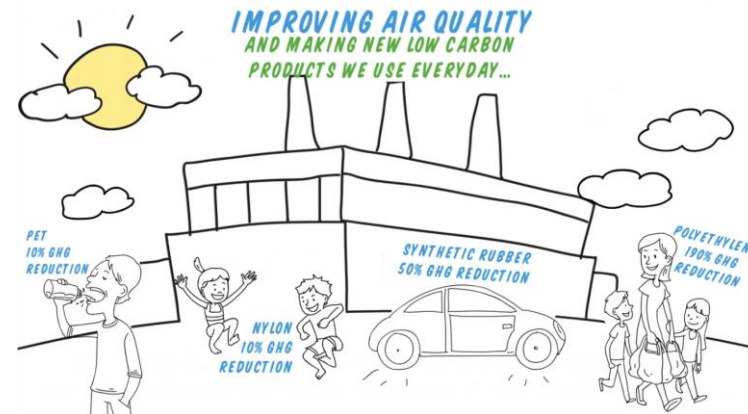
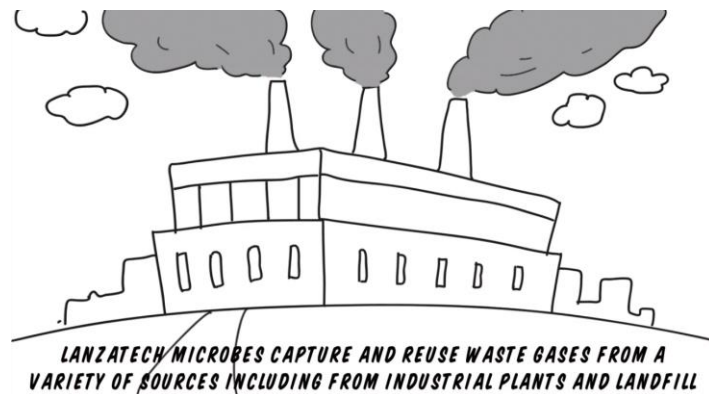


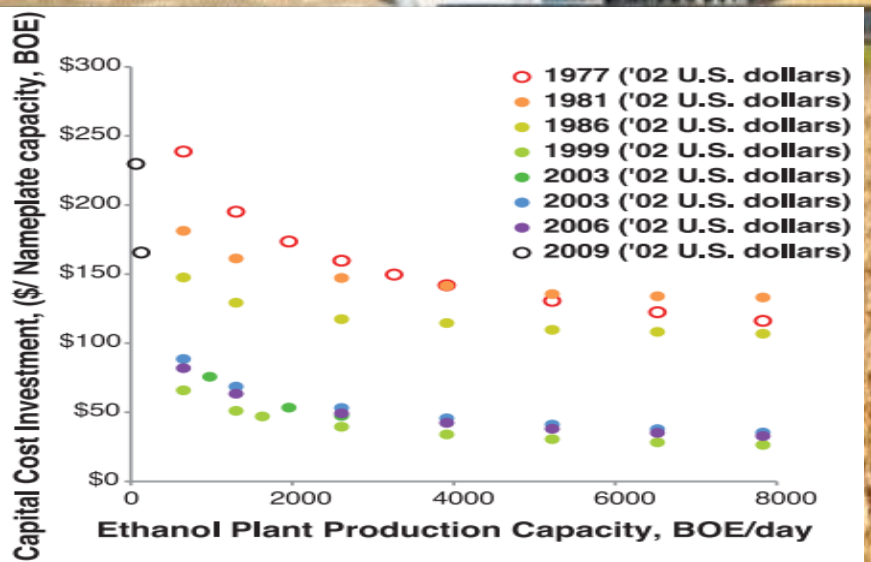


RECYCLES CARBON TODAY FOR A CLEANER TOMORROW



NSTC Interagency Synthetic Biology Workshop, October 17 2019
Dr. Michael Köpke, Director Synthetic Biology, michael.Koepke@lanzatech.com

