Biotechnology:

Driving Solutions for Sustainable Development

ABOUT US

The International Council of Biotechnology Associations (ICBA) is a coalition of non-profit, national biotechnology trade associations formed to educate, and to advocate public understanding of, and to advocate for, public policies that support the growth of the innovative biotechnology industries. The ICBA represents the global voice of the industry in international fora with the goal of promoting continued innovation in the human health, agriculture, and industrial and environmental sectors.

Biotechnology drives solutions for sustainable development

Leveraging biotechnology innovation will be a key to meeting the global call for action around sustainable development. Adopted by the United Nations (U.N.) as a part of the 2030 Agenda for Sustainable Development, the 17 Sustainable Development Goals (SDGs) highlight the interconnected work necessary to address challenges facing the world across social, economic, and environmental fronts. Breakthrough innovations in biotechnology can and, in many cases, already are bringing forward solutions the world needs by providing tools to feed, fuel, and heal communities around the globe. Companies across sectors are coming to the table to address critical challenges throughout the innovation ecosystem. Breakthroughs in biotechnology can:

- Cure once-incurable diseases and enable rapid response to health crises;
- Enhance food security and improve plant health through more resilient seed varieties and advances in crop protection;
- Strengthen agriculture and food systems and promote animal health;
- Address antimicrobial resistance;
- Reduce greenhouse gases and advance climate mitigation, adaptation, and resilience; and
- Support economic and educational well-being by investing in resilient supply chains and workforce development.

The International Council of Biotechnology Associations (ICBA) partners with its national authorities and international organizations to unleash the tools of biotechnology to overcome global challenges.

ICBA Members

Africa BIO | Africa
Association of Biotech-Led Enterprises (ABLE) | India
AusBiotech | Australia
Belgian Life Sciences Industry Association (Bio.be) | Belgium
BIO Deutschland | Germany
BioIndustry Association (BIA) | United Kingdom
BioPharmaChem Ireland | Ireland
Biotech Austria | Austria
BIOTECanada | Canada
Biotechnology Innovation Organization (BIO) | United States of America
Costa Rican Biotechnology and Medical Device Business Association (CRbiomed) | Costa Rica
Czech Bio | Czech Republic
EuropaBio | European Union
Finnish BioIndustries (FIB) | Finland
Foro Argentino de Biotecnologia (FAB) | Argentina
German Association of Biotechnology Industries (DIB) | Germany
Holland BIO | Holland
Hong Kong Biotechnology Organization (HKBIO) | Hong Kong
Hungarian Biotechnology Association | Hungary
Italian Association for the Development of Biotechnology (Assobiotec) | Italy
Japan BioIndustry Association (JBA) | Japan
Korea Biotechnology Industry Organization (KoreaBIO) | South Korea
NZBio | New Zealand
PeruBiotec | Peru
Portugal's Biotechnology Industry Organization (P-BIO) | Portugal
Spanish Bioindustry Association (ASEBIO) | Spain
SwedenBIO | Sweden
Swiss Biotech Association (SBA) | Switzerland
Taiwan Bio Industry Association | Taiwan
The Greek Initiative on the Bioeconomy | Greece

SUSTAINABLE DEVELOPMENT

GOAL 1

Biotechnological innovations contribute to poverty reduction by supporting the resilience of crops and farmers, improving living conditions and health outcomes, and increasing access to affordable medical therapies. The use of biotech crops has been shown to increase farm income by $225 billion USD over 23 years, lowering agricultural emissions, helping farmers withstand the impacts of climate change, and greatly reducing global poverty levels.[1,2]

Increasing farmer income with agricultural biotech:

Biotechnological innovations in agriculture have helped farmers increase their incomes and reduce their vulnerability to climate change. These innovations are particularly beneficial for smallholder farmers. Notable examples of technologies that both increase farm income through higher productivity and lower production costs, as well as improve crop resiliency to climate change, enabling more-stable farm incomes include:

- Drought-tolerant maize: Maize is the most widely grown staple crop in Africa, and more than 300 million Africans depend on it as their main food source. Maize production, however, is severely affected by frequent drought in Africa, leading to crop failure, hunger, and poverty. The public-private Water Efficient Maize for Africa (WEMA) project is developing drought-tolerant and insect-resistant maize.[3] These varieties will help farmers mitigate the risks associated with drought, thus stabilizing yield and increasing farmer income.[4,5]

- Bt cowpea: Scientists in Nigeria, Ghana, and Burkina Faso are working to develop a Bt cowpea that is resistant to the pod borer insect, which can devastate up to 90% of a farmer's crop.[6]

- Golden rice: Golden rice is produced through genetic engineering to biosynthesize beta-carotene, a precursor of vitamin A. It is intended to produce a nutritionally fortified food to be grown and consumed in areas with a shortage of dietary vitamin A.[7]

Napigen is addressing unmet needs of future food supplies by creating hybrid crop plants to boost yields to unprecedented levels.[8] By boosting crop yields, Napigen's technology can increase food production, which is crucial for addressing global hunger and poverty. Higher yields can lead to increased income, which can impact smallholder farmers who make up a substantial proportion of the world's poor. Increased yields can lift farmers and their communities out of poverty.

Increasing the affordability of healthcare:

Additionally, innovations in genetic therapies have made critical healthcare more affordable than ever. Biotech innovations in healthcare can lead to the development of affordable treatments for diseases that disproportionately affect low-income populations.[9,10] In the next decade, the global adoption of digital technology, including by those experiencing poverty in low-and middle-income countries, presents a genuine opportunity to reduce inequality in the healthcare sector, hypothesizes a 2022 study.[11]

SUSTAINABLE DEVELOPMENT

GOAL 2

Innovations in plant breeding have substantially transformed the efficiency of food production since the mid-20th century, with innovations improving crop yields and the nutritional values of food crops.[8,9] Other studies have also highlighted the environmental benefits of biotech crops.[10,11]

Protecting crops with new genes: Herbicide-tolerant soybeans are genetically modified to be resistant to certain herbicides, which allows farmers to use these herbicides for weed control without damaging the crop.[12,13] Bt maize and Bt cowpea have increased farm yields by expressing the insect-resistant genetics in the crops. In Africa, where more than 300 million African farm families rely on maize yields, a pest or disease is a large threat.[14] Innovations that improve crop resilience are essential in achieving the goal of zero hunger.

Developing more-productive crops: One variety of genetically engineered wheat under development is more efficient at converting sunlight, resulting in a 10% increase in yield, regardless of the growth conditions.[15,16] And bean farmers in South America who grow IR Soybean see an average 9.3% increase in their yields.[17]

Alleviating under-nourishment around the world:

- Through the Africa Biofortified Sorghum Project (ABS), an international public-private partnership, researchers are enhancing the bioavailability of iron and zinc, increasing the amount and stability of pro vitamin A (such as beta-carotene) and improving the protein digestibility of sorghum.[18]
- The Banana21 initiative, a public-private partnership funded by the Gates Foundation, is working to develop a genetically engineered cooking banana with a three-fold increase in iron and a four-fold increase of pro-vitamin A.[19]
- Royal DSM, a Dutch biotechnology company, has been providing nutritionally enhanced protein powders to communities across sub-Saharan Africa.

In British Columbia, Canada, one biotech company is innovating to end hunger by extending the shelf life of produce. Meet Okanagan Specialty Fruit (OSF), who created a non-browning apple that stays fresher for a longer duration than conventional apples. This company specializes in the development, growing, processing, and marketing of novel tree fruit varieties developed through bioengineering. Their flagship product, the Arctic apple varieties, provides a sustainable way to reduce food waste and increase fresh fruit consumption[20,21] among children. The OSF's Artic apple is thereby improving nutrition and contributing to the achievement of Zero Hunger.

SUSTAINABLE DEVELOPMENT

GOAL 3

Biotechnological innovations are not only bringing new vaccines and therapies to patients, but also finding cures for diseases that were once incurable. Biotechnological innovations are enabling the rapid introduction of clinical trials of vaccines, the search for effective therapies, and a deep investigation of both the origins and the ways in which viruses spread.[22,23]

Reducing the spread of infectious diseases while containing epidemics and pandemics: Vaccines prevent approximately 10.5 million cases of infectious illnesses each year.[24,25] The British company Oxitec has developed a technology to control the spread of Aedes aegypti, the primary vector for dengue, chikungunya, and Zika virus outbreaks around the world.[26,27]

Increasing survival rates: The survival rates for children with cancer have improved significantly, with 83% of children now surviving, compared to 58% in 1970.[28,29] The survival rates for Chronic Myeloid Leukemia (CML) patients have also improved dramatically: today, 80% of people with CML experience 10-year survival rates.[30,31,32,33,34] And HIV/AIDS is no longer fatal: a 20-year-old diagnosed with HIV can live well into his/her 70s due to the development of antiretroviral (ARV) combination treatments.[35,36,37,38]

Advancing good health practices and treatments: Biotech tests have improved the detection and diagnosis of conditions, leading to better patient prognoses.[39,40] Advances in marine biotechnology have led to the development of over 20,000 novel marine natural products, including products to manage pain, reduce inflammation, treat cancer, and regenerate tissue.[41]

Many biotechnology companies are working toward good health and well-being across the globe. At the forefront of the search for new cures and therapies are the small and medium-sized biopharmaceutical companies.[42] In fact, Dyadic's Gene Expression Platform is driving the development of novel biologic drugs, including vaccines and antibodies, improving global healthcare and enhancing our ability to combat diseases effectively. Their pioneering technology has been shown to enable faster and more efficient vaccine and antigen production.

Their CI gene expression platform takes information from a gene and uses fungal cells to create antigens from them. Dyadic has found additional benefits from their accelerated vaccine production technology — addressing health inequalities. "We have a platform now that can lower the cost and improve the access of vaccines for the world", CEO Mark A. Emalfarb said, noting that he is working with organizations internationally, including in Bangladesh, India, and South Africa to produce vaccines for distributions in those countries.[43]

SUSTAINABLE DEVELOPMENT

GOAL 4

Biotech companies invest in the future of innovation by creating educational opportunities for all levels, but especially younger populations. These programs not only contribute to the growth of the biotech industry but also play a significant role in promoting STEM education and creating opportunities for young people that are accessible as well as equitable.

Providing quality STEM educational opportunities: Employment in STEM occupations has grown 79% in the past three decades, according to the U.S. Bureau of Labor Statistics,[44] and STEM jobs are projected to grow an additional 11% from 2020 to 2030.[45] Amgen is a biopharmaceutical company that has established two major programs to support STEM education:

- Amgen Biotech Experience (ABE): This program empowers teachers to bring biotechnology into their classrooms.[46] Established in 1990, ABE introduces students to the excitement of scientific discovery and builds bridges between school and real-life biosciences.[47] The program provides teachers with professional development and education materials and loans research-grade equipment to high schools in 16 countries all at no cost.[48] ABE has a strong focus on developing and advancing opportunities for underserved and underrepresented populations to access, engage and succeed in pathways to bioscience.[49] Fifty-six percent of participating schools in the United States serve low-income student populations.[50]

- Amgen Scholars Program: This program provides opportunities for undergraduates to participate in cutting-edge, summer research opportunities at world-class institutions.[51] Established in 2006, the Amgen Scholars Program is an undergraduate summer research experience hosted at 24 premier educational and research institutions across the United States, Europe, Asia, Australia, and Canada.[52] Participants conduct a research project under top faculty, participating in seminars and networking events, and taking part in a symposium in their respective region.[53] Throughout the program, participants meet peers, present their research findings, learn about biotechnology, and hear from leading scientists.[54] Financial support for students is a critical component of the program, which helps ensure that eligible students, regardless of income, can participate.[55]

Another example, BASF contributes to the SDGs via its products, solutions, and technologies, but also works toward sustainable learning projects for young people. BASF's Kids Labs project and educational initiatives foster sustainable learning environments for youth, enabling quality education, and building the skills for a brighter future. BASF's youth labs engage young students in science at an early age through inspirational programs, providing hands-on learning that helps today's students become the innovators and leaders of the future.[56] More than 1.2 million kids and teens in 45 countries have taken part in these experimentation programs since the first hands-on workshops in 1997.[57] They also offer a Virtual Lab where junior researchers can experiment just like in a real lab.[58]

SUSTAINABLE DEVELOPMENT

GOAL 5

Biotechnology can develop gender-inclusive opportunities in healthcare, focus on empowering women in science, and invest in gender-transformative opportunities.

