BIOTECH SOLUTIONS FOR CLIMATE REPORT

EXECUTIVE SUMMARY

Examining biotechnology's contributions to addressing the climate crisis

"CLIMATE CHANGE IS ONE OF THE GREATEST PUBLIC POLICY CHALLENGES FACING THIS GENERATION."

New approaches are required at almost every level of the economy. Biotechnology has the potential to be a transformative asset in this struggle, offering vital contributions to near-term greenhouse gas (GHG) reductions and revolutionary tools to avert catastrophic climate change in the longer term. New biotech tools, including gene editing and synthetic biology, can be transformative climate solutions in key emerging industry sectors. Policies supporting the development and deployment of biotech climate solutions should be part of any government effort to address climate change.

Biotechnology can achieve at least 3 billion tons of CO_2 equivalent mitigation annually by 2030, using existing technologies, and emerging biotechnologies could have transformative GHG benefits in a range of industrial sectors. Biotechnology can deliver vital climate solutions in four key areas:

- Producing sustainable biomass feedstock
- Empowering sustainable production
- Developing lower carbon products
- Enhancing carbon sequestration

PRODUCING SUSTAINABLE BIOMASS FEEDSTOCK

Substituting sustainably produced biomass feedstocks for fossil feedstocks is a critical component of decarbonizing the U.S. economy because it leverages the capacity of photosynthesis to remove carbon from the atmosphere. Biomass substitution has provided vital near-term reductions in the carbon intensity of transportation fuels and a rapidly growing array of consumer products. In several key markets, such as aviation fuels, biobased alternatives offer the only viable path to GHG reductions. Biotechnology is being deployed to develop and utilize a range of next-generation sustainable biomass feedstocks to expand the availability and further reduce the carbon intensity of biofuels and biobased products. Future climate gains from biomass will depend critically on the carbon footprint of biomass feedstock production.

Biotech innovations in sustainable biomass production are also transforming the broader agriculture sector. Agriculture accounts for roughly 10% of total U.S. GHG emissions.[1] The vast majority of these emissions are nitrogen emissions from fertilizer and soils and methane emissions from livestock. Biotech is being deployed to tackle both issues.

Key Findings:

- Biofuels from agricultural or municipal waste and dedicated energy crops such as algae, switchgrass, hybrid poplar and miscanthus have achieved GHG reductions of up to 80% versus petroleum with current technology.[2]

- Continued improvements in feedstock production, conversion efficiency, and co-products are expected to yield pathways with negative carbon scores.[3]
- Biotechnology is being deployed to radically reduce agricultural nitrogen emissions: first, by introducing nitrogen-fixing microorganisms, known as agricultural (ag) biologicals, to the soil; and second, by using plant biotechnology to engineer plants to better utilize soil nitrogen. Biotech solutions could reduce nitrous oxide emissions from agriculture by more than 150 million metric tons of carbon equivalent.

- Ag biologicals and plant biotechnology are being similarly leveraged to enhance soil carbon sequestration through introduction of carbon-fixing soil microbes and larger plant root systems. Ag biologicals and plant biotechnology could enhance soil carbon sequestration by up to 600 million metric tons per year if widely deployed.

- Biotechnology is reducing methane emissions from livestock through new animal feeds and feed ingredients, more efficient animals, and solutions for processing and reusing animal waste.

- Plant biotechnology will be critical to continued agriculture sustainability gains, including improvements in crop yields, photosynthetic efficiency, and climate resiliency.
- Together, biotech solutions have the potential to reduce agriculture sector GHG emissions by nearly 1 billion metric tons (1 gigaton) annually – or the equivalent of GHG emissions from more than 100 million U.S. homes.

EMPOWERING SUSTAINABLE PRODUCTION

Manufacturing of everyday products, like apparel, plastics, packaging, carpet and cosmetics, is a major greenhouse gas emitter, responsible for 22% of total GHG emissions.[4] Biotechnology can dramatically reduce these emissions by making their building blocks from renewable feedstocks rather than fossil fuels; in many cases, biology allows drop-in replacements of existing building blocks, enabling faster adoption throughout our economy with homegrown solutions. New biotech tools, including gene editing and synthetic biology, offer the potential for transformative climate solutions in key emerging industry sectors. Biotech offers a sustainable model for manufacturing in the 21st century .

