

# JBEI

Joint BioEnergy Institute

**Building the future of low carbon  
transportation through integrated basic science**

Jay Keasling, CEO

# JBEI Partners - 5 DOE National Labs, 6 Universities

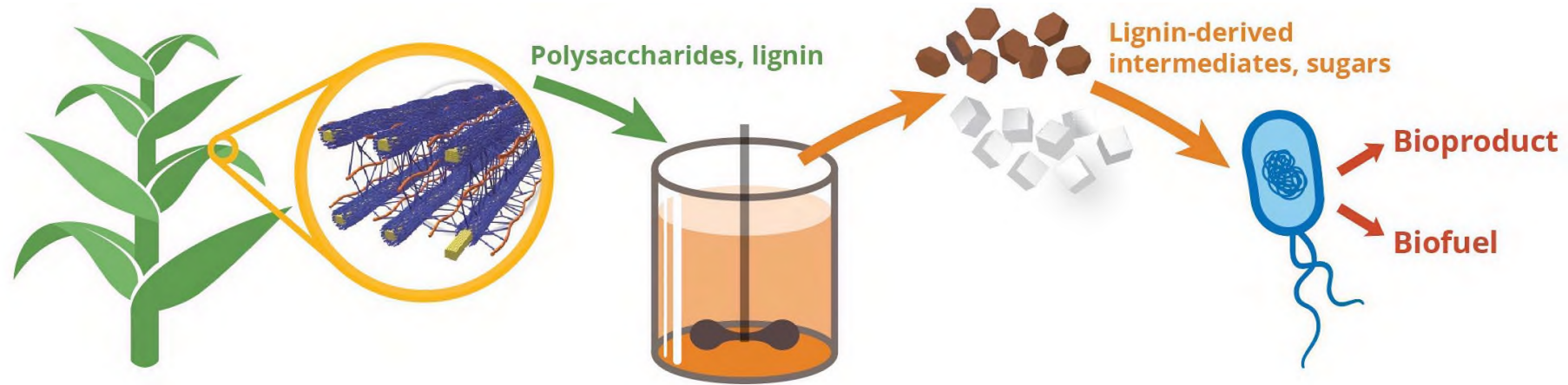


UNIVERSITY OF CALIFORNIA  
SANTA BARBARA



- Funded by DOE
- Started in 2007
- Renewed in 2012
- \$25M/year
- **Renewed in 2017**

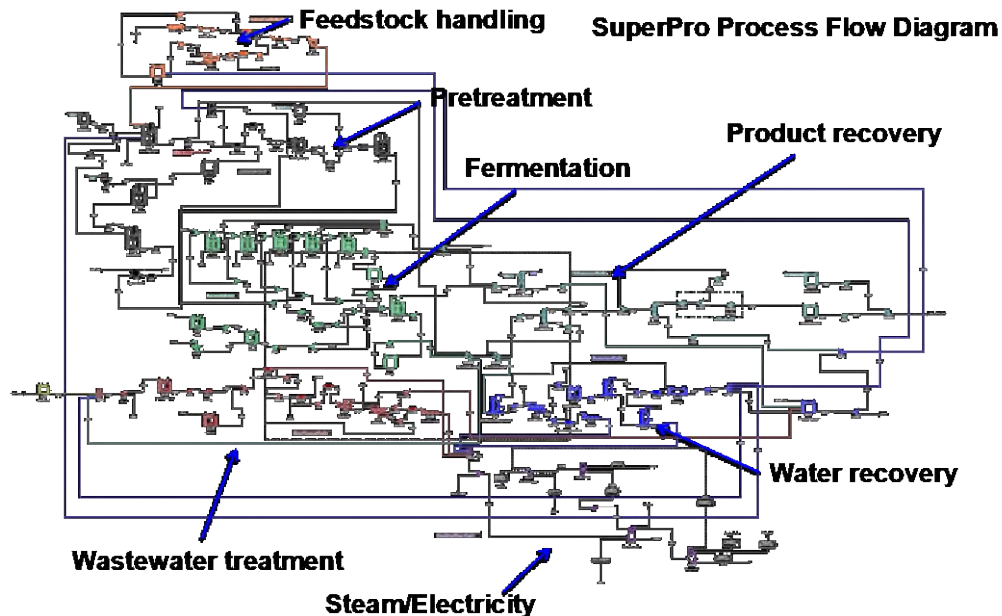
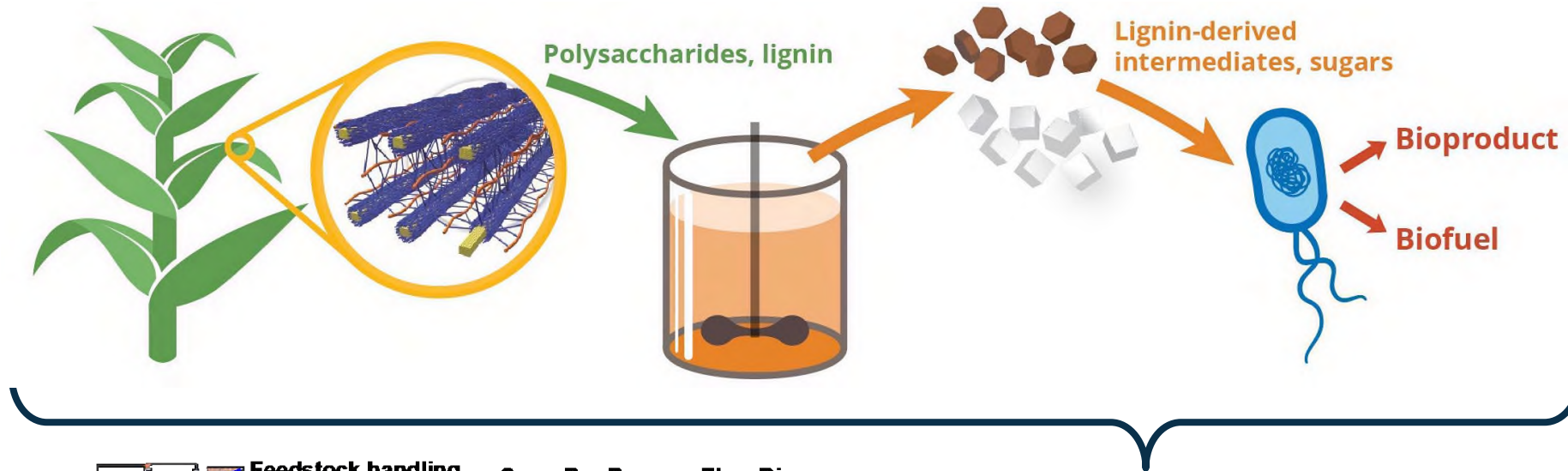
# JBEI provides the basic science for converting biomass to fuels



Establish the **scientific knowledge** and **new technologies** to transform the maximum amount of carbon available in bioenergy crops into biofuels and bioproducts.

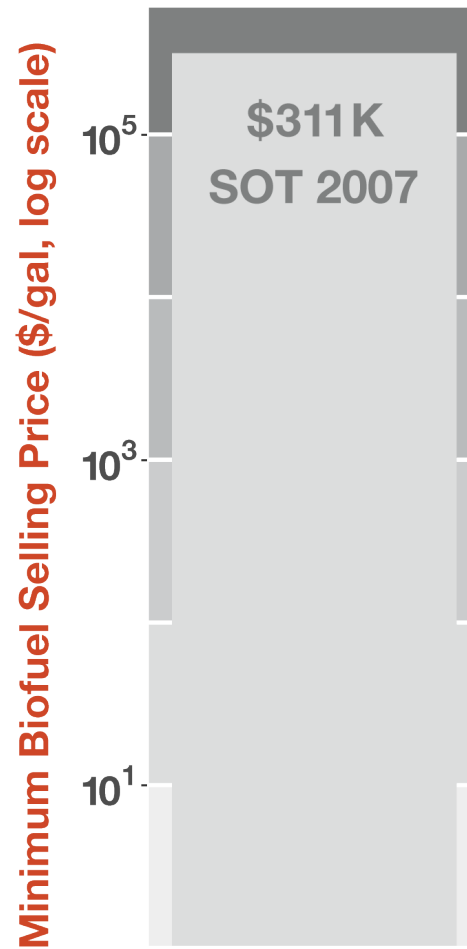


# Technoeconomic model benchmarks economic impact of JBEI goals

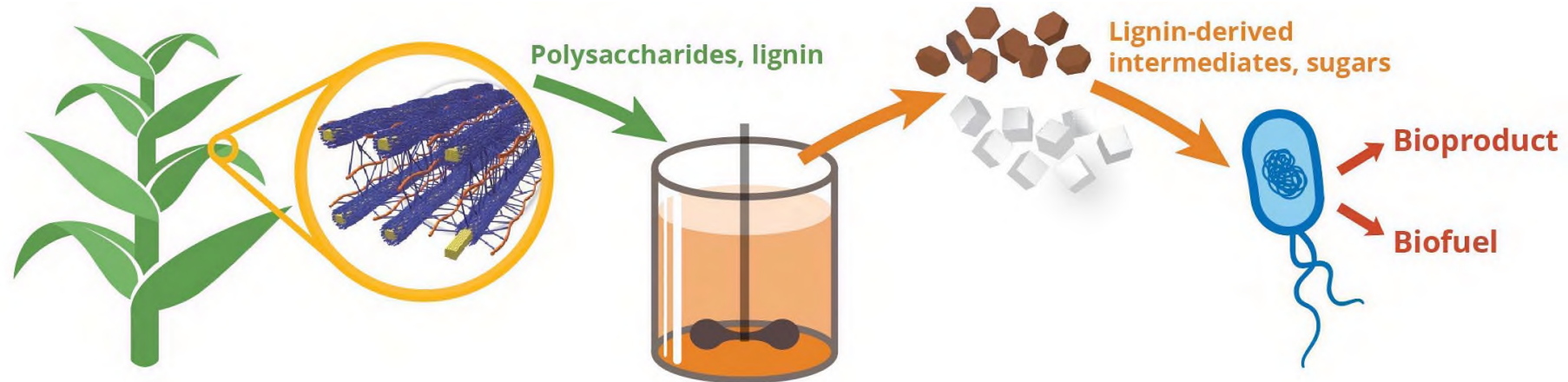


Available at [econ.jbei.org](http://econ.jbei.org)

# Initial calculated fuel price reflects JBEI's high-risk research program



# Eight key factors have the biggest impact on the price of biofuels

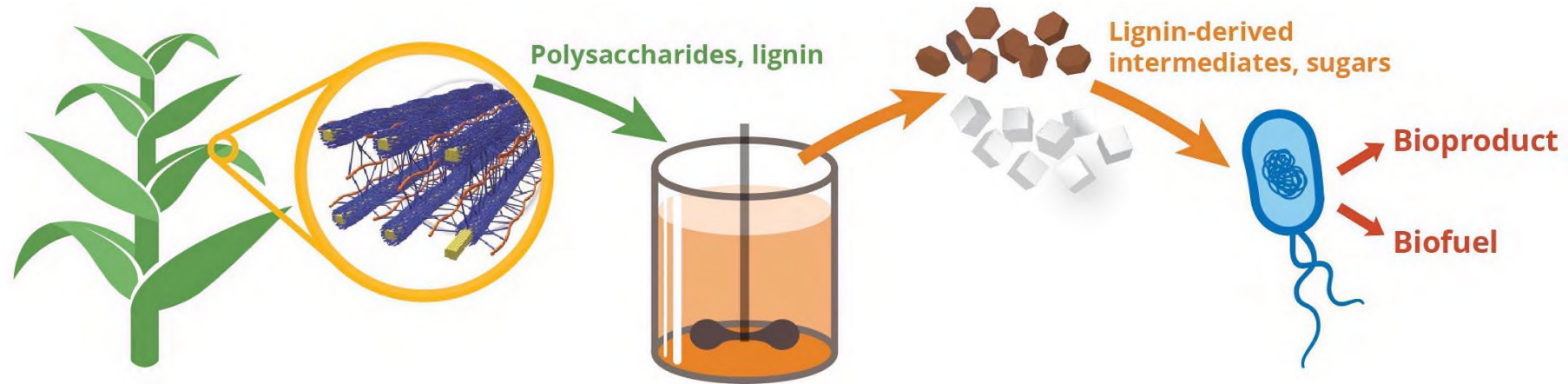


## JBEI technology development & improvement scenarios

<b>Increase C6/C5 ratio</b>	<b>Lower lignin content</b>	<b>Lower IL price</b>	<b>Lower IL use</b>	<b>Less enzyme use</b>	<b>Increase biofuel yield</b>	<b>Increase fermentation productivity</b>
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Lignin  
valorization