Improving health: Biotechnology can contribute to women's health by developing new treatments and preventive measures for diseases that disproportionately affect women, and increase women's participation in clinical trial diversity efforts. Biotechnology research necessitates tracking of key sex and gender factors that are being considered at five critical stages of health biotechnology research and development: priority setting; technology design; clinical trials; commercialization; and health services delivery.[59] This ensures that the needs of all genders are taken into account in the development of new technologies.[60]

Empowering women in science: Biotechnology increases the representation of women in scientific research and leadership roles. For instance, the Department of Biotechnology launched a Biotechnology Career Advancement and Re-orientation Program (BioCARe) for women scientists.[61] Similarly, many companies have made a concerted effort to increase the representation of women in their senior leadership ranks.[62]

Creating economic opportunities: Biotechnology can create new economic opportunities for women, particularly in developing countries. Biotech crops can increase farm productivity and income, which can be particularly beneficial for women farmers. As countries move to make bigger investments in their innovation ecosystems, an opportunity arises to ensure they are gender transformative.[63]

Leading by example: The Biotech Sisterhood, an initiative by women in corporate leadership at biotech companies, is working to overcome barriers to women's advancement and opportunity in the biotech industry through networking and advocacy. They identify unconscious bias in venture capital investment, research funding and corporate leadership development, and advocate for greater focus by policy makers, investors, and biopharma companies on developing treatments and access to treatment for health conditions predominantly experienced by women.

Organon is committed to women's everyday health needs, focusing on reproductive health issues that are unique to women and conditions that disproportionately affect women.[64] They are working to redefine and harness innovation to help women and girls achieve their promise and lead healthier, more empowered lives.[65] Organon is also working to promote balanced gender representation at all levels.[66] They aim to reflect the gender equity within their company that they want to see in the world.[67] Organon has been recognized in Bloomberg's 2023 Gender Equality Index (GEI), a benchmark indicator that tracks the performance of public companies committed to disclosing their efforts to support gender equality.[68]

SUSTAINABLE DEVELOPMENT

GOAL 6

Biotechnology companies develop solutions that reduce water usage and waste, and ensure that water is safe from contaminants.[69] Water is a vital resource – once clean, it can be used for drinking or for growing crops.

Delivering clean drinking water to communities around the world: Innovations like the development of biofilters or biosensors find and remove contaminants from water, ensuring safe and clean drinking water. Biotechnology can utilize certain bacteria and algae to remove pollutants from wastewater, thereby improving water quality.[70] For example, a European-African alliance called SafeWaterAfrica Project developed a novel water-cleaning system that purifies chemical contaminants and disinfects water by removing pathogens.[71] This project was a collaborative effort between academic and industrial partners from Germany, Spain, and Italy who provided knowledge on new technologies for water purification as well as academic and industrial partners from Mozambique and South Africa who contributed with additional technologies and system integration.[72]

Improving water conservation: The development of drought-tolerant crops, both by conventional methods and by genetic engineering, is an important strategy to meet global food demands with less water.[73] Some examples of conventional breeding programs for drought tolerance are the development of rice, wheat, and Indian mustard varieties tolerant to salt and to alkali soils by the Central Soil Salinity Research Institute in Karnal, India.[74]

Reducing wastewater: Industrial wastewater is a major source of pollution around the world; biotech solutions can be used to remove contaminants and reduce wastewater. Novozymes uses enzyme technology to improve sludge management by drying out the biomass in the water. This not only decreases costs, but also can reduce the use of polymers by up to 20%.[75]

SUSTAINABLE DEVELOPMENT

GOAL 7

7 AFFORDABLE AND CLEAN ENERGY

Biotech innovations have led to the development of fuel alternatives like biofuels and microbial fuel cells, which use bacteria to convert chemical energy into electrical energy.[76] Biotechnology can lead to more efficient and sustainable methods, reducing the environmental impact and improving the energy balance of these fuels.

Producing cleaner fuel options with biofuels: Biofuels, a cleaner and more-sustainable source of energy, are produced from a wide range of renewable biomass feedstocks and can contribute to the reduction of greenhouse gas emissions by substituting for hydrocarbons in transportation fuel, providing a cleaner alternative to fossil fuels. Biofuels can be produced from various biological materials and processes, including plants, algae, agricultural waste, and even recycled carbon from the atmosphere.[77] Biofuels contribute to the reduction of greenhouse gas emissions as countries and cities adopt them as a primary source of energy and as production of biofuels increases.

- The United States Biofuel production capacity reqached 23 billion gallons per year, which is a 6% increase from Jan 2022.[78]
- Brazil and Indonesia ranked second and third, with figures at roughly 915 and 390 petajoules, respectively.
- In Germany, biofuels production reached 138 petajoules in 2022, placing the country as the top producer in biofuels in Europe.
- Other countries with significant biofuel production include China, Argentina, India, Netherlands, Thailand, and France.[79]

Reducing emissions with biogas: Biogas is a renewable source of energy, made from organic waste that can be used for heating, electricity, and other operations that require energy-intensive equipment.

- In Europe, Germany is the most advanced in biogas/biomethane. The country's biogas industry has expanded significantly due to the feed-in-tariff (FIT) scheme introduced with the Renewable Energy Sources Act. As of 2020, the cumulative installed capacity of German biogas power plants reached 5,700MW, producing 33TWh of power annually, which is approximately 6% of all electricity generated in Germany.[80]
- Denmark has taken major steps in biogas/biomethane lately. Renewables make up 36% of Denmark's total energy supply in 2019, with bioenergy playing an important role, representing three quarters of renewable energy supply.[81]

- In Finland and Norway, the use of biogas-fueled power plants and vehicles is highlighting the true viability of this fuel. In Finland, the use of liquid biofuels in transport represents 10% of overall transport energy consumption, with increased focus on advanced biofuels[82] and in Norway, the country ruled that 24.5% of traded fuels must be biofuels by 2021 and 9% must be advanced biofuels[83]

- A private facility recently opened in Salt Lake City that takes restaurant food waste and converts it to biomethane, a renewable energy source[84]. Enough natural gas will be created from previously landfilled materials to supply a community of 40,000 people. The solids from the process creates a by-product that is a nutrient-rich, carbon based fertilizer for agricultural products.

Global companies and institutions formed the below50 coalition to promote best-of-breed of sustainable fuels that can achieve significant carbon reductions, and scale up their development and use.[85] Some members of the coalition include Audi, DuPont, DSM, Joule, LanzaTech, Novozymes, and Yale University.

Yet another company "biofueling" the way is Virent, whose BioForming® technology converts plant-based sugars into hydrocarbon fuels to produce a range of products, including gasoline, diesel, and jet fuel, as well as the chemicals used for plastics, fibers, and films. One of the significant achievements of Virent's BioForming® technology is the production of synthesized aromatic kerosene (SAK), a critical component that made 100% sustainable aviation fuel (SAF) possible.[86] In December 2021, United Airlines flew an aircraft full of passengers using 100% SAF in one engine and petroleum-based jet fuel in the other.[87] Leading into COP28, Virgin Atlantic flew the world's first 100% SAF flight from London to New York, powered in part by BIO member, Virent.

SUSTAINABLE DEVELOPMENT

GOAL 8

8 DECENT WORK AND ECONOMIC GROWTH

The global biotechnology market is currently valued at $752.8 billion and growing. The development of breakthrough health initiatives from biotech will transform our future as we tackle global crises including disease, environmental pollution, and food management.[88]

Bringing economic benefits to countries and farmers: Genetically engineered (GE) crops have brought about substantial economic benefits. A study found that GE technology adoption has reduced chemical pesticide use by 37%, increased crop yields by 22%, and increased farmer profits by 68%.[89] These benefits are particularly significant in developing countries.[90]

Alleviating poverty: GE crops also help alleviate poverty for millions of resource-poor farmers and their families around the world. A study found that farmers in developing countries received $4.42 for each dollar invested in genetically engineered crop seeds.[91]

Improving productivity using healthcare biotechnology products: Biotechnology products in healthcare have led to healthier workforces and economic development; for example, biologics have contributed to healthier and more productive labor forces due to less hospitalization, career interruptions, and school and work absenteeism.[92,93] A study conducted by the Global Initiative on Health and the Economy showed GDP losses between 6 and 10% across 19 countries due to absenteeism or presenteeism due to health-related issues.[94] These numbers are projected to rise with the increase in chronic diseases,[95] making biotech even more important to keeping people healthy and workforces productive.

Enhancing economic productivity with biologics: A study showed that over two years, a rheumatoid arthritis patient treated with a novel biologic product remained in employment 31 weeks longer.[96] Furthermore, the bioscience industry's economic impact on the U.S. economy amounted to $2.9 trillion USD in 2021, as measured by overall output.[97] The U.S. bioscience industry employed 2.1 million employees across more than 127,000 U.S. business establishments in 2021. As the overall economy shed 1.5% of its job base, the biosciences industry increased employment by 11% since 2018.[98] In total, the bioscience industry's economic impact on the U.S. economy amounted to $2.9 trillion USD in 2021, as measured by overall output.[99]

Increasing farm capacity: Arzeda is a company that creates designer proteins for biomaterials and thereby has improved the capacity of both farmers and crops leading to economic growth. They aim to solve some of today's hardest problems – from food production and better nutrition to sustainable materials and home care – by creating new designer proteins and enzymes.[100] Their Intelligent Protein Design Technology™ combines physics-based protein design and AI to create entirely new designer proteins and enzymes more efficiently and with less risk.[101] Arzeda's innovative designer proteins are optimizing agricultural processes, leading to higher crop yields, reduced resource use, and improved economic growth for farmers, promoting a more sustainable agriculture industry. Arzeda's approach to protein design will lead to improved work conditions. Workers may be exposed to fewer harmful chemicals by reducing the need for labor-intensive trial-and-error methods, leveraging AI and computational design.[102]

SUSTAINABLE DEVELOPMENT

GOAL 9

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Biotech companies are fueling a new wave of innovation. Research and development in the field of biotechnology is occurring across the globe.[103] Companies are contributing to the innovation ecosystem by incentivizing the construction of biotechnology parks, securing investment in research and development capabilities, and connecting to the international community for investment and ongoing partnership opportunities.