Biomanufacturing Today

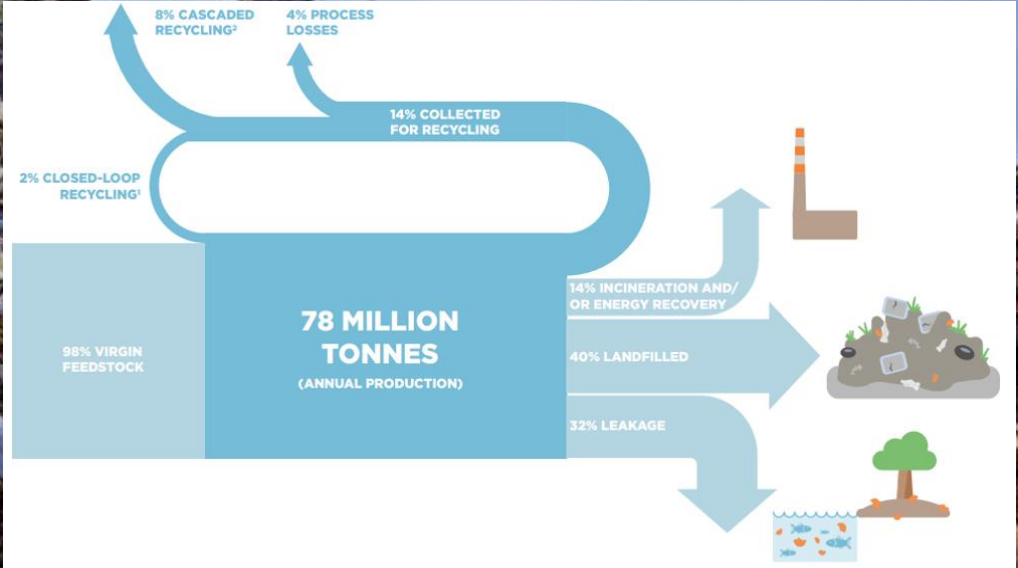


Source: Clomburg JM, Crumbley AM, Gonzalez R. Industrial biomanufacturing: The future of chemical production. *Science* 255: aag0804 (2017)



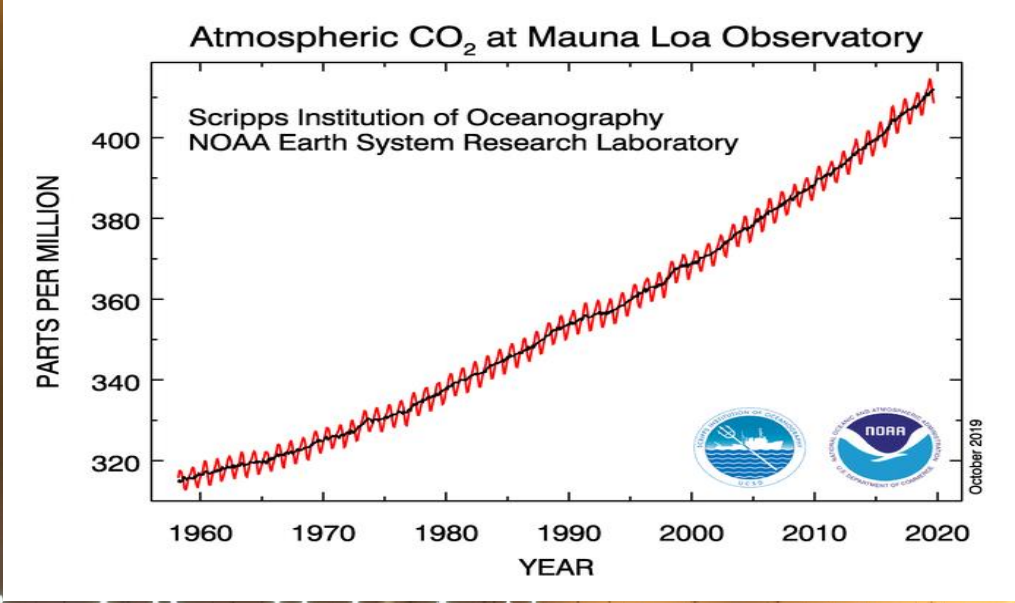
Source: Sugar prices Historical Chart. www.macrotrends.com