# Eight key factors have the biggest impact on the price of biofuels



## JBEI technology development & improvement scenarios

Increase  
C6/C5  
ratio

Lower  
lignin  
content

Lower  
IL  
price

Lower  
IL use

Less  
enzyme  
use

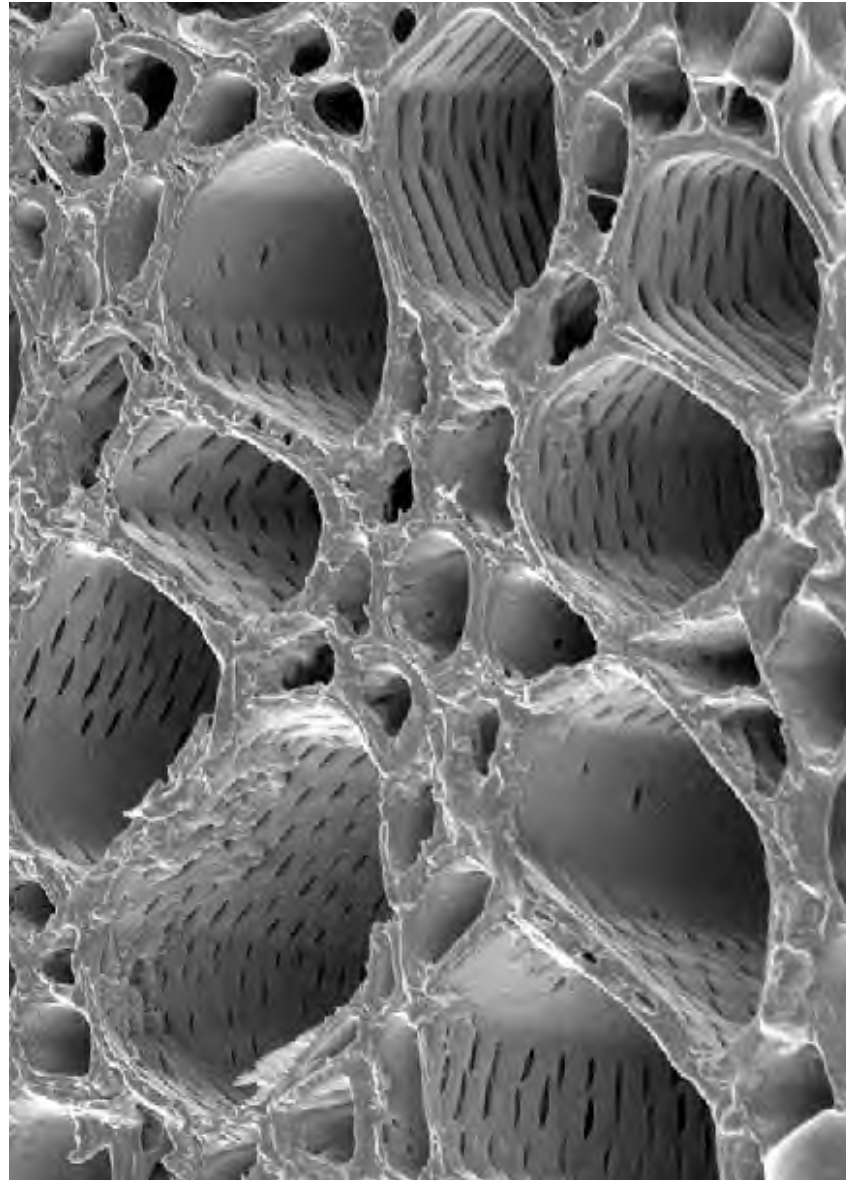
Increase  
biofuel  
yield

Increase  
fermentation  
productivity

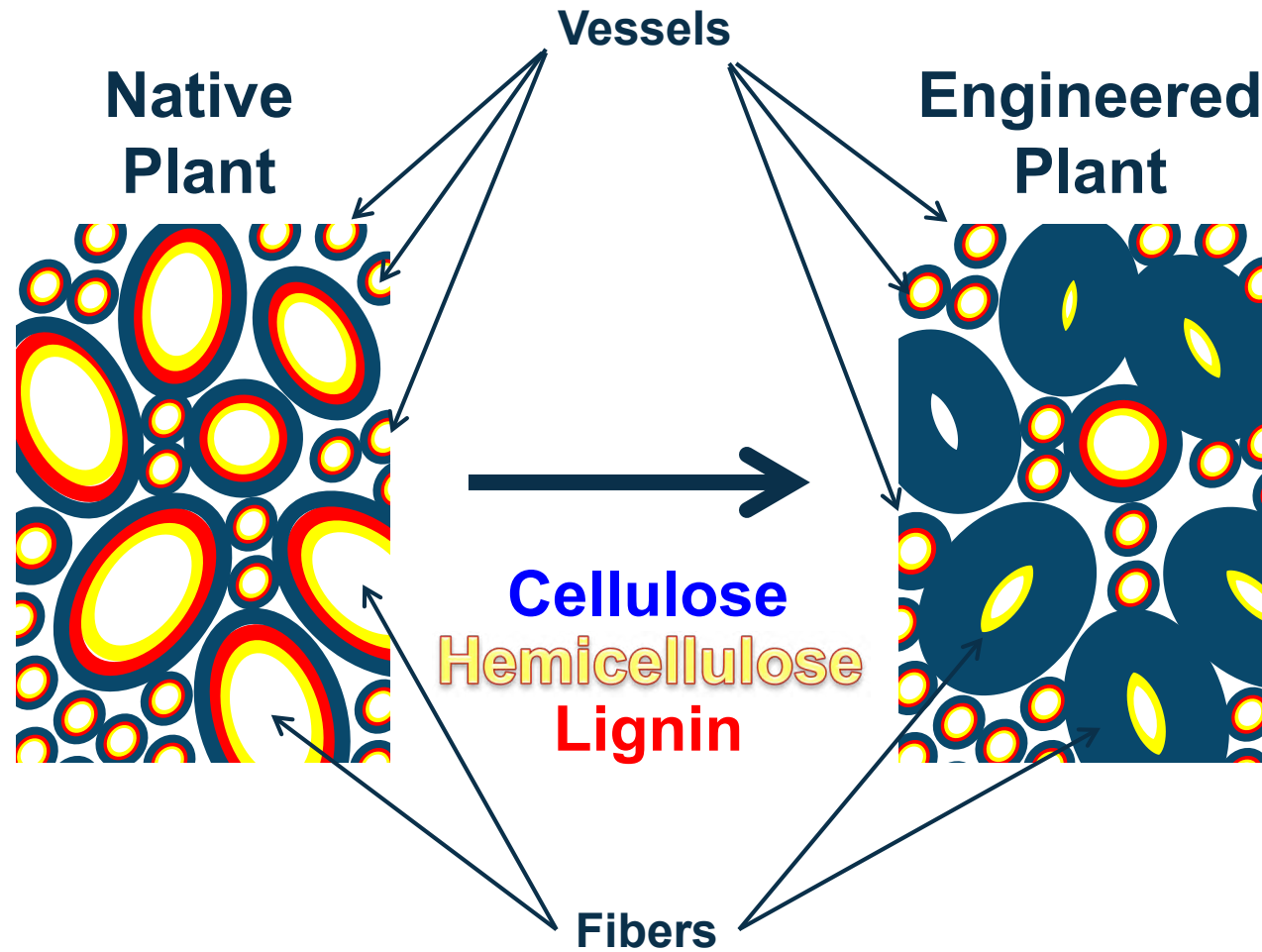
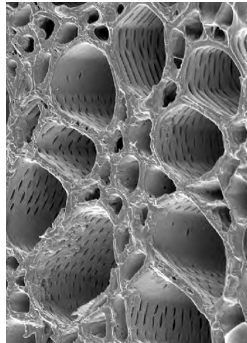
Lignin  
valorization



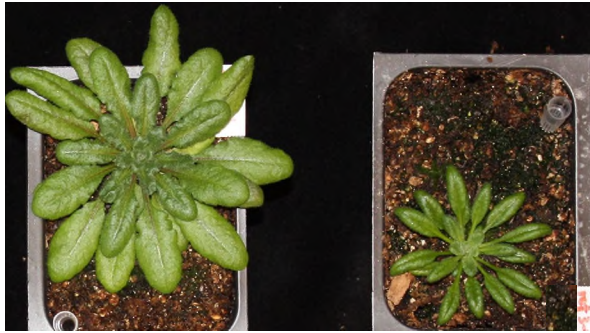
**Plants have lots of holes that we would like to fill with sugar**



