unit (ABPDU).
+ Athens, GA
+ Bioexpession and Fermentation Facility, University of Georgia.

PARTNERSHIPS AND FINANCING

In April 2017, the U.S. Department of Energy selected 38 companies to receive Small Business Vouchers to work with a national lab to pilot new technologies. Kalion was selected to work with Lawrence Berkeley National Lab.

In March 2016, Kalion announced a collaboration with the Warner Babcock Institute for Green Chemistry to develop prototypes for a wide array of novel products derived from glucaric acid.

About: Kalion, Inc. is an early-stage industrial biotech company that provides low-cost access to high-purity glucaric acid and related molecules, using traditional, green, fermentation technology.

Product applications: Glucaric acid is a building block for fibers, coatings and detergents. Glucaric acid is used as a high-value pharmaceutical and nutraceutical ingredient, as well as an additive and potentially for novel polymers. Additional nutraceutical ingredients can also be derived from the pathway.

Technology: Glucaric acid acts as an anti-plasticizer for large chemical markets, including polyvinyl alcohol (PVA) and polyacrylonitrile (PAN). Glucaric can provide major improvements to processability and mechanical properties of existing polymers. Performance typically doubles – although, in one case toughness improved by an order of magnitude. These properties offer a major launching point for the potential impact of this truly novel molecule.

For Kalion, the challenge is providing an effective path to commercialization that allows for high-value products to generate cash, while de-risking the effort so that large-scale, cost-effective and dedicated facilities can be built. Kalion is developing chromosomally integrated genes in the host organisms involved in its biological production process. By integrating the genes, Kalion will be able to lower the production costs by improving yields and stability in the fermentation process and increasing by 50 percent to 150 percent the amount of time during which the system is able to function most productively, thereby increasing concentrations.

KIVERDI

Hayward, CA

Number of employees: <50

KIVERDI PRODUCES PROTEINS AND HIGH-VALUE OILS, LIKE CITRUS OIL AND OMEGA-7 OILS.

About: Kiverdi, Inc. is a privately held biotech company developing beneficial uses of carbon dioxide with a mission to commercialize innovations that will help to sustainably power a growing world. Similar to plants, The Kiverdi process requires three to four orders of magnitude less land than traditional agriculture and significantly less water, and can be fed a concentrated source of carbon dioxide as one might do with a greenhouse or a vertical farm. By recycling carbon dioxide, Kiverdi is addressing the growing demand for cost-competitive, sustainably sourced products that have a low-carbon footprint and do not rely upon diverted food crops. Kiverdi is bridging the gap between sustainability and profitability.

Product applications: Food, feed, biostimulant, detergents, cosmetics, paints, packaging materials, high-value oils.

Technology: Kiverdi's technology transforms carbon dioxide into biobased products without the need for light. This transformation happens inside of a bioreactor specifically designed for gas bioprocessing. The agents of transformation are a special class of microbes, specifically hydrogenotrophs, which are chemoautotrophic and use the carbon gases as nutrients, converting those gases into biobased products like oils and proteins.

KEY FACTS

+ Hayward, CA
+ Kiverdi's technology has been developed in partnership with Lawrence Berkeley National Laboratory.

PARTNERSHIPS AND FINANCING

In October 2017, Agile BioFoundry announced that Kiverdi was one of seven projects selected under a recent $5 million directed funding opportunity.

In September 2017, Kiverdi announced that they have joined the Valorisation Carbone Québec (VCQ) Project as a carbon use partner.

Kiverdi has received funding from the U.S. Department of Energy, the California Energy Commission, and the Iowa Economic Development Authority.

TECHNOLOGY CLASSIFICATION: LABORATORY

COMMERCIAL | DEMONSTRATION | LABORATORY

LANZATECH

Chicago, IL

Number of employees: 140

LANZATECH'S PRODUCT SUITE INCLUDES ETHANOL, 2,3-BUTANEDIOL, 1,3-BUTADIENE, ACETIC ACID, ISOPROPANOL, AND ISOBUTYLENE.

BIOREFINERY CLASSIFICATION: COMMERCIAL | PILOT | DEMONSTRATION | COMMERCIAL

KEY FACTS

- LanzaTech Freedom Pines Biorefinery, Soperton, GA
- Feedstock: Biomass (including MSW) synthesis gas, industrial waste gases, biogas.

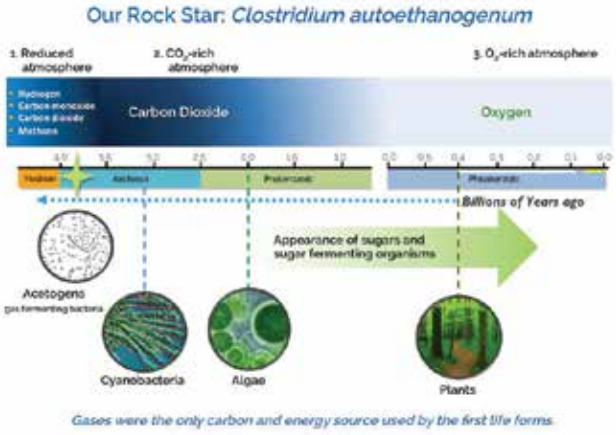
PARTNERSHIPS AND FINANCING

Led by Mitsui & Co., in 2014, the $112 million Series D round included new investors New Zealand Superannuation Fund, Siemens Venture Capital, CICC Growth Capital Fund I, L.P. and Khosla Ventures, Qiming Venture Partners, K1W1 and the Malaysian Life Sciences Capital Fund. LanzaTech has global partnerships across multiple sectors and along the supply chain, from steel, chemicals, aviation and banking.

About: LanzaTech's biological carbon recycling technology opens up new resources for making low-carbon chemicals and fuels. LanzaTech presents a "carbon smart" future where you can choose where the carbon in your products comes from.

Product applications: Styrene-butadiene rubber, plastics, textiles, resins, polyurethane, adhesives, solvents, coatings, paints, fuels, de-icers, cosmetics, pharmaceuticals, personal care, and food.

Technology: Using microbes *(Clostridium autoethanogenum)* that ferment gases (rather than sugars), carbon-rich waste gases and residues are transformed into useful liquid commodities.



LEAF RESOURCES

Eight Mile Plains, Queensland, Australia
Number of employees: <10

LEAF RESOURCES CONVERTS PLANT BIOMASS INTO CLEAN CELLULOSIC SUGARS, LIGNIN AND REFINED GLYCEROL.

About: Leaf Resources is a world-leading industrial biotechnology company converting plant biomass into sustainable everyday products.

Leaf's Glycell™ process converts biomass into industrial sugars – a key component used in producing green and sustainable chemicals. Clean, cellulosic sugars are a major feedstock in the production of renewable chemicals, which have the potential to replace virtually all petroleum-derived chemicals that we use today, with significant carbon and energy savings. These renewable chemicals are then used in the production of everyday household items, such as plastics, paints and synthetic textiles, just to name a few.

Leaf's Glycell™ process is a disruptive technology that not only provides an environmentally friendly alternative to chemical manufacturing, but also competes on price and performance. Leaf Resources is working towards commercialization of its first second-generation biorefinery, in Malaysia.

Product applications: Made from renewable sources, Glycell™ cellulosic sugars deliver high performance for conversion to bioplastics, biobased chemicals and biofuels. The Lignin Barrier Coating (LEAFcoat) is a renewable, biodegradable and recyclable coating ideal for the cardboard, food and beverage packaging, and paper mulch markets.

Technology: Leaf Resources' pretreatment technology – the Glycell™ Process – uses waste glycerol to break down plant biomass at a lower temperature and pressure than conventional approaches, while generating a higher yield of cellulose. The cellulose is then converted to cellulosic sugars through enzymatic hydrolysis, and the lignin, hemicellulose and glycerol become coproducts. The Glycell™ process produces larger quantities of clean sugars at a much faster rate than rival processes.

KEY FACTS

In October 2016, Leaf signed a Memorandum of Understanding with Agensi Inovasi Malaysia and a Letter of Facilitation and Collaboration with Malaysian Bioeconomy Development Corporation to develop at least one commercial biorefinery or second-generation sugar project in Johor and Sarawak, Malaysia.

PARTNERSHIPS AND FINANCING

In November 2017, Leaf Malaysia signed a term sheet for a Malaysian biorefinery site.

In October 2017, Leaf Resources licensed a biodegradable coating product from QUT bluebox, the commercial arm of the Queensland University of Technology. The license is exclusive for Malaysia, United States, Canada and Brazil.

In July 2017, the Queensland state government provided financial incentives from its Biofutures Action Plan fund to help Leaf Resources scope out a potential location for a biorefinery site.

In December 2016, Leaf announced a collaboration with Novozymes to customize enzymes to the Glycell™ process.

In July 2016, Leaf Resources entered into a joint venture with Claeris HoldCo LLC to develop up to five renewable chemical projects.

Above: Lygos CEO Eric Steen (back row, second from left), CTO Jeffrey Dietrich (middle row, second from right) and team at ABPDU.

LYGOS

Berkeley, CA

Number of employees: 43

LYGOS PRODUCES MULTIFUNCTIONAL BIOMONOMERS.

TECHNOLOGY CLASSIFICATION: PILOT

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Advanced Biofuels Process Demonstration Unit (ABPDU) at Lawrence Berkeley National Laboratory.

PARTNERSHIPS AND FINANCING

Lygos is venture-backed and has funding from the U.S. Department of Energy (DOE), U.S. Department of Agriculture, and the National Science Foundation.

In November 2017, Lygos announced a major technical milestone scaling Bio-Malonic™ manufacturing.

In October 2017, Lygos announced a partnership with Agile BioFoundry and DOE to accelerate bioproduct research, development and commercialization.

In December 2016, Lygos closed a $13 million Series A funding round led by OS Fund and IA Ventures, with participation from First Round Capital, Y Combinator's Continuity Fund, Fifty Years, Vast Ventures and various angel investors.

In May 2016, Lygos and Sirrus, Inc., jointly announced that Sirrus has synthesized its Chemilian™ 1,1 di-substituted alkenes using Lygos' "bio-DEM."

About: Lygos makes microbial-based manufacturing solutions. Lygos' first products – Bio-Malonic Acid™ and derivatives – replace petrochemical products. Malonic acid is a C3-dicarboxylic acid with a wide variety of applications, but demand has been held back because its production is expensive and environmentally hazardous. The company was founded in 2011 as a spin-off from the lab of Professor Jay Keasling, Director of the Joint BioEnergy Institute in California.

In July 2017, Lygos appointed industry expert Johan van Walsem as COO to lead commercial operations.

Product applications: Flavors, fragrances, pharmaceuticals, solvents, adhesives.

Technology: Lygos engineered acid-tolerant yeast to produce specialty chemicals. Its flagship product is malonic acid, which is produced from sugar and CO_2. The process uses low-cost microbial fermentation technology.

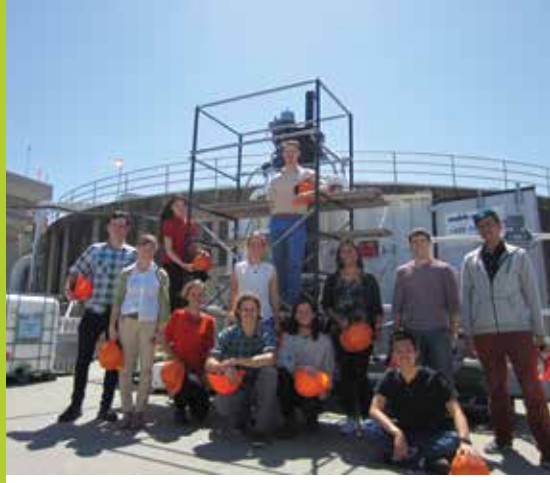
Many of their target products are organic acids, which can be produced at high theoretical yield microbially. A high-yielding process means less sugar is required to produce each kilogram of product – decreasing operating costs and lowering exposure to changing raw material prices.

MANGO MATERIALS

Oakland, CA

Number of employees: 17

MANGO MATERIALS PRODUCES POLYHYDROXYBUTYRATE (PHB) FOR USE IN BIOPLASTICS AND BIOMATERIALS.



MANGOMATERIALS™

About: Mango Materials produces a naturally occurring biopolymer from waste biogas (methane) that is economically competitive with conventional oil-based materials. Mango Materials is a start-up with a first-class team of engineers, scientists, entrepreneurs and innovators. Mango Materials was incorporated in 2010 and received its first round of funding in 2011.

Product applications: Fashion and other fibers, cosmetic and beauty packaging.

Technology: Mango Materials' process takes captured methane and feeds it to methanotrophs, a type of bacteria that consumes the methane and turns it into biopolymer granules. That biopolymer can then be used to create fabrics or bioplastics. The process does not need to be centralized.

Above: Mango Materials team, including VP of Customer Engagement Anne Schauer-Gimenez (second from left), CEO Molly Morse (fourth from left), and CTO Allison Pieja (sixth from left).

KEY FACTS

+ Redwood City, CA

PARTNERSHIPS AND FINANCING

In October 2017, Mango was selected for a National Aeronautics and Space Administration (NASA) Phase II Small Business Technology Transfer (STTR) grant.

In 2012, Mango won the Postcode Lottery Green Challenge competition, which came with a $630,000 prize and which allowed the company to begin producing sample products.

In 2013, Mango was awarded a $500,000 Phase II award from the U.S. National Science Foundation (NSF). The company has received a total investment of $1.56 million from NSF.