The Opportunity



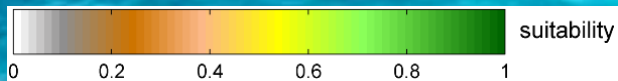
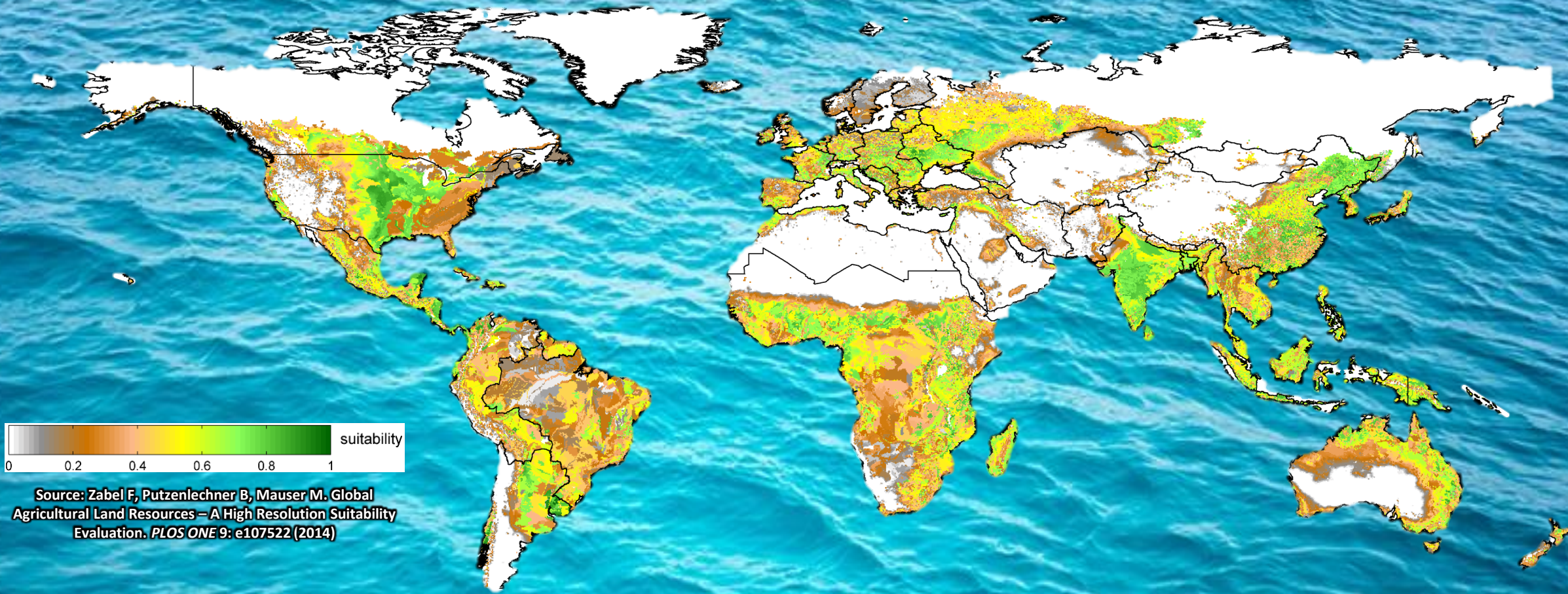
Source: World Economic Forum, Ellen MacArthur Foundation, McKinsey & Company. A new Plastics Economy: Rethinking the Future of Plastics (2016). www.ellenmacarthurfoundation.org/publications

The Opportunity



Source: National Oceanic and Atmospheric Administration (NOAA). Trends in Atmospheric CO₂
www.esrl.noaa.gov/gmd/ccgg/trends/.