# Can we fill the fibers up with cellulose?

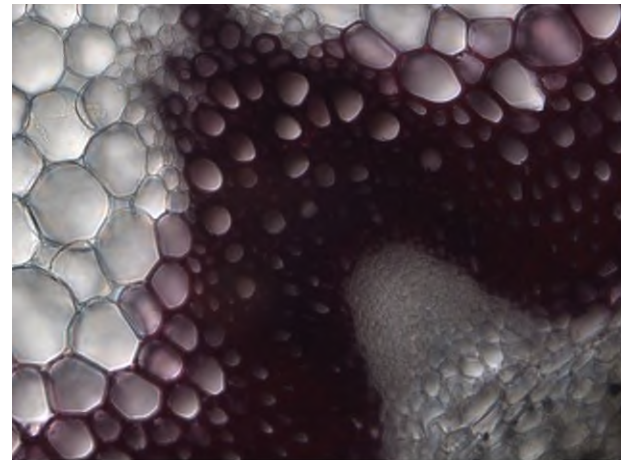


# Why is growth affected when lignin or xylan is highly reduced?

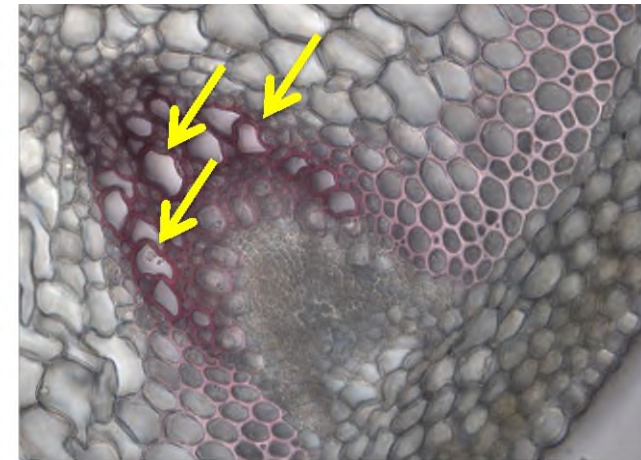


**wt**

**lignin  
mutant**

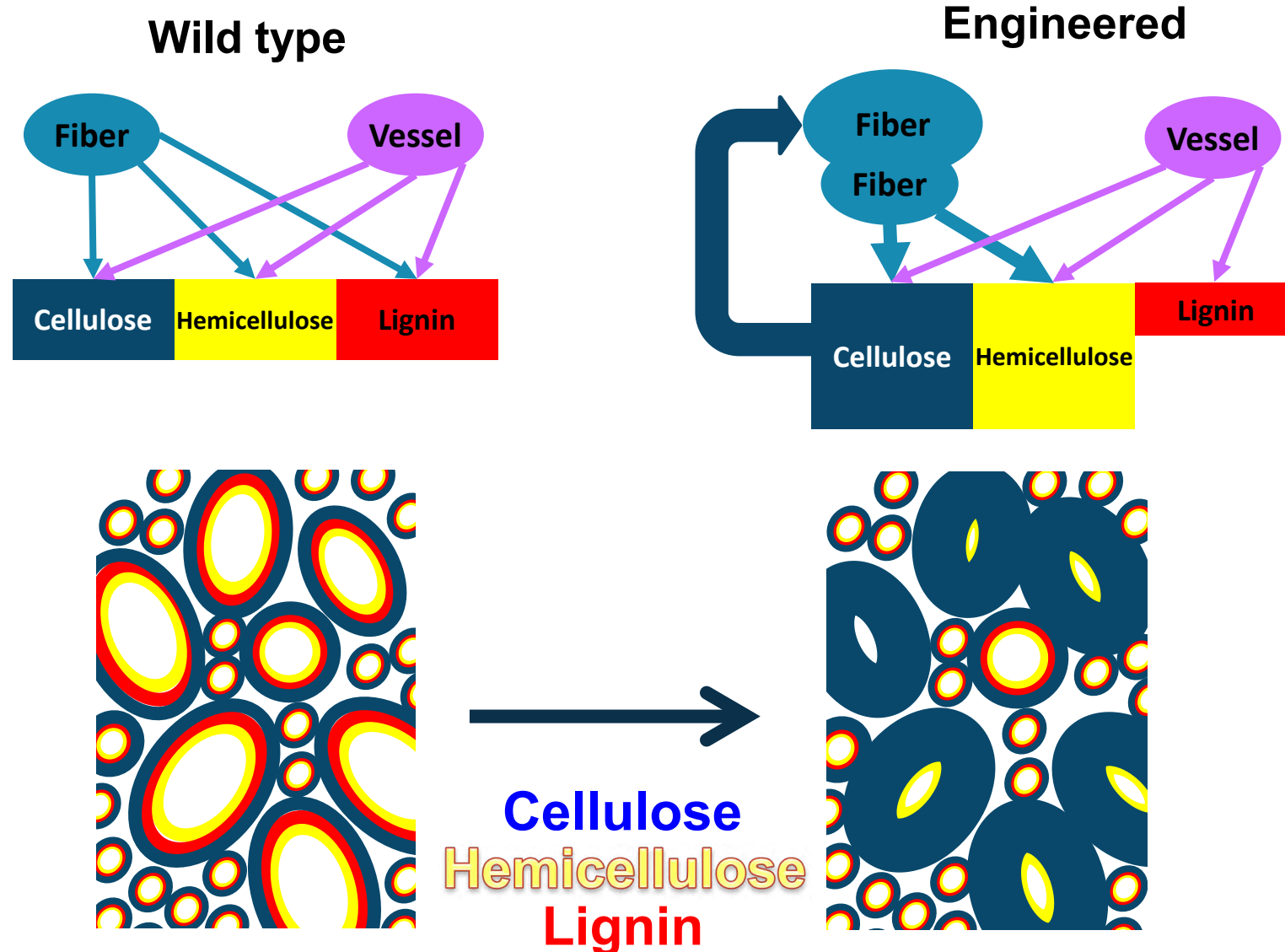


**wt**



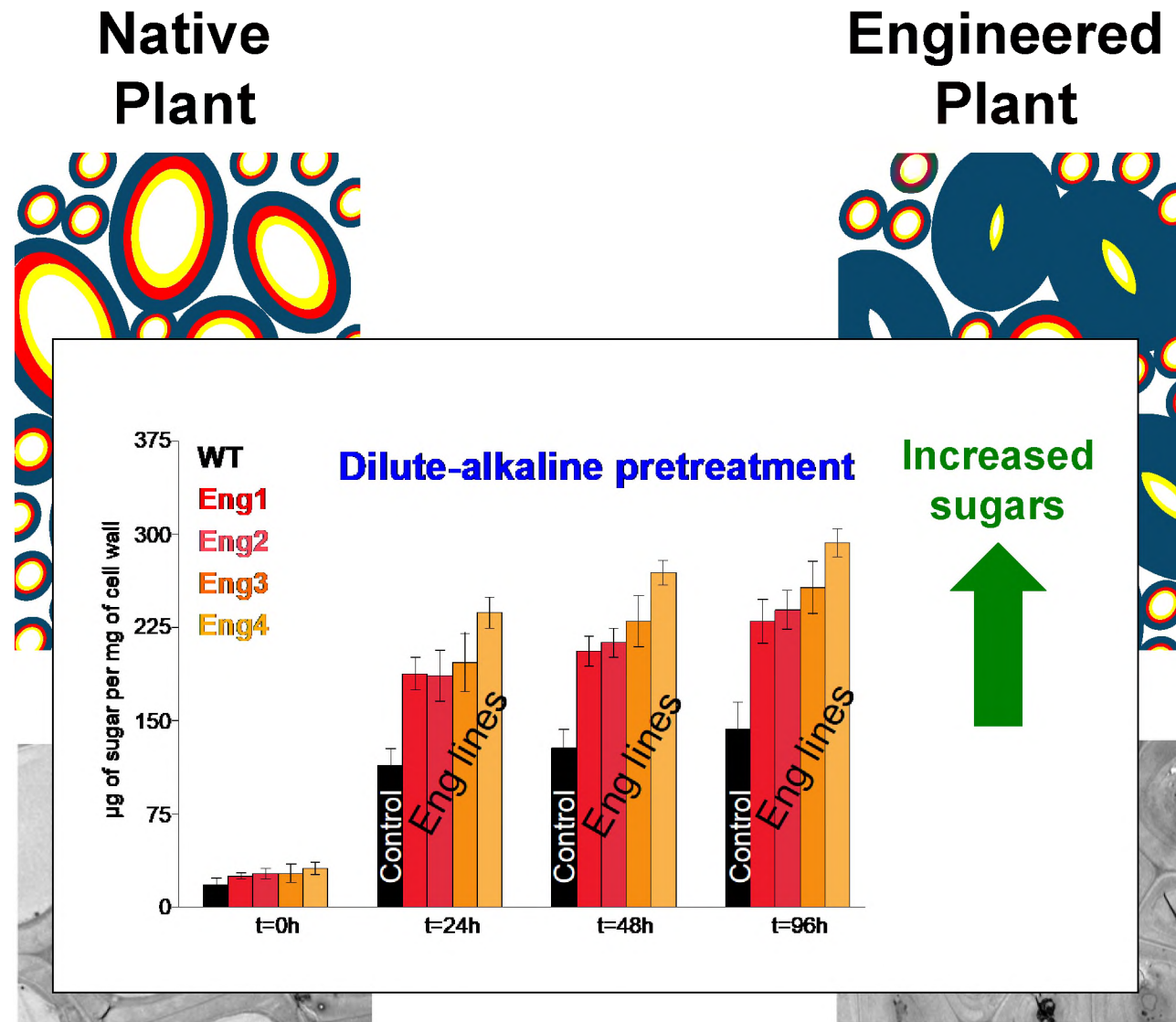
**lignin mutant with  
collapsed xylem  
vessels**

# Transcription factor engineering directs cellulose to fibers and lignin only to vessels

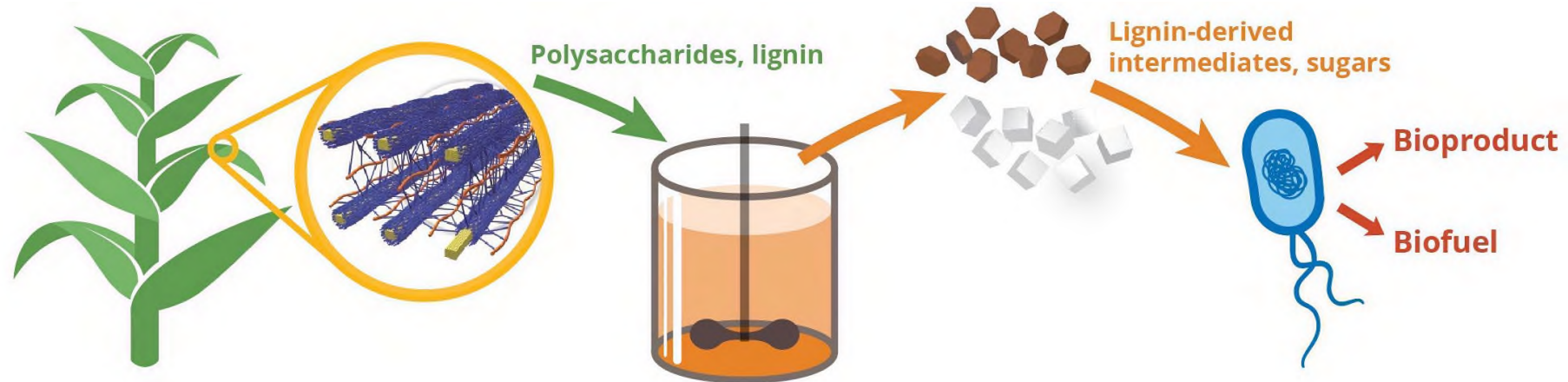


Yang et al 2013 *Plant Biotechnol J* 11:325

# Engineered plants contain approximately twice the sugar as the native plants



# Eight key factors have the biggest impact on the price of biofuels

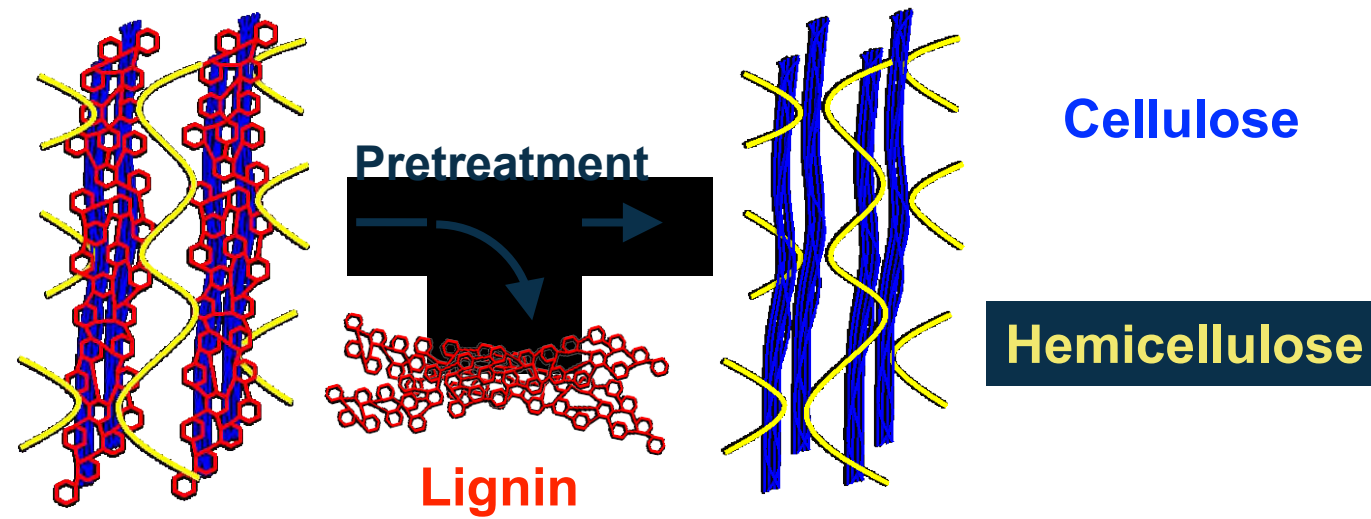


## JBEI technology development & improvement scenarios

Increase C6/C5 ratio	Lower lignin content	Lower IL price	Lower IL use	Less enzyme use	Increase biofuel yield	Increase fermentation productivity
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Lignin valorization