Partnered with NASA and Colorado School of Mines on two STTR projects to explore production of biopolymers in a microgravity environment.

BIOREFINERY CLASSIFICATION: PILOT

COMMERCIAL | DEMONSTRATION | PILOT

MANUS BIO

Cambridge, MA

Number of employees: 15

MANUS BIO'S FIRST CHASSIS PRODUCES NATURAL PRODUCT CHEMICALS AND ENZYMES.

BIOREFINERY CLASSIFICATION: DEMONSTRATION

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Feedstock: Glucose and glycerol.

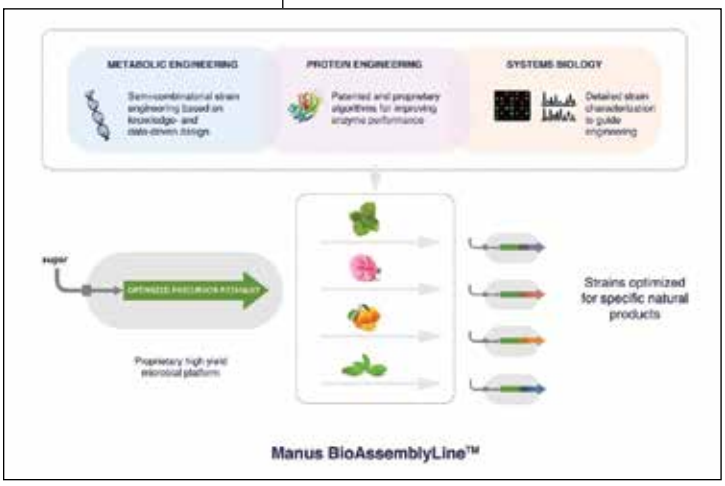
PARTNERSHIPS AND FINANCING

$25 million in non-dilutive funding from early adopting customers. Additional financing from grants (National Science Foundation Small Business Innovation Research, Bill & Melinda Gates Foundation) and equity fundraising, including a Series A financing of over $9 million in December 2017.

About: Manus Bio recreates plant processes in microorganisms to produce natural ingredients through fermentation. Manus Bio's microbial platform has been optimized to convert inexpensive sugar sources into rare and expensive products, providing a low-cost, sustainable, and environmentally friendly source for many ingredients.

Product applications: Flavors, fragrances, food ingredients, sweeteners, neutraceuticals, cosmetic actives, biopesticides, agrochemicals, and pharmaceuticals.

Technology: Manus Bio recreates natural plant processes in microbes using its proprietary commercial strain development platform, which is rooted in modular and data-driven design paired with semi-combinatorial optimization. Manus Bio merges three proprietary technologies – Multivariate Modular Metabolic Engineering (MMME), Pathway Integrated Protein Engineering (PIPE), and Integrated Multivariate Omics Analysis (IMOA) – in order to quickly and efficiently generate microbes that produce a variety of plant-based ingredients. The patented microbial platform has been optimized for high yield of a common precursor pathway, thus making it simple to pursue new products. The use of modular, reconfigurable, and plug-and-play tools and components further shortens the path to commercialization for new ingredients. In essence, Manus Bio has created an efficient BioAssemblyLine™ for the low-cost and sustainable production of an array of high-value natural products.



MBI

Lansing, MI

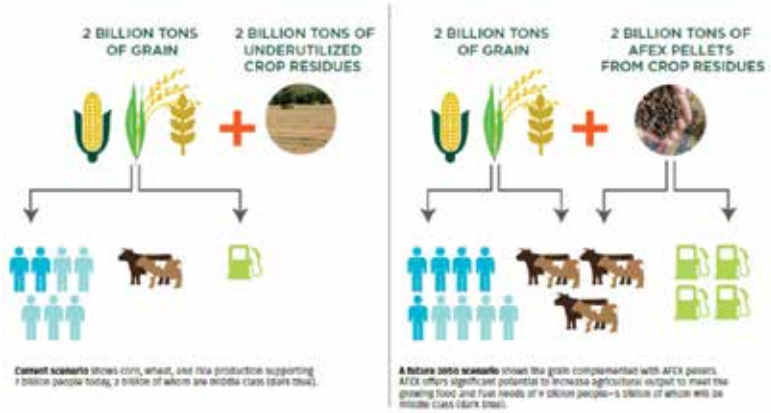
Number of employees: 10

MBI INTERNATIONAL IS COMMERCIALIZING AMMONIA FIBER EXPANSION (AFEX), A TRANSFORMATIONAL BIOTECHNOLOGY THAT SUSTAINABLY EXPANDS OUR CAPACITY TO SUPPLY BOTH FOOD AND ENERGY WHILE IMPROVING ECONOMIC RESILIENCE FOR RURAL COMMUNITIES AROUND THE WORLD.

mbi mission-inspired, market-driven biotech derisking

About: Established in 1981, MBI is closely affiliated with Michigan State University (MSU) and a wholly owned subsidiary of the MSU Foundation. MBI serves as a biotech hub, a technology development and commercialization partner for promising biobased technologies.

Technology: MBI is also licensing patented technologies for the production of biobased fumaric and succinic acid.



KEY FACTS

+ AFEX Pilot Plant, Lansing, MI
+ Feedstock: Corn stover, wheat straw, rice straw, switchgrass.

PARTNERSHIPS AND FINANCING

MBI and MSU have been collaborating under a strategic framework, through which MBI serves as a technology development and commercialization partner for promising biobased technologies.

COMMERCIAL
DEMONSTRATION
PILOT

BIOREFINERY CLASSIFICATION: PILOT

METABOLIC EXPLORER

Saint-Beauzire, France
Number of employees: 70

METABOLIC EXPLORER PRODUCES
1,3-PROPANEDIOL AND BUTYRIC ACID.

BIOREFINERY CLASSIFICATION: COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ METabolic EXplorer has 4,200 square meters of offices, including an integrated pilot facility (from research to manufacturing) located on the Biopôle Clermont-Limagne in Saint-Beauzire, near Clermont-Ferrand, France.

PARTNERSHIPS AND FINANCING

In December 2016, METEX sold its L-methionine technology portfolio to Evonik, a German chemical company, global leader for specialty chemicals.

In June 2017, METEX signed an agreement with TOTAL Développement Régional (TDR) to consider a project to construct a PDO/butyric acid (BA) production facility on TOTAL's Carling Saint-Avold site in Moselle (Greater East Region).

+ First stage: 5 kilotons of PDO and 1 kiloton of butyric acid.
+ Second stage: additional 15 kilotons of PDO and 3 kilotons of butyric acid.

About: A pioneer in industrial biochemistry with some 20 years of experience, METabolic EXplorer (METEX) develops alternative solutions to the petrochemical processes used in manufacturing. Using renewable raw materials, it develops innovative industrial fermentation processes to produce chemical compounds used in basic products of everyday life, such as animal nutrition and health additives, plastics, textiles, cosmetics, and resins, among many others. The company's ambition with its biotechnological innovations is to produce consumer goods in a different way, without oil, in order to meet environmental challenges and consumers' new societal expectations.

Product applications: Animal nutrition and health additives, plastics, textiles, cosmetics.

Technology: METabolic EXplorer uses fermentation to produce basic chemical compounds, offering an alternative to petrochemical-based production. By optimizing the metabolic yield of non-pathogenic bacteria in a contained, controlled environment, the company facilitates the production of chemical compounds used in a wide range of everyday goods. In 2016, nutritional tests conducted on poultry showed 35 percent higher nutritional performance for L-methionine than for petrochemical-based DL-methionine. Offering the feed animal market a competitive biosourced solution, METabolic EXplorer's goal is to become the leading supplier of butyric acid for animal nutrition. Offering cosmetics and biosourced polyesters markets a competitive, non-genetically modified (GMO) 1,3-propanediol (PDO), METEX's goal is to become the top-ranked producer of non-GMO PDO.

MODERN MEADOW

Nutley, NJ

Number of employees: 70

MODERN MEADOW PRODUCES COLLAGEN FOR PRODUCTION OF BIOLEATHER MATERIALS.

Above: Modern Meadow Chief Creative Officer Suzanne Lee and Materials Design Team Lead Amy Congdon.

About: Modern Meadow is pioneering biologically advanced materials. The company harnesses the power of design, biology, and engineering to produce the world's first bioleather materials. Modern Meadow materials enable new design and performance possibilities. The company, by partnering with some of the world's most cherished and innovative consumer brands, aims to bring new life to the material world.

Product applications: Zoa™ Bioleather materials can be applied to similar products where leather is used, such as apparel and accessories.

Technology: Modern Meadow's technology platform uses DNA editing tools to engineer specialized collagen-producing yeast cells. The cells are optimized to manufacture the type and quantity of collagen required. The collagen molecules form a network of fibers, which are then assembled to create biofabricated leather. Because the bioleather materials are designed from the ground up, the company can customize it to be stronger, thinner, or more flexible than traditional leather.

KEY FACTS

+ ON3, Nutley, NJ
+ 72,900 square feet

PARTNERSHIPS AND FINANCING

In October 2017, Modern Meadow launched its brand – Zoa™ – and will partner with brands across multiple consumer goods categories to create products for release within the next 12 to 18 months.

Most recent funding round raised $40 million in Series B – in total, the company has raised $53.5 million.

Investors include Horizons Ventures, Iconiq, Artis Ventures, Temasek Holdings, Breakout Ventures, Red Swan Ventures, Collaborative Fund, and Sequoia.

BIOREFINERY CLASSIFICATION: PILOT

COMMERCIAL | DEMONSTRATION | PILOT




MODULAR GENETICS

Woburn, MA

Number of employees: 6

MODULAR GENETICS IS PRODUCING AN ACYL GLUTAMATE SURFACTANT.

BIOREFINERY CLASSIFICATION: PILOT

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACT

+ Feedstock: Sugar from corn or woody material

PARTNERSHIPS AND FINANCING

Modular Genetics has shown that its surfactant can be produced from sugar derived from rice hulls — a byproduct of rice production. This technology was funded through the NSF Small Business Innovation Research Program. Unilever is testing the new surfactants.

About: Modular Genetics, Inc. is a sustainable chemistry company utilizing advanced technology in synthetic biology to produce specialty chemicals that are cost-competitive, provide superior performance and are environmentally friendly.

Product applications: Detergents, wetting agents, emulsifiers and foaming agents.

Technology: Modular Genetics, Inc.'s automated gene engineering system, CombiGenix™, can synthesize, modify and recombine genes to create novel recombinant DNA molecules by the thousands. By linking CombiGenix™ to sophisticated, proprietary protein design tools and high-throughput screening, Modular has created an automated platform for the evolution of proteins with enhanced functions. Modular has engineered *Bacillus subtilis* strains to convert cellulosic sugar into a surfactant consisting of a fatty acid linked to an amino acid.

MYRIANT

Woburn, MA

Number of employees: 50

MYRIANT IS PRODUCING SUCCINIC ACID (1,4-BUTANEDIOIC ACID), MYRIFILM® COALESCING SOLVENT, MYRINOL™ HP POLYESTER POLYOLS, MYRIBOND™ ADHESION PROMOTING OLIGOMERS, AND UV CURE OLIGOMERS. MYRIANT HAS DEVELOPED TECHNOLOGY TO PRODUCE BIO-ACRYLIC ACID, D- AND L-LACTIC ACID, MUCONIC ACID AND FUMARIC ACID.

About: Myriant Corporation is a global leader innovating and commercializing biobased chemicals.

Product applications: Bioplastics, coatings, adhesives, elastomers, foams, inks, food, fine chemicals, pharmaceutical intermediates.

Technology: To produce biosuccinic acid, Myriant uses a single-step, anaerobic fermentation process that enables higher productivity and yield than other bioproduction processes. Our team of scientists and researchers accomplishes this by developing proprietary biocatalysts – microorganisms, including *E. coli, bacillus, streptomyces, corynebacterium*, and yeast, with altered metabolic pathways – designed to produce our target biochemicals from a variety of feedstocks. The other products are based on biosuccinic acid as a raw material and produced at third-party tolling parters. Myriant has also successfully and efficiently, through molecular biology, shifted the normal metabolic pathway towards the aromatic pathway, allowing efficient production of multiple bioaromatic products and derivatives, such as muconic acid.

KEY FACTS

- Lake Providence, LA
- Capacity: 30 million pounds of biosuccinic acid.
- Feedstock: Dextrose, sorghum grain and sorghum grits.
- With our partner ThyssenKrupp Uhde, we successfully scaled and achieved commercial production of biosuccinic acid at our Lake Providence facility.

PARTNERSHIPS AND FINANCING

Myriant is a subsidiary of PTT Global Chemical Public Company Limited, Thailand's largest and Asia's eighth largest chemical company. Our Lake Providence facility is partially funded through a $50 million cost-sharing award from the United States Department of Energy (DOE), and a Business and Industry (B&I) Loan Guarantee from the United States Department of Agriculture (USDA). Myriant has partnered with Johnson Matthey Davy Technologies (JM Davy) to demonstrate that our biosuccinic acid can be utilized in JM Davy's process as a direct replacement for maleic anhydride to produce biobutanediol.

NATUREWORKS, LLC

Minnetonka, MN

Number of employees: 150

NATUREWORKS IS PRODUCING INGEO™ PERFORMANCE POLYMERS AND VERCET™ PERFORMANCE CHEMICALS.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Blair, NE
+ Capacity: 330 million pounds (150,000 metric tons) of Ingeo™ biopolymer.
+ Feedstock: Greenhouse gases.