Expanding Our Options



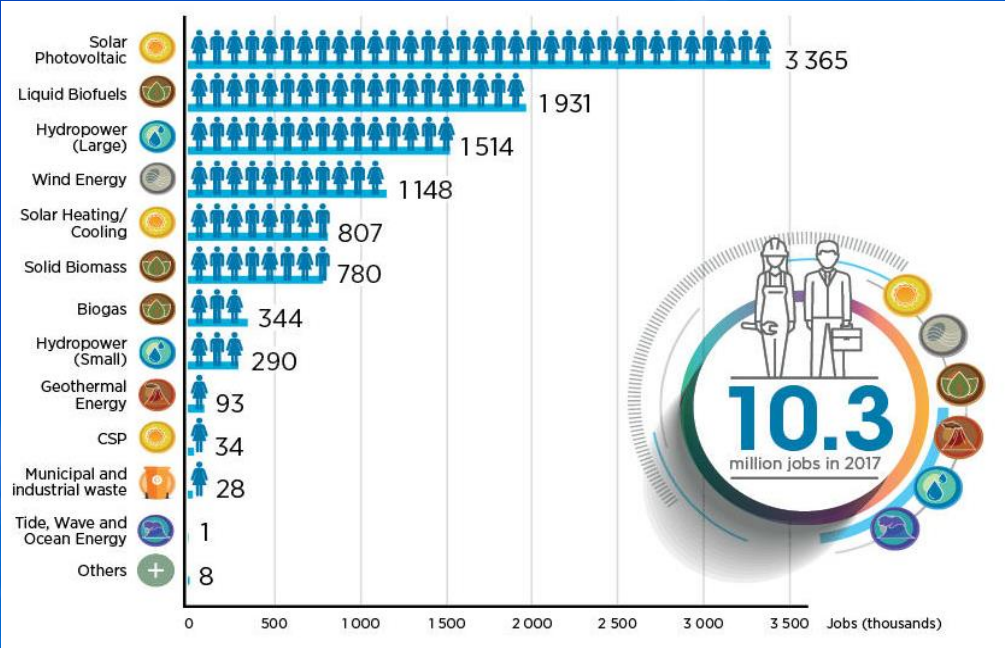
Source: Zabel F, Putzenlechner B, Mauser M. Global Agricultural Land Resources – A High Resolution Suitability Evaluation. *PLOS ONE* 9: e107522 (2014)

Local Input > Global Impact

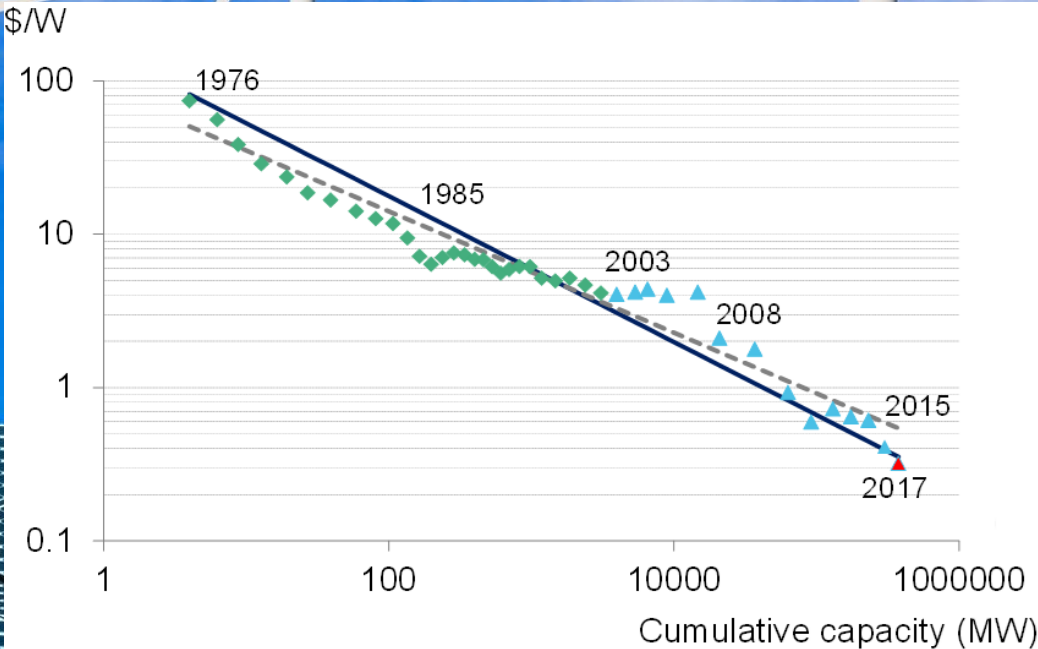


Source: Clomburg JM, Crumbley AM, Gonzalez R. Industrial biomanufacturing: The future of chemical production. *Science* 255: aag0804 (2017)