Launching R&D partnerships with companies, multinational institutions, and NGOs to invest in the industry:

- The African Access Initiative (AAI) is a public-private partnership that targets the growing cancer crisis in Africa. Driven by Africa – for Africa – AAI's innovative approach engages stakeholders across sectors to accelerate access to cancer treatment.[104,105]

- The annual BIO International Convention continues to provide a platform for startup companies and researchers worldwide to showcase their research and innovation, fostering ties with investors, companies, NGOs, and other researchers.[106]

Creating connections with the international community:

- BiotechTown, the first private center in Brazil providing a space and resources for startups to expand their operations, continues to thrive and support the growth of biotech startups.[107]

- BioPark Mauritius, established in March 2015, provides a dedicated space for research and development in the biotechnology sector. Startups focusing on microbiology, chemistry, toxicology, pharmacology, and epidemiology are establishing operations at the biopark.[108]

- The Institute for Biotechnology Research (IBR) at the Jomo Kenyatta University of Agriculture and Technology (JKUAT) in Kenya continues to train the next generation of homegrown scientists.[109]

Corteva Agriscience is actively involved in reinvesting in the innovation industry. They are partnered with research parks, foster startup relationships, and complete capital investments globally. One of their notable projects in Africa is their collaboration with the United States Agency for International Development (USAID) West Africa Trade & Investment Hub, Warc Group, and John Deere to improve smallholder production in Ghana's Upper West Region.[110] This project leverages $1.2 million USD in development funding to increase the productivity and incomes of 20,000 smallholder farmers.[111] The aim is to increase smallholder farmer adoption of climate-optimized hybrid maize seeds, educate farmers on sustainable agriculture practices, and improve access to credit, with the goal of increasing farmers' yields from 2 to 4 metric tons per hectare.[112,113] In terms of industry reinvestment, Corteva Agriscience has made significant commitments. They have announced that they are spending more than $1.3 billion USD on R&D in 2023 and are increasing their R&D investment to 8% of annual net sales by 2025.[114]

SUSTAINABLE DEVELOPMENT

GOAL 10

Biotech companies are constantly finding innovative solutions to global challenges and are consequently creating opportunities to reduce inequalities.

Addressing health inequalities: Biotechnology can contribute to reducing health inequalities by developing affordable treatments for diseases that disproportionately affect low-income populations.[115] A major research partnership led by Imperial College London and University College London has been launched to explore ways of reducing health inequalities in cities around the world.[116] This project is funded by £10 million from the Wellcome Trust and collaborates with institutions in 10 cities, including London,[117] and aims to address health inequalities by developing digital healthcare technologies.[118]

Solving for economic inequalities: Biotechnology can support sustainable agriculture in low-income countries by developing modified crops that are more resilient to climate change and pests. This can help increase farm productivity and income, thereby reducing economic inequalities.[119]

- Agrorite is a Nigerian startup that provides input financing as well as agricultural technology and consultancy to help small farmers be profitable.[120,121] Since 2019, Agrorite has improved the livelihood of smallholder farmers by providing innovative solutions, including warehousing and profitable markets, both locally and internationally for agrocommodities.[122] This not only reduces income inequality but also advances the United Nations' Sustainable Development Goal 2 of Zero Hunger.[123]

- Genentech, a leading biotechnology company, is actively working to reduce inequalities through their technologies.[124] Genentech has launched the Health Equity Innovation Fund, which focuses on strengthening trust and community engagement in clinical trials between communities of color and healthcare providers, and incorporating bias training and accountability with healthcare providers to achieve high-quality care for all patients.[125] They also have the Diverse Future of STEM Fund, which reinforces their commitment to breaking down barriers for underrepresented students across all stages of their education journey, from K-12 to postgraduate support.[126] These initiatives are designed to address systemic racism in healthcare and STEM education pathways, and they embody Genentech's commitment to using biotechnology to drive social change.[127,128]

- Genentech also recognizes that climate change has the potential to impact everyone's health and wellbeing, and exacerbates many of the diseases they work to treat.[129] They have set ambitious sustainability goals to reduce their global environmental footprint 50% by 2029, and achieve true zero emissions by 2050.[130] This includes transitioning to 100% sustainable electricity for their South San Francisco campus by 2025, reducing Scope 1 and 2 greenhouse gas emissions by 75% by 2029 (compared to 2019), and electrifying their sales and site vehicle fleet by 2030.[131]

SUSTAINABLE DEVELOPMENT

GOAL 11

11 SUSTAINABLE CITIES AND COMMUNITIES

Biotechnology can contribute to sustainable urban development by providing innovative solutions in areas such as waste management and energy production. For example, biofuels produced from urban waste can provide a renewable source of energy, while biotechnological processes can be used to treat wastewater.[132] Furthermore, biotech companies hold capacity-building training programs that develop and embed sustainable practices into cities and communities.

- Investing in sustainable production: Biotechnology can help achieve sustainable and efficient management and use of natural resources,[133] including microbes essential for industries such as pharmaceuticals and food production. Harnessing the power of microbes to convert renewable resources into electricity, fuels, and chemicals has paved the way for a "green bioeconomy".[134] Living Seawalls combines ecological and engineering know-how to bring marine life back to concrete urban coastlines.[135]

- Reducing waste: Biotechnology can contribute to the reduction of consumer-level food waste and food loss in the production and supply processes.[136] For example, genetically modified crops can be more resilient to pests and diseases, reducing crop loss.[137] One company, Greencity Solutions, tested 16,000 species of moss to find the most effective ones for use in moss wall biofilters. Living walls are becoming more common architectural features, and with the new moss version, cities have an improved ability to bring the fresh smell and clean air of a forest to crowded, busy locations, as well as reducing waste.[138]

- Promoting sustainable practices: Biotechnology companies are being encouraged to adopt sustainable practices and integrate information regarding sustainability into their reporting cycle.[139] This can help promote responsible consumption and production within the biotech industry.[140] Scottish biotech start-up Oceanium uses sustainably-farmed seaweed to create food and nutrition products and compostable biopackaging.[141] BitaGreen develops software and maps that identify how urban green infrastructure helps to reduce flooding and increase the quality of life.[142]

Many biotech companies are making positive changes in the space.

Both Renmatix and Modern Meadow's sustainable supply chain projects are turning carbon pollution into valuable resources, creating circular and sustainable supply chains that benefit communities and cities while addressing pollution.

Simplot's sustainability efforts are woven into the fabric of their company.[143] They are committed to finding ways to produce more with less as they contribute to feeding the world's growing population.[144] As part of their 4 Sight 2030 Goals, Simplot has pledged to reduce energy, water, carbon, and waste across all of their production facilities worldwide.[145] They aim to reduce energy use by 15% per ton of product, reduce freshwater intake by 15% per ton of product, reduce carbon emissions by 20% per ton of product, and achieve zero waste to landfill in their food processing plants.[146] This addresses many of the sustainable development goals.

SUSTAINABLE DEVELOPMENT

GOAL 12

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Biotechnology can play a key role in promoting sustainable consumption and production patterns. For example, it is a driver in the development of bio-based materials that are biodegradable and thus reduce waste. Bio-based plastics and innovative bioprocesses that are genetically engineered to break down plastic waste more rapidly and effectively can contribute to emissions reduction targets, which can lead to economic benefits in terms of avoided costs related to climate change.

Replacing petroleum-based plastics with bioplastics: Bioplastic can replace waste destined for a landfill with biodegradable, compostable consumer products.[147,148] In terms of market share, bioplastics currently represent approximately 1% of the global plastics production volume.[149] This share is expected to grow as bioplastics become more sophisticated and diverse.[150] By 2030, it is expected that bioplastics will account for a 40% share of the global plastics market.[151] In 2023, the Coca-Cola Company unveiled the world's first PET plastic bottle made entirely from plant materials using innovative technology from Virent.[152] The bottle is fully recyclable and made from renewable plant materials.[153]

Reducing the use of crop protection products with genetically engineered (GE) crops: From 1996 to 2018, crop biotechnology reduced the spraying of crop protection products by 776 million kilograms, a global reduction of 8.6%.[154] As a result, farmers who grow biotech crops have reduced the environmental impact associated with their crop protection practices by 19%.[155]

Helping to ensure the environmentally sound management of chemicals:

- Phytonix, a biotech company, uses photosynthesis and cyanobacteria to produce renewable chemicals.[156,157] Their process directly reduces greenhouse gas (GHG) emissions at the rate of one metric tonne of CO2 per 138 gallons of biobutanol produced.[158] This significantly carbon-negative process is expected to produce industrial chemicals at less than half the cost of the incumbent fossil producers.[159]

- One biotech leader in this space is Vestaron, whose innovations contribute to climate mitigation through the development of peptide-based biopesticides.[160] These biopesticides are derived from naturally occurring peptides, making them a more environmentally friendly alternative to traditional synthetic pesticides.[161] By reducing the reliance on synthetic pesticides, Vestaron's products can help decrease the emission of harmful chemicals into the environment.[162] This not only helps protect biodiversity but also reduces the carbon footprint associated with the manufacturing and application of synthetic pesticides.[163] Moreover, the use of biopesticides can contribute to sustainable agriculture practices, which play a significant role in climate change mitigation.[164] Sustainable agriculture practices, including the use of biopesticides, can help reduce greenhouse

gas emissions, enhance the soil's ability to sequester carbon, and improve farm resilience to climate change.[165,166] Through its innovative biopesticides, Vestaron is playing a part in the broader efforts to mitigate climate change.

- Similarly, Recombinetics leverages their proprietary gene-editing platform to improve the health and welfare of food animals. Healthier animals mean less disease, which can reduce the need for antibiotics and other treatments that can have environmental impacts. By improving animal health and productivity, they can help to reduce the environmental footprint of livestock farming.[167]

SUSTAINABLE DEVELOPMENT

GOAL 13

13 CLIMATE ACTION

Biotechnological innovations can help mitigate climate change by reducing greenhouse gas emissions. Biofuels serve as a cleaner alternative to fossil fuels. Moreover, genetically modified crops are more resilient and adaptable to changing climate conditions, thereby ensuring food security.[168,169] Biotech as an industry is agile and ready to meet the emerging needs of climate action as it grows.