# Ionic liquids pretreatment produces clean cellulose/hemicellulose



Ionic liquids



Biomass

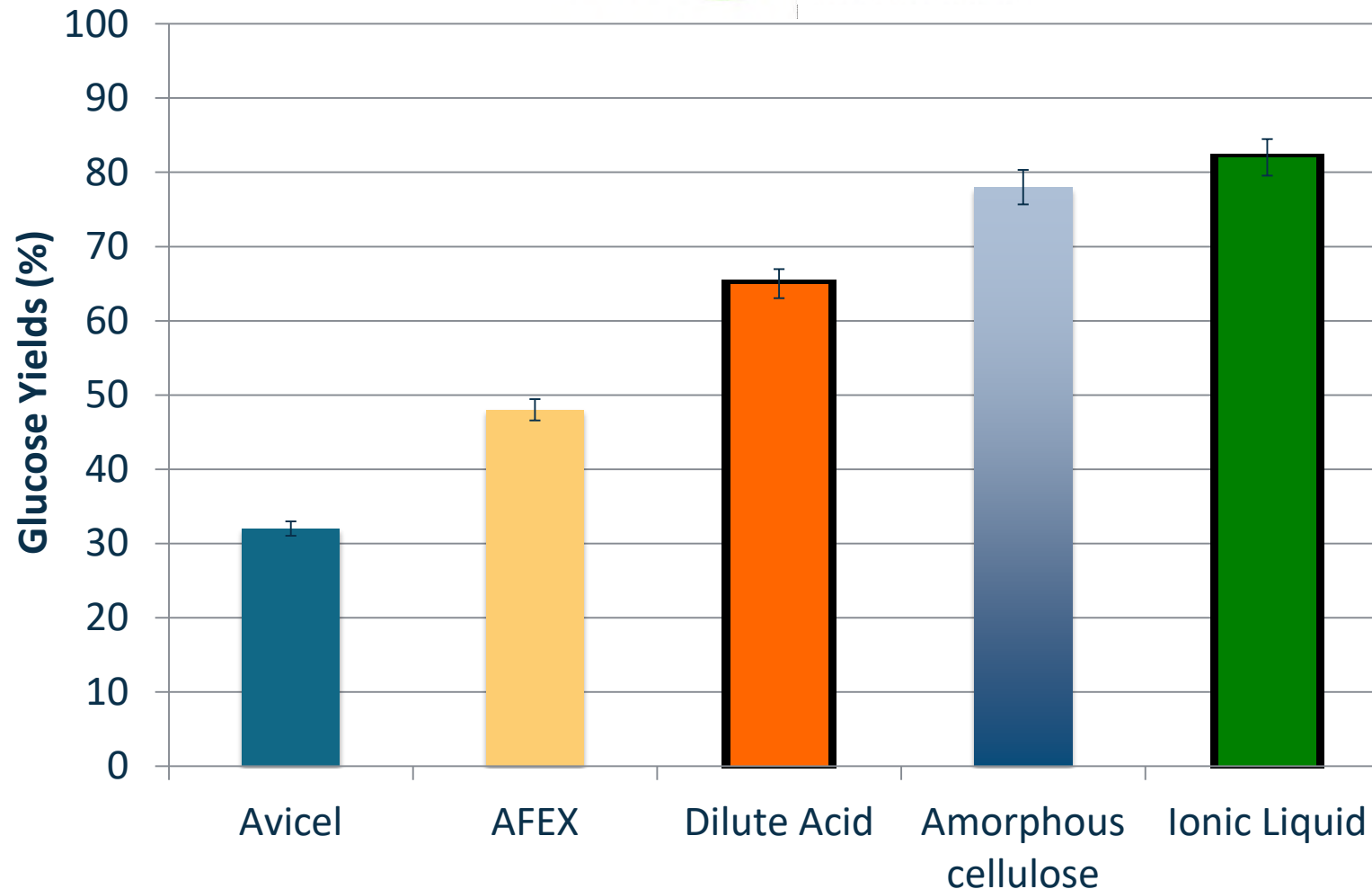
Mix  
Heat  
Stir



Add  
Anti-solvent



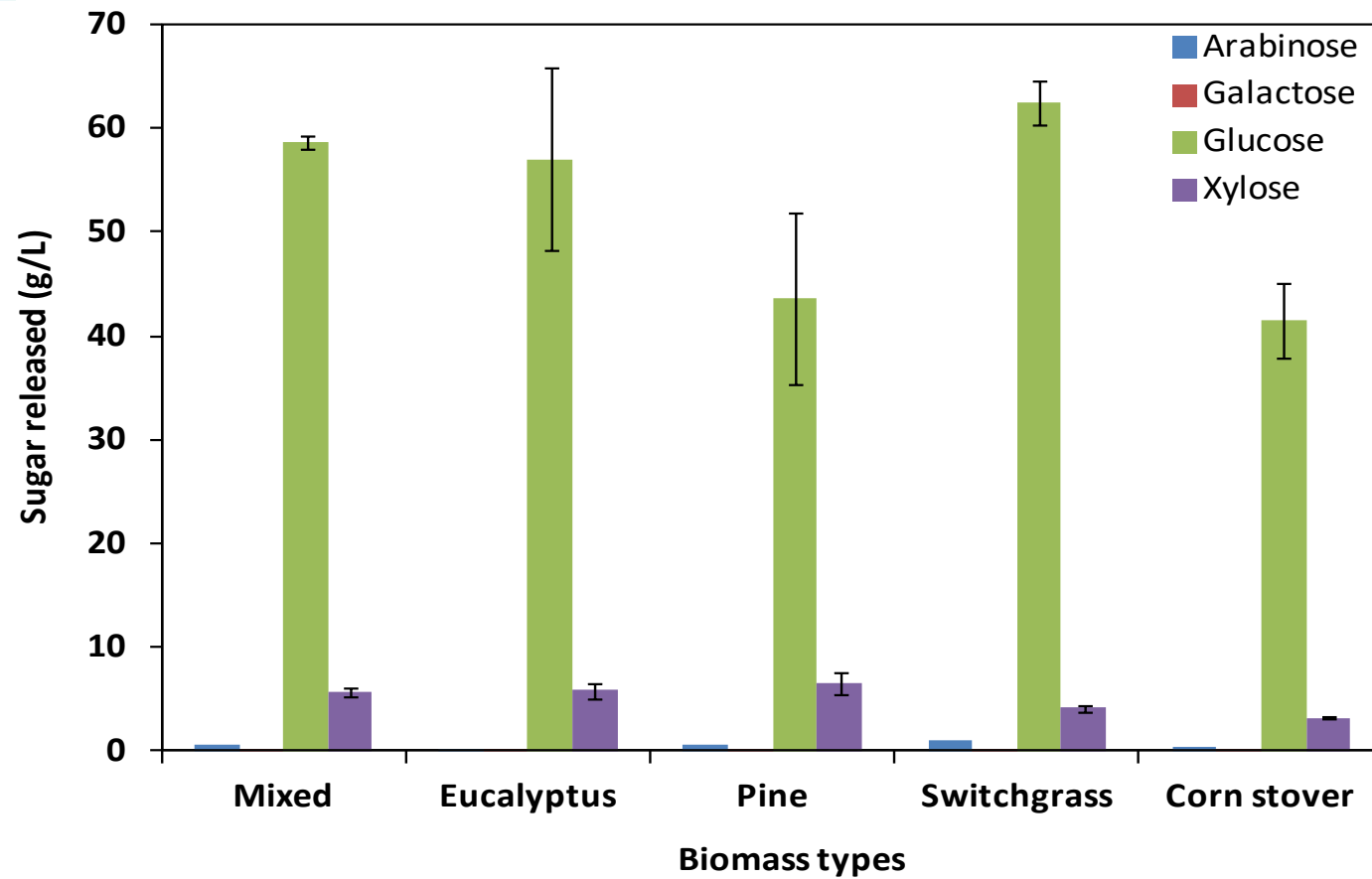
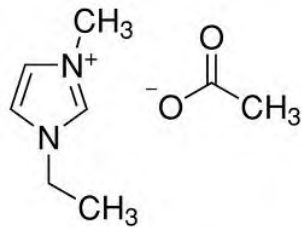
# IL pretreatment generates higher sugar yields than any other pretreatment



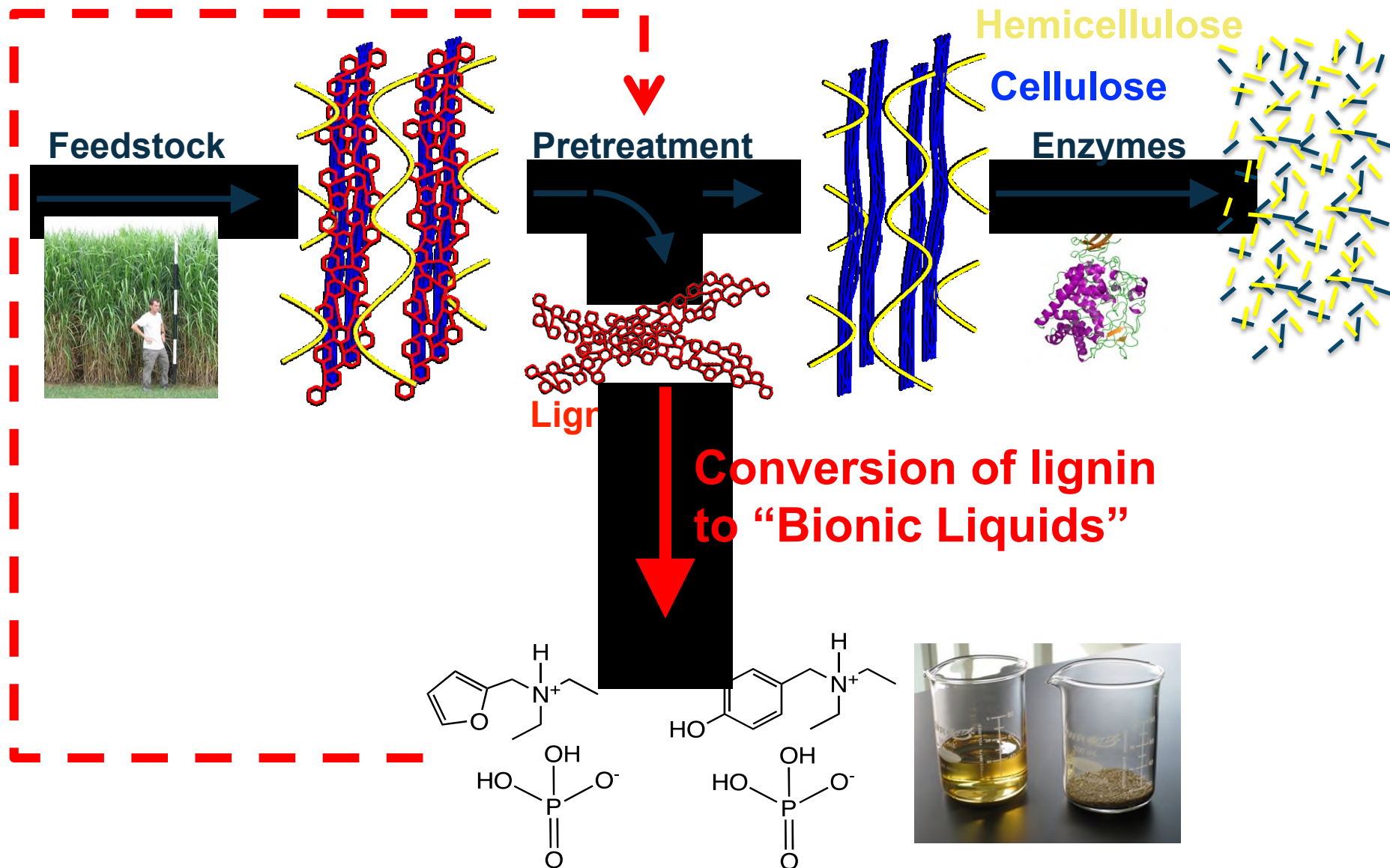
Gao et al 2014 *Biotech for Biofuels* 7:71  
Singh et al 2015 *Frontiers in Energy Res* 2:1



