Biomanufacturing for a Sustainable Future

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19 November 2015

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Joint BioEnergy Institute

FutureBio
INSTITUTE

Joint BioEnergy Institute

Seven Partners

Berkeley Lab

University of California Berkeley

Sandia National Laboratories

UC Davis University of California

Pacific Northwest National Laboratory

Carnegie Institution for Science

Lawrence Livermore National Laboratory

One Location

- Funded by DOE
- Started in 2007
- Renewed in 2012
- $25M/year

JBEI's Mission: Basic Science to Convert Cellulosic Biomass to Drop-in Fuels

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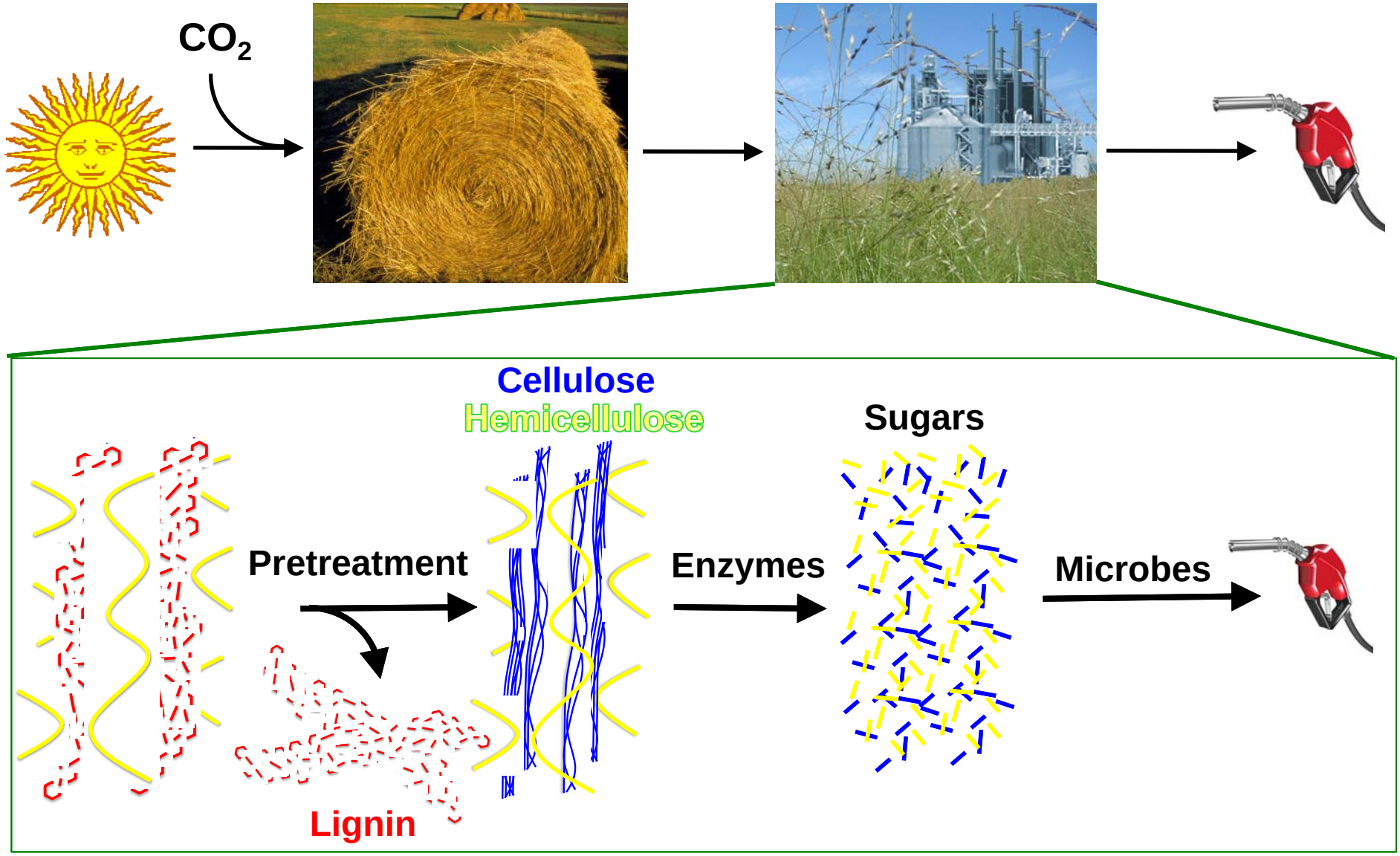
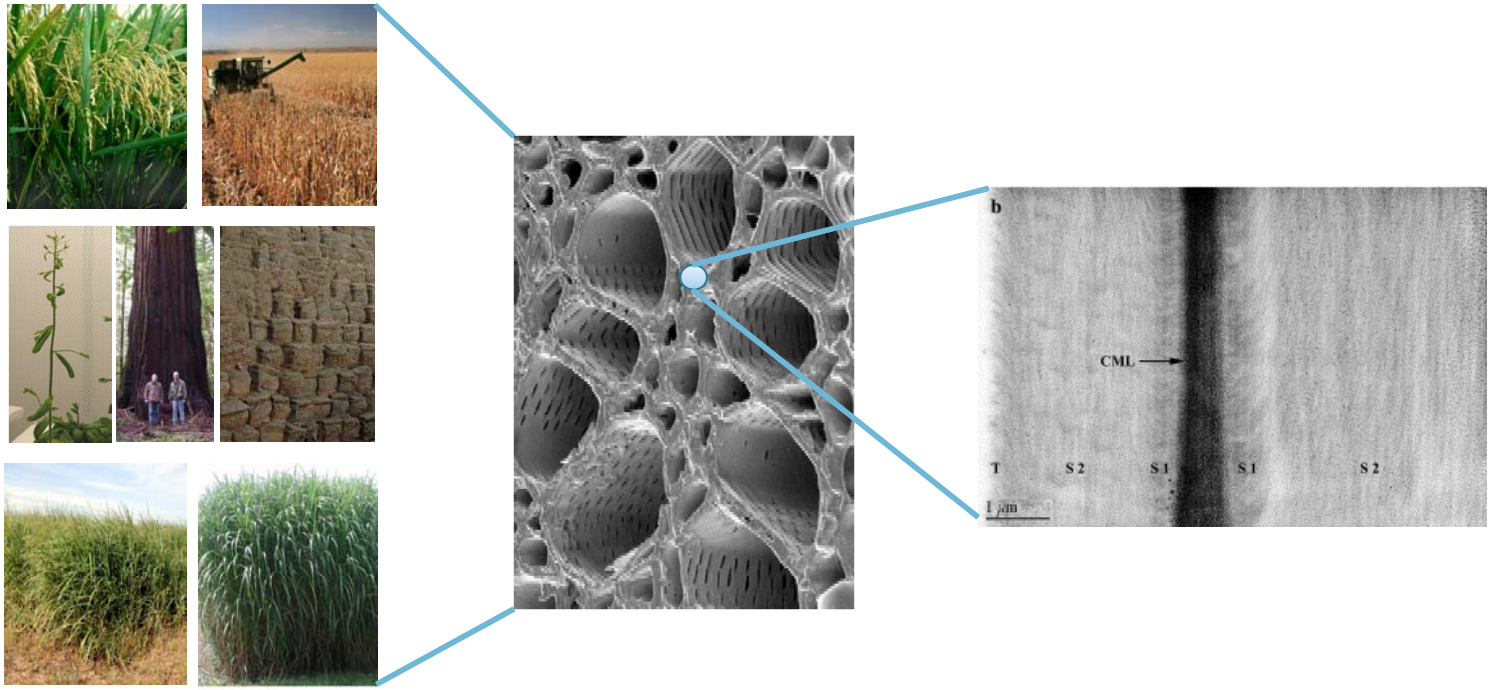


Engineering cell wall deposition in fibers



Challenges

- High-density biomass would reduce transport costs and increase fuel yields
- More sugar but less lignin is preferable