Reducing agricultural emissions with GE crops: Biotech crops continue to contribute to the reduction of greenhouse gases. Recent studies suggest that if the European Union adopted genetically modified crops more widely across its farmlands, it could reduce its agricultural emissions by almost 10%.[170,171,172] This is due to the fact that GE crops are typically more productive, reducing the need for land and thus decreasing deforestation.[173,174,175]

Decarbonizing air travel: Airlines are increasingly using biofuels to reduce carbon emissions from air travel. In 2022, United Airlines announced a strategic investment in NEXT Renewable Fuels, which is developing a flagship biofuel refinery in Port Westward, Oregon, with expected production beginning in 2026.[176] The biorefinery could produce up to 50,000 barrels per day of Sustainable Aviation Fuel (SAF), renewable diesel, and other renewable fuels.[177] Qantas Airlines completed the world's first U.S.-Australia biofuel flight in 2018, using a blend of biofuel processed from Brassica Carinata, a non-food mustard seed.[178] The flight resulted in a 7% drop in emissions along the route.[179]

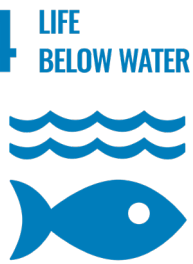
Driving resilient innovation through partnerships: The below50 coalition – which includes companies like Audi, DuPont, DSM, Joule, LanzaTech, Novozymes, and Yale University – continues to promote sustainable fuels that can achieve significant carbon reductions.[180,181] The coalition has grown over the years, with more companies joining to contribute to the development and use of sustainable fuels.[182] Virgin Atlantic and LanzaTech are collaborating to produce jet fuel derived from waste industrial gases from steel mills via a fermentation process.[183,184] This results in carbon savings of 65% compared to conventional jet fuel.[185,186] In 2023, Virgin Atlantic announced a partnership with LanzaTech to develop and commercialize a new sustainable aviation fuel.[187] They aim to have three UK plants running by 2025, producing up to 125 million gallons of sustainable fuel per year.[188,189]

LanzaTech is a biotechnology company that focuses on the production of bio-ethanol.[190] Their technology allows for the capture and processing of carbon-rich gases before they enter the atmosphere, which helps to reduce environmental harm.[191] In 2021, their commercial plants produced more than 30 million gallons of ethanol from waste carbon, the equivalent of offsetting 150,000 metric tons of CO2 from the atmosphere.cxcvii[192,193] They also recycle over 90% of the water they use, and the spent bacterial biomass from their process can be used as a nutrition source for aquaculture.[194]

LanzaJet, a spin-off of LanzaTech, is a sustainable fuels technology company dedicated to carbon recycling and expanding sustainable aviation fuels (SAF) and renewable diesel to reduce greenhouse gas emissions and to decarbonize the aviation and transportation industries.[195,196] Their technology converts ethanol derived from a variety of sustainable sources into SAF, which has the potential to reduce lifecycle greenhouse gas emissions by at least 70% compared to conventional jet fuel.[197] LanzaJet has achieved a major construction milestone for the world's first alcohol-to-jet SAF commercial production plant.[198]

SUSTAINABLE DEVELOPMENT

GOAL 14



Biotechnology supports the development of sustainable aquaculture practices, which can help ensure food security without depleting marine biodiversity.[199,200] Biotechnology can also contribute to the preservation of marine ecosystems by innovating in food production processes and technologies, and by safeguarding the sea from indirect threats like pollutants and nutrient runoff.

Innovating in food production from the sea: Biotechnology companies are using genomics technology and recombinant DNA technology to address issues with overfishing and ensure a healthy marine ecosystem. Kepley Biosystems is a U.S.-based life science startup developing OrganoBait, a synthetic alternative to bait fish.[201] This could help reduce the demand for wild-caught bait fish. Aker BioMarine[202] is a Norwegian fishing and biotech company providing krill[203] products through a fully documented and secured catch-and-process chain. Krill is mainly used for the production of krill meal and krill oil, which is used for animal or aquaculture feed and for human consumption through health products and omega-3 supplements. AlgaSpring, based in the Netherlands, is the largest producer of the marine phytoplankton Nannochloropsis; phytoplankton plays a crucial role in oceanic food chains and in regulating carbon dioxide levels.[204]

Safeguarding ecosystems from direct and indirect threats: Biotechnology has developed marine-derived biosensors to monitor marine environments by revealing the presence of an element, molecule, or organism of interest. In 2011, a team at the Virginia Institute of Marine Science reported the creation of a portable biosensor that could detect marine pollutants, including oil, much more quickly and economically.[205] Furthermore, DNA-based monitoring tools can also validate the identity of species and alert to the presence of invasive species.[206] Bawat A/S is a company based in Hørsholm, Denmark, whose product protects the eco balance of the global oceans by providing sustainable solutions for ships' ballast water management. The management systems are simple, flexible, cost-effective, and sustainable solutions[207] that keeps chemicals, filters, and UV out of the water by innovating the pasteurization process for ballast water in the world's oceans. Marine biotechnology can also play a role in remediation through the identification of bacteria that can metabolize certain types of hydrocarbons. These bacteria can be used to break down pollutants without any danger to the ecosystem.[208]

AquaBounty's bioengineered fish offer opportunities for improved nutrition, reduced chemical usage, and enhanced sustainability in aquatic ecosystems, providing new ways to safeguard life below water.[209] AquaBounty's land-based Recirculating Aquaculture System (RAS) is far less susceptible to disease-related pressures of conventional salmon farming and has the added benefit of keeping the conventional treatments out of coastal waterways.[210] Their RAS system features biological filters to remove waste and return freshwater to maintain an optimal growing environment for the salmon. According to AquaBounty's 2022 SDG report, its innovations in energy and water management via salmon farming have both economic and environmental advantages.[211]

SUSTAINABLE DEVELOPMENT

GOAL 15

Biotechnology is a promising tool for improving soil health and nutrient cycling in sustainable agriculture. Microorganisms with specific properties can be added to soil to promote plant growth, suppress plant pathogens, and enhance soil structure and fertility. Biofertilizers and biopesticides are examples of utilizing natural resources to enhance soil health, plant health, and productivity. Biotechnology has vast potential in sustainable agriculture, providing several opportunities to enhance agricultural productivity, quality, and sustainability.

Supporting sustainable forest management: Genetically engineered trees can be more resistant to diseases and pests, reducing the need for chemical pesticides.[212] Moreover, biotechnology can contribute to the restoration of degraded land.[213]

Preserving water and topsoil with GE crops: Certain bacteria and fungi can be used to restore soil fertility and structure.[214]

- Herbicide-tolerant genetically modified crops enable farmers to apply conservation tillage. Less tilling means less soil erosion, as well an improved moisture retention. No-till agriculture also protects water by reducing clogged waterways. Additionally, future nitrogen use efficient genetically modified crops could also help reduce chemical runoff while potentially increasing yield by 15% per acre.[215]

- Insect-resistant crops require less pesticide applications than conventional crops, better preserving biodiversity - for example, the Bt eggplant, where pesticide use on eggplants was reduced by as much as 92% because of biotechnology.[216]

- GE crops use one-fifth less farmland to produce food, resulting in less deforestation and the preservation of biodiversity.[217] From 1996-2015, the 574 million tons of productivity gained through biotechnology has saved 174 million hectares of land from being ploughed and cultivated.[218]

Reducing chemical pesticide use: Companies like Aphea.Bio are developing technologies to make biopesticides out of microorganisms, offering an organic alternative to chemical pesticides.[219] Global Bioenergies, a French company, is harnessing microorganisms to break down agricultural or forestry waste to produce fuels,[220] and in December 2022, the U.S. Department of Agriculture announced an investment of $9.5 million USD to support the scale-up of sustainable bioproduct manufacturing in the United States.[221]

Calysta, a biotech company based in Silicon Valley, seeks to improve global protein availability while preserving biodiversity for this and future generations.[222] Their technology has a tiny water footprint, requires no animal or plant products, and can be placed anywhere in the world. Their product, Feedkind,[223] "can produce 100,000 tonnes per year on just 10 hectares of developed land." An equivalent quantity of soy protein would require a quarter of a million hectares of arable land.

SUSTAINABLE DEVELOPMENT

GOAL 16

Biotechnology is playing a role through the sector's contributions to justice in healthcare and the environment. Biotechnology advancements are helping to address health disparities and ensure that lifesaving treatments and vaccines are accessible to all.[224,225] Furthermore, the ethical and responsible use of biotechnological innovations can promote peaceful and inclusive societies. Transparency in biotechnological research and development can foster trust and cooperation among nations.[226]

Improving health outcomes: Biotechnology provides breakthrough products and technologies to combat debilitating and rare diseases.[227] The Biotechnology Innovation Organization (BIO) launched the BIOEquality Agenda in 2020 as one step to counteract systemic injustice, inequality, and unfair treatment of underserved communities.[228] This initiative seeks to expand diversity in the biotech industry and within clinical trials.

Protecting the environment: Biotechnology can help to reduce our environmental footprint.[229] This can contribute to environmental justice by ensuring that all communities have access to a clean and healthy environment.

Enhancing food security: Biotechnology can help to feed the hungry by improving agricultural productivity.[230] This can help to address food insecurity and ensure that all individuals have access to sufficient, safe, and nutritious food.

Cleaning energy supplies: Biotechnology can help to use less and cleaner energy.[231] This can contribute to energy justice by ensuring that all communities have access to affordable and sustainable energy.

Maximizing the efficiency of industrial manufacturing: Biotechnology can help to have safer, cleaner, and more efficient industrial manufacturing processes.[232] This can contribute to economic justice by creating jobs and promoting sustainable economic growth.

BioNTech, a German biotechnology company, has made significant contributions to peace, justice, and strong institutions through its development of the first authorized COVID-19 vaccine. The vaccine, known as the Pfizer-BioNTech COVID-19 Vaccine, was first authorized for emergency use by the U.S. Food and Drug Administration in December 2020.[233] This marked a major public health step towards ending the pandemic.

The development and distribution of the vaccine have addressed health disparities in several ways. The vaccine has been tested in clinical trials that included thousands of participants from racial and ethnic minority, American Indian and Alaska Native, and other diverse communities.[234] This ensures that the vaccine is safe and effective for a wide range of populations.[235] Furthermore, the vaccine helps to reduce the severe impacts of COVID-19, which has disproportionately affected certain communities.[236] In this way, BioNTech's work in developing the COVID-19 vaccine has contributed to the promotion of peace (by helping to end the pandemic), justice (by addressing health disparities), and strong institutions (by working with regulatory bodies to ensure the vaccine's safety and efficacy).

SUSTAINABLE DEVELOPMENT

GOAL 17

17 PARTNERSHIPS FOR THE GOALS

Biotechnology companies often engage in partnerships with governments, NGOs, academia, and other stakeholders. These collaborations facilitate knowledge sharing, capacity building, and the mobilization of resources needed to implement sustainable development initiatives.[237]

Fostering global partnerships for health:

- The Access Accelerated program is a partnership involving more than 20 biopharmaceutical companies and associations, the World Bank, and the Union of International Cancer Control. The initiative works with stakeholders in select cities in low- and middle-income countries to address specific issues affecting access to Non-Communicable Disease (NCD) care.[238]
- The African Access Initiative (AAI) is a partnership of companies, governments, healthcare providers, and NGOs focused on sustainably expanding access to cancer medicines and technologies, improving healthcare infrastructure, and building clinical and R&D capacity in Africa.[239]
- MSD for Mothers in Uganda supports building a health ecosystem, including strengthening franchise clinics, engaging local transport providers to improve linkages to care, working with drug shops to provide essential supplies, promoting savings schemes, and training community health workers to raise awareness about safe motherhood and the importance of giving birth in a facility.[240]
- GlaxoSmithKline partnered with Hôpital Sacré Coeur and Project HOPE to build, implement, and sustain a central vaccine/pharmaceutical handling system comprising a central temperature-controlled warehouse and supply chain with distributable cold-chain capabilities in Northern Haiti.[241]

Building partnerships for knowledge sharing:

- Biotechnology Society of Nigeria (BSN): BSN aims to advance the biotech sector in Nigeria by promoting collaboration between the local and the international community.[242]
- Africa Pavilion at the annual BIO International Convention: African R&D innovations are showcased and international partnerships are fostered with investors, companies, NGOs, and other researchers.[243]
- BIO Ventures for Global Health: Along with pharmaceutical companies, BVGH is providing fellowships and equipment donation to build capacity for research in Low and Middle-Income Countries (LMICs).[244,245]

- Sanofi Pasteur and Biovac agreement: Sanofi Pasteur entered into a technology transfer agreement with Biovac, a South African developer and manufacturer of vaccines, to entrust Biovac with late-stage manufacturing operations for the processing of the multi-national's bulk product into a finished vaccine product for sale and distribution.[246]

J.R. Simplot is committed to leveraging biotechnology for sustainable agriculture and food security on a global scale through partnerships. Simplot partners with the Biotechnology Potato Partnership[247] to support smallholder farmers in Bangladesh and Indonesia through blight-resistant potato research. In another project, Simplot partnered with the Sainsbury Laboratory and the University of Leeds to share the company's expertise in blight resistance.[248]