PARTNERSHIPS AND FINANCING

NatureWorks is an independent company invested in by Cargill and PTT Global Chemical, who announced a $150 million investment in NatureWorks.

About: NatureWorks, LLC is an advanced materials company offering a broad portfolio of renewably sourced polymers and chemicals to the packaging, polymers, fibers, and chemicals markets.

Product applications: Ingeo™ is a whole new raw material with performance attributes and economics that compete with traditional plastics and fibers. Ingeo™ can make a coffee capsule compostable, become a nonwoven that promotes skin health in a diaper, and simplify transparency in form-fill-seal yogurt packaging.

The recently launched Vercet™ platform is designed to produce custom solutions based on lactides and lactide intermediates for the coatings, adhesives, sealants, and elastomers, toner, and surfactants industries.

Technology: Microorganisms convert sugar into lactic acid through fermentation. A two-step process transforms the lactic acid molecules into rings of lactide. This lactide monomer can be used as the building block for the Vercet™ platform, creating alkyd polyesters, polyols, and polymeric resins. For Ingeo™, the process continues as the lactide ring opens and links together to form the long chain of Ingeo™ polylactide polymer.

Current NatureWorks research and partnerships are focusing on new production technologies that convert greenhouse gases like CO_2 or methane into lactic acid.

NESTE

Espoo, Finland

Number of employees: 5,000

NESTE'S PORTFOLIO OF RENEWABLES INCLUDES RENEWABLE DIESEL, JET FUEL, GASOLINE, PROPANE, AS WELL AS ISOALKANES AND SOLUTIONS FOR CHEMICALS PRODUCTION.

NESTE
The only way is forward

About: Neste builds sustainable solutions for the needs of transport, businesses and consumers. Our global range of products and services allows customers to reduce their carbon footprint by combining high-quality, low-emission renewable products and oil products to tailor-made service solutions. We are the world's largest producer of renewable diesel refined from waste and residues, and we offer renewable solutions also to the aviation and chemical industries.

Product applications: Our renewable chemicals, such as Neste MY Renewable Isoalkane, have a broad range of applications ranging from paints and coatings to lubricants. The biobased polymers we offer together with our partners are a renewable solution for producing parts for cars, packaging, consumer goods and electronics. Our high-performing drop-in renewable fuels benefit consumers, heavy transport, public and private fleets, mining and construction, as well as the aviation sector.

Technology: We refine renewable products with our own NEXBTL technology. It relies on a hydrotreatment process that converts natural oils, such as vegetable oil and a range of industrial wastes and residues, into high-purity isoparaffinic hydrocarbon oils with a low sulfur and aromatic content. Almost any vegetable oil or waste fat can be refined into high-quality renewable fuels and chemicals with this technology.

We use more than 10 different raw materials today to produce Neste MY renewable products. Waste and residue account for 80 percent of our renewable raw material usage.

KEY FACTS

+ We produce Neste MY Renewable Diesel and a range of other renewables in Porvoo, Finland; Rotterdam, Netherlands; and Singapore.
+ Capacity: 21.9 million barrels (2.6 million tons) per year, with plans to increase to 4 million tons by 2022.

PARTNERSHIPS AND FINANCING

In November 2017, we announced fuel distribution partnerships in California with IPC (USA), Inc.; Ramos Oil Company; Van De Pol Petroleum; and Western States Oil.

In November 2017, we entered into an agreement with American Airlines to reduce American's environmental footprint with our renewable fuels.

In January 2017, we announced the start of R&D cooperation with Bioenergy La Tuque in La Tuque, Québec, Canada, to study forest residues as a raw material in biofuel production.

In September 2016, we announced a partnership with IKEA around the production of bioplastics.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

NEWLIGHT TECHNOLOGIES

Costa Mesa, CA

NEWLIGHT TECHNOLOGIES IS USING GREENHOUSE GAS TO PRODUCE AIRCARBON™ POLYHYDROXYALKANOATE (PHA) THERMOPLASTIC.

BIOREFINERY CLASSIFICATION: COMMERCIAL | PILOT | DEMONSTRATION | COMMERCIAL

KEY FACTS

+ Feedstock: Air and captured methane-based farm carbon emissions.

PARTNERSHIPS AND FINANCING

In June 2016, Newlight signed a 20-year master off-take agreement with Vinmar International, Ltd.

Under the terms of the off-take agreement, Vinmar will initially purchase and Newlight will sell 1 billion pounds of AirCarbon PHA, including 100 percent of AirCarbon PHA from Newlight's planned 50 million pound per year production facility for 20 years. The contract will also cover 100 percent of the output from a 300 million pound per year AirCarbon production facility and a 600 million pound per year AirCarbon production facility for a total of up to 19 billion pounds over 20 years.

In October 2016, Newlight signed a supply, collaboration, and production license with IKEA, wherein IKEA will use Newlight's AirCarbon technology to produce up to 10 billion pounds of AirCarbon for use in IKEA home furnishings.

About: Newlight is a sustainable materials company dedicated to using carbon sequestration technology to produce clean, high-performance materials that reduce cost, maintain or improve performance, and capture carbon on a market-driven basis.

Product applications: AirCarbon™ can be used in extrusion, blown film, cast film, thermoforming, fiber spinning, and injection molding applications, replacing fossil-fuel based polypropylene, polyethylene, acrylonitrile butadiene styrene (ABS), polystyrene, and thermoplastic polyurethane (TPU).

Technology: First, concentrated greenhouse gas emissions such as biogas are directed into Newlight's patented conversion reactor. Next, those carbon emissions are combined with air and Newlight's biocatalyst, which pulls oxygen out of air and carbon and hydrogen out of methane. Finally, carbon, oxygen, and hydrogen are reassembled to form a long chain thermopolymer.

NOVOMER

Boston, MA

Number of employees: 50

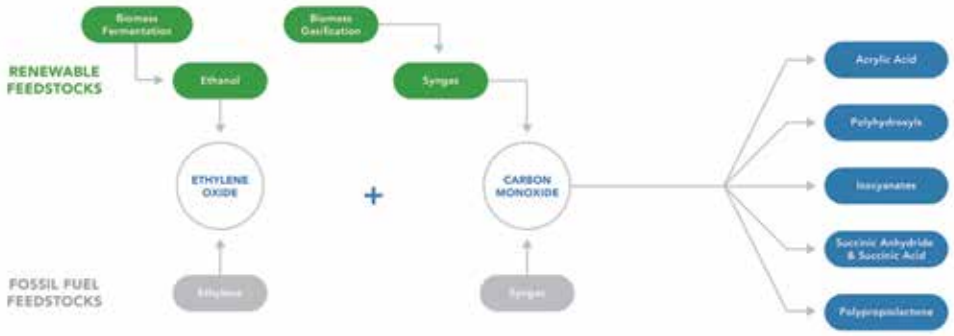
NOVOMER HAS A COETH™ TECHNOLOGY PLATFORM THAT PRODUCES ACRYLIC ACIDS, ACRYLATES, THERMOPLASTICS, POLYMERS, POLYOLS, AND A VARIETY OF OTHER CHEMICALS.

Novomer
Catalyzing Green Chemistry

About: Novomer is a leading materials company commercializing a family of low-cost, high-performance, sustainable polymers and chemicals.

Product applications: Absorbent polymers, paints, packaging materials, fibers, composites, rigid and flexible foams, coatings, adhesives, sealants, elastomers, polyesters, and other plastics.

Technology: Novomer is commercializing a platform that uses biobased carbon monoxide (CO) and ethylene oxide to produce C3 and C4 chemicals. The COEth™ technology platform combines CO with ethylene oxide from bioethanol to form a family of chemicals and novel polymers that can be composed of 100 percent biobased materials.



KEY FACTS

- Planned capacity: 600,000 kilotons per year within five years.
- Feedstock: CO and ethylene oxide.
- Novomer is scaling up production of the COEth™ Process in a demonstration plant in Rochester, NY, and at large-scale operations in Adana, Turkey, and other planned global locations.

PARTNERSHIPS AND FINANCING

Novomer has numerous industry partnerships and a broad array of financial and strategic investors.

BIOREFINERY CLASSIFICATION: COMMERCIAL
COMMERCIAL
DEMONSTRATION
PILOT

ORIGIN MATERIALS

Sacramento, CA

Number of employees: 50

ORIGIN MATERIALS IS PRODUCING FURANS.

BIOREFINERY CLASSIFICATION: PILOT

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Sacramento, CA
+ Feedstock: Wood chips, waste paper, cardboard.

PARTNERSHIPS AND FINANCING

Origin Materials has raised $90 million in financing to date.

About: Origin Materials (formerly Micromidas) produces furanic intermediates – using cellulosic biomass feedstocks such as wood chips, corn stover, sugar cane bagasse, and empty palm fruit bunches – and converts them into both furanic and aromatic chemicals, polymers, and resins.

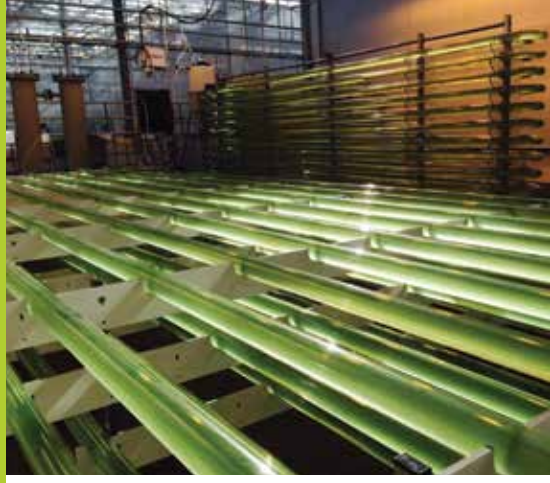
Product applications: Furans are readily derivatized to produce monomers, plasticizers, or renewable (but chemically identical) variants of commodity chemicals such as *para*-xylene.

Technology: The Origin Materials process is a chemo-catalytic process that selectively produces a furan intermediate from feedstocks containing cellulose or hemicellulose.

PHOTANOL

Amsterdam, Netherlands
Number of employees: 9

PHOTANOL PRODUCES LACTIC ACID.

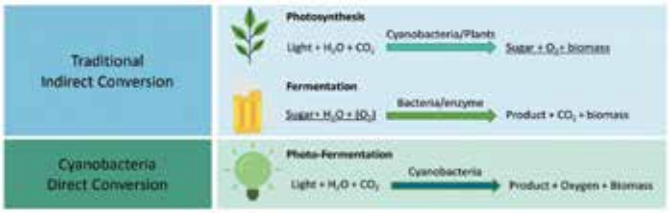


Photanol

About: Photanol is a platform renewable chemicals company that utilizes proprietary, engineered cyanobacteria to process carbon dioxide (CO_2) and sunlight into valuable chemical products.

Product applications: Biochemicals, sweeteners, fragrances, flavorings, coatings and plastic.

Technology: Photanol's technology is based on the genetic modification of cyanobacteria to produce a broad range of biochemicals. These bacteria are natural photosynthesizers, drawing energy from sunlight and carbon from CO_2. These cyanobacteria convert carbon dioxide into sugars; genes are added so the bacteria can ferment those sugars into useful products, like organic acids.



KEY FACTS

+ Science Park, Amsterdam, Netherlands
+ Capacity: 1000 liters.

PARTNERSHIPS AND FINANCING

In September 2014, Photanol and AkzoNobel announced a partnership, utilizing AkzoNobel's processing technology knowledge and Photanol's proprietary technology.

Photanol has received investment from ICOS Capital and UvA Holding.

BIOREFINERY CLASSIFICATION: PILOT

COMMERCIAL
DEMONSTRATION
PILOT

PHYTONIX

Asheville, NC

Number of employees: 10

PHYTONIX IS PRODUCING *N*-BUTANOL.

BIOREFINERY CLASSIFICATION: PILOT

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Black Mountain, NC
+ Feedstock: Carbon dioxide.

PARTNERSHIPS AND FINANCING

Phytonix has several strategic partnerships, including: Uppsala University (Sweden), Arizona State University, and two large multinational industrial corporations.

About: Phytonix Corporation ("Phytonix" or "Px") is an industrial biotechnology company producing sustainable chemicals directly from carbon dioxide. Phytonix's objective is to be the global leader in bio-safe, direct solar chemicals and fuel production utilizing carbon dioxide as the sole feedstock and energy from the sun.

Product applications: Industrial chemical market and fuels.

Technology: Phytonix has developed engineered cyanobacterial species that secrete *n*-butanol in a significantly carbon-negative, photosynthetic process. Phytonix commercial facilities will be a modular and scalable system where the cyanobacteria will grow.

POET

Sioux Falls, SD
Number of employees: 1,800

POET IS PRODUCING BIOFUEL, DAKOTA GOLD® DRIED DISTILLERS GRAINS, AND VOILA™ CORN OIL, AMONG OTHER PRODUCTS.

About: POET, one of the world's largest biofuel producers, is a leader in biorefining, through its efficient, vertically integrated approach to production.

Product applications: Films, packaging, adhesives, edible coatings and glazes, plastics, rubber, asphalt paving additives, and high-energy additive to feed rations.

Technology: Our patented raw starch hydrolysis process, named BPX, converts starch to sugar with a proprietary blend of enzymes, while other biofuel producers use a jet cooker to break down starch with heat. BPX reduces energy use in the plant by 8 to 15 percent and increases yield by 0.10 to 0.15 gallons per bushel. After years of development, we brought the process to commercial scale production in 2004 and it is now deployed in all of our facilities.