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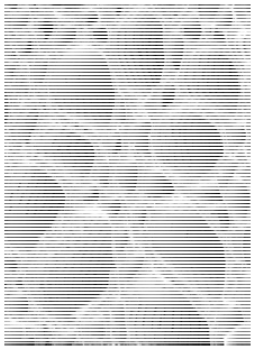
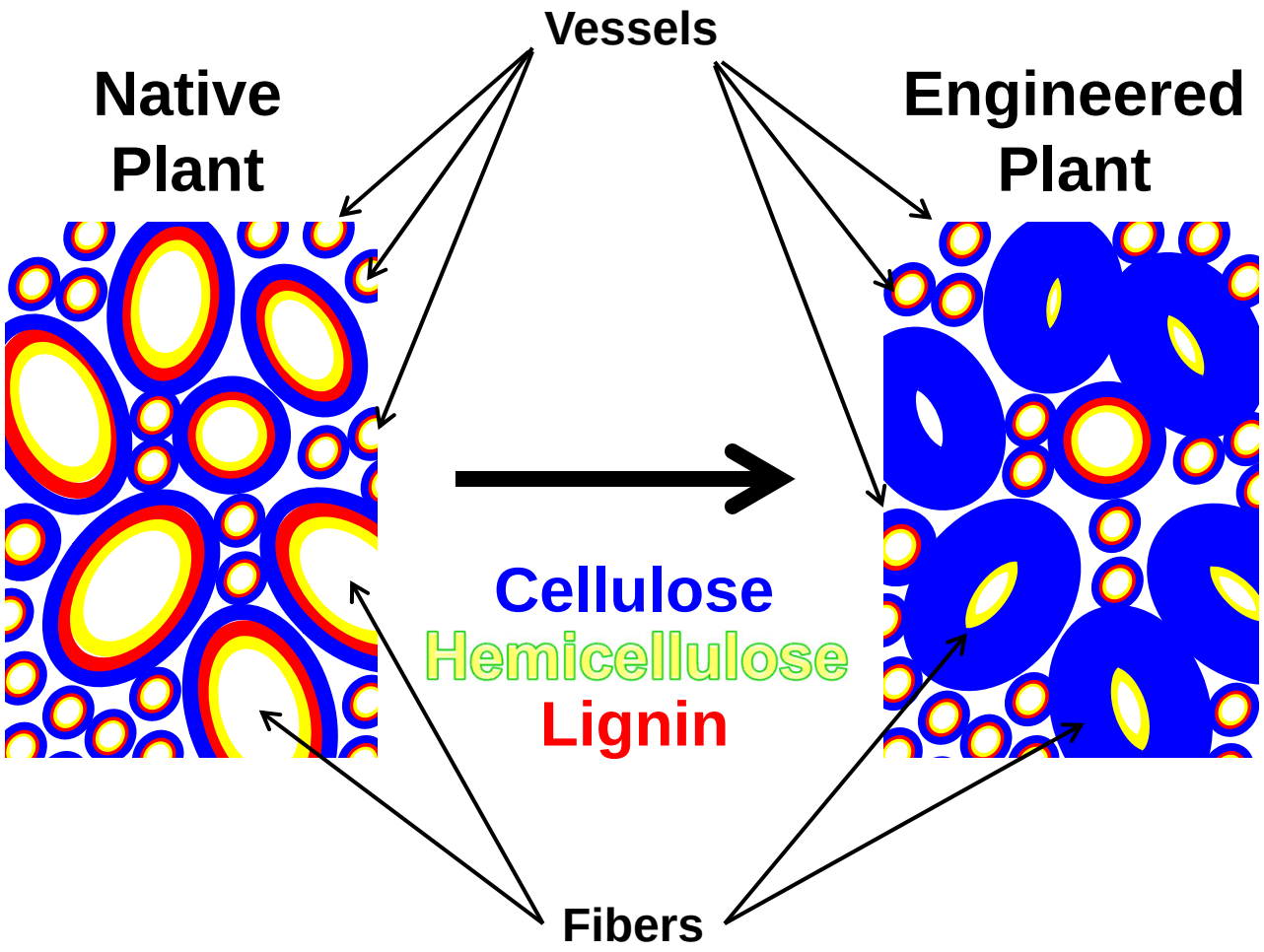
Can we fill the fibers up with cellulose?





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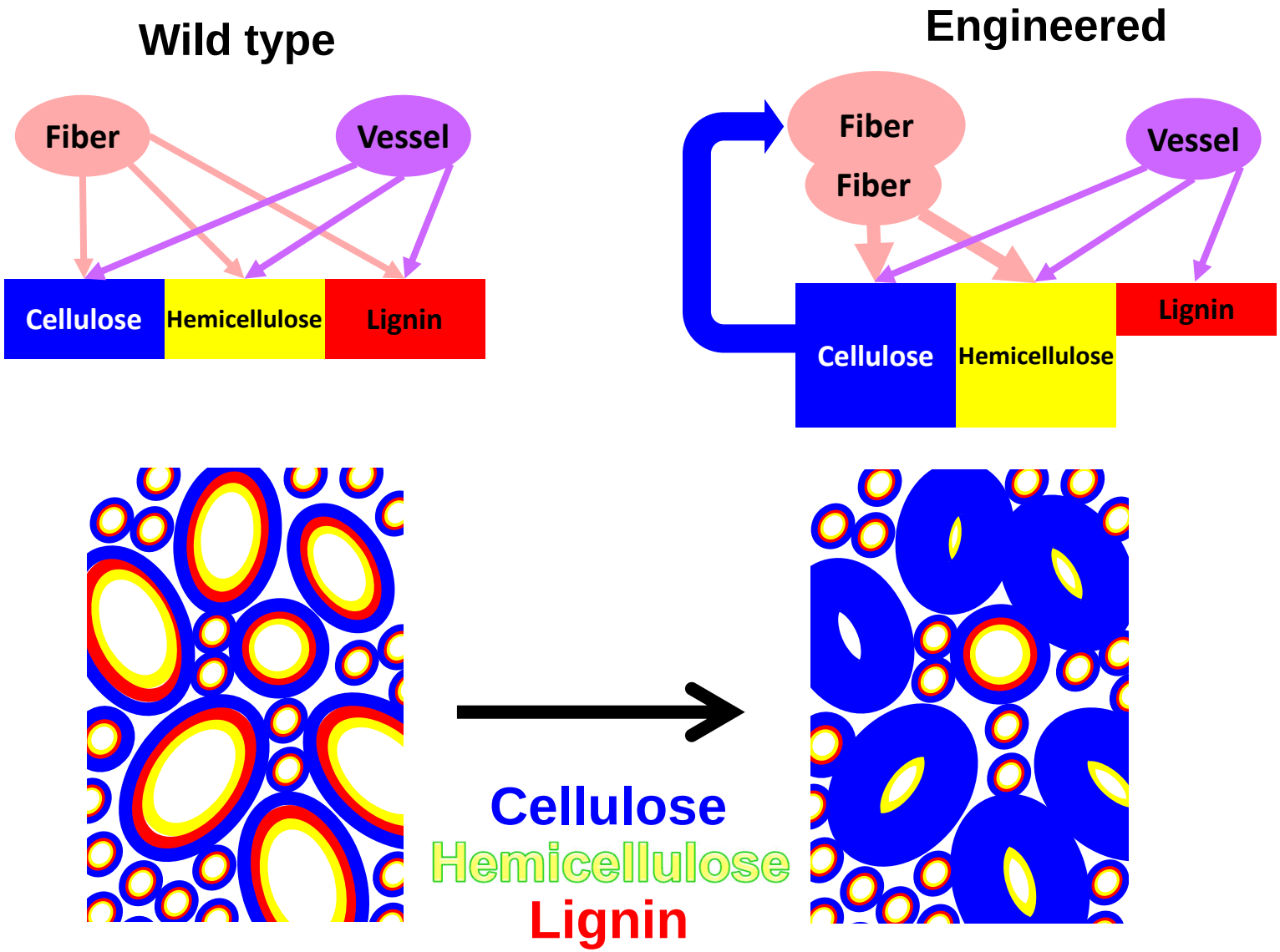
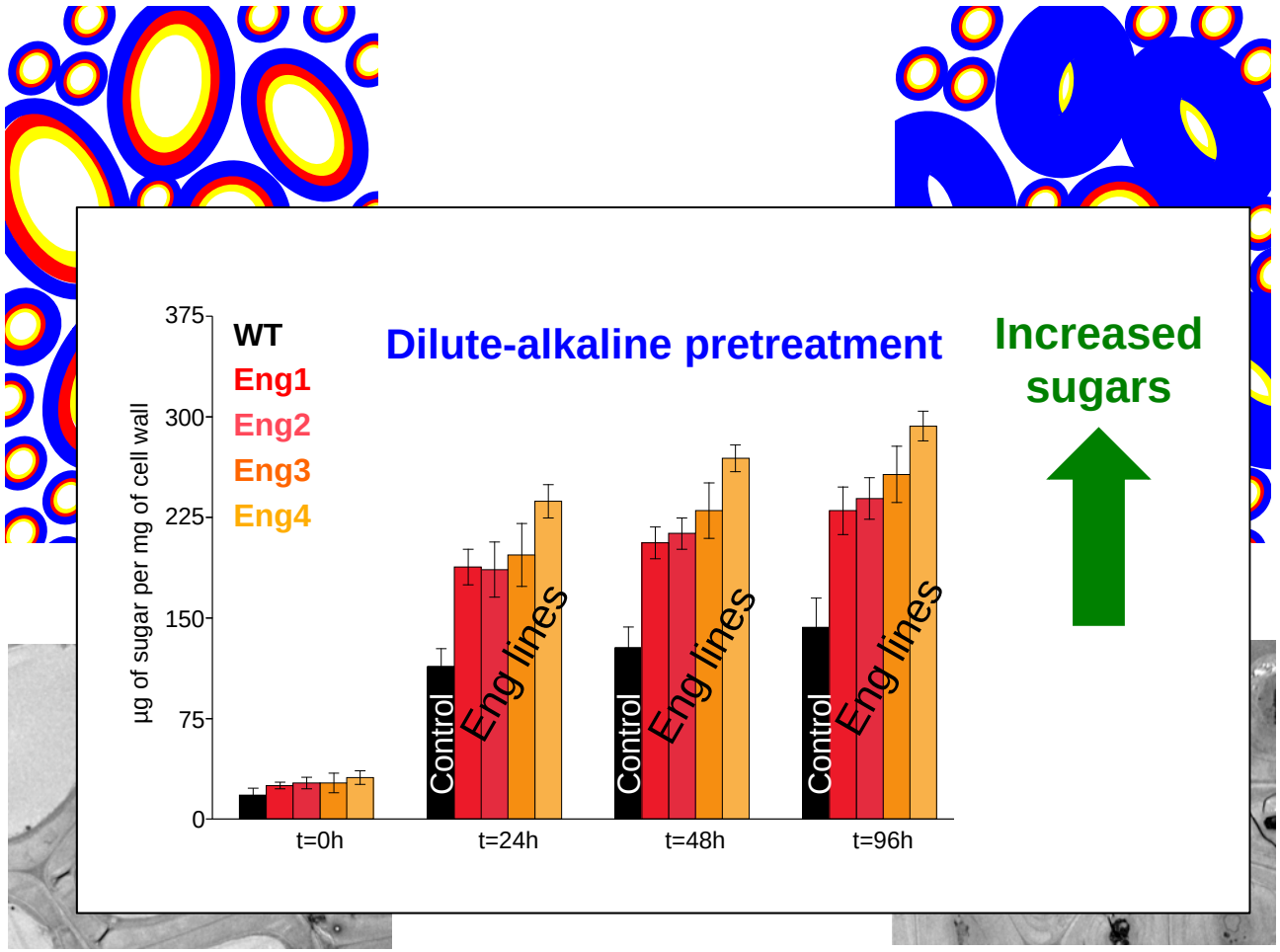
Genetic changes direct cellulose to fibers