Endnotes

1 AgriLinks, Agricultural Biotechnology: A Vital Tool to Address Food Security and Climate Change, February 24, 2022, at https://agrilinks.org/post/agricultural-biotechnology-vital-tool-address-food-security-and-climate-change

2 Genetic Literacy Project, Why grow GMOs? Over 23 years, biotech crops boosted farm income $225 billion, cuts pesticide use and slashed carbon emissions, July 15, 2020, at https://pgeconomics.co.uk/press+releases/3/Global+economic+benefits+of+GM+crops+reach+++%26%2336%3B150+billion

3 Alliance for Science, WEMA achieves major milestone in African agriculture, May 29, 2018, at https://allianceforscience.org/blog/2018/05/wema-achieves-major-milestone-african-agriculture/#:~:text=The%20WEMA%20project%20has%20developed,drought%20tolerance%20and%20insect%20resistance

4 AgriLinks, Agricultural Biotechnology: A Vital Tool to Address Food Security and Climate Change, February 24, 2022, at https://agrilinks.org/post/agricultural-biotechnology-vital-tool-address-food-security-and-climate-change

5 World Trade Association, "The Role of the WTO SPS Agreement in Enabling Access to Tools and Technologies and Facilitating International Trade: A Case Study on Fall Armyworm", G/SPS/W/305, September 11, 2018

6 Frontiers, Constraints and Prospects of Improving Cowpea Productivity to Ensure Food, Nutritional Security and Environmental Sustainability, October 22, 2021, at https://www.frontiersin.org/articles/10.3389/fpls.2021.751731/full

7 Genetic Literacy Project, Why grow GMOs? Over 23 years, biotech crops boosted farm income $225 billion, cuts pesticide use and slashed carbon emissions, July 15, 2020, at https://pgeconomics.co.uk/press+releases/3/Global+economic+benefits+of+GM+crops+reach+++%26%2336%3B150+billion

8 PIARCS PBC, About PIARCS, http://piarcs.org

9 World Trade Association, "The Role of the WTO SPS Agreement in Enabling Access to Tools and Technologies and Facilitating International Trade: A Case Study on Fall Armyworm", G/SPS/W/305, September 11, 2018

10 Springer Nature, SDG 3: Good Health & Well-Being, 2023, at https://www.springernature.com/gp/researchers/sdg-programme/sdg3?utm_source=bing&utm_medium=cpc&utm_campaign=MLSR_ALLPR_BAWG_US_PMLS_01AH5_USmedSDG03&utm_term=sdg%20goal%203&utm_content=SDG03%7CGeneric%7CGood%20Health%20%26%20Well%20Being%7CBroad&msclkid=54149378fcd312edfe6df62a19ab1790&utm_source=bing&utm_medium=cpc&utm_campaign=MLSR_ALLPR_BAWG_US_PMLS_01AH5_USmedSDG03&utm_term=sdg%20goal%203&utm_content=SDG03%7CGeneric%7CGood%20Health%20%26%20Well%20Being%7CBroad

11 BIOHK2023, Biotech crops good for environment, December 28, 2020, at https://2023.bio-hk.com/news/industry-news/biotech-crops-good-for-environment/

12 Genetic Literacy Project, Why grow GMOs? Over 23 years, biotech crops boosted farm income $225 billion, cuts pesticide use and slashed carbon emissions, July 15, 2020, at https://pgeconomics.co.uk/press+releases/3/Global+economic+benefits+of+GM+crops+reach+++%26%2336%3B150+billion

13 Genetic Literacy Project, Why grow GMOs? Over 23 years, biotech crops boosted farm income $225 billion, cuts pesticide use and slashed carbon emissions, July 15, 2020, at https://pgeconomics.co.uk/press+releases/3/Global+economic+benefits+of+GM+crops+reach+++%26%2336%3B150+billion

14 Frontiers in Nutrition, Conservation Agriculture Affects Grain and Nutrient Yields of Maize (Zea Mays L.) and Can Impact Food and Nutrition Security in Sub-Saharan Africa, January 26, 2022, at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8826957/#:~:text=Maize%20is%20the%20main%20staple,intake%20(1%2C%204)

15 AgriLinks, Agricultural Biotechnology: A Vital Tool to Address Food Security and Climate Change, February 24, 2022, at https://agrilinks.org/post/agricultural-biotechnology-vital-tool-address-food-security-and-climate-change

16 World Trade Association, "The Role of the WTO SPS Agreement in Enabling Access to Tools and Technologies and Facilitating International Trade: A Case Study on Fall Armyworm", G/SPS/W/305, September 11, 2018

17 AgriLinks, Agricultural Biotechnology: A Vital Tool to Address Food Security and Climate Change, February 24, 2022, at https://agrilinks.org/post/agricultural-biotechnology-vital-tool-address-food-security-and-climate-change

18 GMO Answers, Improving Nutrition in the Developing World with GMOs, 2021, https://gmoanswers.com/improving-nutrition-developing-world-gmos

19 GMO Answers, Improving Nutrition in the Developing World with GMOs, 2021, https://gmoanswers.com/improving-nutrition-developing-world-gmos

20 Okanagan Specialty Fruits, About OSF, 2023, at https://osfruits.com

21 Genetic Literacy Project, Why grow GMOs? Over 23 years, biotech crops boosted farm income $225 billion, cuts pesticide use and slashed carbon emissions, July 15, 2020, at https://pgeconomics.co.uk/press+releases/3/Global+economic+benefits+of+GM+crops+reach+++%26%2336%3B150+billion

22 McKinsey & Co., The Bio Revolution: Innovations transforming economies, societies, and our lives, May 13, 2020, at https://www.mckinsey.com/industries/life-sciences/our-insights/the-bio-revolution-innovations-transforming-economies-societies-and-our-lives

23 AATF, PBR Cowpea, An innovation of hope, July 10, 2023, at https://www.aatf-africa.org/news-pbr-cowpea-an-innovation-of-hope/

24 Medical News Today, Screening sharply improves lung cancer long-term survival, study finds, 2023, https://www.medicalnewstoday.com/articles/screening-sharply-improves-lung-cancer-long-term-survival#What-researchers-found-in-lung-cancer-screening-study

25 GMO Answers, Improving Nutrition in the Developing World with GMOs, 2021, https://gmoanswers.com/improving-nutrition-developing-world-gmos

26 Nature, Biotech firm announces results from first US trial of genetically modified mosquitoes, April 18, 2022, at https://www.nature.com/articles/d41586-022-01070-x

27 GMO Answers, Improving Nutrition in the Developing World with GMOs, 2021, https://gmoanswers.com/improving-nutrition-developing-world-gmos

28 World Trade Association, "The Role of the WTO SPS Agreement in Enabling Access to Tools and Technologies and Facilitating International Trade: A Case Study on Fall Armyworm", G/SPS/W/305, September 11, 2018

29 BioSpace, Small and Medium Biotech Companies Still Growing in Uncertain Times, September 6, 2022, at https://www.biospace.com/article/how-small-to-medium-biotech-companies-are-growing-in-uncertain-times/

30 BioSpace, Small and Medium Biotech Companies Still Growing in Uncertain Times, September 6, 2022, at https://www.biospace.com/article/how-small-to-medium-biotech-companies-are-growing-in-uncertain-times/

31 Cornell Chronicle, Bt eggplant improving lives in Bangladesh, July 16, 2018, at https://news.cornell.edu/stories/2018/07/bt-eggplant-improving-lives-bangladesh

32 AATF, PBR Cowpea, An innovation of hope, July 10, 2023, at https://www.aatf-africa.org/news-pbr-cowpea-an-innovation-of-hope/

33 American Cancer Society, Survival Rates for Chronic Myeloid Leukemia, June 19, 2018, at https://www.cancer.org/cancer/types/chronic-myeloid-leukemia/detection-diagnosis-staging/survival-rates.html

34 My Leukemia Team, Chronic Myeloid Leukemia Survival Rates and Outlook, August 23, 2021, at https://www.myleukemiateam.com/resources/chronic-myeloid-leukemia-survival-rates-and-outlook

35 BioSpace, Small and Medium Biotech Companies Still Growing in Uncertain Times, September 6, 2022, at https://www.biospace.com/article/how-small-to-medium-biotech-companies-are-growing-in-uncertain-times/

36 Healthline, Facts About HIV: Life Expectancy and Long-Term Outlook, January 23, 2023, at https://www.healthline.com/health/hiv-aids/life-expectancy

37 National Institute of Health, Benefits of Early Antiretroviral Therapy in HIV Infection, August 10, 2015, at https://www.nih.gov/news-events/nih-research-matters/benefits-early-antiretroviral-therapy-hiv-infection

38 Biotechnology Innovation Organization, Healing the World, https://archive.bio.org/articles/healing-world

39 USA Today, In 'major breakthrough,' new test can detect Parkinson's disease before symptoms appear, April 14, 2023, at https://www.usatoday.com/story/news/

health/2023/04/14/parkinsons-test-detect-disease-before-symptoms-appear/11648232002/

40 Science Daily, Using artificial intelligence for early detection and treatment of illnesses, August 20, 2021, at https://www.sciencedaily.com/releases/2021/08/210820135346.htm

41 Frontiers, The Essentials of Marine Biotechnology, March 16, 2021, at https://www.frontiersin.org/articles/10.3389/fmars.2021.629629/full

42 BioSpace, Small and Medium Biotech Companies Still Growing in Uncertain Times, September 6, 2022, at https://www.biospace.com/article/how-small-to-medium-biotech-companies-are-growing-in-uncertain-times/

43 The Palm Beach Post, CEO: 'From blue jeans to genes', at https://d2ghdaxqb194v2.cloudfront.net/2606/192055.pdf

44 The Harvard Gazette, Growing gap in STEM supply and demand, November 18, 2021, at https://news.harvard.edu/gazette/story/2021/11/increasing-access-and-opportunity-in-stem-crucial-say-experts/

45 The Harvard Gazette, Growing gap in STEM supply and demand, November 18, 2021, at https://news.harvard.edu/gazette/story/2021/11/increasing-access-and-opportunity-in-stem-crucial-say-experts/

46 AMGEN Foundation, Amgen Biotech Experience, 2023, at https://www.amgenfoundation.org/science-education/amgen-biotech-experience

47 AMGEN Foundation, Amgen Biotech Experience, 2023, at https://www.amgenfoundation.org/science-education/amgen-biotech-experience

48 AMGEN Foundation, Amgen Biotech Experience, 2023, at https://www.amgenfoundation.org/science-education/amgen-biotech-experience

49 AMGEN Foundation, Amgen Biotech Experience, 2023, at https://www.amgenfoundation.org/science-education/amgen-biotech-experience

50 AMGEN Foundation, Amgen Biotech Experience, 2023, at https://www.amgenfoundation.org/science-education/amgen-biotech-experience

51 AMGEN Foundation, Amgen Scholars, 2023, at https://www.amgenfoundation.org/science-education/amgen-scholars-program

52 AMGEN Foundation, Amgen Scholars, 2023, at https://www.amgenfoundation.org/science-education/amgen-scholars-program

53 AMGEN Foundation, Amgen Scholars, 2023, at https://www.amgenfoundation.org/science-education/amgen-scholars-program

54 AMGEN Foundation, Amgen Scholars, 2023, at https://www.amgenfoundation.org/science-education/amgen-scholars-program

55 AMGEN Foundation, Amgen Scholars, 2023, at https://www.amgenfoundation.org/science-education/amgen-scholars-program

56 BASF, STEAM Education in North America, 2023, at https://www.basf.com/us/en/who-we-are/community/Science-Education.html