KEY FACTS

- **POET Footprint: 27 corn ethanol biorefineries, 1 cellulosic ethanol biorefinery.**
- **Capacity: 1.8 billion gallons per year.**
- **Feedstock: Corn, corn stover.**

PARTNERSHIPS AND FINANCING

In partnership with Royal DSM of the Netherlands, POET-DSM Advanced Biofuels opened a commercial-scale biofuel plant in Emmetsburg, IA – dubbed "Project LIBERTY" – in September 2014. Project LIBERTY's feedstock is corn crop residue – cobs, leaves, husk and some stalk.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

PRAJ MATRIX

Pune, India

Number of employees: 100

PRAJ MATRIX IS DEVELOPING CELLULOSIC ETHANOL, BIOCHEMICALS BASED ON PENTOSE SUGARS, HEXOSE SUGARS AND LIGNIN, AND ADVANCED STRAIN DEVELOPMENT.

BIOREFINERY CLASSIFICATION: DEMONSTRATION

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

- Praj's second-generation integrated biorefinery, Central India – first of its kind plant in the tropics.
- Capacity: 12 tons per day biomass (dry). 1 million liters annually.
- Feedstocks: Corncobs, corn stover, bagasse, cane trash, rice straw, cotton stalk.
- Integrated with effluent treatment system.
- R&D platform for the development of renewable fuels and chemicals.

PARTNERSHIPS AND FINANCING

Praj and Gevo, Inc. entered into a joint development and development license agreement in November 2015, with the goal of Praj adapting Gevo's isobutanol technology to using non-corn-based sugars and lignocellulose feedstocks. The companies announced at the 2017 BIO World Congress that the technology would now be available for licensing to processors of sugarcane juice and molasses.

In September 2016, Indian Oil Corporation Ltd. selected Praj as its technology partner for setting up three second-generation bioethanol plants based on indigenously developed technology.

About: Praj is a global process solutions company driven by innovation and integration capabilities. Praj's business verticals comprise bioenergy, high-purity water solutions, and engineering businesses: namely critical process equipment and systems, breweries, and industrial wastewater treatment systems. Over the past three decades, Praj has focused on environment, energy and agri-process applications.

Praj Matrix is the common innovation engine for all the business units of Praj Industries. Matrix undertakes research programs to serve the technology requirements of Praj's business units. It also conducts research in the emerging areas of industrial biotechnology, like second-generation biofuels, advanced biochemicals, health and wellness products.

Matrix provides customized research solutions and services to bridge the gap in expertise and capability in microbial development, bioprocessing and process engineering.

Product applications: Food and nutritional ingredients, fragrance and flavors, cosmetics, dietary supplements, biofuels.

Technology: Praj has developed, at lab and pilot scale (1 metric ton per day), a second-generation lignocellulose to ethanol program, which has now been scaled up to a demonstration plant of 12 metric tons per day dry biomass.

Praj has also developed the biorefinery concept for the lignocellulose sugars to be converted to value added chemicals – like furfural, xylitol – which can be bolted on to the second-generation ethanol plant.

PRIMORDIAL GENETICS

San Diego, CA

Number of employees: 8

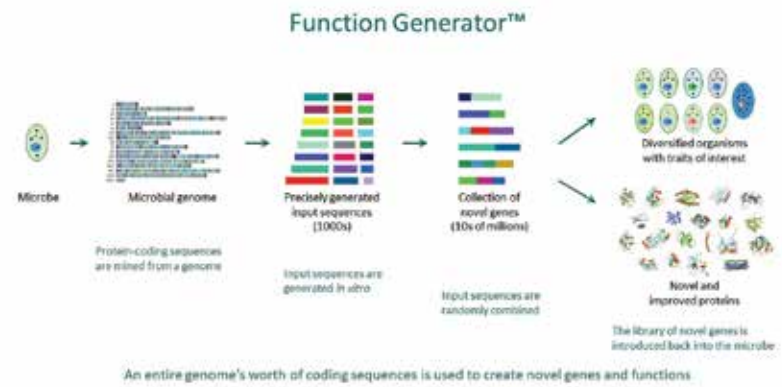
PRIMORDIAL GENETICS OPTIMIZES ENZYMES AND MICROBES TO ENABLE NOVEL PRODUCTS AND EFFICIENT BIOPRODUCTION.

Above: Primordial Genetics team including (back row, left to right) President Helge Zieler, Kadir Tung, (middle row, left to right) Alan Greener, Karen Xu, (front row, left to right) Sabrina German, VP Research and Development Justin Stege, Dominick Mendola.

About: Primordial Genetics is a biotechnology company focused on creating and improving bioproduction systems. We also discover and diversify proteins and enzymes for use in pharmaceutical, agricultural and industrial manufacturing applications. Function Generator™, the company's flagship technology, allows rapid and flexible development of novel biological products and traits required for microbial production of high-value compounds and materials.

Product applications: Pharmaceuticals, feed and food ingredients, renewable chemicals, food processing and agricultural biotechnology.

Technology: Our Function Generator™ technology is a powerful empirical approach to increase phenotypic diversity for productivity enhancements and growth optimizations of industrial microbes. Compound genes conferring improved phenotypes are assembled from a genome-wide set of native coding sequences. High-complexity combinatorial expression libraries of these Function Generator™ genes are then transferred into an organism of interest followed by selection or screening for desirable characteristics.



PARTNERSHIPS AND FINANCING

January 2018: Primordial won an NIH small business grant to pursue the application of Function Generator™ to enable functional expression of protein drug targets.

September 2017: Established a collaboration with a flavor and fragrance company to discover new metabolic enzymes for food ingredient manufacturing.

July 2016: Bayer CropScience LP signed a research collaboration to evaluate Primordial Genetics' proprietary Function Generator™ technology.

November 2015: Primordial Genetics signed a Collaboration and Option Agreement with Arcturus Therapeutics, a San Diego-based pharmaceutical company.

July 2013: Primordial Genetics launches its laboratory operations in San Diego's JLABS biotechnology incubator.

RENMATIX

King of Prussia, PA
Number of employees: 65

RENMATIX IS PRODUCING CELLULOSIC SUGARS.

BIOREFINERY CLASSIFICATION: COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

- Integrated Plantrose Complex (IPC), Kennesaw GA
- Capacity: 3 dry tons of biomass to sugar per day.
- Feedstock: Wood chips, agricultural residues, energy crops, municipal solid waste, other.
- Renmatix acquired the former Mascoma 56,000-square-foot manufacturing facility in Rome, NY. The new Feedstock Processing Facility (FPF) opened officially on April 20, 2015, as the third U.S. location for Renmatix. This move creates a secure supply for Renmatix and its development partners at the IPC in Kennesaw, GA, where the second step in production of Plantro® sugars is performed.

PARTNERSHIPS AND FINANCING

Renmatix has publicly disclosed joint development agreements with BASF, UPM, and Total. As announced in 2015, Total will utilize Renmatix's proprietary Plantrose™ Process with specific feedstocks to extract sugar for use in production of biobased products of strategic interest to Total. Existing Renmatix investors, including BASF and Kleiner Perkins Caufield & Byers, joined Total in the initial tranche of a Series D fundraise.

About: Renmatix's proprietary Plantrose™ Process pioneers the use of supercritical hydrolysis to break down non-food biomass quickly, using no significant consumables.

Product applications: Fermentation or catalytic conversion to bio-chemicals and biofuels or direct utilization of coproducts for existing markets of food ingredients, consumer goods, and varied industrial uses.

Technology: The water-based Plantrose™ Process consists of two core steps. The first is fractionation of biomass and separation of the remaining solids, which contain cellulose and lignin. The second is cellulose hydrolysis of the pretreated solids under elevated conditions utilizing supercritical water, or water at higher temperatures and pressures, as the primary solvent. The company won the 20th Annual Presidential Green Chemistry award in 2015 for its work in harnessing water as a new solution to the difficult problem of economically extracting cellulosic sugar from biomass.

REVERDIA

Geleen, Netherlands

Number of employees: 40

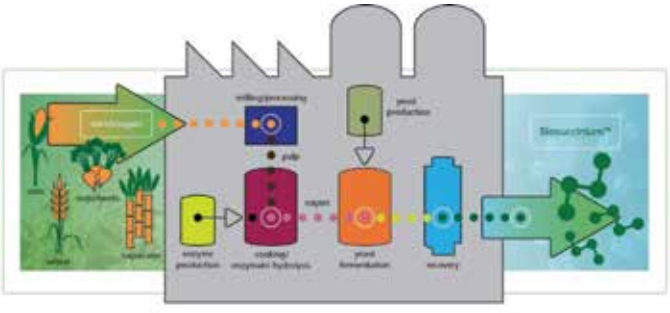
REVERDIA IS PRODUCING SUSTAINABLE SUCCINIC ACID.

About: Reverdia is a global leader in the market for sustainable succinic acid, focusing on market development by establishing partnerships with direct and indirect customers, building on customer needs and Reverdia's strengths.

Product applications: Biopolymers (e.g., polybutylene succinate), polyurethanes, coatings, pharma and cosmetics.

Technology: Reverdia uses low-pH yeast Biosuccinium® technology to produce biobased succinic acid.

Reverdia's low-pH yeast fermentation process has best-in-class carbon performance, as demonstrated by the published cradle-to-gate lifecycle assessment by the University of Utrecht.



KEY FACTS

+ Cassano Spinola, Italy
+ Capacity: 10,000 metric tons per year.
+ Feedstock: Glucose.

PARTNERSHIPS AND FINANCING

Business Model: Reverdia captures value though product sales and technology licensing.

Reverdia is a joint venture between Royal DSM, the global Life Sciences and Materials Sciences company, and Roquette Frères, the global starch and starch-derivatives company. Reverdia has many commercial partnerships in place, including partnerships with Covestro, Vaude, Xinfu, Xinhuarun, Bonderalia, Mäder and Proviron. Many other partnerships exist but have not been published in the public domain.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

RHO RENEWABLES

San Francisco Bay Area, CA
Number of employees: 6

RHO RENEWABLES PRODUCES SPECIALTY CHEMICAL POLYKETIDES AND RHOCTANE™ HIGH ENERGY DENSITY FUEL OXYGENATE.

TECHNOLOGY CLASSIFICATION: LABORATORY | DEMONSTRATION | COMMERCIAL

KEY FACTS

+ Advanced Biofuels Process Development Unit, Emeryville, CA

PARTNERSHIPS AND FINANCING

Rho has a development partnership with Sasol Performance Chemicals, part of Sasol Ltd.

Rho was awarded a grant from the U.S. Department of Energy for the study of one of its biofuel molecules, in collaboration with the Advanced Biofuels Process Development Unit at Lawrence Berkeley National Lab.

About: Rho Renewables, Inc. is using both classical yeast genetic engineering and modern molecular biology tools to develop powerful fermentation systems for the high-yield production of monocyclic aromatic compounds that have significant market potential.

Product applications: Biofuels; flavors and fragrances.

Technology: Rho's technology targets primarily the production of high-value specialty chemicals that are based on monocyclic aromatic ring structures. The company harnesses the power of the class of enzymes known as polyketide synthases (PKSs) to convert sugars to more desirable and valuable chemical products. These sophisticated and highly evolved enzymes can be engineered to function in common baker's/brewer's yeasts, thereby taking advantage of the multi-hundred years of knowledge gained in cultivating such organisms to make products of benefit to mankind at huge scale.

Rho scientists have developed a platform of yeast strains for the production of additional high-value monocyclic aromatic compounds, such as styrene and other important monomers for renewable polymer products. These processes are currently being optimized for scale-up to pilot scale and beyond.

ROYAL DSM

Heerlen, Netherlands
Number of employees: 25,000

ROYAL DSM IS MASTERING MICROBES AND ENZYMES TO CREATE SUSTAINABLE SOLUTIONS.

About: Royal DSM is a global science-based company active in health, nutrition and materials. By connecting its unique competences in life sciences and materials sciences, DSM is driving economic prosperity, environmental progress, and social advances to create sustainable value for all stakeholders simultaneously.

Product applications: Biofuels, food and nutrition, advanced materials.

Technology: DSM uses its biological sciences competences to find, make, and apply microbes and enzymes to create more sustainable processes, ingredients and building blocks for new products. These competences specifically help to engineer and characterize enzymes and microbial strains in detail, up to the molecular level; to assess their performance under application conditions; and to develop data and computation-driven model systems for building efficient "design-build-test-learn" engineering cycles.

On April 3, 2017, DSM opened the Rosalind Franklin Biotechnology Center, a state-of-the-art biotechnology facility at its site in Delft, to accelerate DSM's biotechnology research and development capabilities for applications in food and nutrition, feed, fuel, pharma and biobased materials. The completion of this new biotechnology center is part of a €100 million investment program by DSM to scale up research and development (R&D) efforts.

Innovations currently under development in the new biotechnology center include the production of fermentative steviol glycosides – the reduced-calorie, sweet-tasting molecules in the Stevia plant – as an answer to the growing global demand for sugar-reduced food and beverages. Another promising technology has emerged from the Proteins of the Future (POFU) project, turning an inedible agricultural by-product of rapeseed oil extraction into valuable plant protein for a wide range of uses in food.

KEY FACTS

+ Rosalind Franklin Biotechnology Center, Delft, Netherlands
+ Feedstock: Biomass.

PARTNERSHIPS AND FINANCING

POET-DSM Advanced Biofuels, LLC, is a 50/50 joint venture between Royal DSM and POET, LLC. The company is a cooperative effort of two innovators that provides a key to unlocking the opportunity of converting corn crop residue into cellulosic bioethanol.