Engineered plants contain approximately twice the sugar as the native plants

Native Plant

Engineered Plant



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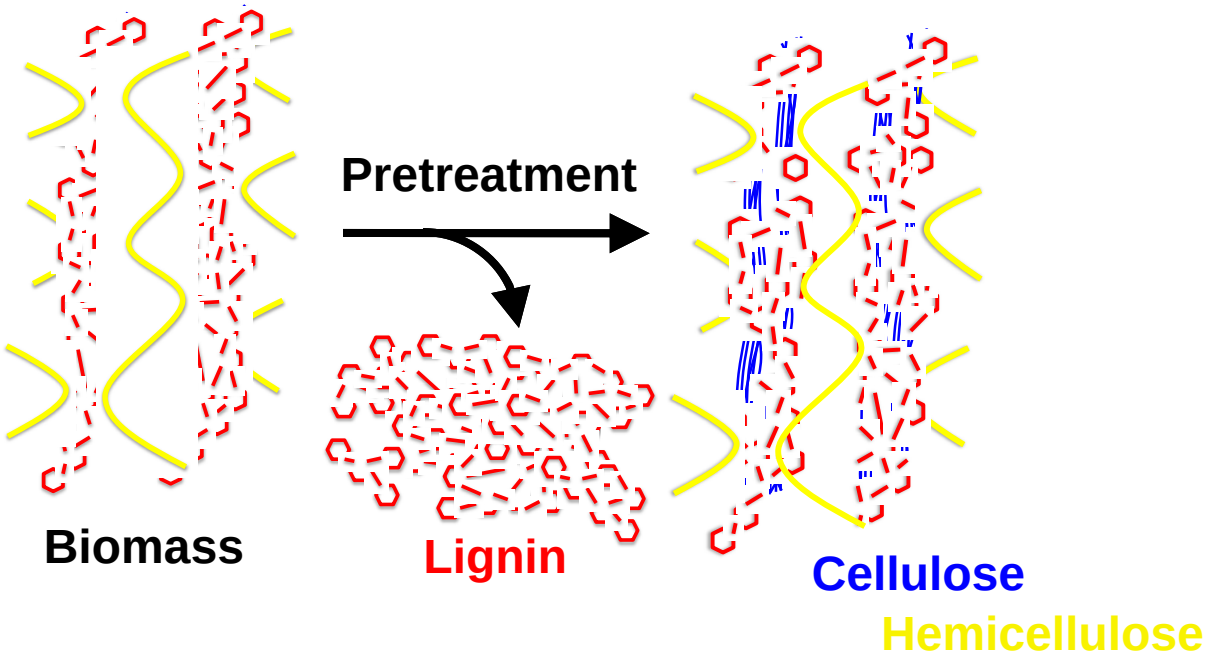
Some key challenges in converting lignocellulosic biomass to fuels



Challenges

- We need better pretreatment processes that yield cleaner cellulose/hemicellulose

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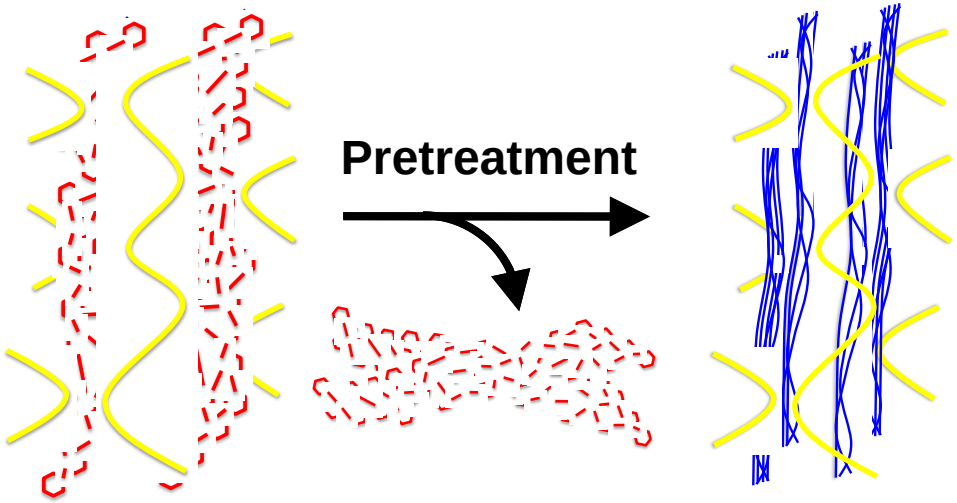
Ionic liquids for pretreatment