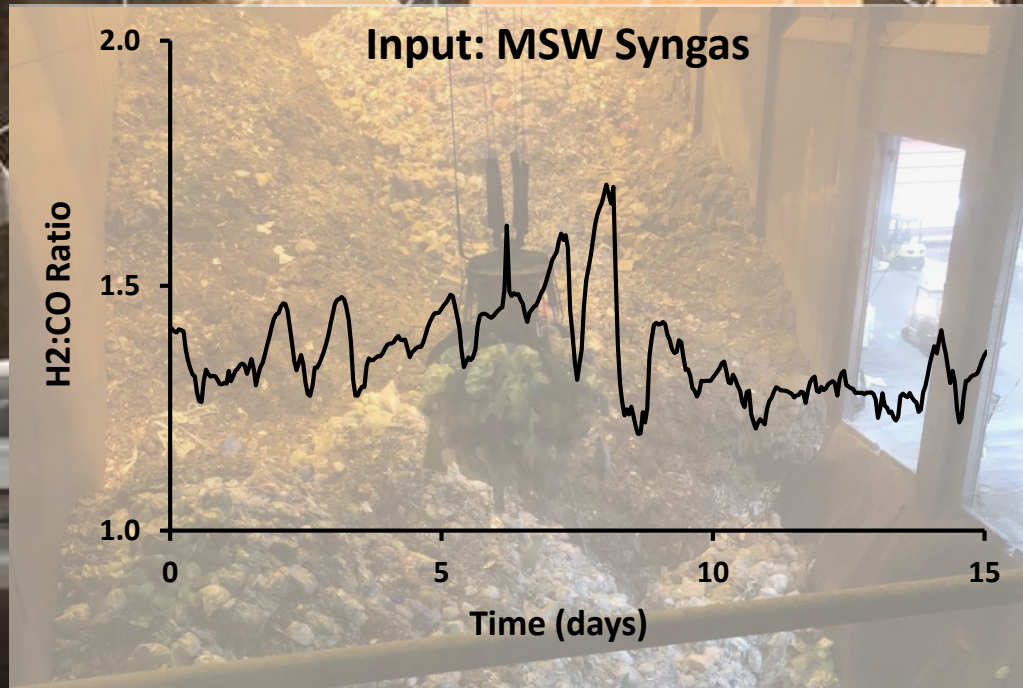
Renewable Energy Revolution



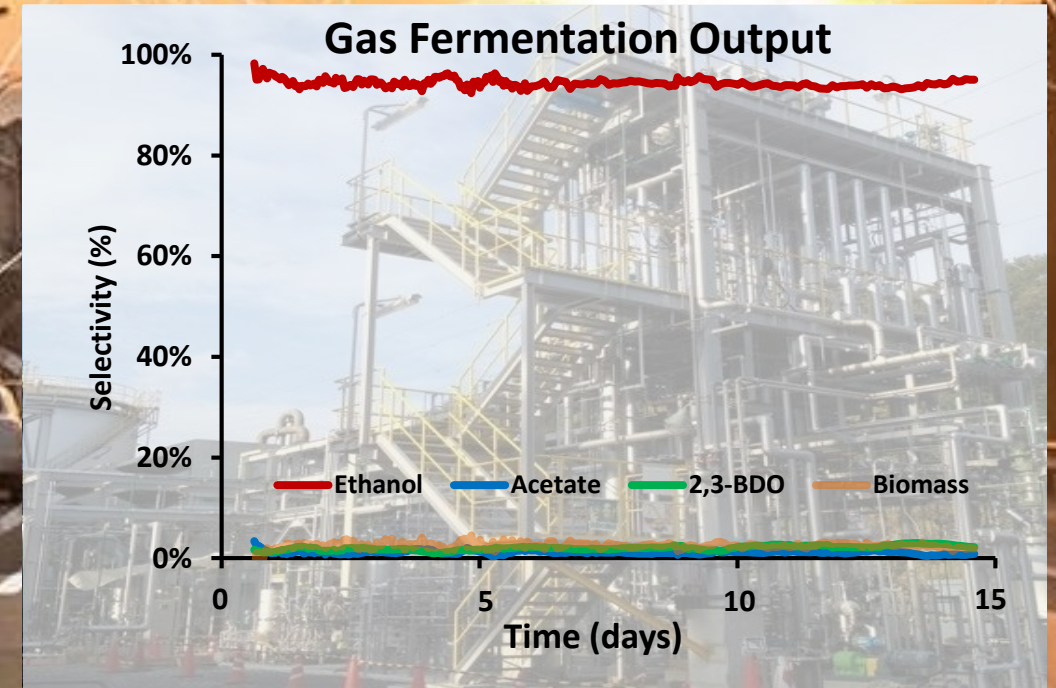
Source: International Renewable Energy Agency (IRENA).
www.irena.org/newsroom/pressreleases/2018/May/Renewable-Energy-Jobs-Reach-10-Million-Worldwide-in-2017