The Reverdia joint venture, formed by Royal DSM and Roquette Frères, focuses on the production, commercialization and market development of Biosuccinium™, sustainable succinic acid. Biosuccinium™ is the first non-fossil-feedstock-derived chemical building block that allows customers in the chemical industry to choose a biobased alternative with a lower eco-footprint for a broad range of applications, from packaging to footwear.

S2G BIOCHEMICAL

Vancouver, British Columbia, Canada
Number of employees: 12

S2G BIOCHEMICAL PRODUCES XYLITOL, PROPYLENE GLYCOL AND ETHYLENE GLYCOL.

BIOREFINERY CLASSIFICATION: PILOT

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

- Vancouver, British Columbia, Canada
- Capacity: 40 million metric ton market.
- Feedstock: Hemicellulose conversion technology.
- Commercial Demonstration (under construction).

PARTNERSHIPS AND FINANCING

In first quarter 2018, S2G will announce remaining partner and government funding for its commercial demonstration plant in Eastern Canada.

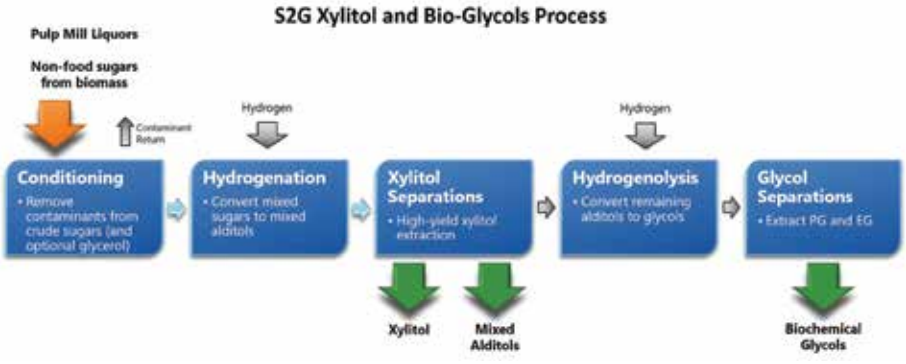
In June 2017, S2G BioChem announced that it started work in Sarnia, Ontario, on the company's first stand-alone biorefinery demonstration plant to produce xylitol and value-added bioglycols. Funding will be provided by Bioindustrial Innovation Canada's (BIC) Commercialization of Sustainable Chemistry Innovation fund (COMM SCI).

In October 2016, S2G BioChem announced a license and collaboration agreement with Mondelēz International to commercialize a sustainably sourced supply of the food ingredient xylitol.

About: S2G BioChem is a global-leading bioproducts conversion company revolutionizing the production of food ingredients and biochemicals by high-efficiency utilization of forestry and agricultural residues. As the only company in the world to coproduce a sustainable and cost-effective source of xylitol and value-added bioglycols, S2G is galvanizing a new era of biorefining for a wide variety of consumer and industrial products we use every day. S2G's success is the result of over 20 years of design, engineering and biorefinery operation.

Product applications: Xylitol is a low-calorie sweetener preferred by producers of gum and candy. Propylene glycol is used in liquid detergents, lotions, personal care products and car antifreeze. Ethylene glycol is an ingredient in polyethylene plastics.

Technology: S2G's bioglycol plants are based on a highly efficient two-stage conversion of crude C5/C6 hemicellulose sugars to xylitol and mixed glycols, resulting in a profitable revenue stream for pulp mills and biorefineries and an economical source of low-cost xylitol and sustainable bioglycol for users.



SENOMYX

San Diego, CA

Number of employees: 60

SENOMYX IS PRODUCING COMPLIMYX® BRAND OF FLAVOR INGREDIENTS, WHICH INCLUDE SWEETMYX®, SAVORYMYX®, AND BITTERMYX® OFFERINGS.

About: Senomyx, Inc. is using proprietary taste science technologies to discover, develop, and commercialize new flavor ingredients and natural high-intensity sweeteners that have benefits for consumers and consumer products manufacturers.

Product applications: Flavoring.

Technology: With an advanced understanding of human taste bud science, precise screening platforms and taste testing capabilities, Senomyx has developed a process that mimics the natural function of the taste bud and enables discovery of new flavors that boost the taste of sweeteners and other flavors in foods and allow for the reduction of sugar and high-fructose corn syrup.

KEY FACTS

+ San Diego, CA
+ Senomyx flavors and flavor boosters are produced using the highest quality ingredients, in accredited food manufacturing facilities.

PARTNERSHIPS AND FINANCING

Senomyx has partnered with several leading global food, beverage and ingredient supply companies over the years. These companies are currently marketing our sweet taste boosters, savory flavors, and a cooling agent ingredient in flavor systems and numerous end product offerings around the globe. In fact millions of consumers in North America, Europe, Latin America, Asia, Africa, Australia and the Middle East have enjoyed the great taste and health benefits of Senomyx's flavor ingredients in many of their favorite food and beverage products. Additionally, Senomyx continues to conduct research to identify and develop new novel sweet taste ingredients, including both boosters and natural high-intensity sweeteners.

SOLIX ALGREDIENTS

Fort Collins, CO

Number of employees: <50

SOLIX PRODUCES ALGAE-BASED ASTAXANTHIN AND DHA.

BIOREFINERY CLASSIFICATION: COMMERCIAL | PILOT | DEMONSTRATION | COMMERCIAL

KEY FACTS

+ Fort Collins, CO

PARTNERSHIPS AND FINANCING

In December 2016, Solix announced that Solasta® Astaxanthin received the "Approved Quality" seal certification from ConsumerLab.com.

In May 2016, Solix announced certification by UL Registrar as meeting the Natural Product Association's (NPA) requirements for compliance with the U.S. Food and Drug Administration's (FDA) Good Manufacturing Practices (GMPs) for dietary supplements. Solix's Fort Collins, CO facility and its GMP-related documentation underwent a comprehensive review and audit to verify compliance with NPA's GMP certification requirements. The audited facility is used for the manufacture, packaging, and warehousing of Solix's Solasta Astaxanthin® products.

Investors include I2BF, Rusnano, Bohemian Asset Management, Southern Ute Alternative Energy, Shanghai Alliance Investment, Ltd., Valero and Infield Capital.

Solix has raised $68.8 million in seven funding rounds, including $31 million in a series C round in 2012.

About: Solix Algredients is a business-to-business supplier of algae-based natural ingredients that benefit health-conscious consumers. Since 2006, a focus on understanding algae and applying that expertise commercially has been the focal point for Solix. Solix applies that decade-plus algae supply chain knowledge to market Solasta® Astaxanthin, Solmega® DHA omega-3 and other natural algal ingredients.

Product applications: Dietary supplements, food/beverage, personal care.

Technology: Natural, non-genetically modified strains of *Haematococcus pluvialis* are cultivated in enclosed photobioreactors using purified water to produce algal biomass used in the production of Solasta® Astaxanthin. The astaxanthin is extracted in the United States by a process that uses supercritical CO_2 to ensure safety, quality, and consistency. Solasta® conforms to the stringent USP astaxanthin standard. Solmega® DHA is produced through a tightly controlled process using a proprietary, natural, non-genetically modified strain of *Schizochytrium* species.

STORA ENSO

Helsinki, Finland
Number of employees: 25,000

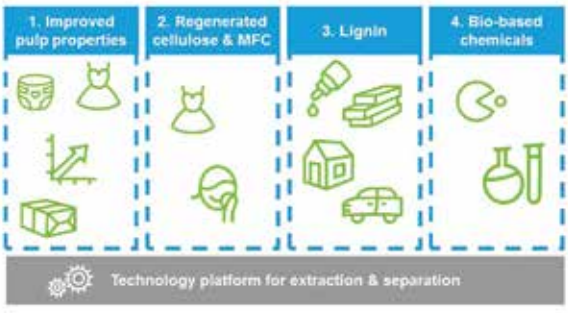
STORA ENSO PRODUCES PACKAGING, BIOMATERIALS, PAPER, AND WOOD PRODUCTS.

About: Stora Enso is a leading provider of renewable solutions in packaging, biomaterials, wooden constructions and paper on global markets. Our aim is to replace fossil-based materials by innovating and developing new products and services based on wood and other renewable materials.

Product applications: Paper, packaging, wood products, biomaterials, adhesives, textiles.

Technology: In the United States, Stora Enso has a pilot facility and a demonstration plant. In 2014, Stora Enso acquired Virdia's extraction and separation technology and developed a biorefinery concept. Virdia developed the CASE process, which converts cellulosic biomass to high-quality fermentable sugars and lignin, using acid hydrolysis. The demonstration plant in Raceland will use sugarcane bagasse and turn it into xylose, which can then be further refined to xylitol, which is used, for example, in dental care applications. In addition, Stora Enso is looking at different product platforms to use the different fractions of a tree (or other biomass) for cellulose-, lignin- or hemicellulose-based products.

The different product platforms are:



KEY FACTS

+ Raceland, LA
+ Capacity: Demonstration plant.
+ Feedstock: Sugarcane bagasse.
+ Stora Enso has a pilot facility in Danville, VA to develop technologies for the conversion of biomass into highly refined sugars and lignin.

PARTNERSHIPS AND FINANCING

In 2016, Stora Enso announced a joint development and license agreement with Rennovia to cooperate on biobased chemicals development.

BIOREFINERY CLASSIFICATION: DEMONSTRATION

COMMERCIAL
DEMONSTRATION
PILOT

SWEETWATER ENERGY

Rochester, NY

Number of employees: 21

SWEETWATER ENERGY IS PRODUCING HIGH-QUALITY, SUSTAINABLE CARBON IN THE FORM OF CELLULOSIC SUGARS AND CLEAN LIGNIN.

BIOREFINERY CLASSIFICATION: DEMONSTRATION

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

- Rochester, NY
- Capacity: 3-4 metric tons feedstock input per day.
- Feedstock: Mixed hardwoods (chips or sawdust), corn stover, wheat straw.
- The company's first commercial facility will be constructed in Northern Minnesota and will produce hardwood-derived cellulosic sugar and clean lignin that will then be fully processed into final market-ready products: 4.1 million gallons of industrial alcohol, 550,000 gallons of fuel alcohol, and over 6,000 metric tons of high-quality activated carbon. Sweetwater's wood-based industrial alcohol and activated carbon compete directly on price and performance with incumbent feedstocks.
- Sweetwater has presold industrial alcohol, in two-year contracts, and is in active contract negotiations for lignin-derived, activated carbon products from the Minnesota facility.

PARTNERSHIPS AND FINANCING

Sweetwater has been awarded a $30 million loan and incentives package from the state of Minnesota for a first commercial project (total project CAPEX = $60 million) and is currently active in their Series B to raise an additional $100 million in capital.

About: Sweetwater Energy owns ground-breaking, patented technology that will be economically disruptive for the chemicals, fuels and advanced materials industries. Globally, sustainable carbon products can now economically compete with petroleum.

Product applications: Biochemicals, biofuels, bioplastics, activated carbon, advanced packaging and construction materials.

Technology: Sweetwater's technology efficiently processes low-cost, sustainable biomass, such as wood and agricultural residues, into two platform products: highly fermentable cellulosic sugar and clean lignin fiber. Sweetwater's technology converts over 95 percent of the available cellulose and hemicellulose in biomass feedstocks into highy fermentable, monomeric C5 and C6 sugars. The technology Sweetwater owns has been proven to significantly outperform competing global technologies in terms of sugar yield, inhibitor profile, and ethanol yield (90 gallons per dry metric ton of feedstock). It also produces a unique, clean lignin that has been proven to be a valuable feedstock for many high-end applications, including activated carbon, advanced packaging and construction materials; ultimately supporting a value of 10 to 20 times over its thermal value. Further, Sweetwater's highly scalable hardware has been reliably proven as heavy industrial duty in multiple industries worldwide.

SYLVATEX

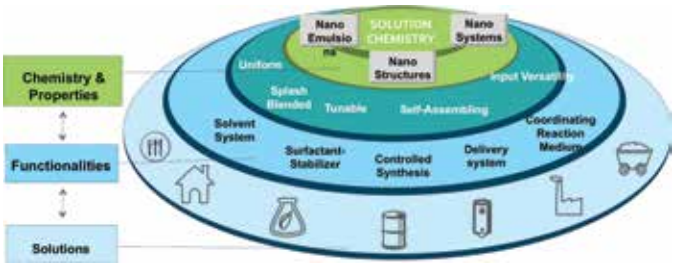
San Francisco, CA
Number of employees: 9

SYLVATEX PRODUCES MICROX – A PLATFORM TECHNOLOGY THAT OFFERS UNIQUE ADVANTAGES IN ECONOMICS, PERFORMANCE PROPERTIES FOR NANO-SCALE SYSTEMS, AND IS MADE FROM ALL PLANT-BASED MATERIAL.

About: Sylvatex is a nano-chemistry company utilizing renewable inputs to create a nanoparticle that can be used in multiple applications. Founded in 2012, Sylvatex is currently focused on the application of its technology platform around nanomaterial production, specifically targeting lithium-ion cathode material. The MicroX platform allows for material (e.g., alcohol, water, lithium and a variety of metals and anions) to combine within a micelle solution to produce cathode material particles of uniform size and shape in a "one-pot" synthesis of lithium metal oxide materials. The MicroX platform allows for tailored coatings that produce higher-performing, lower-cost, less-toxic materials with operations occurring at ambient temperatures, leading to lower energy consumption during production – all with a blendstock that is also recyclable.