Ionic liquids

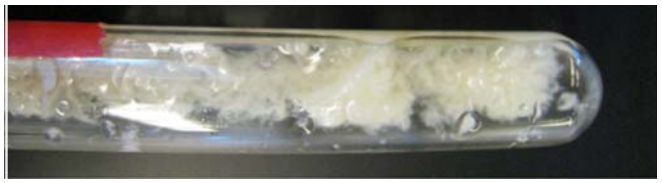
Biomass

Mix
Heat

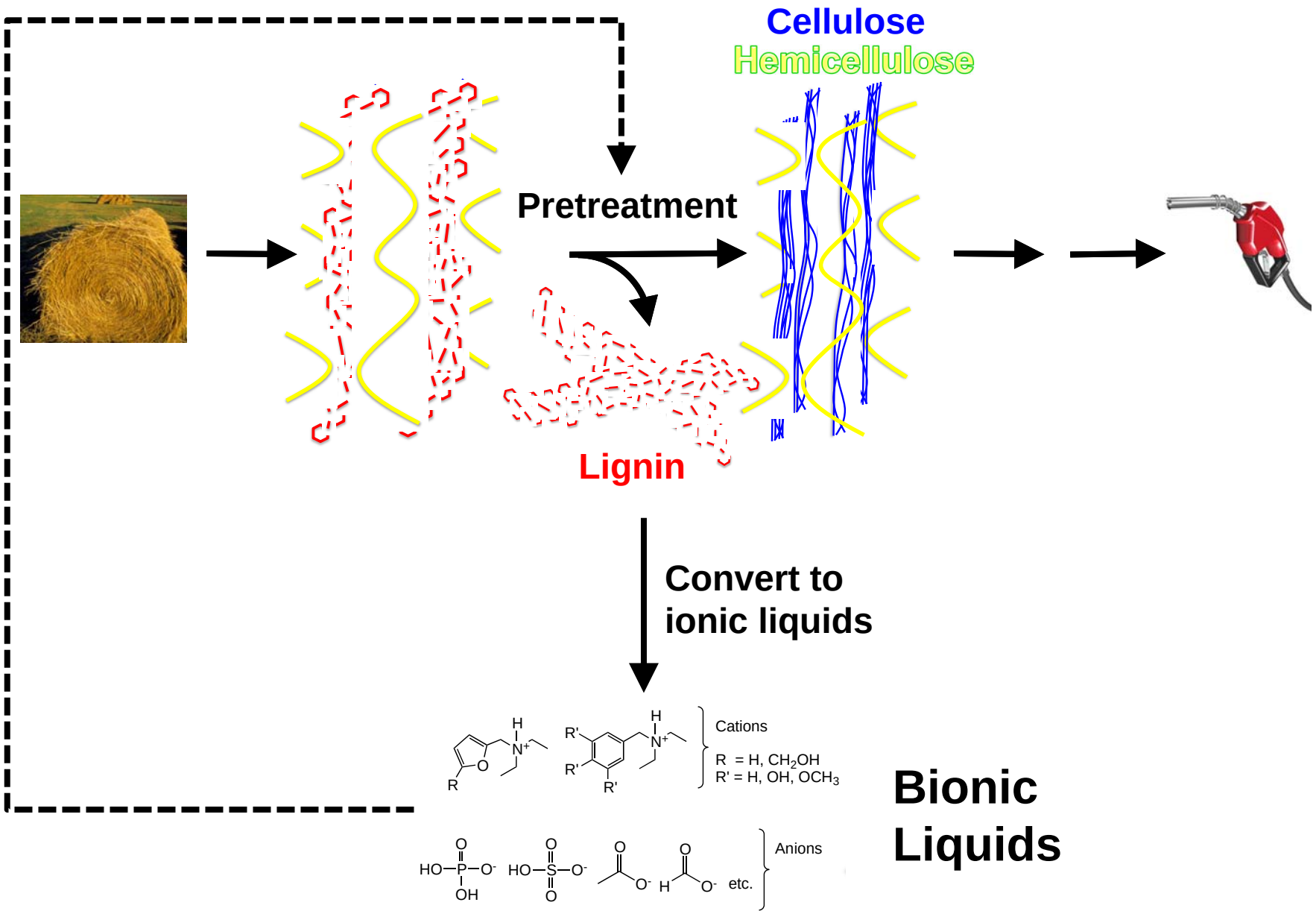
Stir

Add

Anti-solvent



Biological ionic (Bionic) liquids from lignin



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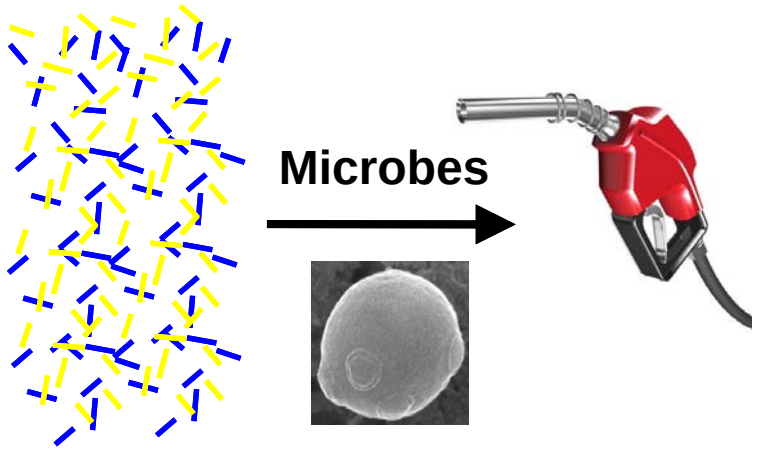
Some key challenges in converting lignocellulosic biomass to fuels



Challenges

- We need fuels for all types of engines

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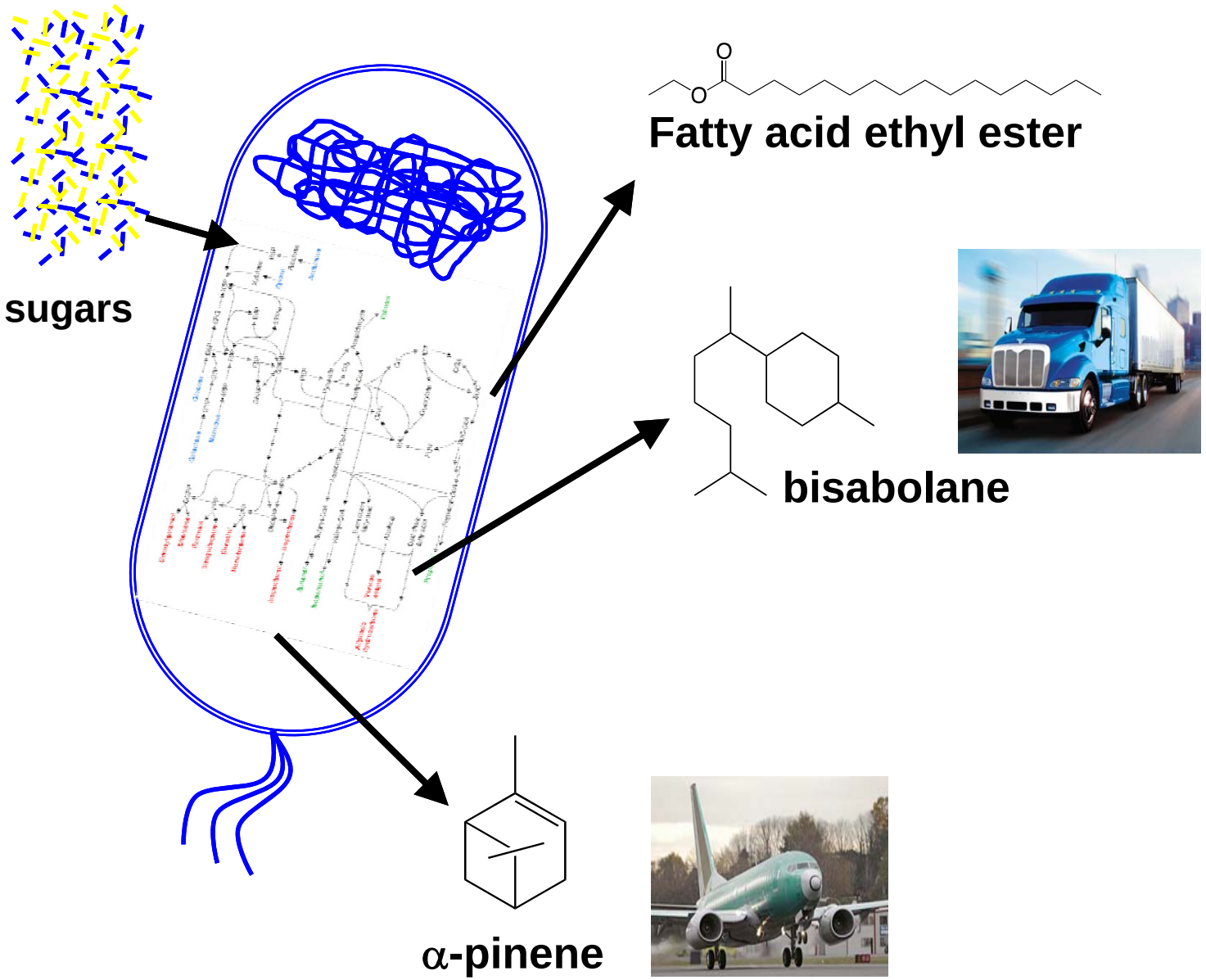
Advanced biofuels from biomass