Biology Is Capable Of Processing Chaotic Inputs

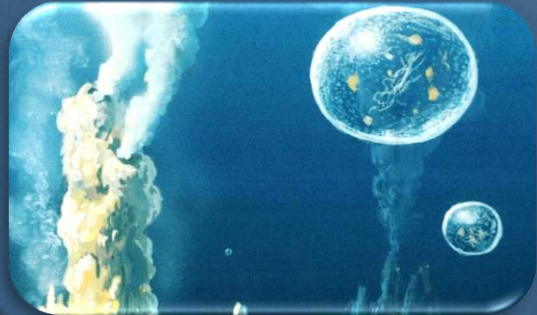


Source: Sekisui-LanzaTech



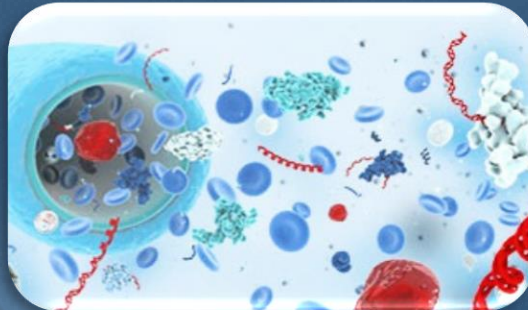
Source: Sekisui-LanzaTech

Range of Available Production Systems



Breadth of Organisms

- Traditional Systems
- Autotrophs
- Extremophiles
- Polymer-degraders



Cell-Free Systems

- No constraints of cellular metabolism
- High biocatalyst loadings

Unleashed by Synthetic Biology

LanzaTech's World-First
Anaerobic Biofoundry



Strain Engineering Capacity

Advanced Genetic Toolbox

- Multiplexed CRISPR Genome Editing
- Genetic Circuits
- Cell-free prototyping

Gap: 100

Enabling Technologies

- DNA Sequencing & Synthesis
- Biofoundries
- Microfluidics, Optofluidics

De Novo Design

- Designer Enzymes
- De Novo Pathways
- Synthetic Genomes

2010

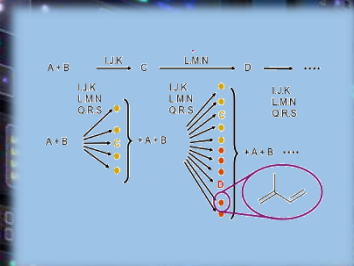
2015

2020

Year



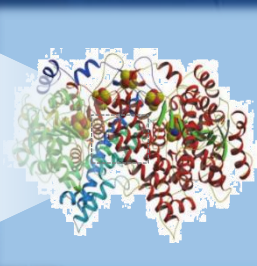
Integrated, Multi-Scale Modelling



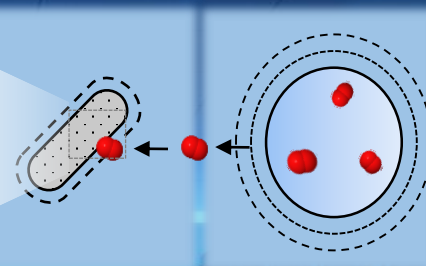
Pathway Discovery



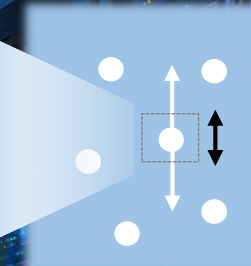
DNA Design



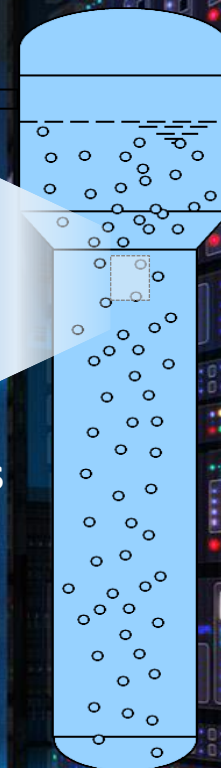
Enzyme Kinetics



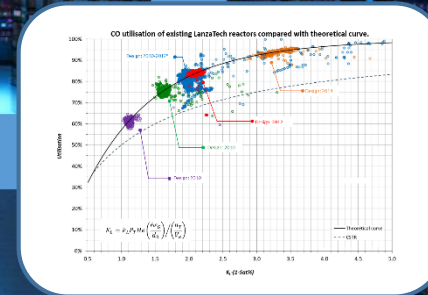
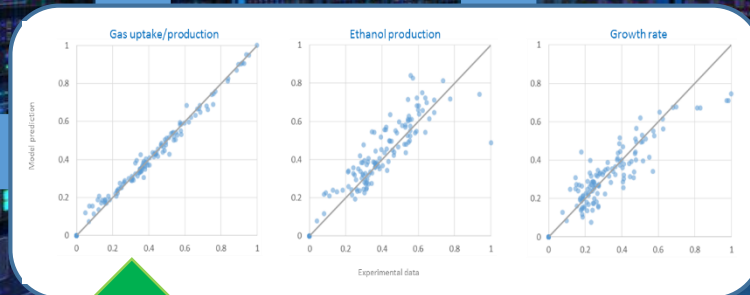
Metabolism