Product applications: Nanomaterials production (e.g., lithium-ion cathode), fuels, chemicals, cosmetics, flavors and fragrances.

Technology: Sylvatex has developed a microemulsion technology to encapsulate oxygenates, such as ethanol, methanol or butanol, with a vegetable oil surfactant in its patent pending MicroX nano-chemistry system. Originally developing a fuel additive for enhancing diesel performance properties, the company has leveraged the versatility of its technology and has expanded its focus on commercializing the MicroX nano-chemistry system as a platform technology.



KEY FACTS

+ San Francisco, CA

PARTNERSHIPS AND FINANCING

In 2017, Sylvatex established a partnership with Valicor for process develoment and pilot production of MicroX.

Raised over $2 million since inception with the close of its seed funding round in second quarter 2014. Currently seeking Series A funding ($4 million) with nearly $1.5 million raised from strategic investors and partners.

In 2016, Sylvatex was included in the second round of the Department of Energy's Small Business Vouchers pilot program, which provides access to 12 national laboratories to accelerate technology development.

Key established relationships with Lawrence Berkeley National Lab's Advanced Biofuels and Bioproducts Process Development Unit and Molecular Foundry, U.S. Department of Agriculture, and National Renewable Energy Lab.

TECHNOLOGY CLASSIFICATION: DEMONSTRATION/PILOT
COMMERCIAL
DEMONSTRATION
PILOT

SYNGULON

Liège, Belgium

Number of employees: 6

SYNGULON DEVELOPS BACTERIOCIN-BASED TECHNOLOGIES.

TECHNOLOGY CLASSIFICATION: LABORATORY | DEMONSTRATION | COMMERCIAL

PARTNERSHIPS AND FINANCING

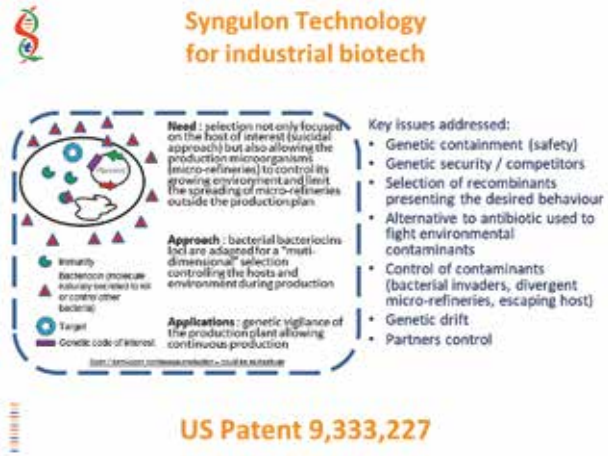
Syngulon is a start-up "in-the-lab," founded in 2013, incubated by Wallonia Space Logistics (WSL), an incubator for engineering sciences. Syngulon's scientists work in close cooperation with several academic labs in Belgium (Université libre de Bruxelles, Université Catholique de Louvain, Université de Liège, Université de Mons) and outside Belgium (including University College London).

Since 2016, Syngulon has a Scientific Advisory Board including Professors from Institut Pasteur in Paris and Georgetown University in Washington, DC.

About: Syngulon is developing original genetic technologies to improve the efficiency of microorganisms (also called microrefineries) involved in industrial bioproduction.

Product applications: Green chemical production microorganisms (bacteria, yeast or algae).

Technology: A pressing concern with microbial systems is that re-engineered microbes may escape and produce undesirable effects on the environment. To address this biosafety issue, multiple mechanisms for constraining microbial replication and horizontal gene transfer have been proposed, including the use of host–construct dependencies, such as selection using toxin–antitoxin pairs, conditional plasmid replication, or the requirement for a specific metabolite for bacterial function. Syngulon proposes an innovative genetic firewall – including a new selection genetic circuit using the bacteriocin gene platform – to boost microbial fermentation.



SYNTHETIC GENOMICS

San Diego, CA
Number of employees: 200

SYNTHETIC GENOMICS IS SOLVING SUSTAINABILITY CHALLENGES IN PARTNERSHIP WITH GLOBAL LEADERS.

SYNTHETIC GENOMICS®

About: Synthetic Genomics is ushering in a new age of novel, bio-based solutions for humankind's most pressing issues, from the well-being of our global population to the health of our planet. With an unprecedented understanding of the DNA-based operating system of life, Synthetic Genomics writes genomes that produce improved or entirely new products capable of transforming medicine, agriculture, biomanufacturing and beyond.

Product applications: RNA-based vaccines, novel biopharmaceuticals, revolutionary cell-based production of biopharmaceuticals and biodiesel, organ transplantation, automated manufacture of precision medicines.

Technology: Synthetic Genomics is leading the genome-writing revolution to create biobased, consumer-friendly products that are sustainable and economically advantaged. Our Archetype® technology is at the convergence of big data analysis and cell engineering to design genomes for high-value products. We use proprietary technologies, bioinformatics and bioengineering capabilities in an organism-agnostic approach.

KEY FACTS

- Research services, commercialized through its subsidiary SGI-DNA, are revolutionizing biotechnology with next-generation genomic solutions, such as the world's first DNA printer. Includes automated, on-demand manufacture of DNA constructs for human clinical trials.
- Bioproduction expertise creates value through design of novel, more efficient cell-host systems. Extends across production hosts: phototrophic, heterotrophic, viral, mammalian and fully synthetic.
- Applied products include vaccines, biologics and therapeutics, human nutrition, biofuels and biobased chemicals.

PARTNERSHIPS AND FINANCING

In addition to developing its applied products, Synthetic Genomics partners with leading global organizations across many industries. Partners include GlaxoSmithKline, Merck, Janssen Pharmaceutical and United Therapeutics, Seqirus and Advaxis (healthcare); ExxonMobil (algae-based biofuel); and ADM (omega-3 DHA).

TECHNOLOGY CLASSIFICATION: COMMERCIAL
COMMERCIAL
DEMONSTRATION
PILOT

SYNVINA

Amsterdam, Netherlands
Number of employees: 70

SYNVINA PRODUCES 2,5-FURANDICARBOXYLIC ACID AND POLYETHYLENEFURANOATE.

BIOREFINERY CLASSIFICATION: PILOT

COMMERCIAL
DEMONSTRATION
PILOT

KEY FACTS

+ Amsterdam, Netherlands
+ Brightlands Chemelot Campus, Geleen, Netherlands.

PARTNERSHIPS AND FINANCING

In June 2017, the European Joint Undertaking on Bio-Based Industries (BBI) granted €25 million to "PEFerence," a consortium of 11 companies led by Synvina. The grant supports the establishment of an innovative value chain for biobased raw materials as well as chemicals and materials based on polyethylenefuranoate and the intended construction of a 50,000-ton FDCA reference plant.

In May 2017, the European PET Bottle Platform (EPBP) granted interim approval for the recyclability of Synvina's polyethylenefuranoate at market penetration of up to 2 percent in the European bottle recycling market, sufficient for Synvina's intended 50,000-ton reference plant.

About: Synvina is a joint venture between BASF and Avantium, which came together with the aim of producing and marketing furandicarboxylic acid (FDCA) and polyethylenefuranoate (PEF). These newly developed products will bring major performance improvements, such as increased barrier properties and thinner packaging for various applications in the packaging industry. www.synvina.com

Product applications: Polyamides for engineering plastics and fibers; polyurethanes for foams, coatings and adhesives; and esters for personal care products and lubricants. PEF is suitable for bottles, fibers, and multiple film types, including pouches, wrappers and shrink film.

Technology: Avantium's YXY technology platform produces a wide range of novel, 100 percent biobased materials and products by converting plant-based sugars into chemical building blocks. The most prominent example is furandicarboxylic acid for the production of polymers for the packaging industry. However, there is a wide range of other applications, such as fibers, other polymers like polyamides or other polyesters.

TESELAGEN BIOTECHNOLOGY

San Francisco, CA
Number of employees: 14

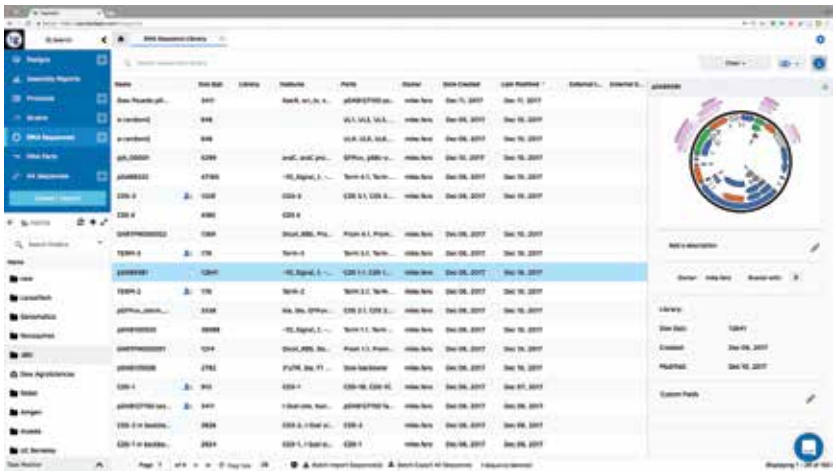
TESELAGEN PRODUCES SOFTWARE FOR SYNTHETIC BIOLOGY.

About: TeselaGen builds secure enterprise-quality software platforms for designing, building and precision editing DNA, enabling the development of vaccines, biologic medicines, and sustainably sourced chemicals.

Product applications: Medications, chemicals, enzymes and bio-based materials.

Technology: TeselaGen's award winning Synthetic Evolution™ information technology platform provides a seamless design-to-delivery solution for ag-tech, industrial biotech and medical biotech companies.

TeselaGen's patented automated protocol-generation software is under exclusive license from Lawrence Berkeley National Laboratory in all fields of use. The Synthetic Evolution™ Design, Build, and Test modules feed the Evolve machine learning pipeline that optimizes product development and radically shortens time to market.



KEY FACTS

+ San Francisco, CA
+ CEO – Michael Fero

PARTNERSHIPS AND FINANCING

TeselaGen is privately held and is based in the software hub of San Francisco, CA.

In December 2017, TeselaGen signed a license and collaboration agreement with LanzaTech.

In November 2017, TeselaGen signed a license agreement with Arzeda.

In August 2017, TeselaGen broadened its partnership with Dow AgroSciences.

In September 2017, TeselaGen received a $1 million machine learning grant to support the Evolve platform module.

In February 2017, TeselaGen received a Small Business Innovation Research Phase IIB grant to support development of the Synthetic Evolution™ Design-Build-Test-Evolve biodesign platform.

TOTAL CORBION PLA

Gorinchem, Netherlands
Number of employees: 200

TOTAL CORBION PRODUCES LUMINY® POLYLACTIC ACID AND PURALACT® LACTIDE MONOMERS.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Rayong, Thailand
+ Capacity: 75 kilotons per year.

PARTNERSHIPS AND FINANCING

In August 2017, Total Corbion announced that PLA resins from Bonsucro-certified sugarcane are available for order. Total Corbion PLA is Bonsucro Chain of Custody certified.

In March 2017, Total Corbion PLA announced the start-up of the joint venture formed in November 2016. Corbion's existing lactide plant and under construction 75 kiloton per year plant are transferred into the joint venture.

About: Total Corbion PLA is a 50/50 joint venture between Total and Corbion and a global technology leader in polylactic acid (PLA) and lactide monomers. The Luminy® PLA portfolio, which includes both high heat and standard PLA grades, is an innovative material that is used in a wide range of markets from packaging to consumer goods, fibers and automotive. Total Corbion PLA, headquartered in the Netherlands, will start up a new production plant in Thailand in the second half of 2018.

Product applications: PLA is extremely versatile and can be injection molded into plastic parts; extruded into sheet or film; foamed; thermoformed into packaging items; or spun into fibers/filaments for non-wovens and textiles.

Technology: Corbion liaises with various local sugar suppliers across the globe for each of its production plants, including, for example, Mitr Phol for their plant in Rayong, Thailand. Corbion converts these sugar feedstocks to lactic acid through a fermentation process. The lactic acid is then converted by Total Corbion PLA to lactide monomers, in a production facility located adjacent to Corbion's lactic acid plant. Total Corbion PLA is currently building a 75 kiloton per year PLA polymerization plant on the same site in Thailand, which is expected to be operational in the second half of 2018.

TWIST BIOSCIENCE

San Francisco, CA
Number of employees: ~250

TWIST BIOSCIENCE MANUFACTURES SYNTHETIC DNA AND DNA LIBRARIES.

Above: CEO Emily Leproust, Ph.D., COO Bill Banyai, Ph.D., and CTO Bill Peck, Ph.D. (left to right).

About: At Twist Bioscience, we work in service of customers who are changing the world for the better. Our customers – by using our synthetic DNA tools – are developing ways to better lives and improve the sustainability of the planet. We believe that the faster our customers succeed, the better for all of us, and Twist Bioscience is uniquely positioned to help accelerate their efforts.

Our innovative silicon-based DNA synthesis platform provides precision at a scale that we believe is otherwise unavailable to our customers. Our platform technologies overcome inefficiencies and enable cost-effective, rapid, precise, high-throughput synthesis and sequencing, providing both the quality and quantity of the tools customers need to rapidly realize the opportunity ahead.