# Ionic liquid pretreatment works on a variety of feedstocks and mixed feedstocks

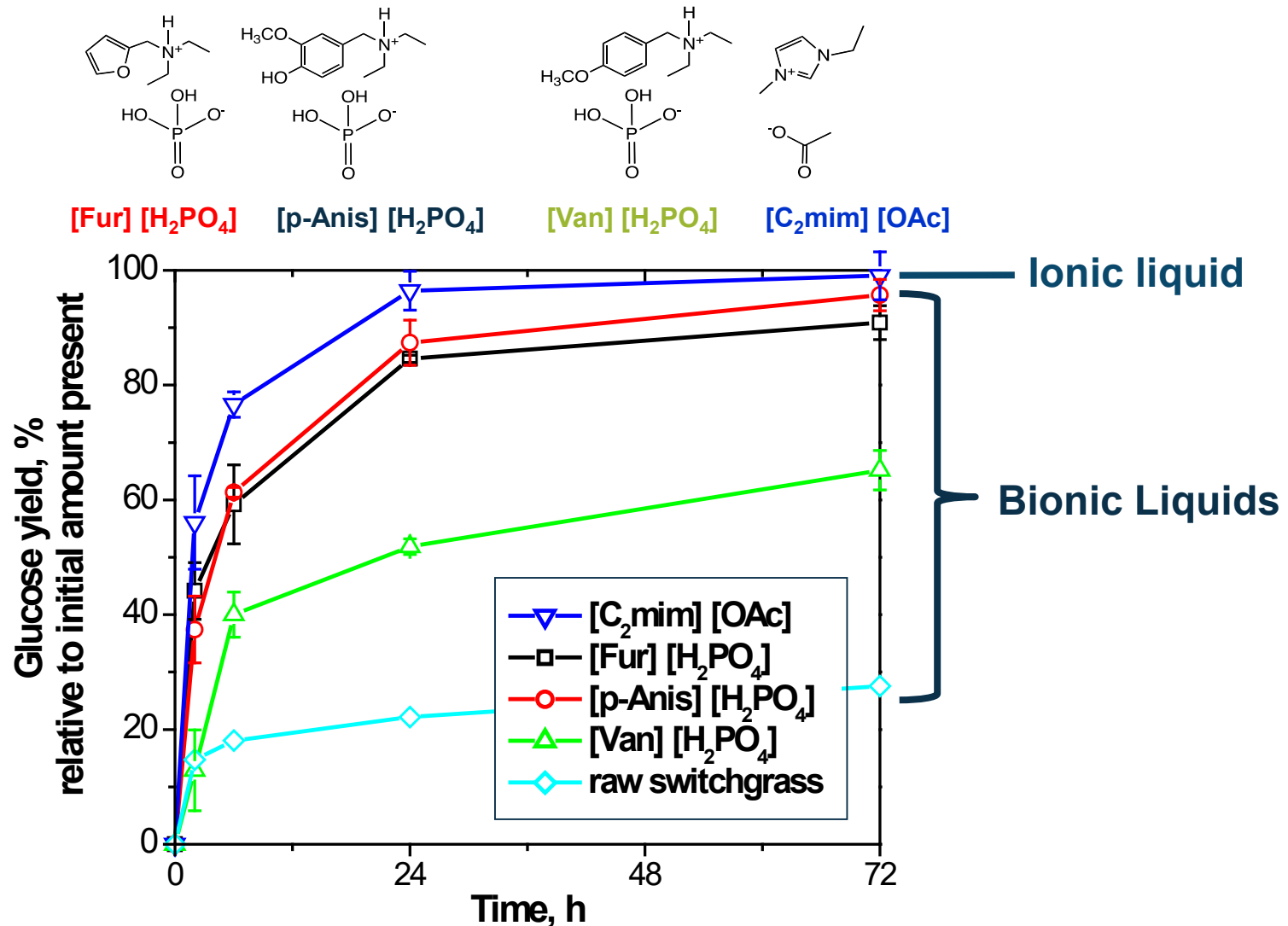


# Ionic liquids can be made from lignin: "Bionic Liquids"

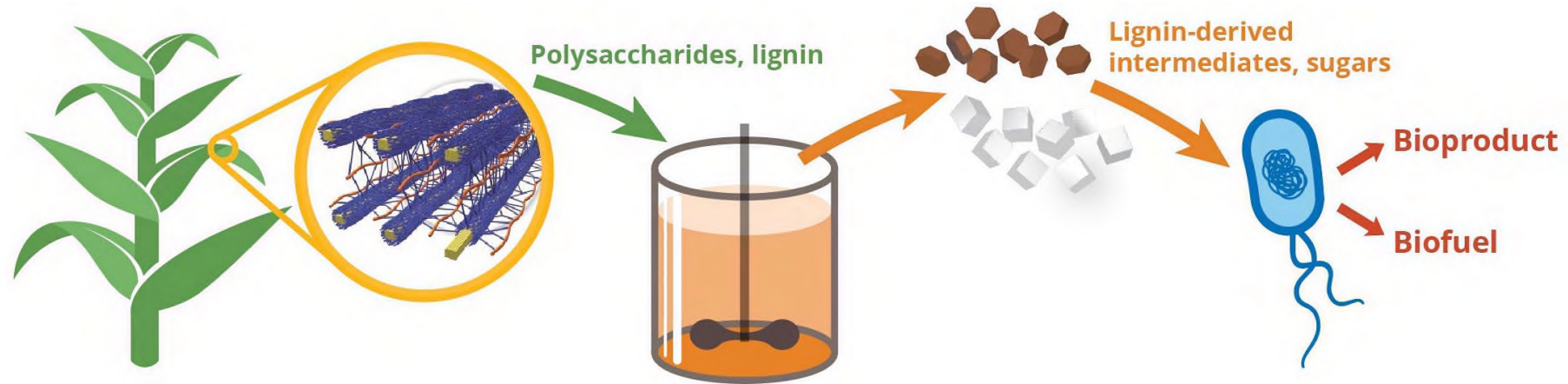


Socha et al 2014 PNAS 111:35

# “Bionic Liquids” have comparable performance to petroleum-based ILs



# Eight key factors have the biggest impact on the price of biofuels

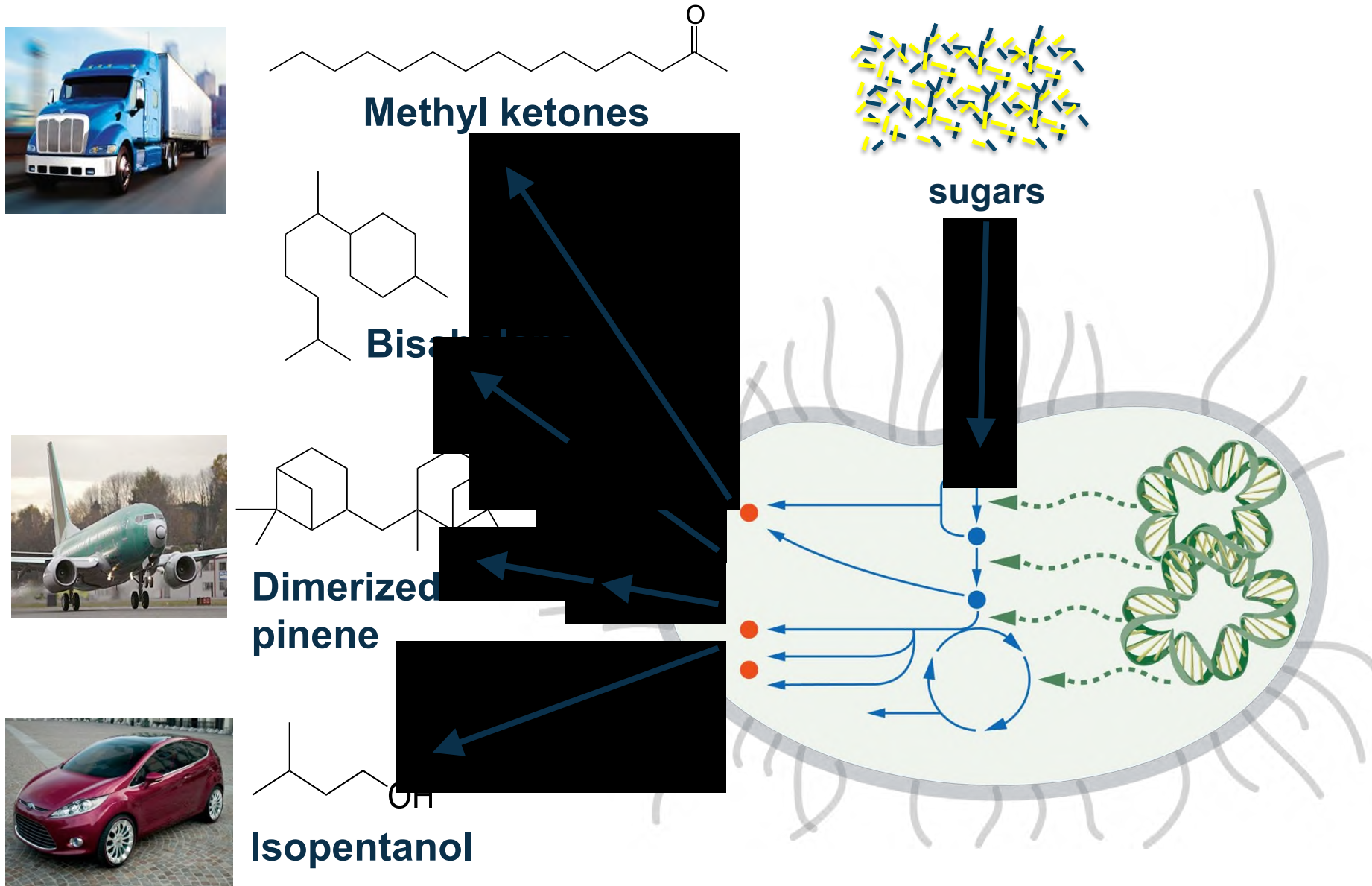


## JBEI technology development & improvement scenarios

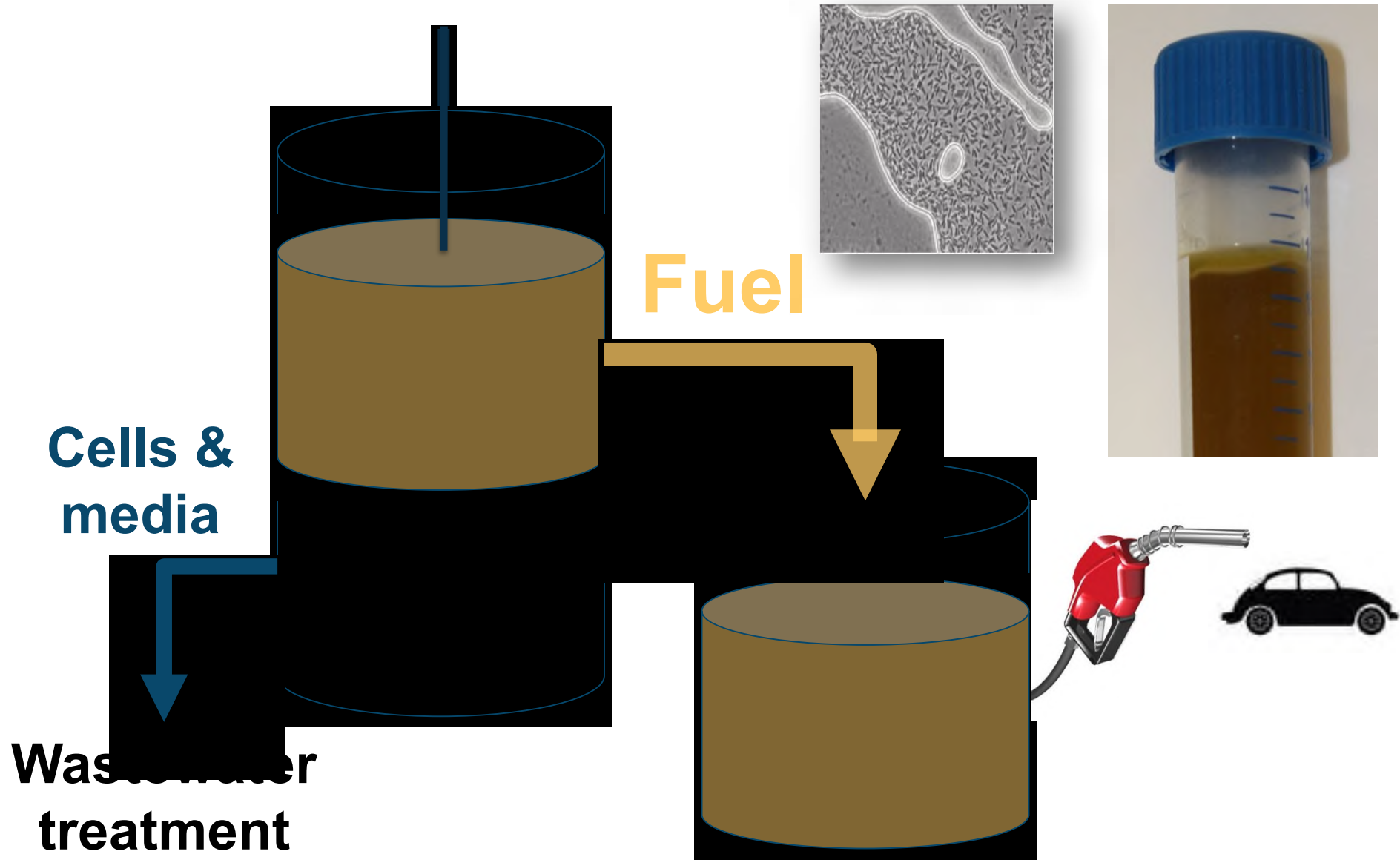
Increase C6/C5 ratio	Lower lignin content	Lower IL price	Lower IL use	Less enzyme use	<b>Increase biofuel yield</b>	<b>Increase fermentation productivity</b>
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Lignin valorization

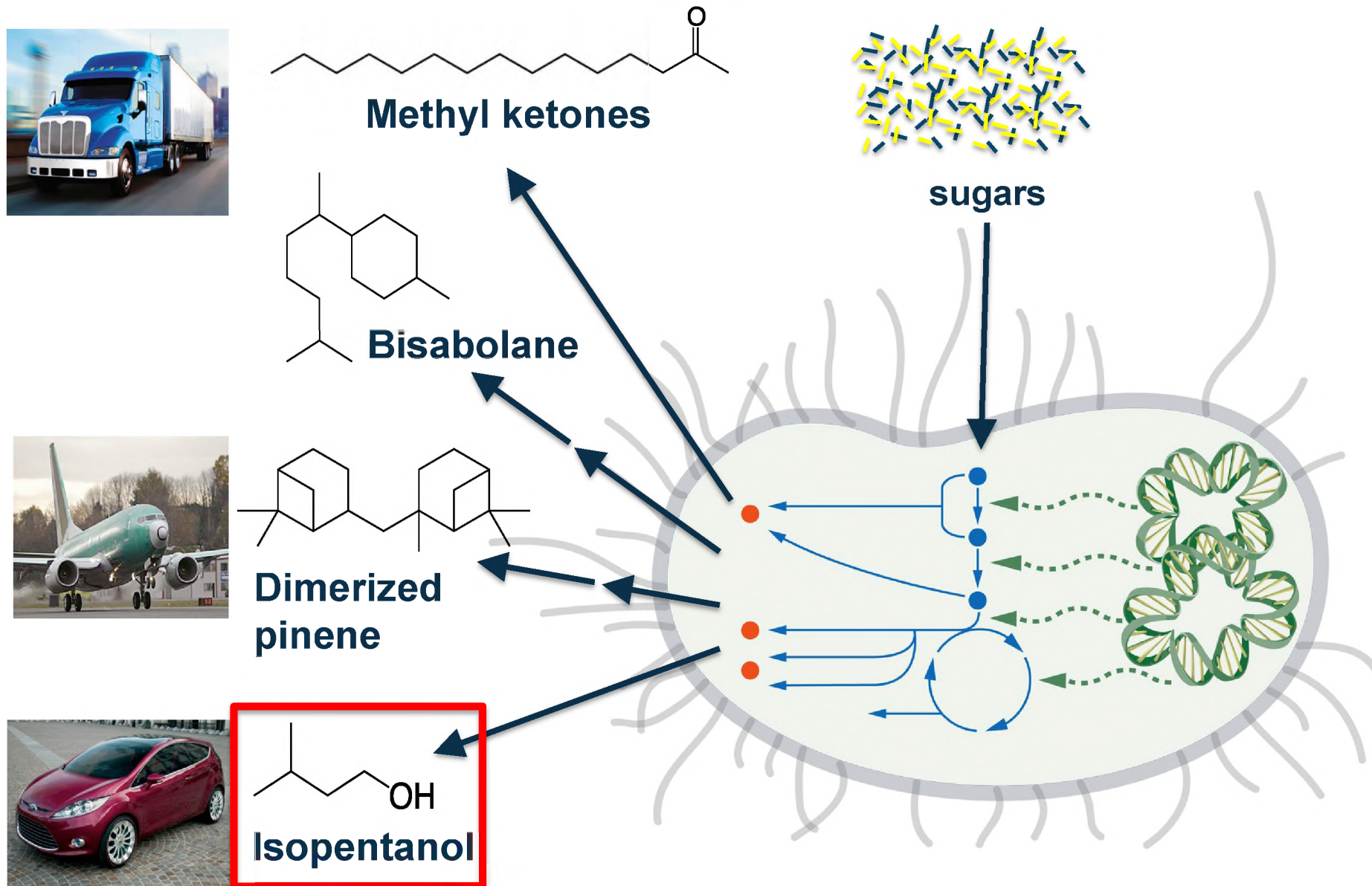
# Engineered microbes convert sugars into advanced biofuels