Mass transfer



Hydrodynamics



Economics

Data Warehouse / Machine Learning

Crossing the Valley of Death

LanzaTech's World-First Commercial-Scale Gas Fermentation Plant



Ease of Funding



Discovery

Applied R&D



Engineering Development



Pilot and Demonstration



\$\$

\$\$\$



First Commercial



Diffusion



Adapt and adopt from others



Continuous improvement at scale



Sustainable Enterprise

Evolution

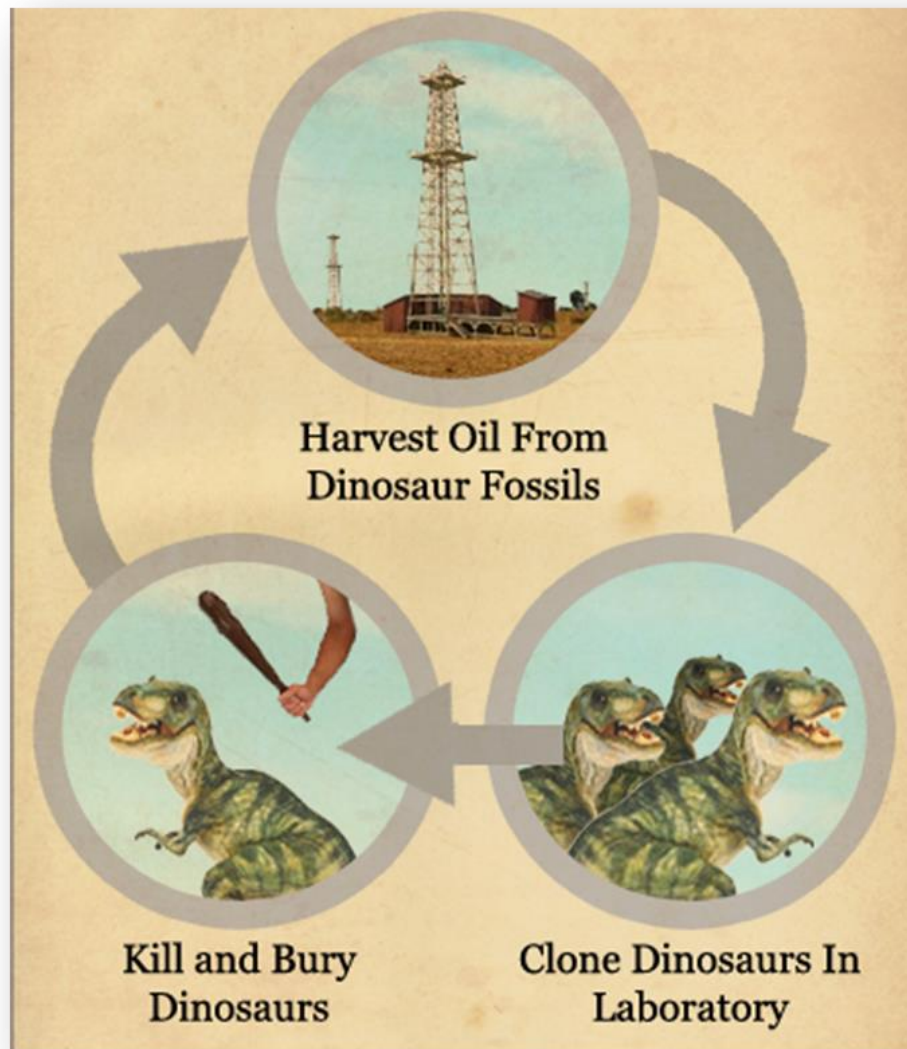


What Is It Going To Take?

A
INNOVATION



the Game Changer...