57 BASF, Curiosity and interest in science for a brighter future, 2023, at https://www.basf.com/global/en/who-we-are/sustainability/we-value-people-and-treat-them-with-respect/societal-commitment/future-skills/education.html

58 BASF, Virtual Lab, 2023, at https://basf.kids-interactive.de/us-en

59 BMC International Health and Human Rights, Sex, gender, and health biotechnology: points to consider, July 21, 2009, at https://bmcinthealthhumrights.biomedcentral.com/articles/10.1186/1472-698X-9-15

60 BMC International Health and Human Rights, Sex, gender, and health biotechnology: points to consider, July 21, 2009, at https://bmcinthealthhumrights.biomedcentral.com/articles/10.1186/1472-698X-9-15

61 Government of India Department of Biotechnology, Department of Biotechnology supports women scientists to achieve SDG5 towards gender equality in STEM fields, March 9, 2021, at https://dbtindia.gov.in/dbt-press/department-biotechnology-supports-women-scientists-achieve-sdg5-towards-gender-equality

62 Harvard Business Review, How One Biotech Company Narrowed the Gender Gap in Its Top Ranks, June 2, 2021, at https://hbr.org/2021/06/how-one-biotech-company-narrowed-the-gender-gap-in-its-top-ranks

63 World Economic Forum, 4 ways inclusive innovation ecosystems can accelerate gender equality, March 6, 2023, at https://www.weforum.org/agenda/2023/03/international-womens-day-4-ways-inclusive-innovation-ecosystems-can-accelerate-gender-equality/

64 Organon, Organon Launches as New Global Women's Health Company, June 3, 2021, at https://www.organon.com/news/organon-launches-as-new-global-womens-health-company/

65 Organon, Environmental, Social & Governance (ESG) 2022 Report, 2023, at https://www.organon.com/about-organon/environmental-social-governance/

66 Organon, Environmental, Social & Governance (ESG) 2022 Report, 2023, at https://www.organon.com/about-organon/environmental-social-governance/

67 Organon, Environmental, Social & Governance (ESG) 2022 Report, 2023, at https://www.organon.com/about-organon/environmental-social-governance/

68 Organon, Organon recognized in Bloomberg's 2023 Gender Equality Index, January 31, 2023, at https://www.organon.com/stories/organon-recognized-in-bloombergs-2023-gender-equality-index/

69 Mass Challenge, 5 Biotechnology Trends and Innovations to Watch in 2023, January 23, 2023, at https://masschallenge.org/articles/trends-in-biotechnology/

70 PIARCS PBC, About PIARCS, http://piarcs.org

71 Springer Link, Wastewater Treatment and Reuse: a Review of its Applications and Health Implications, May 10, 2021, at https://link.springer.com/article/10.1007/s11270-021-05154-8

72 Springer Link, Wastewater Treatment and Reuse: a Review of its Applications and Health Implications, May 10, 2021, at https://link.springer.com/article/10.1007/s11270-021-05154-8

73 International Service for the Acquisition of Agri-biotech Applications (ISAAA), Pocket K No. 32: Biotechnology for the Development of Drought Tolerant Crops, March 2008, at https://www.isaaa.org/resources/publications/pocketk/32/default.asp

74 International Service for the Acquisition of Agri-biotech Applications (ISAAA), Pocket K No. 32: Biotechnology for the Development of Drought Tolerant Crops, March 2008, at https://www.isaaa.org/resources/publications/pocketk/32/default.asp

75 Labiotech, Biotech Drives the Water Purification Industry Towards a Circular Economy, January 20, 2021, at https://www.labiotech.eu/in-depth/water-purification-industry-circular-economy/

76 Mass Challenge, 5 Biotechnology Trends and Innovations to Watch in 2023, January 23, 2023, at https://masschallenge.org/articles/trends-in-biotechnology/

77 Mass Challenge, 5 Biotechnology Trends and Innovations to Watch in 2023, January 23, 2023, at https://masschallenge.org/articles/trends-in-biotechnology/

78https://www.eia.gov/todayinenergy/detail.php?id=60281

79 Statista, Leading countries based on biofuel production worldwide in 2022, June 2023, at https://www.statista.com/statistics/274168/biofuel-production-in-leading-countries-in-oil-equivalent/

80 Mitsui & Co., Germany's Biogas Industry and the Prospective Business Opportunities, February 2022, at https://www.mitsui.com/mgssi/en/report/detail/__icsFiles/afieldfile/2022/03/24/2202du_yoshizawa_e.pdf

81 IEA Bioenergy, Implementation of bioenergy in Denmark – Update 2021, October 2021, at https://www.ieabioenergy.com/wp-content/uploads/2021/11/CountryReport2021_Denmark_final.pdf

82 IEA Bioenergy, Implementation of bioenergy in Finland – Update 2021, October 2021, at https://www.ieabioenergy.com/wp-content/uploads/2021/11/CountryReport2021_Finland_final.pdf

83 SINTEF, The status of biofuels in Norway and around the world, 2022, February 15, 2022, at https://blog.sintef.com/sintefenergy/status-of-biofuels-in-norway-and-world-wide-2022/

84 POLITICO Magazine, How Cities Are Turning Food Into Fuel, November 21, 2019, at https://www.politico.com/news/magazine/2019/11/21/food-waste-fuel-energy-sustainability-070265

85 World Business Council for Sustainable Development, Global companies unite in below50 to scale up sustainable fuels for a low-carbon, June 1, 2016, at https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/News/Global-companies-unite-in-below50-to-scale-up-sustainable-fuels-for-a-low-carbon

86 Virent, Virent's Bio-Based Fuel Used In Historic Commercial Passenger Flight Using 100% Sustainable Aviation Fuel, December 2, 2021, at https://www.virent.com/news/virents-bio-based-fuel-used-in-historic-commercial-passenger-flight-using-100-sustainable-aviation-fuel/

87 Virent, Virent's Bio-Based Fuel Used In Historic Commercial Passenger Flight Using 100% Sustainable Aviation Fuel, December 2, 2021, at https://www.virent.com/news/virents-bio-based-fuel-used-in-historic-commercial-passenger-flight-using-100-sustainable-aviation-fuel/

88 Mass Challenge, 5 Biotechnology Trends and Innovations to Watch in 2023, January 23, 2023, at https://masschallenge.org/articles/trends-in-biotechnology/

89 PLOS ONE, A Meta-Analysis of the Impacts of Genetically Modified Crops, November 3, 2014, at https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0111629

90 PG Economics, New report highlights 20 years of economic and environmental benefits from using biotech GM crops, June 5, 2017, at https://www.pgeconomics.co.uk/press+releases/2/New+report+highlights+20+years+of+economic+and+environmental+benefits+from+using+biotech+GM+crops/

91 Frontiers, Opportunities for Orphan Crops: Expected Economic Benefits From Biotechnology, June 23, 2022, at https://www.frontiersin.org/articles/10.3389/fpls.2022.825930/full
492 PLOS ONE, The Cost-Effectiveness of Biologics for the Treatment of Rheumatoid Arthritis: A Systematic Review, March 17, 2015, at https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0119683

93 Biotechnology Innovation Organization, Innovation Saves, https://www.bio.org/sites/default/files/legacy/bioorg/docs/BIO_infographic_Innovation%20Saves_final.pdf

94 PLOS ONE, The Cost-Effectiveness of Biologics for the Treatment of Rheumatoid Arthritis: A Systematic Review, March 17, 2015, at https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0119683

95 The Organization for Economic Cooperation and Development (OECD), The Role of Marine Biotechnology in the Bioeconomy, May 30, 2012, at https://www.oecd.org/sti/emerging-tech/session%205%20calewaert.%20pdf.pdf

96 MDPI, Indirect Costs of Rheumatoid Arthritis Depending on Type of Treatment—A Systematic Literature Review, August 17, 2019, at https://www.mdpi.com/1660-4601/16/16/2966

97 Biotechnology Innovation Organization, Biotech Sector Thrives, Generating Nearly $3 Trillion Economic Impact – New Report Shows, October 26, 2022, at https://www.bio.org/press-release/biotech-sector-thrives-generating-nearly-3-trillion-economic-impact-new-report-shows

98 Biotechnology Innovation Organization, Biotech Sector Thrives, Generating Nearly $3 Trillion Economic Impact – New Report Shows, October 26, 2022, at https://www.bio.org/press-release/biotech-sector-thrives-generating-nearly-3-trillion-economic-impact-new-report-shows

99 Biotechnology Innovation Organization, Biotech Sector Thrives, Generating Nearly $3 Trillion Economic Impact – New Report Shows, October 26, 2022, at https://www.bio.org/press-release/biotech-sector-thrives-generating-nearly-3-trillion-economic-impact-new-report-shows

100 Arzeda, About Arzeda, 2023, at https://arzeda.com

101 Arzeda, About Arzeda, 2023, at https://arzeda.com

102 Arzeda, Supercharging Nature Through Intelligent Protein Design, 2023, at https://arzeda.com/how-we-innovate/

103 McKinsey & Co., The Bio Revolution: Innovations transforming economies, societies, and our lives, May 13, 2020, at https://www.mckinsey.com/industries/life-sciences/our-insights/the-bio-revolution-innovations-transforming-economies-societies-and-our-lives

104 BIO Ventures for Global Health, About African Access Initiative, 2023, at https://bvgh.org/african-access-initiative/

105 BIO Ventures for Global Health, Improving Cancer Patient Outcomes in Africa: A Holistic, Multi-Sector Approach, 2023, at https://www.wins.org/wp-content/uploads/2022/01/Intro-to-AAI-January-2022.pdf

106 Biotechnology Innovation Organization, Biotech Sector Thrives, Generating Nearly $3 Trillion Economic Impact – New Report Shows, October 26, 2022, at https://www.bio.org/press-release/biotech-sector-thrives-generating-nearly-3-trillion-economic-impact-new-report-shows

107 Valuer, Innovative Companies & SDG 9: Industry, Innovation, and Infrastructure, August 25, 2020, at https://www.valuer.ai/blog/identifying-new-business-models-and-technologies-within-sdg9
108 Statistics Mauritius, Sustainable Development Goals, 2020, at https://statsmauritius.govmu.org/Pages/Statistics/By_Subject/SDGs/SB_SDG.aspx

109 National Institute of Standards and Technology, Institute for Bioscience and Biotechnology Research (IBBR), 2023 at https://www.nist.gov/ibbr

110 Corteva Agriscience, Working Together to Support Smallholder Farmers in Ghana, November 8, 2022, at https://www.corteva.com/resources/blog/working-to-support-smallholder-farmers-in-ghana.html

111 Corteva Agriscience, Working Together to Support Smallholder Farmers in Ghana, November 8, 2022, at https://www.corteva.com/resources/blog/working-to-support-smallholder-farmers-in-ghana.html

112 Corteva Agriscience, Working Together to Support Smallholder Farmers in Ghana, November 8, 2022, at https://www.corteva.com/resources/blog/working-to-support-smallholder-farmers-in-ghana.html