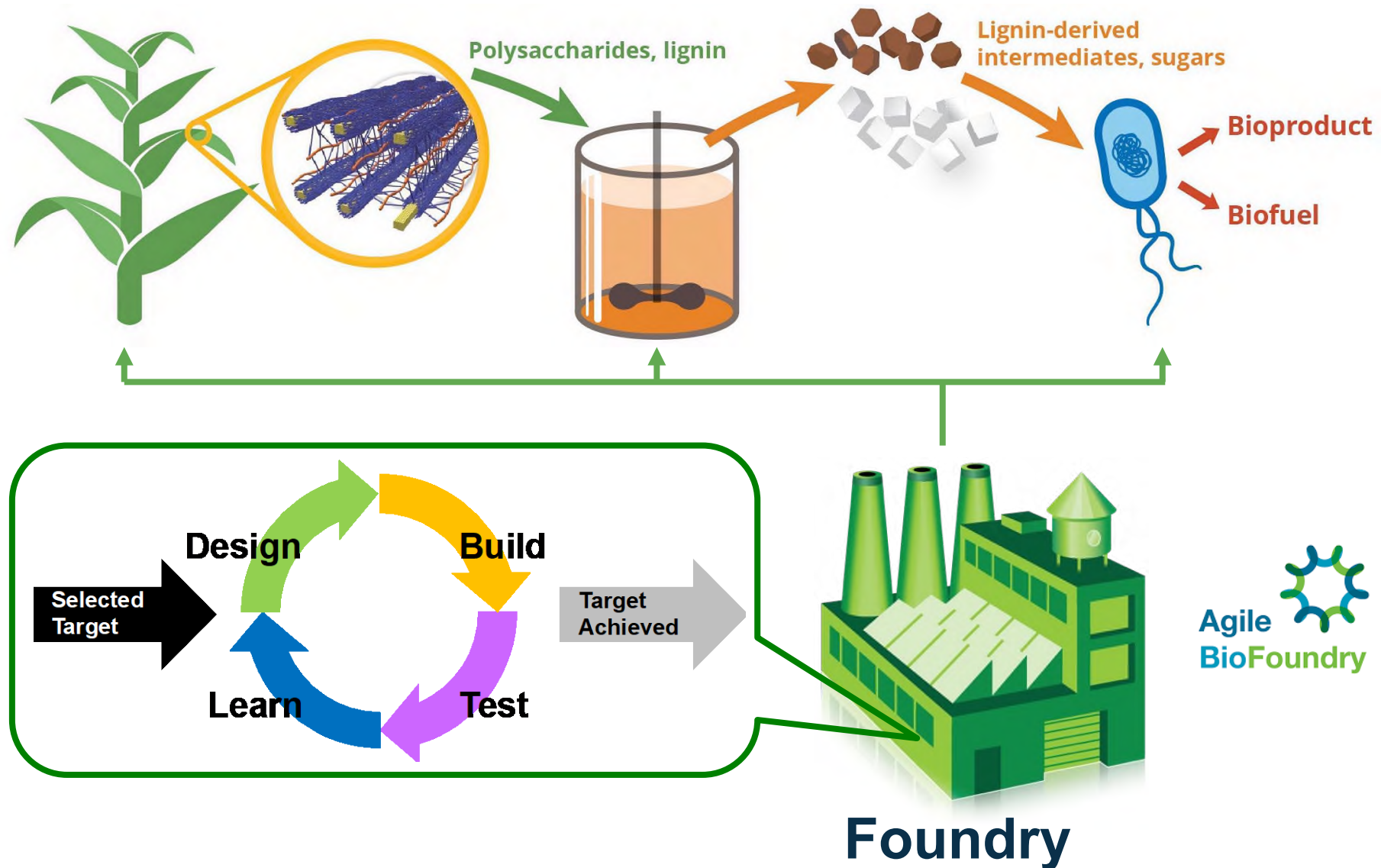
# Phase separation allows simple purification of fuel



# Engineered microbes convert sugars into advanced biofuels

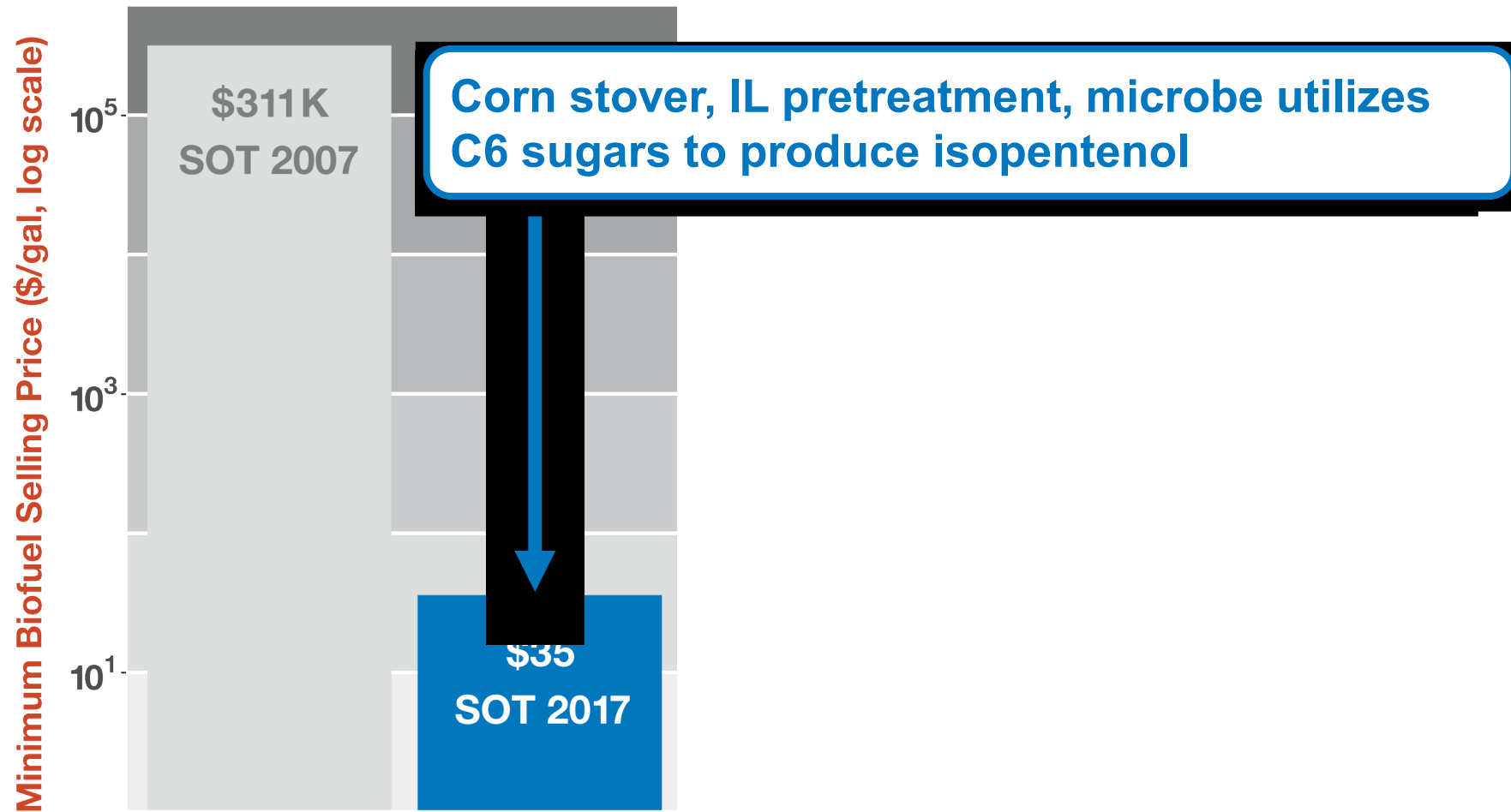


# The DBTL technologies developed in JBEI will outfit the next generation of biofoundries

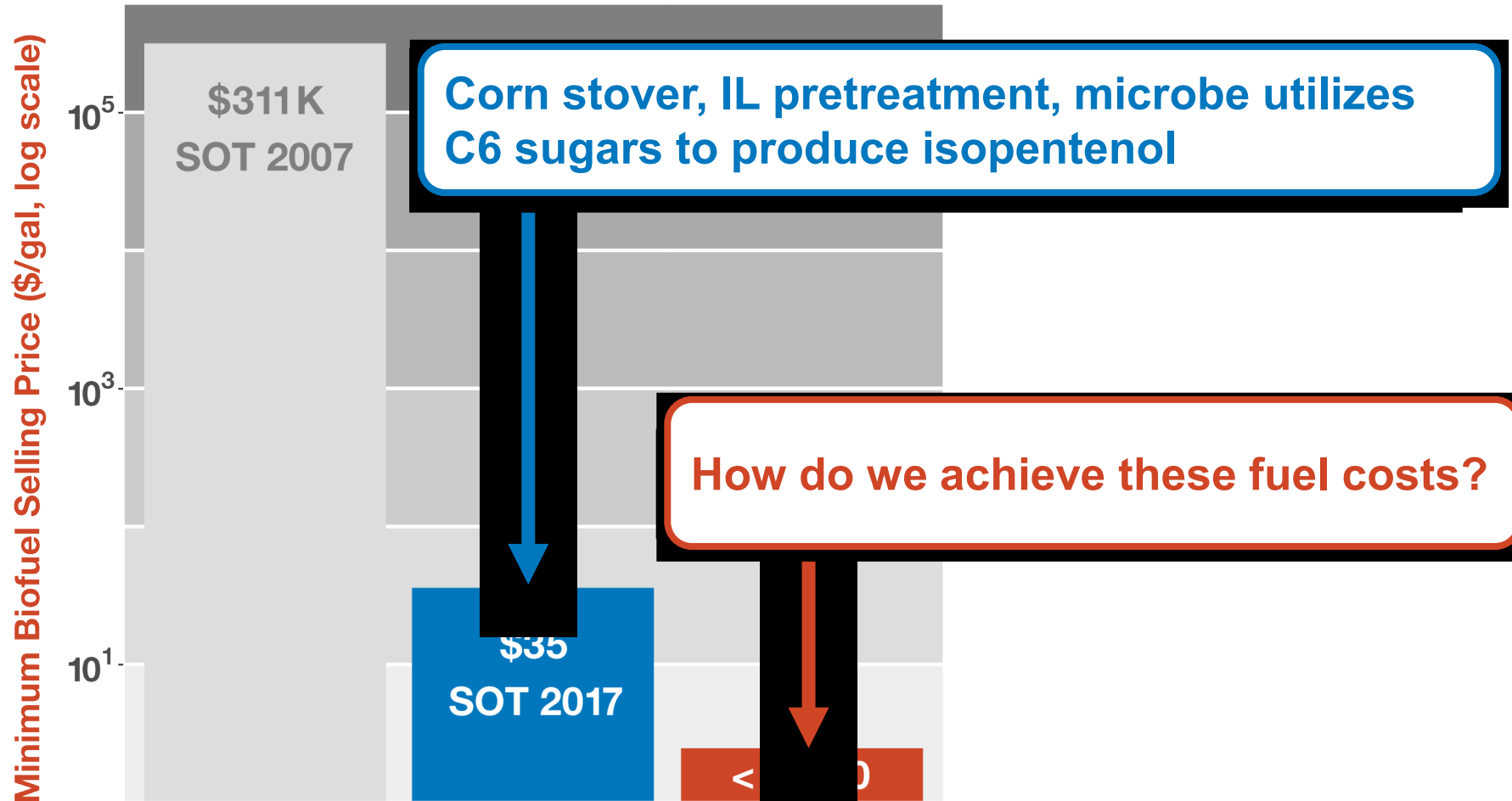




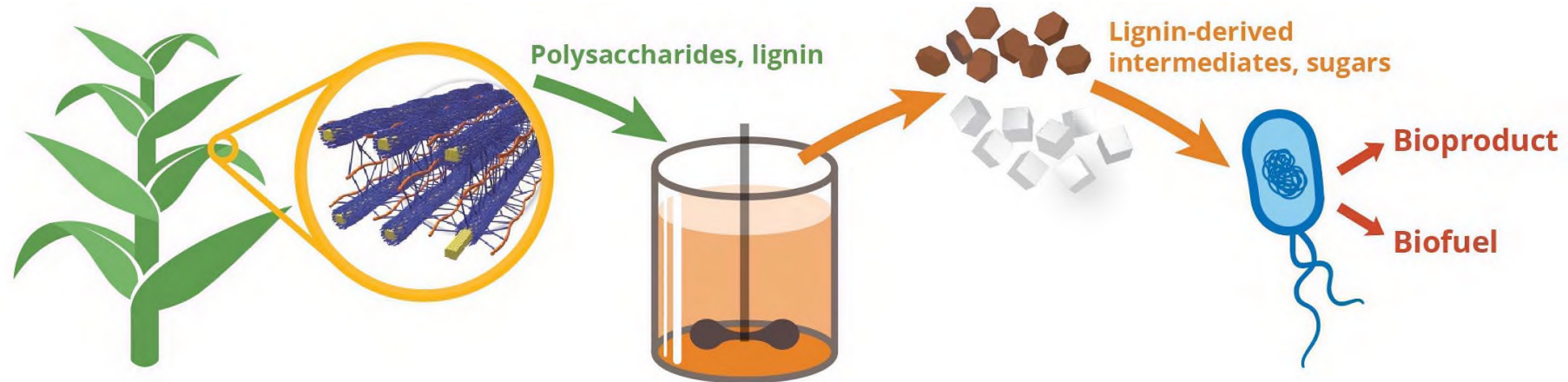
# JBEI's research program has reduced the fuel cost 10,000 fold



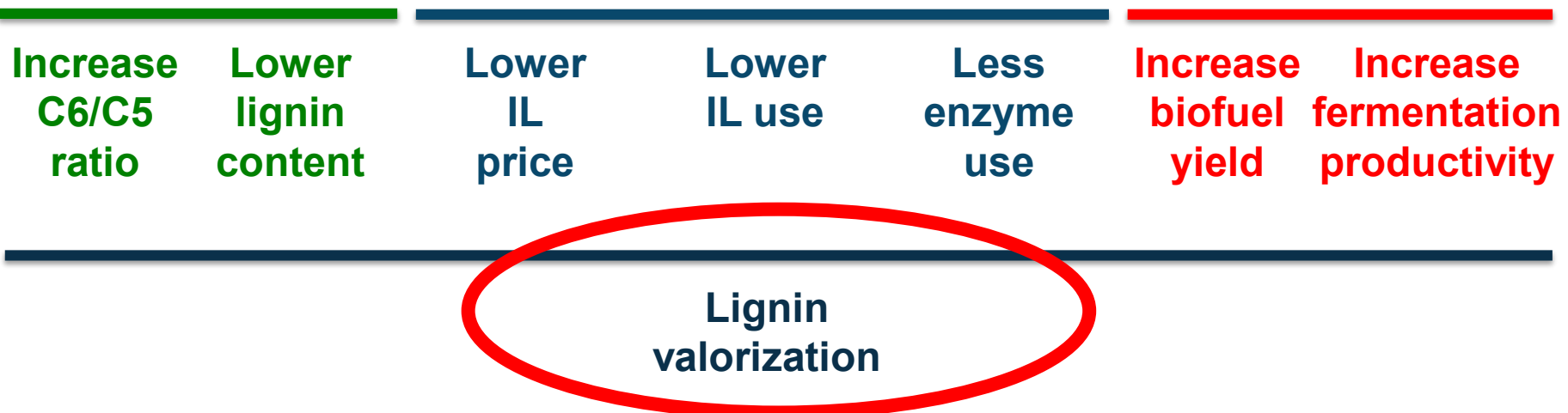
# How do we make biofuels affordable?