Product applications: Health care, agriculture, industrial chemicals, academic research and data storage. Key product offerings include synthetic genes and gene fragments; oligo pools; synthetic DNA libraries; and exome and custom target enrichment solutions.

Technology: We developed the Twist Bioscience DNA synthesis platform to address the limitations of throughput, scalability, and cost inherent in legacy DNA synthesis methods. Our core technologies combine expertise in silicon, software, fluidics, chemistry, and motion and vision control to miniaturize thousands of parallel chemical reactions on silicon and write thousands of strands of DNA in parallel. With a footprint that is similar to the size of a 96-well plate that produces one gene, we are able to produce 9,600 genes in parallel. We have combined our DNA synthesis technology with proprietary software and scalable commercial infrastructure to create our vertically integrated DNA synthesis platform capable of delivering very large volumes of high-quality synthetic DNA at low cost.

KEY FACTS

Founded in 2013, Twist Bioscience is headquartered in San Francisco, CA, with facilities in South San Francisco and Carlsbad, CA, as well as Tel Aviv, Israel.

TECHNOLOGY CLASSIFICATION

Commercial Synthetic DNA Provider

PARTNERSHIPS AND FINANCING

Raised $208 million since founding in 2013.

In 2017, Twist Bioscience agreed to terms to supply 1 billion base pairs to Ginkgo Bioworks.

In 2016, Twist supplied DNA to Microsoft Corporation for its work with the University of Washington to develop DNA as a data storage medium. Twist extended the scope of this relationship during 2017.

Signed an agreement to supply thousands of genes for public benefit through the BioBricks Foundation in 2017.

Serve as an original equipment manufacturer supplier of synthetic DNA to four synthetic DNA manufacturers.

VERDEZYNE

Carlsbad, CA

Number of employees: 65

VERDEZYNE IS DEVELOPING TECHNOLOGY TO PRODUCE THE DIACIDS DODECANEDIOIC ACID, ADIPIC ACID, AND SEBACIC ACID AS WELL AS MULTIPLE CAROTENOIDS, INCLUDING LYCOPENE AND BETA-CAROTENE.

BIOREFINERY CLASSIFICATION: COMMERCIAL

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ Nusajaya, Iskandar, Malaysia
+ Capacity: 6 kilotons per year of diacids.
+ Feedstock: Fatty acids isolated from soy, palm kernel, coconut and other plant-based oils.
+ Drop-in renewable replacements for petrochemicals.

PARTNERSHIPS AND FINANCING

Verdezyne has raised ~$66 million in equity capital, plus MYR $250 million in project finance to fund construction of a plant in Bio-XCell's premier biotechnology and ecosystem park in southern Malaysia. Construction on the project began in first quarter 2017 with completion expected in third quarter 2018.

About: Verdezyne, Inc., is a privately owned industrial biotechnology company that is leveraging the power of biology to produce chemicals from renewable, non-food sources.

Product applications: The diacids are used in nylon or other polymers for use in a variety of applications, including: engineering resins, automotive parts, athletic apparel, carpeting and toothbrush bristles. The carotenoids find applications as food colorants, antioxidants in cosmetics, and in animal and human nutrition.

Technology: Verdezyne has developed a proprietary platform that uses fermentation to convert multiple non-food-based renewable feedstocks into a number of widely used, high-value chemicals.

VIRENT

Madison, WI

Number of employees: 45

VIRENT IS PRODUCING DIRECT REPLACEMENT FUELS AND CHEMICALS.

About: Using patented catalytic chemistry, Virent converts soluble biomass-derived sugars into BioFormate®, a mixture of molecules very similar to petroleum reformate that can be used to produce products identical to those made from petroleum, including gasoline, jet fuel, and chemicals used for plastics and fibers.

Virent is a wholly owned subsidiary of Andeavor (a leading U.S. refiner and marketer of fuels, interested in low-carbon fuels).

Product applications: Fuels (gasoline, jet fuel), aromatic chemicals (paraxylene, benzene).

Technology: Virent's BioForming® process provides a true biorefinery capable of producing multiple products from various feedstocks, using heterogeneous catalysts common to the petroleum and catalyst industry. Virent's products are drop-in equivalents to their petroleum counterparts, but with a significantly reduced carbon footprint. The Virent catalytic process is similar to processes in the refining and petrochemical industry and is more readily scalable than other types of biobased technologies. The flexible product slate allows for optimization in response to shifting market opportunities between fuels and chemicals production. Virent's process can work with a variety of feedstocks, including ethanol, sugars, and lignocellulosic materials from wood, corn and bagasse.

KEY FACTS

- Madison, WI
- Capacity: ~25 metric tons per year of BioFormate. Multiple metric tons per year of bio-paraxylene.
- Feedstock: Sugars.
- Several products have been produced at demonstration scale and validated with industrial leaders, including renewable gasoline and jet fuel and bio-paraxylene for polyester beverage packaging and polyester fibers for textiles.

PARTNERSHIPS AND FINANCING

In July 2016, Virent announced the formation of a Strategic Consortium to commercialize the BioForming technology for low-carbon fuels and bio-paraxylene. Consortium members include Andeavor; Johnson Matthey (a U.K.-based global specialty chemicals and sustainable technologies company with expertise in scaling up new technologies); Toray Industries (a Japan-based integrated chemical group with global operations and strong businesses in polyester fibers and textiles), and The Coca-Cola Company (interested in bio-PET for packaging).

WHITE DOG LABS

WHITE DOG LABS

New Castle, DE

WHITE DOG LABS PRODUCES ACETONE, ISOPROPANOL, ETHANOL AND PROTEINS.

BIOREFINERY CLASSIFICATION: PILOT

COMMERCIAL | DEMONSTRATION | PILOT

KEY FACTS

+ New Castle, DE
+ Capacity: 1,000 – 18,000 liters.
+ Feedstock: Dextrose, glycerol, cellulosic sugar, CO_2, syngas, H_2.

PARTNERSHIPS AND FINANCING

Two U.S. Department of Energy (DOE) Awards:

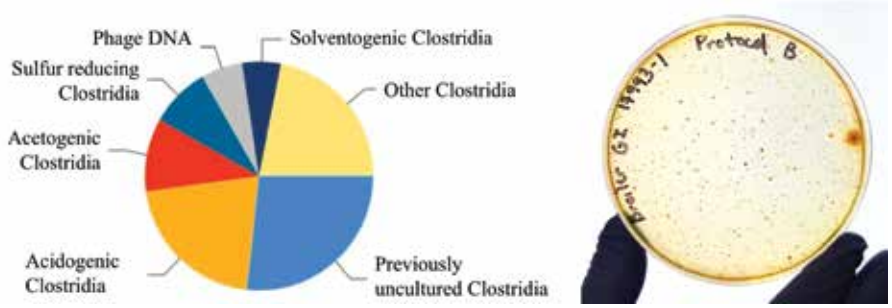
+ DOE Bioenergy Incubator
+ DOE Integrated Biorefinery

Joint Development with Air Liquide.

About: White Dog Labs, Inc. (WDL) is a biotechnology company developing a novel class of fermentation technologies and a new synthetic biology platform to address global challenges, including food sustainability and climate change. Our technology improves the efficiency of fermentation processes by 50 to 100 percent, improving the economics of bioproducts, from fuels and chemicals to protein rich feeds.

Product applications: Biofuels, renewable chemicals, advanced nutrition ingredients.

Technology: WDL has isolated and developed organisms that are capable of consuming sugar and CO_2 concurrently – MixoFerm™. MixoFerm™ can improve the efficiency of fermentation processes by up to 100 percent, which improves production economics for bioproducts, ranging from fuels and chemicals to protein rich feeds. Additionally, WDL has created novel processes to specifically isolate previously unculturable *Clostridia* microbiota from healthy host systems. Subsequently, WDL is exploring application of these newly discovered organisms for commercial probiotic and synbiotic applications.



ZYMERGEN

Emeryville, CA

Number of employees: 400

ZYMERGEN ENGINEERS AND OPTIMIZES PRODUCTION MICROBES FOR USE IN BIOBASED PRODUCTS.

About: Zymergen is a molecular technology company ushering in a new age of manufacturing and industrial innovation. Leveraging the power of machine learning, automation, and bioengineering, Zymergen takes a radically different approach to improving the performance of materials and to discovering new molecular products that touch every industry -- from agriculture to chemicals and materials, pharmaceuticals, and more. The technology is in use today, serving Fortune 500 companies and major corporations across the globe.

Product applications: Specialty materials for electronics and industrial applications, flavors and fragrances, pharmaceuticals, home and industrial cleaning, personal care, defense, aerospace.

Technology: Zymergen develops and optimizes production microbes to improve the economics of existing products and to create wholly new ones. The company uses a combination of robots and proprietary software to build and test thousands of new strains of DNA at a time, employing machine learning algorithms to more effectively search the genome for sources of improvement.

KEY FACTS

+ Emeryville, CA
+ Seattle, WA

PARTNERSHIPS AND FINANCING

In October 2016, Zymergen raised $130 million in Series B funding, led by Softbank with participation from previous investors DCVC, True Ventures, AME Cloud Ventures, DFJ, Innovation Endeavors, Obvious Ventures, and Two Sigma Ventures. Zymergen also received funding from new investors Iconiq Capital, Prelude Ventures, and Tao Capital Partners. The round brought Zymergen's total amount raised to $174 million.

In 2018, Zymergnen announced it had acquired functional metagenomics company Radiant Genomics, adding Radiant's technologies for natural product and enzyme discovery as well as approximately two terabites of genetic data to Zymergen's core platform.

TECHNOLOGY CLASSIFICATION: COMMERCIAL

PILOT | DEMONSTRATION | COMMERCIAL

COMPANY	PRODUCT
AB ENZYMES GMBH	Enzymes
ADVANCED BIOCATALYTICS CORPORATION	Surfactants
ADVANCED ENZYME TECHNOLOGIES	Enzymes; Probiotics
AEQUOR, INC	Antifouling, Antibiofilm Chemicals
AGRIVIDA	Enzymes
AJINOMOTO	Amino Acids
AKZONOBEL	Acetic Acid; Acetone; *n*-Butanol; Epichlorohydrin; Fatty Acids
ALJADIX	Microalgae Biofuel
AMERICAN PROCESS	Cellulosic Sugar; Ethanol; Nanocellulose
AMSILK	Silk Biopolymers; Spider Silk
AMYRIS	Farnesene; Isoprene
ANELLOTECH	Benzene; Toluene; Xylene
ARBIOM	Glucose; Lignin; Xylose
ARCHER DANIELS MIDLAND (ADM)	Citric Acid; Ethanol; 2,5-Furandicarboxylic Acid (FDCA); Furandicarboxylic Methyl Ester (FDME); Glycerin; Lecithin; Polyols; Polytrimethylene Furandicarboxylate (PTF); Propylene Glycol (1,2-Propanediol); Sorbitol; Soy Methyl Ester; Starches; Sugars; Xanthan; Waxes
ARKEMA	Fatty Acids and Esters; Polyamides; Polyphthalamide (PPA)
ARZEDA	1,3-Butadiene; Enzymes; Levulinic Acid
AVA BIOCHEM	2,5-Furandicarboxylic Acid; 5-Hydroxymethylfurfural (5-HMF)
AVANTIUM	Alkoxymethyl-Furfural; Furandicarboxylic Acid; Methyl Levulinate; Monoethylene Glycol (MEG)
BASF ENZYMES LLC	1,4-Butanediol (1,4-BDO); Enzymes; Polytetrahydrofuran (PolyTHF®)
BIOAMBER	Adipic Acid; 1,4-Butanediol; Succinic Acid
BIOBLEND RENEWABLE RESOURCES	Engine Oil; Greases; Hydraulic Fluid; Lubricants
BIOBTX	Aromatics; Benzene; Bio-Oil; Toluene; Xylene
BIO-CAT/BIO-CAT MICROBIAL	Enzymes
BIOCATALYSTS LTD	Enzymes
BIOFIBER SOLUTIONS	Biocycled Paper Products
BIO-ON	Polyhydroxyalkanoate (PHA)
BIORESOURCE INTERNATIONAL	Enzymes
BIOSYNTHETIC TECHNOLOGIES	Biosynthetic Oils
BLUE MARBLE BIOMATERIALS	Acetic Acid; Acrylic Acid; Butyric Acid; Butyl Butyrate; Caproic Acid; Dimethyl Sulfide; Ethyl Butyrate; Ethyl Thioacetate; Ethyl Thiobutyrate; Ethyl Thiopropionate; Lactic Acid; 3-Mercapto-Butanone; 3-Mercapto-Pentanone; 5-Methyl Furfuryl Mercaptan; Methyl Thioacetate; Methyl Thiobutyrate; Propionic Acid; s-Propyl Acetate; Propyl Butyrate; Propyl Hexanoate; Propyl Propionate; Propyl Thioacetate; Thiobutyric Acid; Thiopropionic Acid; Thioacetic Acid
BORREGAARD	Ethanol; Cellulosic Sugars; Lignin; Vanillin