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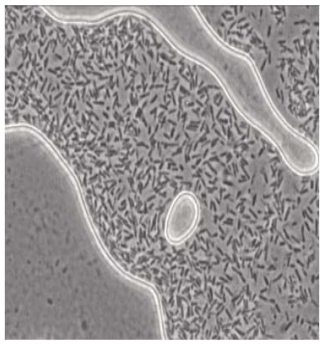
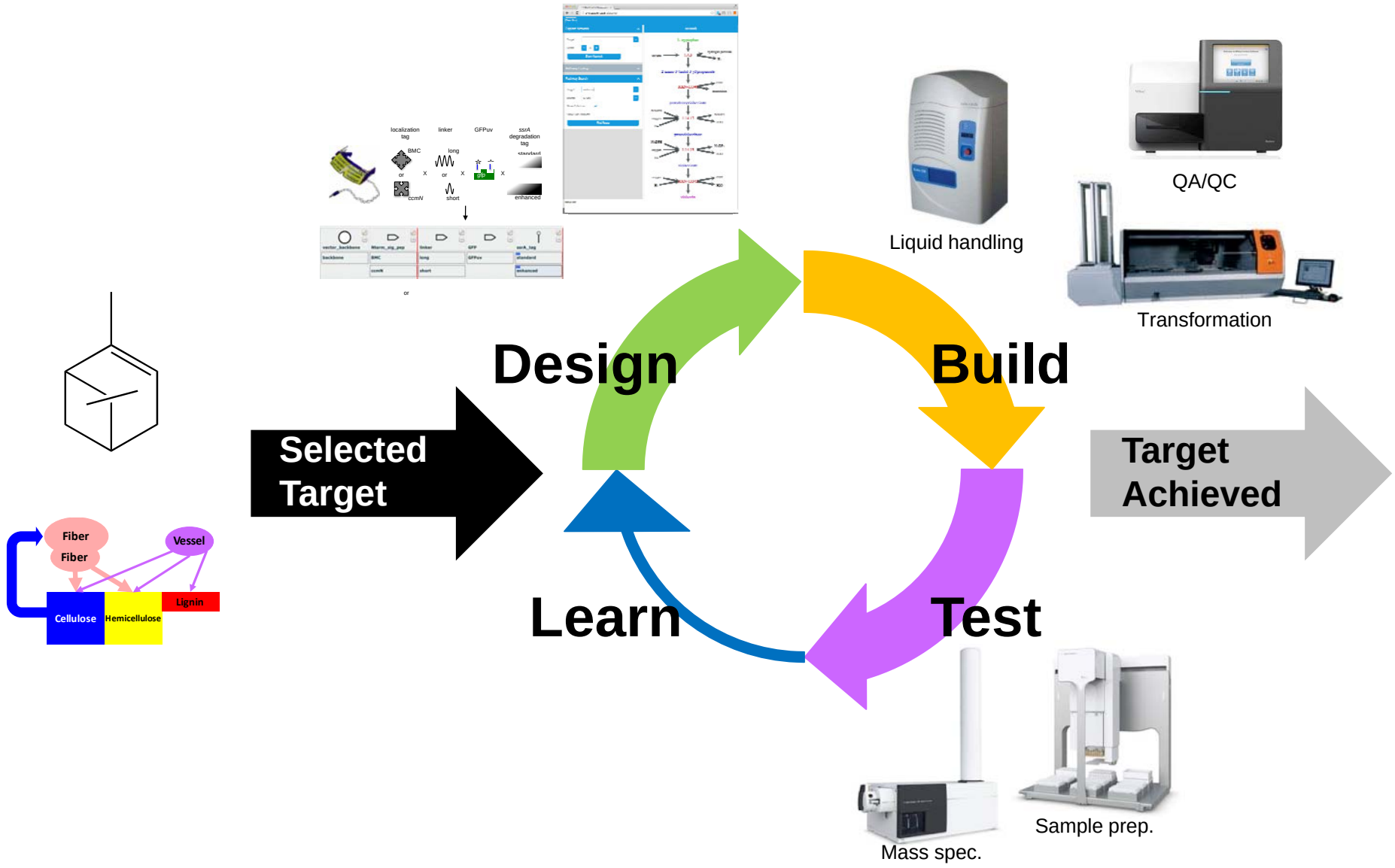
Phase separation allows simple purification of fuel



JBEI's advancements were made possible, in part, through the development of technologies



Major issues of our time

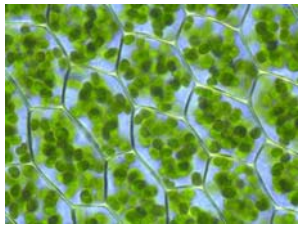
Food. Water. Energy. Environment. Health.





Biology will be part of the solution to all of these challenges

Engineered plants with improved photo-synthetic efficiency to increase productivity

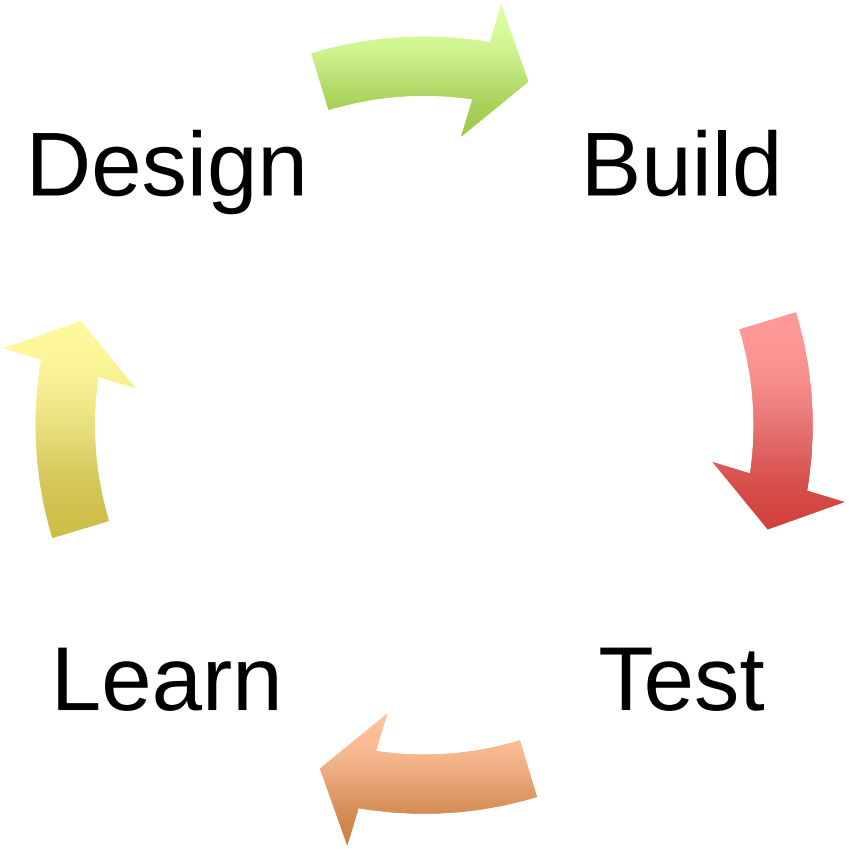


Engineered plants and microbiomes for improved nutrient uptake and reduced fertilizer application

Fuels and chemicals sustainably produced from biomass

Biosynthesis of new classes of natural products as antibiotics

Can the tools developed with JBEI funding improve biological engineering generally

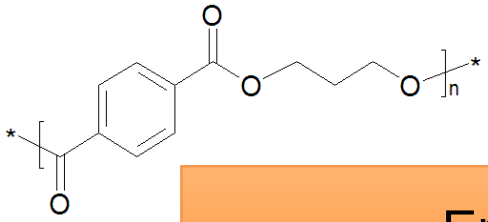


Biology is engineered iteratively because we know so little about it.