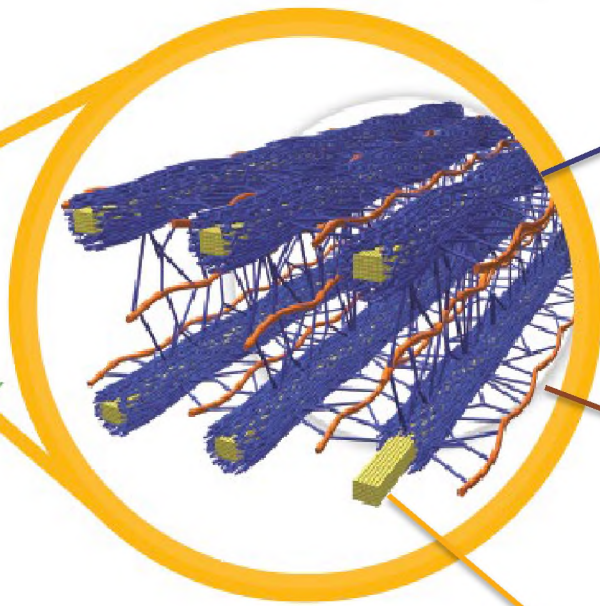
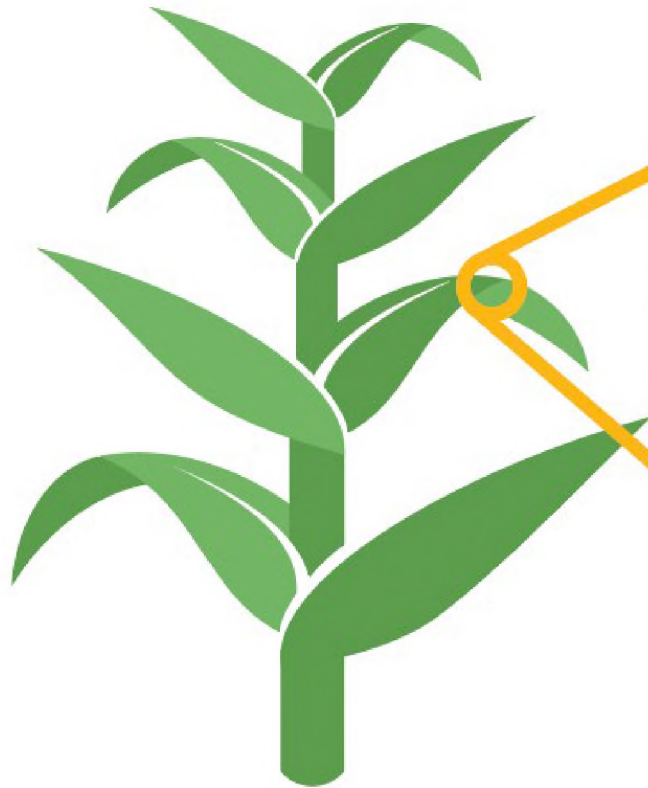
# Eight key factors have the biggest impact on the price of biofuels



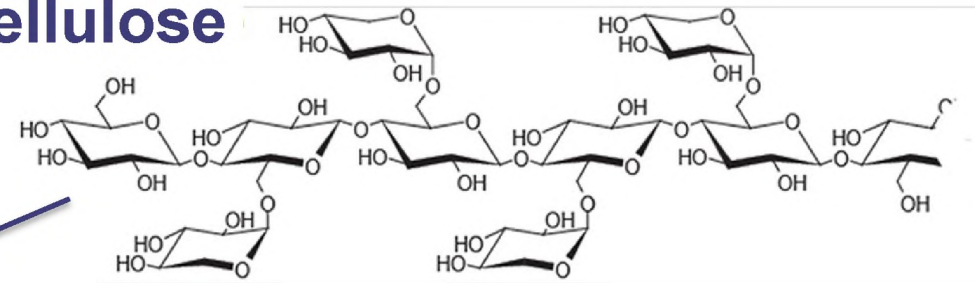
## JBEI technology development & improvement scenarios