APPENDIX A. RENEWABLE CHEMICAL AND BIOBASED PRODUCT COMPANIES

COMPANY	PRODUCT
BOSK BIOPRODUCTS	Polyhydroxyalkanoate
BRASKEM	Butadiene; Ethanol; Ethylene; Isoprene; Propylene; Polyethylene; Polypropylene
CALYSTA BIOSYSTEMS	FeedKind® Protein; Lactic Acid
CARGILL	Citric Acid; Ethanol; Glucaric Acid; Glycerin; 3-Hydroxypropionic Acid; Isoprene; Itaconic Acid; Lactic Acid; Lecithin; Maltodextrin; Palm Oil; Polyols; Sorbitol; Starches; Sugars; Triglycerides; Xanthan Gum
CATHAY INDUSTRIAL BIOTECHNOLOGY	Brassylic Acid (DC13); Dodecanedioic Acid (DC12); Hexadecanedioic Acid (DC16); Pentadecanedioic Acid (DC15); 1,5-Pentamethylene Diamine; Tetradecanedioic Acid (DC14); Undecanedioic Acid (DC11)
CEAPRO	Botanical Peptides; Oils; Polyphenols
CELANESE	Cellulose Diacetate
CELLANA LLC	Algae Ink™; Biocrude Oil; Omega-3 Oils; ReNew™ Feed/Food
CELLUCOMP	Cellulose Nanofibers
CHEMISTRIA	Organic Acids (Acetic, Gluconic, Lactic, Succinic)
CHRISTIAN HANSEN	Enzymes
CJ CHEILJEDANG	Amino Acids; Enzymes; Nucleotides; Polyhydroxyalkanoate
C-LECTA	Enzymes
CODEXIS	Enzymes
COOL PLANET ENERGY SYSTEMS	Biocarbon; Hydrocarbon
CORBION	2,5-Furandicarboxylic Acid; Lactic Acid; Polylactic Acid (PLA); Succinic Acid
COVESTRO	Hexamethylene Diisocyanate; Pentamethylene Diisocyanate; Waterborne Polyurethanes
CRODA	Ethylene Oxide; Non-ionic Surfactants
DANIMER SCIENTIFIC	Medium Chain Length Polyhydroxyalkanoate
DEINOVE	Carotenoids; Muconic Acid
DOMTAR	Absorbents; Paper; Pulp
DUPONT INDUSTRIAL BIOSCIENCES	Enzymes; Ethanol; 2,5-Furandicarboxylic Acid; Isoprene; Plasticizers; Polyesters; Polyols
DUPONT TATE & LYLE BIOPRODUCTS	1,3-Propanediol
EARTH ENERGY RENEWABLES	Alcohol; Esters; Fatty Acids; Ketones
EASTMAN CHEMICAL COMPANY	Cellulose Acetate; Cellulose Acetate Butyrate; Cellulose Acetate Propionate; *n*-Butanol
ECOSYNTHETIX	Starch Vinyl Emulsions; Starch Vinyl Polymers
ECOVIA	*iso*-Butanol; EcoSynth™ Platform; Polyglutamic Acid
EDENIQ	Cellulosic Sugars
ELEVANCE RENEWABLE SCIENCES	Esters; Ethylene; Hydrocarbons from Olefin Metathesis
EMERY OLEOCHEMICALS	Aliphatic Esters; Polyols
ENERKEM	Ethanol; Methanol

COMPANY	PRODUCT
ENMEX	Enzymes
ENSYN	Renewable Fuel Oil
EPYGEN	Enzymes
EVOLVA	Nootkatone; Resveratrol; Stevia; Valencene; Vanillin
EVONIK	Amino Acids; Enzymes
FIRMENICH SA	Alcohols; Naphtho[2,1-*b*]furan; Sesquiterpene
GENOMATICA	Adipic Acid; Butadiene; 1,4-Butanediol; Caprolactam; Hexamethylenediamine
GEORGIA PACIFIC	Adhesives; Binders; Cellulose; Crude Tall Oil; Pulp; Resins
GEVO	*iso*-Butanol; Butene; Ethanol; Isooctane; p-Xylene
GFBIOCHEMICALS	Levulinates; Levulinate Ketals
GIVAUDAN	Flavors; Fragrances
GLOBAL BIOENERGIES	Butadiene; Isobutene; Propylene
GLUCAN BIORENEWABLES LLC	Furan
GRAIN PROCESSING CORPORATION	Corn Syrup; Maltodextrins; Starches
GRANBIO	*n*-Butanol
GREEN BIOLOGICS	Acetone; *n*-Butanol
GREEN LIFE CAN LLC	Polyalphaolefins; Polyolesters
GREENLIGHT BIOSCIENCES	Fatty Acids; Pyrimidines; Ribose
GREENYUG	Ethyl Acetate
HELIAE	Feed Additives; Microalgal Soil Inputs
IKEA	Polyhydroxyalkanoate
INGREDION	Corn Oil; Dextrose; Maltodextrins; Polyols; Proteins; Starches
INSCRIPTA	ENZYMES (Gene Editing)
INTREXON	1,4-Butanediol; *iso*-Butanol; Farnesene; Isoprene
INVISTA	Adipic Acid; Adiponitrile; 1,3-Butadiene; 2,3-Butanediol; Polyamide (Nylon 6,6)
ITACONIX	Itaconic Acid; Polyitaconic acid
JUNGBUNZLAUER	Citric Acid; Citrate Ester; Gluconate; Lactic Acid; Xanthan Gum
KALION	Glucaric Acid; *s*-3-Hydroxybutyrolactone (3-HBL)
KIVERDI	Citrus Oil; Omega-7 Oils; Sugars
KRATON PERFORMANCE POLYMERS	Fatty Acids; Pine Oil; Pine Pitch; Rosin Acids; Sulphate Turpentine; Tall Oil
LALLEMAND	Bacteria Cultures; Yeast
LANZATECH	Acetic Acid; 1,3-Butadiene; 2,3-Butanediol; *iso*-Butylene; Ethanol; *iso*-Propanol
LEAF RESOURCES LTD	Cellulosic Sugars
LESAFFRE ADVANCED FERMENTATIONS (LEAF)	Biofuels
LOGOS TECHNOLOGIES	Rhamnolipids; Surfactants
LONZA	Niacin; Proteins; Surfactants

COMPANY	PRODUCT
L'OREAL	Carrageenan; c-Glycoside; Rhamnose; c-Xyloside
LYGOS	Malonic Acid
MANGO MATERIALS	Polyhydroxyalkanoate
MANUS BIOSYNTHESIS	Enzymes; Natural Product Chemicals
MARA RENEWABLES	Algae Oils; Docosahexaenoic Acid (DHA); Omega-3 Fatty Acid
MBI INTERNATIONAL	Fumaric Acid; Succinic Acid
MERCURIUS BIOREFINING	Ethyl Formate; Ethyl Levulinate; Formic Acid; Furfural
METABOLIC EXPLORER	Butyric Acid; 1,3- Propanediol
MIBELLE BIOCHEMISTRY	Algae; *cm*-Glucan (Magnesium Carboxymethyl Beta-Glucan); Peptides
MODERN MEADOW	Collagen
MODULAR GENETICS	Acyl Glutamate Surfactant
MYRIANT	Acrylic Acid; Fumaric Acid; Lactic Acid; Muconic Acid; Succinic Acid
NATUREWORKS LLC	Lactic Acid; Lactide; Polylactic Acid
NATUREX	Ionic Liquids; Natural Deep Eutectic Solvents
NEOL BIOSOLUTIONS SA	Arachidonic Acid; Erucic Acid; Gondoic Acid; Nervonic Acid
NESTE	Isoalkanes; Naphtha; Propane
NEWLIGHT TECHNOLOGIES	Polyhydroxyalkanoate
NOURITECH	FeedKind® Protein
NOVAMONT	Mater-Bi™ Bioplastics
NOVOMER	Acrylic Acid; Butanediol; Polypropylene Carbonate Polyols; Succinic Acid
NOVOZYMES	Enzymes
NUCELIS LLC	Squalane; Ergosterol; Vitamin D
OAKBIO	*n*-Butanol; Polyhydroxyalkanoate
ORIGIN MATERIALS	5-Chloromethyl Furfural; Furandicarboxylic Acid; Terephthalic Acid
PHOTANOL	Erythritol
PHYTONIX	*n*-Butanol
PLAXICA	Lactic Acid; Polylactic Acid
POET	Corn Oil; Ethanol; Sugar
PRAJ MATRIX	Cellulosic Ethanol; Hexose; Lignin; Pentose Sugars
PROVIVI	Olefin Chiral Pesticides
PTT GLOBAL CHEMICAL	Butanediol; Lactic Acid; Polylactic Acid; Succinic Acid
PUREVISION TECHNOLOGY	Cellulosic Sugar
RENEWABLE ENERGY GROUP (REG LIFE SCIENCES LLC)	Fatty Acids
RENMATIX	Cellulosic Sugar
RENNOVIA	Adipic Acid; Glucaric Acid; 1,6-Hexanediol; Hexamethylenediamine
REVERDIA	Succinic Acid

COMPANY	PRODUCT
RHO RENEWABLES	Fuel Oxygenate; Polyketide Synthases
RODENBURG BIOPOLYMERS	Adipic Acid; Aphthalic Acid Ester; Barium Sulphate; Polylactic Acid; Succinic Acid
ROQUETTE	Gluconic Acid; Isosorbide; Isosorbide Polymers; Proteins; Sodium Gluconate; Starch; Succinic Acid
ROYAL DSM	Alkyd Resins; Carotenoids; Cellulosic Ethanol; Enzymes; Polyamides; Polyester Elastomer (Castor Oil Based); Succinic Acid
S2G BIOCHEMICALS	Ethylene Glycol; Propylene Glycol; Xylitol
SABIC	Polyethylene; Polypropylene
SEKISUI CHEMICAL	Butadiene; Ethanol; Isoprene; *iso*-Propanol
SENOMYX	Artificial Flavors
SIRRUS CHEMISTRY	1,1-Disubstituted Alkene Monomers
SOLEGEAR	Polylactic Acid
SOLIX ALGREDIENTS	Astaxanthin
SOLUGEN	Hydrogen Peroxide
SOLVAY	Acetone; *n*-Butanol; Cellulose Acetate; Epichlorohydrin; Glycerin; Guar Gum; Surfactants; Vanillin
STORA ENSO	Lignin; Sugars
SUCCINITY GMBH	Succinic Acid
SWEETWATER ENERGY	Cellulosic Sugars
SWISSAUSTRAL BIOTECH SA	Enzymes; Microbial Biobank
SYLVATEX	Micro-Emulsion Additive; Inverse Micelles
SYMRISE	Flavors; Fragrances;
SYNTHEZYME	Enzymes; ω (omega) Hydroxy Fatty Acids; Polyesters; Surfactants
SYNVINA	Furandicarboxylic Acid; Polyethylene Furanoate (PEF)
TATE & LYLE	Corn Syrup; Citric Acid; Diacids; Distiller Grain; Ethanol; Gluten; Oil; Starch; Waxy Corn
TERRAVERDAE BIOWORKS	Polyhydroxyalkanoate
THE COCA-COLA COMPANY	Polyethylene terephthalate
TOTAL CORBION	Polylactic Acid
TRELYS	Amino Acids
UNILEVER	Polymers; Surfactants
VERDEZYNE	Adipic Acid; Dodecanedioic Acid; Sebacic Acid
VIRENT	Aromatics; Benzene; *p*-Xylene
WHITE DOG LABS	Acetone; *iso*-Butanol; *n*-Butanol; Butyrate; *iso*-Propanol
ZIVO BIOSCIENCE	Algae
ZUCHEM	Mannitol; Monosaccharides; Oligosaccharides; Xylitol

APPENDIX B. BIOTECHNOLOGY SERVICE PROVIDER COMPANIES

COMPANY	PRODUCT
ATUM	Bioengineering; Gene Synthesis; Protein Expression
BIOPETROLIA	Yeast Platform; Gene Engineering
BIOTA TECHNOLOGY	Hydrocarbon DNA Sequencing
CARIBOU BIOSCIENCES	Genome Engineering
CHAIN BIOTECHNOLOGY LTD	Clostridium Platform; Genetic Engineering
CHEMDIV	Contract Research
CONAGEN	Metabolic Engineering
DMC BIOTECHNOLOGIES	Microbial Metabolic Control
DYADIC INTERNATIONAL	C1 (*Myceliophthora thermophile*) Platform: Protein Expression
ENEVOLV	Microbial Engineering
ENOBRAQ	Yeast Engineering
GINKGO BIOWORKS	Gene Synthesis; Microorganism Engineering
GREENLIGHT BIOSCIENCES	Cell-Free Bioprocessing Technology
ICM	Ethanol Fermentation; Feedstock Milling
INDUSTRIAL MICROBES (iMICROBES)	Genetic Engineering; Methane Feedstock
INGENZA	Bioprocess Optimization; Fermentation; Protein Engineering
MICROBIOGEN	Yeast Engineering
MOGENE LC	Genomic Sequencing; Microarrays; Microassays
MOLECULAR ASSEMBLIES	DNA Synthesis
OLIGOS BIOTECHNOLOGY	Engineering Fungus
NATIONAL CORN-TO-ETHANOL RESEARCH CENTER (NCERC)	Bioprocess and Fermentation Piloting
PARETO BIOTECHNOLOGIES	Polyketide Pathways
PRIMORDIAL GENETICS	Function Generator™ Platform
PROSPECT BIO	Trove™ Biosensor Metagenomic Library
PROTEONIC	UNic™ Recombinant Protein Translation and Production
SYNGULON	Bacteriocin-based Technologies
SYNTHETIC GENOMICS	Advanced Genomics – Microbial Cell Lines; DHA Omega-3; Astaxanthin
TESELAGEN	Combinatorial Gene Design and Editing
TWIST BIOSCIENCE	Gene Synthesis on Silicon
ZYMERGEN	Strain Improvement; Biomaterials
ZYMOCHEM	Microbial Engineering

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