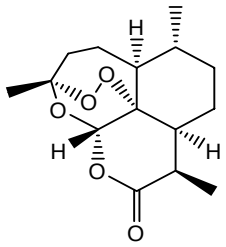
A single turn of this cycle can take months.

We need to turn the crank faster and in higher throughput.

Hosts and tools are not shared



Engineering E. coli to produce 1,3-PDO

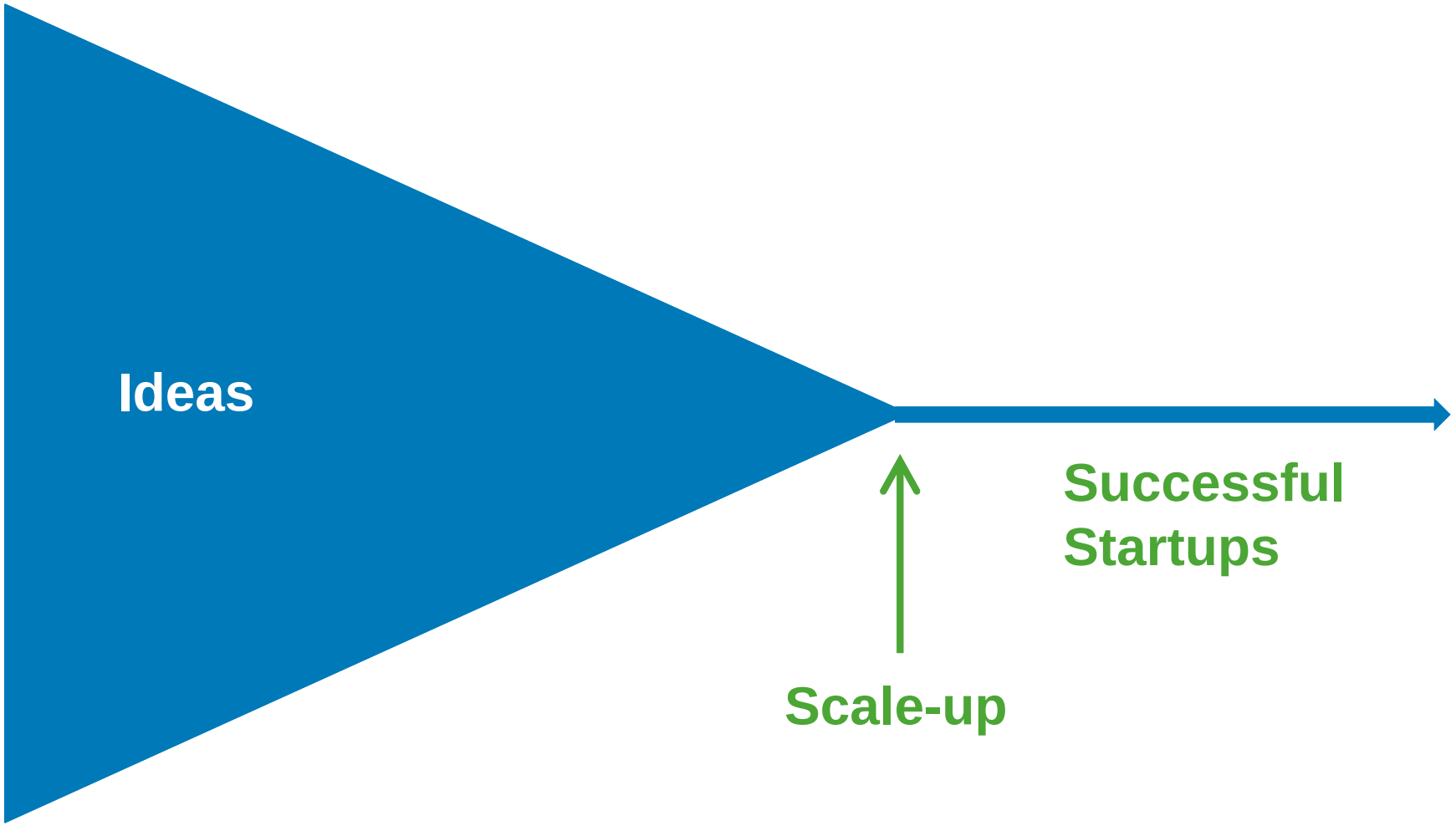


Engineering yeast to produce Artemisinin

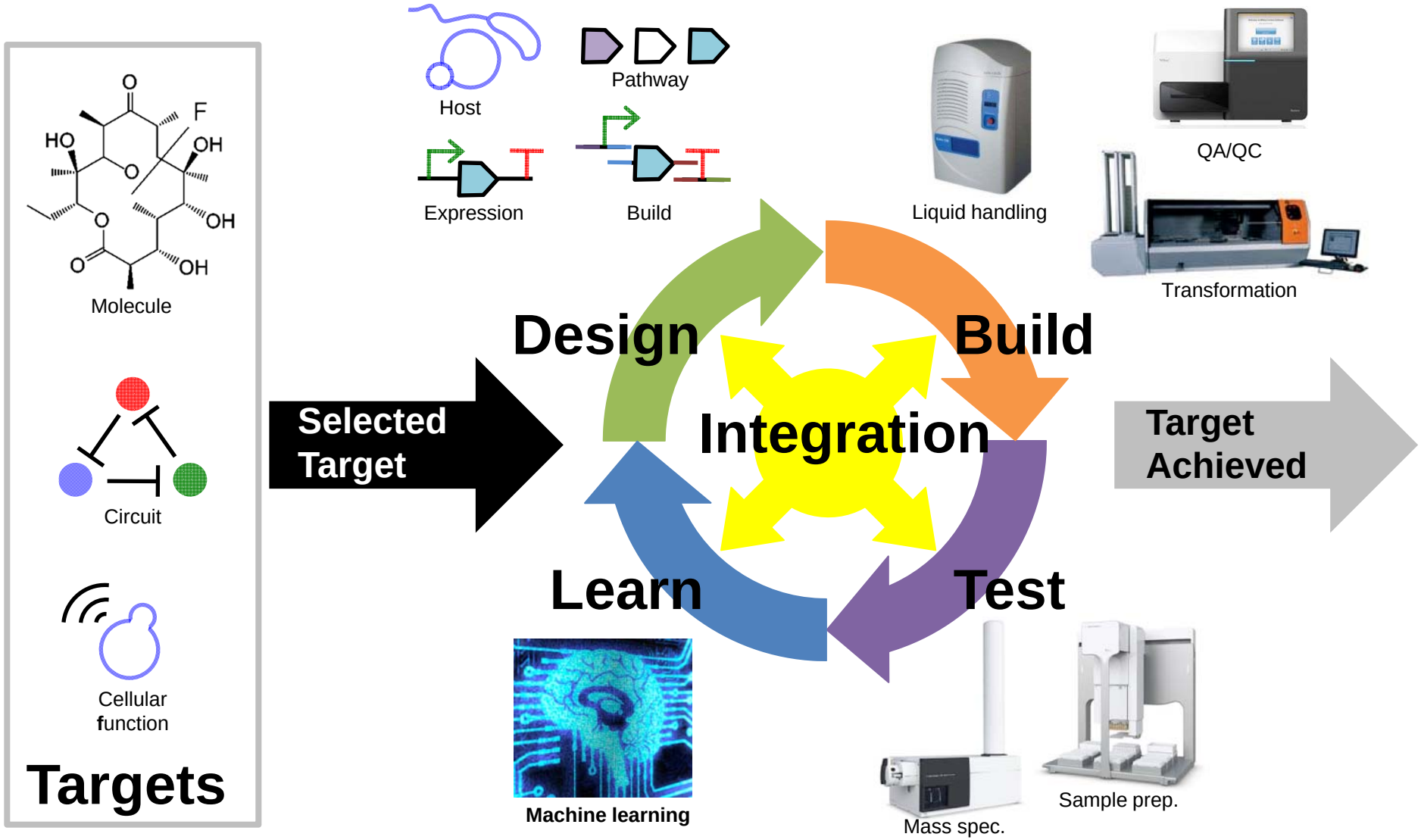
Engineering process X to produce Product 3