113 Corteva Agriscience, About Dow DuPont, 2023, at https://www.corteva.in/who-we-are/our-merger.html

114 Corteva Agriscience, Agricultural Transformation in Focus at Corteva Agriscience 'Growing for Good' Initiative, June 29, 2023, at https://www.corteva.com/resources/media-center/agricultural-transformation-in-focus-at-corteva-agriscience-growing-for-good-initiative.html

115 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

116 UK Research and Innovation, Innovative healthcare tech could transform medical treatments, June 9, 2023, at https://www.ukri.org/news/innovative-healthcare-tech-could-transform-medical-treatments/

117 UK Research and Innovation, Innovative healthcare tech could transform medical treatments, June 9, 2023, at https://www.ukri.org/news/innovative-healthcare-tech-could-transform-medical-treatments/

118 UK Research and Innovation, Innovative healthcare tech could transform medical treatments, June 9, 2023, at https://www.ukri.org/news/innovative-healthcare-tech-could-transform-medical-treatments/

119 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

120 Agrorite, AgriBusiness Made Easy, 2023, at https://www.agrorite.com

121 StartUs Insights, Discover 5 Social Tech Startups to Watch in 2021, 2020, at https://www.startus-insights.com/innovators-guide/discover-5-social-tech-startups-to-watch-in-2021/

122 Agrorite, AgriBusiness Made Easy, 2023, at https://www.agrorite.com

123 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

124 DESIGN – I CAN'T FIGURE HOW TO GET RID OF THIS SPACE

125 Genentech, Giving for a More Just Healthcare System, February 10, 2021, at https://www.gene.com/stories/giving-for-a-more-just-healthcare-system

126 Roche, Genentech R&D (gRED), 2023, at https://www.roche.com/innovation/structure/genentech

127 Roche, Genentech R&D (gRED), 2023, at https://www.roche.com/innovation/structure/genentech

128 Genentech, Giving for a More Just Healthcare System, February 10, 2021, at https://www.gene.com/stories/giving-for-a-more-just-healthcare-system

129 Genentech, Sustainability, 2023, at https://www.gene.com/good/sustainability

130 Genentech, Sustainability, 2023, at https://www.gene.com/good/sustainability

131 Genentech, Sustainability, 2023, at https://www.gene.com/good/sustainability

132 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

133 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

134 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

135 World Economic Forum, 15 innovations bringing nature back into our cities, January 27, 2022, at https://www.weforum.org/agenda/2022/01/15-innovations-helping-cities-become-nature-positive-biodiverse-hubs/

136 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

137 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

138 Spring Wise, Five Innovations for Sustainable Cities, November 2, 2022, at https://www.springwise.com/innovation-snapshot/five-innovations-for-sustainable-cities/

139 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

140 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

141 World Economic Forum, 14 innovative projects helping to save the planet and make the world a better place, January 13, 2021, at https://www.weforum.org/agenda/2021/01/innovations-oceans-forests-social-justice-coronavirus/

142 World Economic Forum, 15 innovations bringing nature back into our cities, January 27, 2022, at https://www.weforum.org/agenda/2022/01/15-innovations-helping-cities-become-nature-positive-biodiverse-hubs/

143 Simplot, Feeding the World Responsibly, 2023, at https://www.simplot.com/sustainability

144 Simplot, Feeding the World Responsibly, 2023, at https://www.simplot.com/sustainability

145 Simplot, 4Sight 2030 Goals, 2023, at https://www.simplot.com/sustainability/planet/4sight2030

146 Simplot, 4Sight 2030 Goals, 2023, at https://www.simplot.com/sustainability/planet/4sight2030

147 Springer Link, Biodegradation of petroleum based and bio-based plastics: approaches to increase the rate of biodegradation, April 13, 2022, at https://link.springer.com/article/10.1007/s00203-022-02883-0

148 Green Chemistry, Review of recent advances in the biodegradability of polyhydroxyalkanoate (PHA) bioplastics and their composites, August 17, 2020, at https://pubs.rsc.org/en/content/articlelanding/2020/gc/d0gc01647k

149 Statista, Global bioplastics industry - statistics & facts, June 5, 2023, at https://www.statista.com/topics/8744/bioplastics-industry-worldwide/#topicOverview

150 Statista, Global bioplastics industry - statistics & facts, June 5, 2023, at https://www.statista.com/topics/8744/bioplastics-industry-worldwide/#topicOverview

151 Statista, Market share of bioplastics worldwide from 2015 to 2030, October 2017, at https://www.statista.com/statistics/981791/market-share-bioplastics-worldwide/

152 Coca-Cola Company, Coca-Cola Unveils New Prototype Bottle Made From 100% Plant-Based Sources, October 21, 2021, at https://www.coca-colacompany.com/media-center/coca-cola-unveils-new-prototype-bottle-made-from-100-percent-plant-based-sources

153 Coca-Cola Company, Coca-Cola Collaborates with Tech Partners to Create Bottle Prototype Made from 100% Plant-Based Sources, October 22, 2021, at https://www.coca-colacompany.com/media-center/100-percent-plant-based-plastic-bottle

154 Alliance for Science, New study: GMO crops reduce pesticide use, greenhouse gas emissions, July 27, 2020, at https://allianceforscience.org/blog/2020/07/new-study-gmo-crops-reduce-pesticide-use-greenhouse-gas-emissions/

155 Alliance for Science, GMO crops have reduced pesticide poisoning among farmers, report finds, November 18, 2021, at https://allianceforscience.org/blog/2021/11/gmo-crops-have-reduced-pesticide-poisoning-among-farmers-report-finds/

156 The Biofuels Digest, Phytonix: Converting CO2 Emissions into Sustainable Solar Chemicals & Fuels, June 21, 2022, at https://www.biofuelsdigest.com/bdigest/2022/06/21/phytonix-converting-co2-emissions-into-sustainable-solar-chemicals-fuels/

157 Phytonix, 2021 First Place Global Award-Winning Company, December 8, 2021, at https://phytonix.com

158 Phytonix, Combining Ancient & New, 2019, at https://phytonix.com/?page_id=58

159 Phytonix, Combining Ancient & New, 2019, at https://phytonix.com/?page_id=58

160 NASA Global Climate Change, Responding to Climate Change, November 8, 2023 at https://climate.nasa.gov/solutions/adaptation-mitigation/

161 NASA Global Climate Change, Responding to Climate Change, November 8, 2023 at https://climate.nasa.gov/solutions/adaptation-mitigation/

162 NASA Global Climate Change, Responding to Climate Change, November 8, 2023 at https://climate.nasa.gov/solutions/adaptation-mitigation/

163 NASA Global Climate Change, Responding to Climate Change, November 8, 2023 at https://climate.nasa.gov/solutions/adaptation-mitigation/

164 Frontiers, Agriculture's Contribution to Climate Change and Role in Mitigation Is Distinct From Predominantly Fossil CO2-Emitting Sectors, February 3, 2021, at https://www.frontiersin.org/articles/10.3389/fsufs.2020.518039/full

165 Frontiers, Agriculture's Contribution to Climate Change and Role in Mitigation Is Distinct From Predominantly Fossil CO2-Emitting Sectors, February 3, 2021, at https://www.frontiersin.org/articles/10.3389/fsufs.2020.518039/full

166 Springer Link, Strategies for mitigation of climate change: a review, July 30, 2020, at https://link.springer.com/article/10.1007/s10311-020-01059-w

167 Recombinetics™, Finding New Answers for Global Food Security, 2023, at https://recombinetics.com/acceligen/

168 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

169 Springer Link, Biofuels and their connections with the sustainable development goals: a bibliometric and systematic review, November 24, 2020, at https://link.springer.com/article/10.1007/s10668-020-01110-4

170 World Business Council for Sustainable Development, We Mean Business and WBCSD to expand the reach of below50, June 19, 2017, at https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/News/We-Mean-Business-and-WBCSD-to-expand-the-reach-of-below50

171 Anthropocene, Here's how GMO crops could reduce greenhouse gas emissions—particularly in Europe, February 11, 2022, at https://www.anthropocenemagazine.org/2022/02/heres-how-gmo-crops-could-reduce-greenhouse-gas-emissions-particularly-in-europe/

172 Science Daily, Genetic engineering can have a positive effect on the climate, February 8, 2022, at https://www.sciencedaily.com/releases/2022/02/220208105310.htm

173 World Business Council for Sustainable Development, We Mean Business gets behind below50, June 19, 2017, at https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/News/We-Mean-Business-and-WBCSD-to-expand-the-reach-of-below50

174 Anthropocene, Here's how GMO crops could reduce greenhouse gas emissions—particularly in Europe, February 11, 2022, at https://www.anthropocenemagazine.org/2022/02/heres-how-gmo-crops-could-reduce-greenhouse-gas-emissions-particularly-in-europe/

175 Science Daily, Genetic engineering can have a positive effect on the climate, February 8, 2022, at https://www.sciencedaily.com/releases/2022/02/220208105310.htm

176 United Airlines, United Becomes First U.S. Airline to Invest in Biofuel Refinery, November 15, 2022, at https://united.mediaroom.com/2022-11-15-United-Becomes-First-U-S-Airline-to-Invest-in-Biofuel-Refinery

177 United Airlines, United Becomes First U.S. Airline to Invest in Biofuel Refinery, November 15, 2022, at https://united.mediaroom.com/2022-11-15-United-Becomes-First-U-S-Airline-to-Invest-in-Biofuel-Refinery

178 Qantas, World First U.S.-Australia Biofuel Flight Takes Off, January 29, 2018, at https://www.qantasnewsroom.com.au/media-releases/world-first-us-australia-biofuel-flight-takes-off/

179 Qantas, World First U.S.-Australia Biofuel Flight Takes Off, January 29, 2018, at https://www.qantasnewsroom.com.au/media-releases/world-first-us-australia-biofuel-flight-takes-off/

180 World Business Council for Sustainable Development, We Mean Business gets behind below50, June 19, 2017, at https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/News/We-Mean-Business-and-WBCSD-to-expand-the-reach-of-below50

181 Biofuels Digest: Below 50: Coalition of the Willing for Low-Carbon Transport Fuels, June 5, 2016, at https://www.biofuelsdigest.com/bdigest/2016/06/05/below50-coalition-of-the-willing-for-low-carbon-transport-fuels/

182 World Business Council for Sustainable Development, We Mean Business and WBCSD to expand the reach of below50, June 19, 2017, at https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/News/We-Mean-Business-and-WBCSD-to-expand-the-reach-of-below50

183 Virgin Atlantic, Low carbon fuel project achieves breakthrough as LanzaTech produces jet fuel from waste gases for Virgin Atlantic, September 14, 2016, at https://www.virginatlantic.com/gb/en/media-centre/press-releases/lanzatech-and-virgin-atlantic-fuel-breakthrough.html
184 Virgin Atlantic, Virgin Atlantic and LanzaTech sustainable fuel project takes flight, 2023, at https://flywith.virginatlantic.com/gb/en/stories/virgin-atlantic-and-lanzatech-celebrate-as-revolutionary-sustainable-fuel-project-takes-flight.html

185 World Business Council for Sustainable Development, We Mean Business and WBCSD to expand the reach of below50, June 19, 2017, at https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/News/We-Mean-Business-and-WBCSD-to-expand-the-reach-of-below50
186 Virgin Atlantic, Virgin Atlantic and LanzaTech sustainable fuel project takes flight, 2023, at https://flywith.virginatlantic.com/gb/en/stories/virgin-atlantic-and-lanzatech-celebrate-as-revolutionary-sustainable-fuel-project-takes-flight.html