What Is It Going To Take?



What Is It Going To Take?

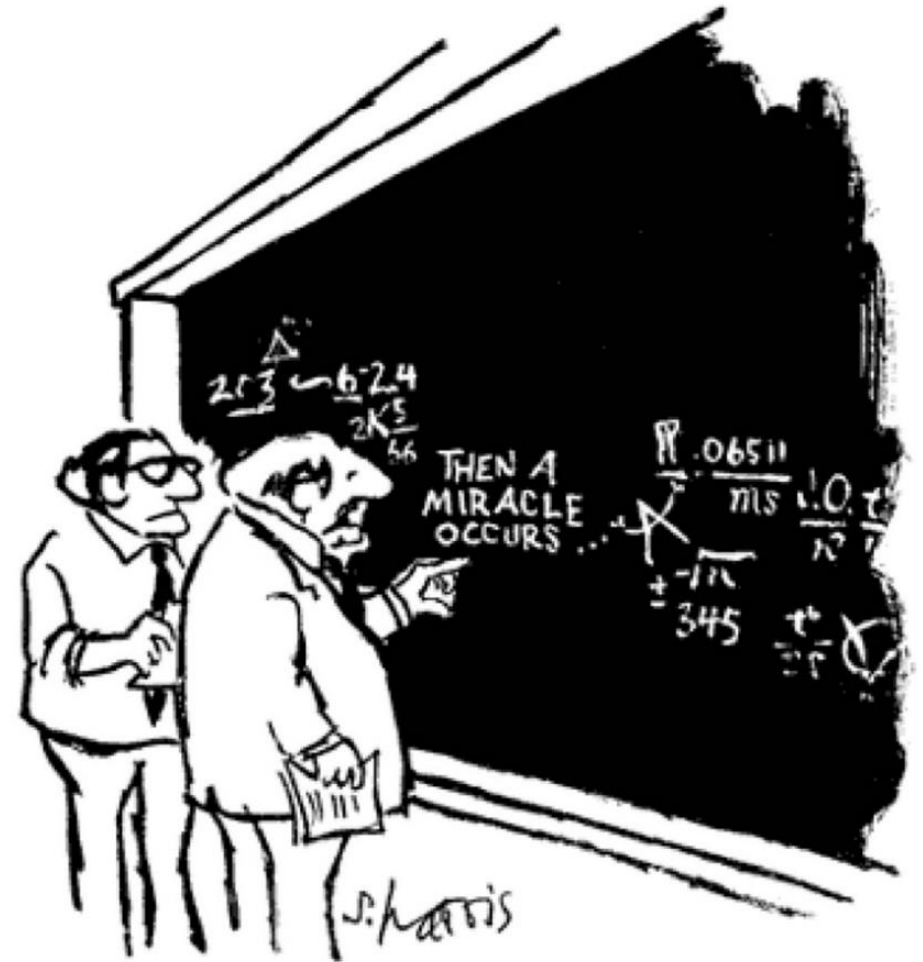


We must adopt technology neutral positions and support all solutions.

We must fail quickly and move on.

We must collaborate to address environmental concerns and get new fuels and chemicals to market quickly.

We need funding for every scale of commercialization from proof of concept through to first commercial units.



"I think you should be more explicit here in step two."

Need to Ensure all Solutions can Contribute Quickly