Time for commercialization

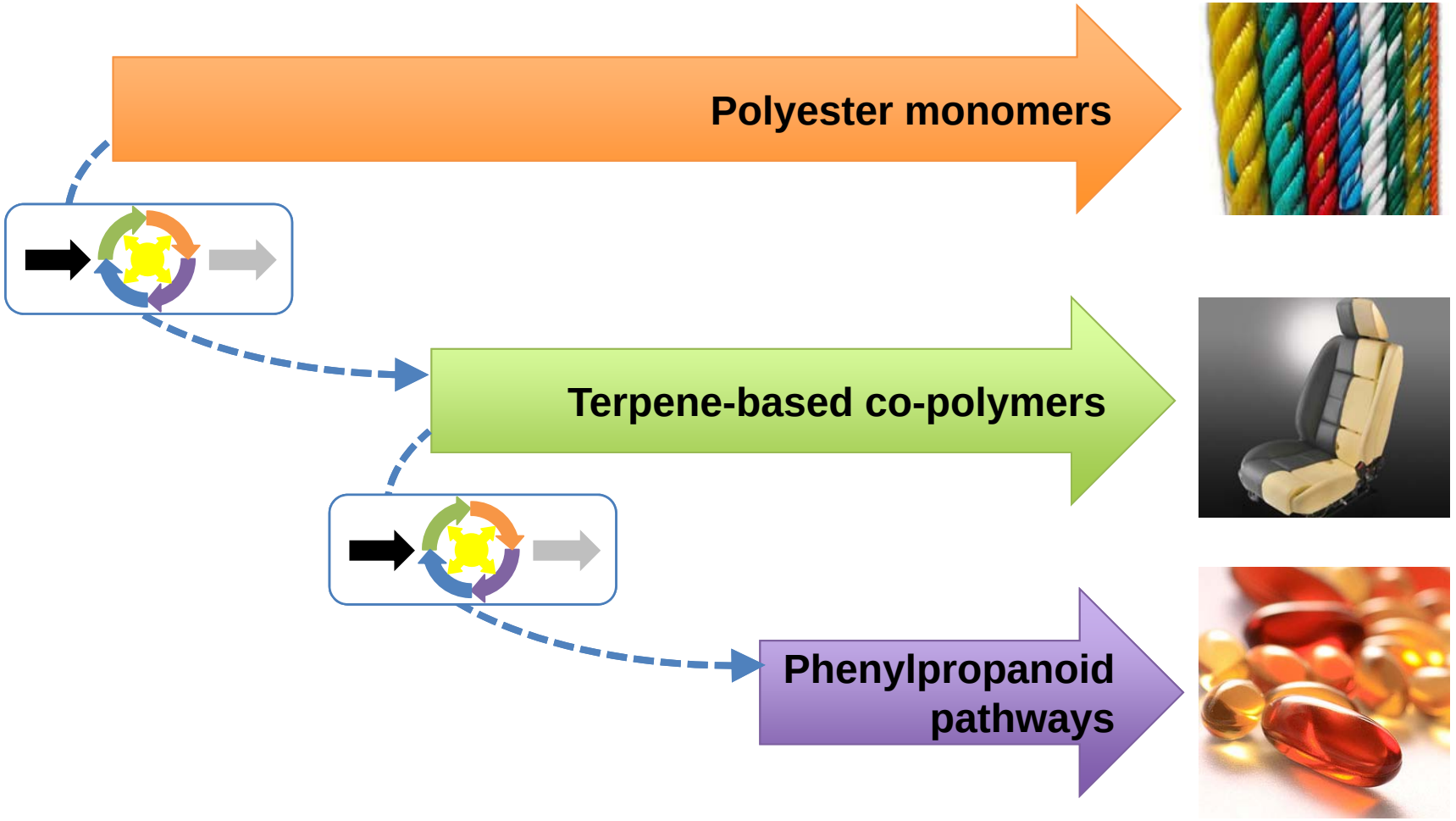
Development costs limit startups



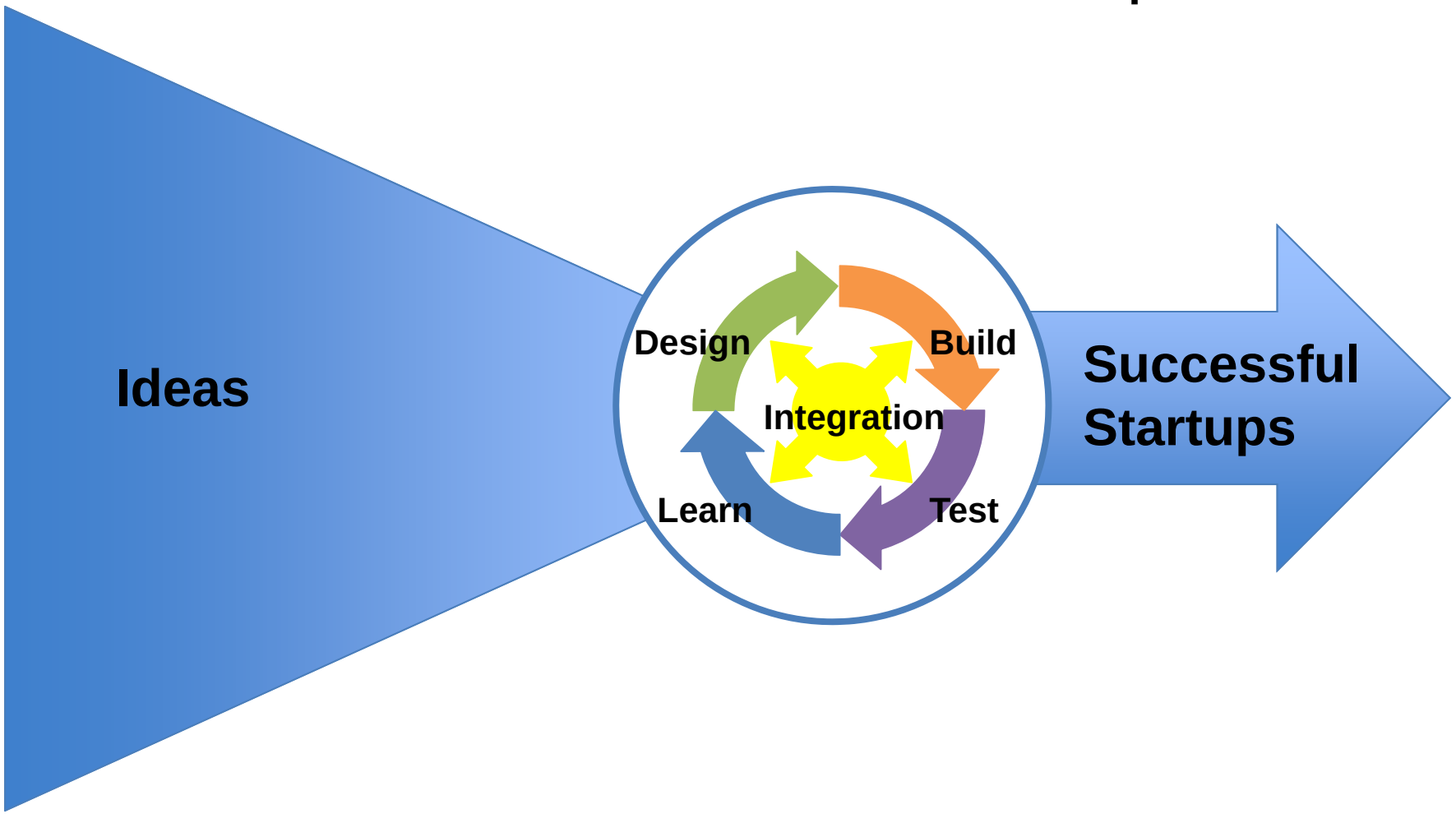
A professional biological foundry



Potential improvements in commercialization time with a professional foundry



Profession biological foundry would increase the chance of successful startups



Biomanufacturing vision

The FutureBio Institute will be the worldwide leading institute for the development of *sustainable* biomanufacturing