187 The Guardian, Jet planes and sugar cane: Qantas and Airbus get on board biofuel factory in Queensland, March 30, 2023, at https://www.theguardian.com/business/2023/mar/30/sugar-cane-aviation-fuel-qantas-airbus-jet-planes-biofuel-factory-queensland-australia

188 The Guardian, Jet planes and sugar cane: Qantas and Airbus get on board biofuel factory in Queensland, March 30, 2023, at https://www.theguardian.com/business/2023/mar/30/sugar-cane-aviation-fuel-qantas-airbus-jet-planes-biofuel-factory-queensland-australia

189 Virgin Atlantic, Virgin Atlantic and LanzaTech sustainable fuel project takes flight, 2023, at https://flywith.virginatlantic.com/gb/en/stories/virgin-atlantic-and-lanzatech-celebrate-as-revolutionary-sustainable-fuel-project-takes-flight.html

190 Craft, LanzaTech, 2023, at https://craft.co/lanzatech
191 LanzaTech, Recycling Carbon with Biology, 2023, at https://lanzatech.com

192 Craft, LanzaTech, 2023, at https://craft.co/lanzatech

193 LanzaTech Investor Relations, 2021 Impact Report, 2022, at https://ir.lanzatech.com/static-files/d28354d2-97e3-4de8-bf31-7246cd58bf39

194 LanzaTech Investor Relations, 2021 Impact Report, 2022, at https://ir.lanzatech.com/static-files/d28354d2-97e3-4de8-bf31-7246cd58bf39

195 LanzaJet, Someday is now, 2023, at https://www.lanzajet.com

196 LanzaJet, What We Do, 2023, at https://www.lanzajet.com/what-we-do/

197 LanzaJet, LanzaJet Joins the Air Transport Action Group, Helping to Foster the Global Aviation Sector's Climate Ambition, July 12, 2023, at https://www.lanzajet.com/atag/#:~:text=LanzaJet's%20technology%20converts%20ethanol%20derived%20from%20a%20variety,towards%20achieving%20carbon%20neutrality%20in%20the%20aviation%20industry

198 LanzaJet, LanzaJet Achieves Next Major Milestone with Innovative Sustainable Fuels Production Technology Fully Constructed at its Freedom Pines Fuels Facility, April 20, 2023, at https://www.lanzajet.com/lanzajet-achieves-next-major-milestone-with-innovative-sustainable-fuels-production-technology-fully-constructed-at-its-freedom-pines-fuels-facility/

199 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

200 Valuer, Innovative Companies and SDG14: Life Under Water, July 28, 2020, at https://www.valuer.ai/blog/identifying-new-business-models-and-technologies-within-sdg-14

201 OECD, The Role of Marine Biotechnology in the Bioeconomy, May 30, 2012, at https://www.oecd.org/sti/emerging-tech/Session%205%20CALEWAERT.%20pdf.pdf

202 Aker Biomarine, About, 2023, at https://www.akerbiomarine.com

203 Wikipedia, Krill, November 7, 2023, at https://en.wikipedia.org/wiki/Krill

204 International Service for the Acquisition of Agri-biotech Applications (ISAAA), Pocket K No. 52: Marine Biotechnology, 2023, at https://www.isaaa.org/resources/publications/pocketk/52/default.asp

205 The Organization for Economic Cooperation and Development (OECD), The Role of Marine Biotechnology in the Bioeconomy, May 30, 2012, at https://www.oecd.org/sti/emerging-tech/session%205%20calewaert.%20pdf.pdf

206 The Organization for Economic Cooperation and Development (OECD), The Role of Marine Biotechnology in the Bioeconomy, May 30, 2012, at https://www.oecd.org/sti/emerging-tech/session%205%20calewaert.%20pdf.pdf
207 Valuer, Innovative Companies and SDG 14: Life Under Water, July 28, 2020, at https://www.valuer.ai/blog/identifying-new-business-models-and-technologies-within-sdg-14

208 The Organization for Economic Cooperation and Development (OECD), The Role of Marine Biotechnology in the Bioeconomy, May 30, 2012, at https://www.oecd.org/sti/emerging-tech/session%205%20calewaert.%20pdf.pdf
209 The Atlantic, What Will It Take for Americans to Eat Genetically Engineered Salmon?, February 26, 2018, at https://www.theatlantic.com/science/archive/2018/02/aquabounty-genetically-engineered-salmon/553757/

210 CapEdge, AquaBounty 2022 FY Annual Report, 2023, at https://capedge.com/filing/1603978/0001603978-23-000007/AQB-10K-2022FY#highlight=Sustainable%20Development%20Goals%2C%20%20SDGs

211 CapEdge, AquaBounty 2022 FY Annual Report, 2023, at https://capedge.com/filing/1603978/0001603978-23-000007/AQB-10K-2022FY#highlight=Sustainable%20Development%20Goals%2C%20%20SDGs

212 Mass Challenge, 5 Biotechnology Trends and Innovations to Watch in 2023, January 23, 2023, at https://masschallenge.org/articles/trends-in-biotechnology/

213 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

214 Mass Challenge, 5 Biotechnology Trends and Innovations to Watch in 2023, January 23, 2023, at https://masschallenge.org/articles/trends-in-biotechnology/

215 GMO Answers, GMO Soil, Air, and Water, 2021, at https://gmoanswers.com/soil-air-water

216 Cornell Chronicle, Bt eggplant improving lives in Bangladesh, July 16, 2018, at https://news.cornell.edu/stories/2018/07/bt-eggplant-improving-lives-bangladesh

217 Forbes, The Environmentalist Case In Favor Of GMO Food, February 26, 2018, at https://www.forbes.com/sites/omribenshahar/2018/02/26/the-environmentalist-case-in-favor-of-gmo-food/?sh=9395b4737de3

218 International Service for the Acquisition of Agri-biotech Applications (ISAAA), Pocket K No. 32: Biotechnology for the Development of Drought Tolerant Crops, March 2008, at https://www.isaaa.org/resources/publications/pocketk/32/default.asp

219 Valuer, The 10 SDG Innovation Areas and Trending Technologies, February 12, 2021, at https://www.valuer.ai/blog/sdg-roundup-10-sdg-innovation-areas-and-trending-technolo-

gies

220 Global Bioenergies, About Us, 2023, at https://www.global-bioenergies.com/our-raison-detre/?lang=en

221 U.S. Department of Agriculture, USDA Invests $9.5M to Develop New Bioproducts from Agricultural Commodities, December 20, 2022, at https://www.usda.gov/media/press-releases/2022/12/20/usda-invests-95m-develop-new-bioproducts-agricultural-commodities

222 Calysta, Overview, 2023, at https://calysta.com

223 Feedkind, Overview, 2023, at https://feedkind.com

224 United Nations Office on Drugs and Crime, Global progress report on Sustainable Development Goal 16 indicators, 2023, at https://www.unodc.org/documents/data-and-analysis/sdgs/SDG16_2023.pdf

225 Biotechnology Innovation Organization, Healing the World, 2023, at https://archive.bio.org/articles/healing-world

226 SDG16 Hub, SDG 16 Innovation in Action, 2023, at https://www.sdg16hub.org/dashboard/sdg-16-innovation-action-0

227 ThoughtCo., Societal Concerns with Biotechnology, June 25, 2019, at https://www.thoughtco.com/societal-concerns-with-biotech-3973289

228 Nature Biotechnology, BIO's plan to promote opportunity and access for the underserved, September 11, 2020, at https://www.nature.com/articles/s41587-020-0688-8#:~:text=While%20the%20BIOEquality%20Agenda%20will,(lesbian%2C%20gay%2C%20bisexual%2C

229 ThoughtCo., Societal Concerns with Biotechnology, June 25, 2019, at https://www.thoughtco.com/societal-concerns-with-biotech-3973289

230 ThoughtCo., Societal Concerns with Biotechnology, June 25, 2019, at https://www.thoughtco.com/societal-concerns-with-biotech-3973289

231 ThoughtCo., Societal Concerns with Biotechnology, June 25, 2019, at https://www.thoughtco.com/societal-concerns-with-biotech-3973289

232 ThoughtCo., Societal Concerns with Biotechnology, June 25, 2019, at https://www.thoughtco.com/societal-concerns-with-biotech-3973289

233 U.S. Food and Drug Administration, FDA Approves First COVID-19 Vaccine, August 23, 2021, at https://www.fda.gov/news-events/press-announcements/fda-approves-first-covid-19-vaccine

234 U.S. Food and Drug Administration, Vaccine Ready: Addressing COVID-19 Health Disparities among Racial and Ethnic Minority Communities, April 12, 2021, at https://www.fda.gov/news-events/fda-voices/vaccine-ready-addressing-covid-19-health-disparities-among-racial-and-ethnic-minority-communities

235 U.S. Food and Drug Administration, Vaccine Ready: Addressing COVID-19 Health Disparities among Racial and Ethnic Minority Communities, April 12, 2021, at https://www.fda.gov/news-events/fda-voices/vaccine-ready-addressing-covid-19-health-disparities-among-racial-and-ethnic-minority-communities

236 U.S. Department of Health and Human Services Office of Minority Health, COVID-19 Vaccines and Racial and Ethnic Minority Populations, 2023, at https://www.minorityhealth.hhs.gov/covid-19-vaccines-and-racial-and-ethnic-minority-populations

237 The International Council of Biotechnology Associations (ICBA), Biotechnology: Driving Solutions for Sustainable Development, 2019, https://www.bio.org/sites/default/files/2019-11/ICBA%202019_SDG%20Brochure_Final.pdf

238 Access Accelerated, 22 Biopharma Companies Partner to Launch Access Accelerated, January 18, 2017, at https://accessaccelerated.org/news-and-events/test-post-f/

239 BIO Ventures for Global Health, About African Access Initiative, 2023, at https://bvgh.org/african-access-initiative/

240 MSD, MSD for Mothers: Helping end maternal mortality, September 14, 2022, at https://www.msd.com/stories/msd-for-mothers-helping-end-maternal-mortality/

241 Project HOPE, Project HOPE and GSK Develop Cold Storage Facility to Ensure Crucial Medicines Available for Patients in Northern Haiti, May 18, 2016, at https://www.projecthope.org/project-hope-gsk-develop-cold-storage-facility/

242 Finelib.com, 34th Annual International Conference of the Biotechnology Society of Nigeria (BSN), September 26, 2023, at https://www.finelib.com/events/health-care-events/34th-annual-international-conference-of-the-biotechnology-society-of-nigeria-bsn/150

243 BIO International Convention, 2023, at https://www.bio.org/events/bio-international-convention

244 BIO Ventures for Global Health, BVGH Programs, 2023, at https://bvgh.org

245 Biotechnology Innovation Organization, BIO Launches BIO Ventures for Global Health With Initial Grant from Bill & Melinda Gates Foundation, June 6, 2004, at https://archive.bio.org/media/press-release/bio-launches-bio-ventures-global-health-initial-grant-bill-melinda-gates-foundat

246 BizCommunity, Biovac to manufacture combo vaccines for Sanofi Pasteur, April 3, 2012, at https://www.bizcommunity.com/Article/196/398/73258.html

247 Spudman, Biotech potatoes can bring improved performance, quality to global markets, May/June 2020, at https://spudman.com/article/biotech-potatoes-improved-performance-quality-global-markets/

248 The Sainsbury Laboratory, Funding approved to develop new potato at The Sainsbury Laboratory, June 1, 2015, at https://www.tsl.ac.uk/news/new-potato-at-the-sainsbury-laboratory