Key Findings:

- Biomanufacturing – the use of enzymes and microorganisms in manufacturing – can reduce GHG emissions 80% or more relative to traditional chemical routes for a variety of chemicals and consumer products.[5]

- CRISPR and other gene editing tools have dramatically increased the speed and reduced the cost of genetic engineering and are being deployed to tackle a range of global challenges, including climate change.

- Biology-based parallel computing and DNA data storage have the potential to cut the energy and carbon footprints of computing and data storage – sectors expected to account for 14% or more of global GHG emissions by 2040[6] – by 99% or more versus current technology. [7]
- Biological sensors, coatings and ingredients can substantially reduce food and feed waste, which is responsible for roughly 7 percent of total global GHG emissions.[8]

DEVLOPING LOWER-CARBON PRODUCTS

As awareness of the climate crisis expands, consumers are increasingly demanding lower-carbon options and more sustainable replacements for existing products. This means finding low-emission alternatives that provide the same level of performance, durability and cost-effectiveness as mature fossil-based systems. Biotechnology allows for the production of low-carbon consumer products through the substitution of biomass or other recycled carbon feedstocks and by enabling more efficient, biologically-based production, satisfying an increasingly important market segment while reducing emissions.

Key Findings:

- First-generation biofuels have reduced U.S. transportation sector GHG emissions by 980 million tons over the past thirteen years,[9] equivalent to taking roughly 16 million vehicles off the road, or 19 coal-fired power plants offline, for that period.[10] Biotech innovations in feedstocks, processing, co-products, and carbon recycling continue to lower their carbon intensity.

- With lifecycle GHG reductions of 80% or more versus petroleum, next-generation feedstocks will more than double the transportation GHG emissions reductions achieved by first-generation biofuels and are poised to deliver carbon-negative transportation solutions.

- Biobased products produced from biomass or biologically recycled waste gases added $459 billion to the U.S. economy in 2016[11] and are built from carbon that would otherwise reside in the atmosphere, creating a pivotal pathway for atmospheric carbon removal.
- Biobased plastics and polymers, such as PLA, PHA, and BDO have achieved lifecycle GHG reductions of up to 80% versus their petroleum-based counterparts.[12] A rapidly growing list of new biobased chemical building blocks is now in development.

- Biotechnology is lowering the carbon footprint of animal products and making possible a growing array of sustainable, low-carbon options for meat and animal products through:

  - Plant-based and cultured meats with up to 89% lower lifecycle GHG emission.[13]
  - Algae and microbial feed ingredients that reduce enteric methane emissions from ruminant animals by 68% or more, [14,15] avoiding the equivalent of up to 140 million metric tons of carbon annually.
  - Other biotech ingredient options for fish feed that reduce its carbon footprint by up to 30%.[16]
  - Anaerobic digestion of animal waste, with the potential to reduce U.S. GHG emissions by 151 MTCO2 eq. annually by 2050 using current technology.[17]

ENHANCING CARBON SEQUESTRATION

A broad scientific consensus exists that reducing carbon emission alone will be insufficient to avert catastrophic climate change. Almost every model of a successful stabilization of global temperatures includes a substantial component of carbon dioxide removal from the atmosphere as well.[18] Biotechnology has multiple critical roles in achieving the needed carbon removal.

Key Findings:

- Biological carbon capture is the most feasible near-term pathway to meaningful atmospheric carbon removal. Development of thermochemical systems for point-source and direct-air capture remains an important technology pursuit, but photosynthesis and other biological pathways remain the only established mechanisms for carbon capture on a scale sufficient for carbon removal.

- Bioenergy with Carbon Capture and Sequestration (BECCS) could cost-effectively remove over 700 million metric tons of carbon per year by 2040, or more than half the emissions from all U.S. coal power plants.[19]

- Algae and other microbial carbon capture systems applied to biomass energy or other biorefinery systems offer one of the most carbon-negative climate solutions available.

- Suitable land and other infrastructure exists to deploy algae-based carbon capture systems at more than 500 power plants and ethanol facilities in the U.S. These systems would have a potential to capture more than 200 million tons of CO2 annually.[20]

CONCLUSION

Biotechnology is a crucial enabling technology to combat climate change. It offers gigaton solutions from existing technologies and potentially transformative solutions in multiple sectors of the economy. Current and future biotechnology innovations will be needed to achieve a zero-carbon economy and play a key role in carbon capture and sequestration to take us beyond zero. Policies supporting the development and deployment of biotech climate solutions should be part of any government effort to address climate change.

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