FutureBio Institute Programs

- Advanced Bioengineering Center (ABC)
  - Develops biological components, software, and hardware to improve the DBTL cycle
- FutureBio Foundry (FBF)
  - Uses biological components, software, and hardware to successfully build biological systems for many purposes
- Open Collaboration Facility (OCF)
  - Enables companies, government agencies, academics to use FBF and the latest tools created by ABC to solve important problems

FutureBio Foundry

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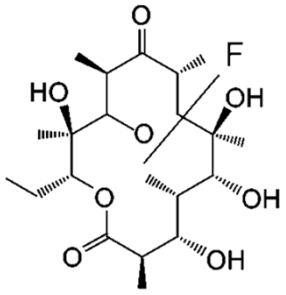
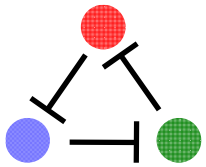
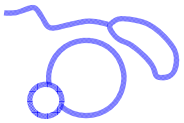


Molecule

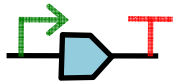

Circuit

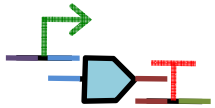

Cellular function

Targets


Host


Pathway


Expression


Build

Selected Target

Design

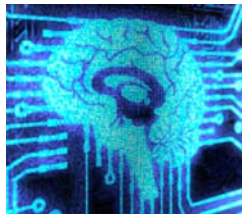
Build

Integration

Learn

Test

Target Achieved


Machine learning


Liquid handling


QA/QC


Transformation


Mass spec.


Sample prep.

How the components fit together

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Science & Technology Needs

Applications Needs

Advanced Bioengineering Center

Design Build Learn Test

Foundry

Open Collaboration Facility

Problem

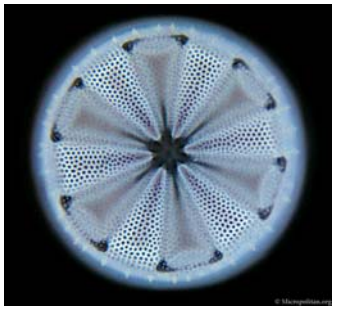
Solution

Science & Technology Solutions

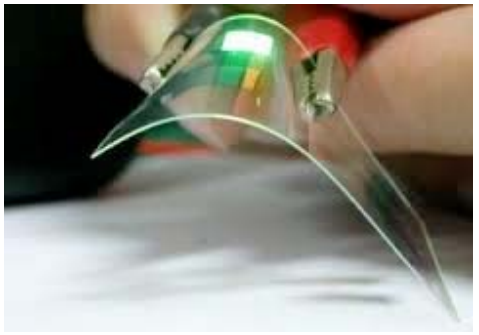
Applications Solutions

FBI Target: Advanced Materials

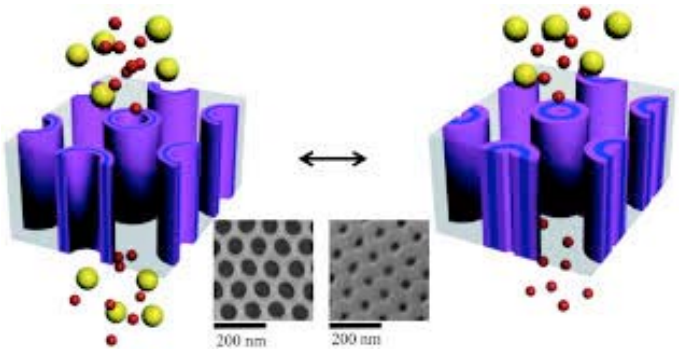
- Proteins that serve as templates for inorganic and bio-inorganic composite materials



- Low cost, high MW conductive polymers for nanoelectronics and flexible electronics



- Structured, responsive nanoporous membranes with active transporters for pollutants and desalination



FBI Target: Safe, Effective Engineered Microbial Communities

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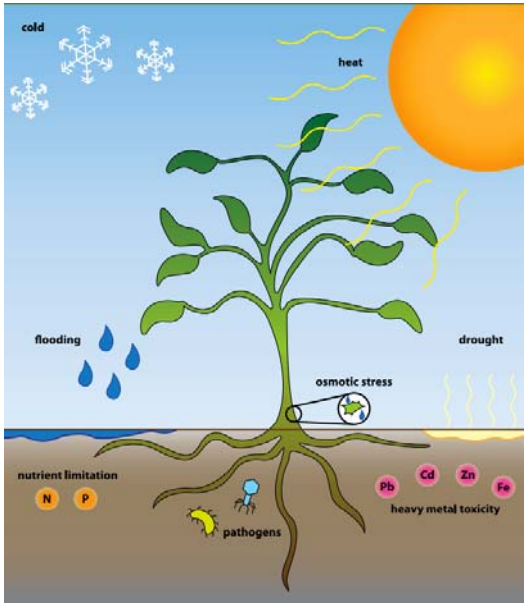
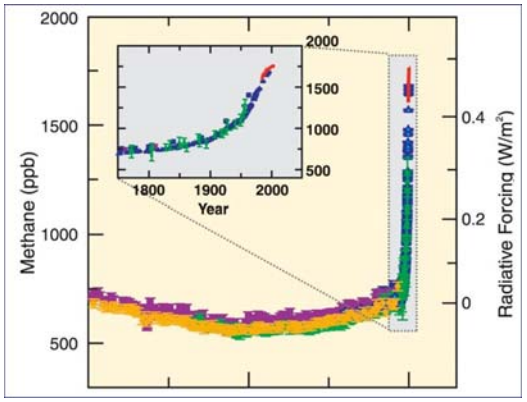
- Development of “safe” soil and symbiotic bacteria for support of particular plant processes.
- Development of safe rumen platform microbes for nutrient and methane mediation.
- Demonstrated contained, persistent microbes improving plant growth and nutrient utilization in ruminant-stomach-like environments.





FBI Target: Rapid Production of Efficacious Antimicrobials

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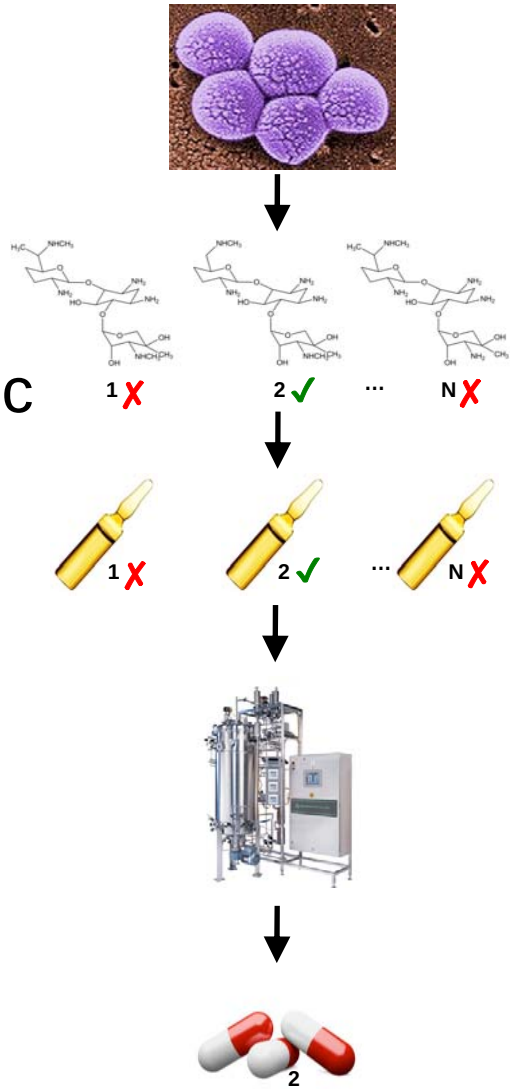
- Explore biosynthetic diversity for new antimicrobial scaffolds and tailoring enzymes
- Develop a robust capability to identify, design, and construct microbial metabolic pathways that will produce many thousands of antimicrobial variants
- Produce a vast library of antimicrobials
- Scalable and reliable antimicrobial biomanufacturing processes



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Thank you