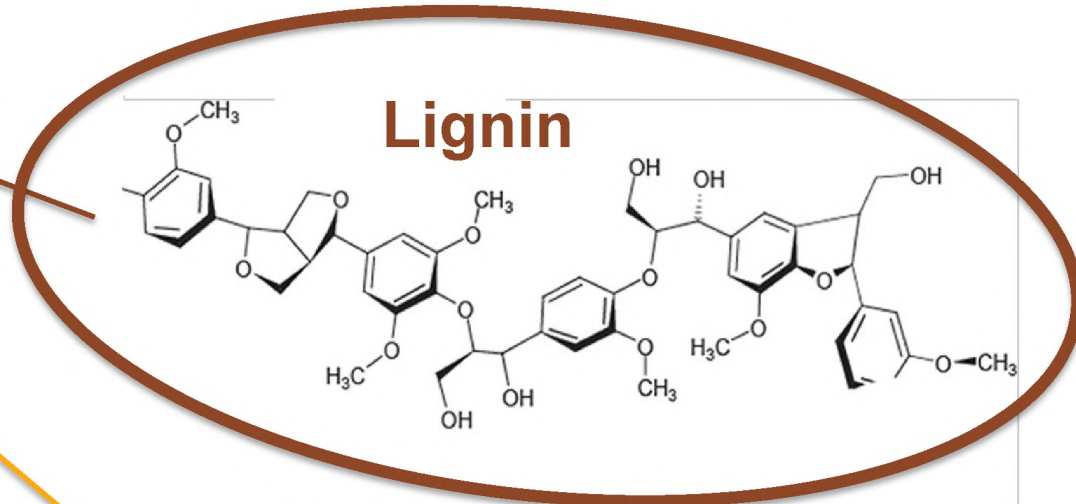
# Lignin utilization



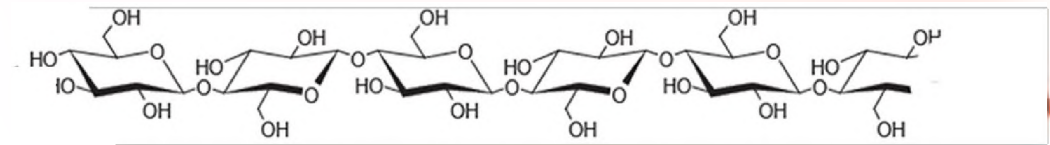
Hemicellulose



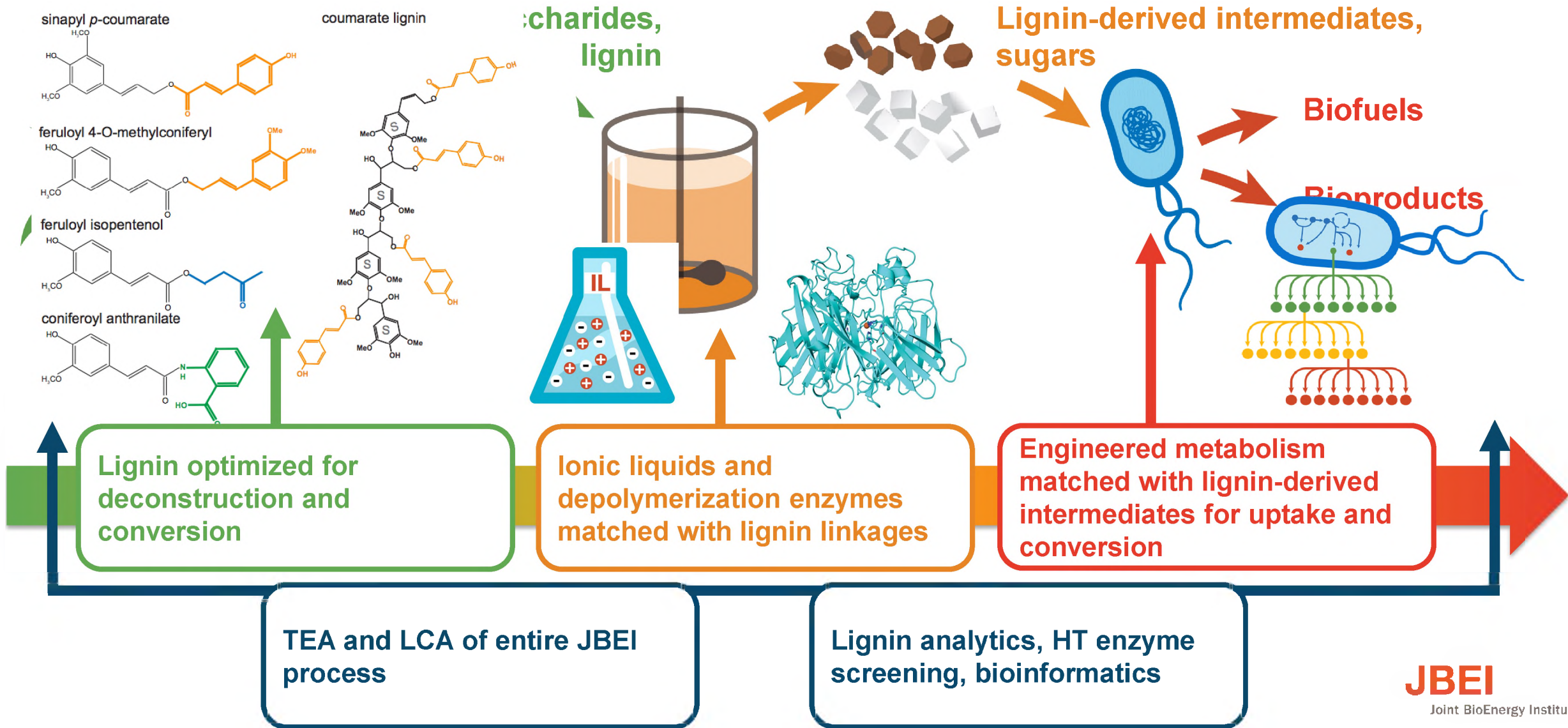
Lignin



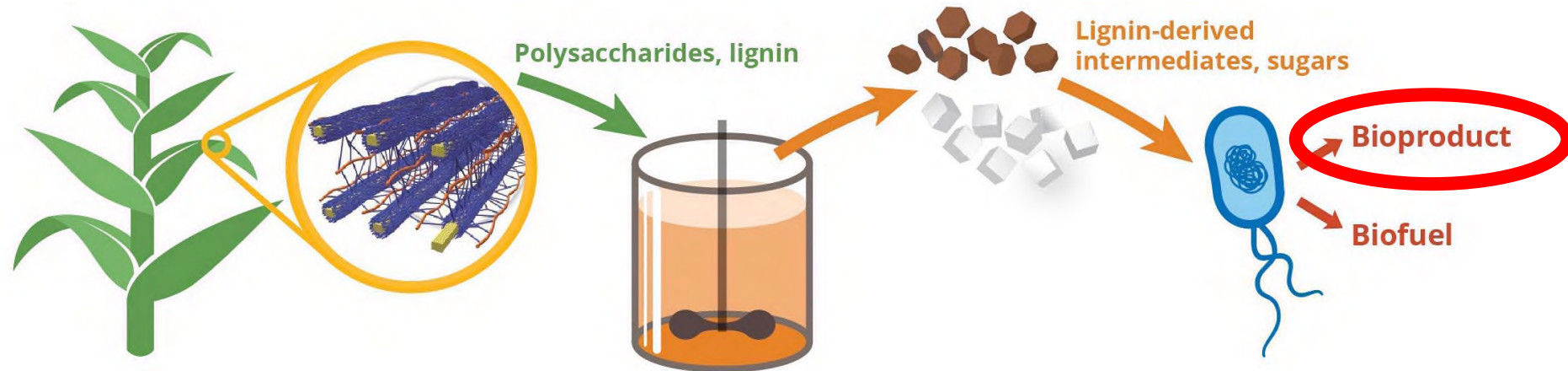
Cellulose



# JBEI's efforts to utilize lignin



# Eight key factors have the biggest impact on the price of biofuels

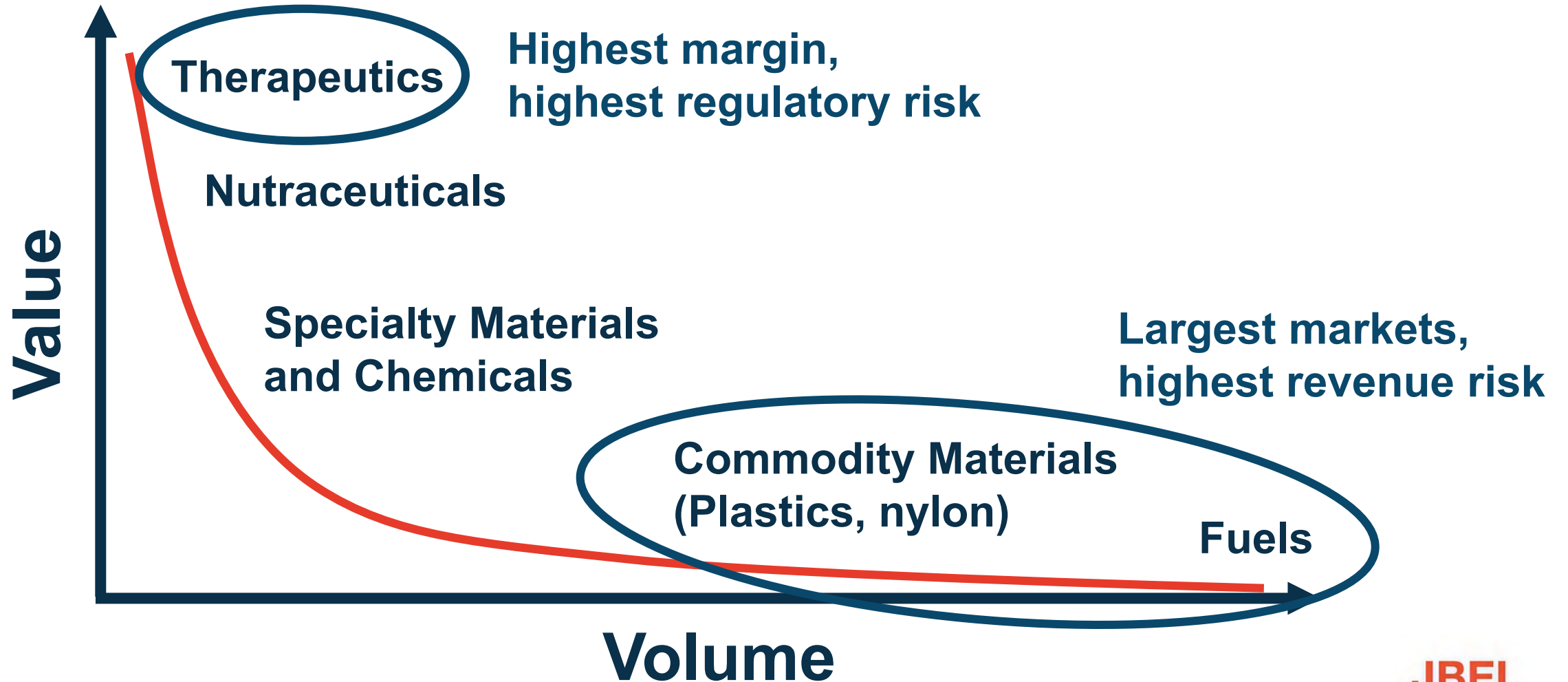


## JBEI technology development & improvement scenarios

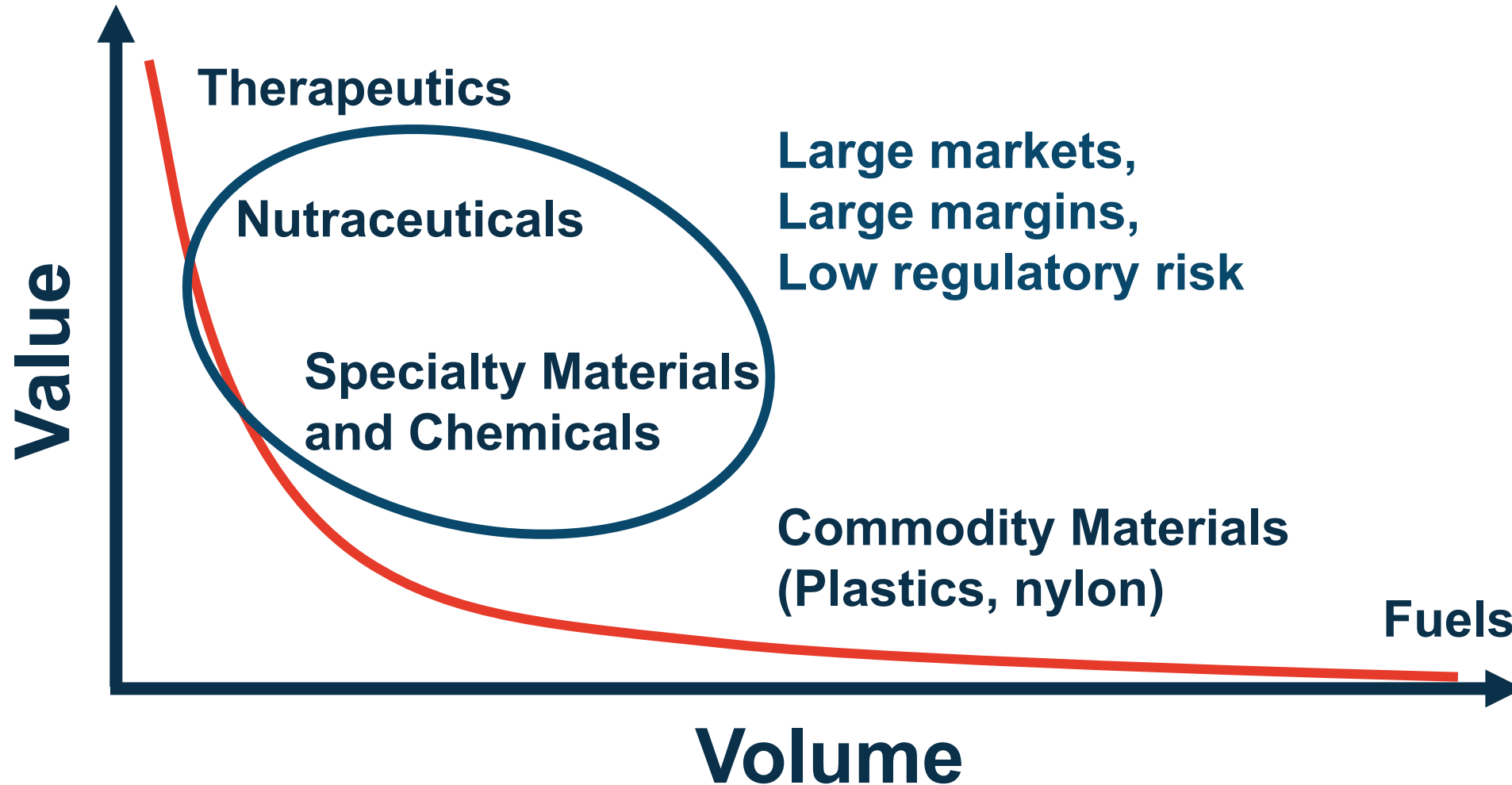
<b>Increase C6/C5 ratio</b>	<b>Lower lignin content</b>	<b>Lower IL price</b>	<b>Lower IL use</b>	<b>Less enzyme use</b>	<b>Increase biofuel yield</b>	<b>Increase fermentation productivity</b>
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**Lignin  
valorization**

# Target bioproducts



# Target bioproducts





# Safe colorants for food and dyes for clothing

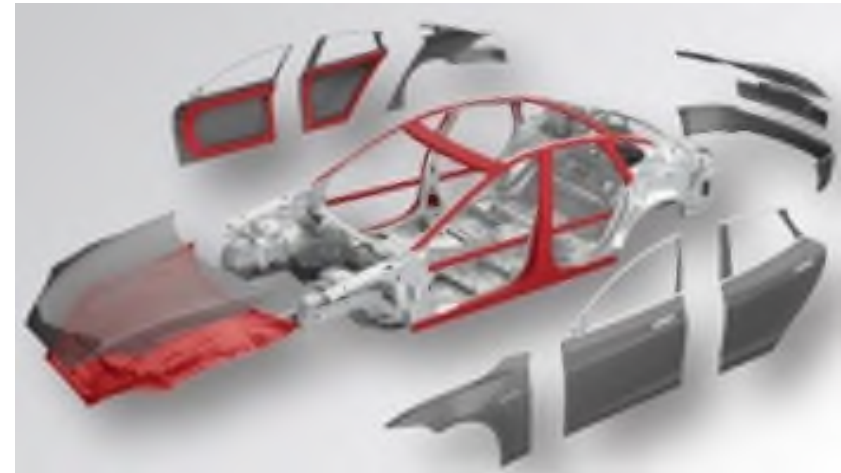


# Rare flavors and fragrances

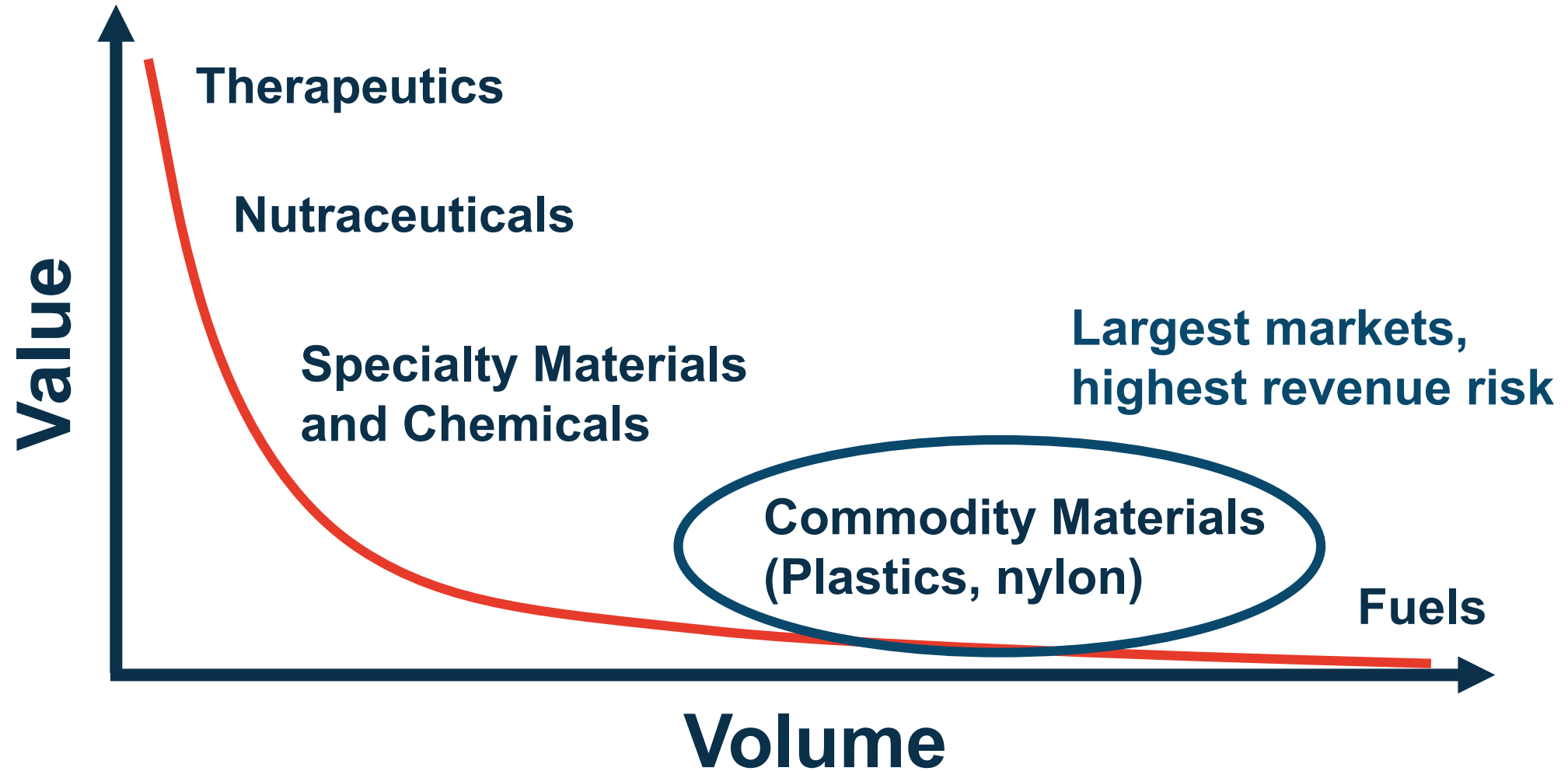




# High performance materials for clothing, electronics, airplanes, and automobiles



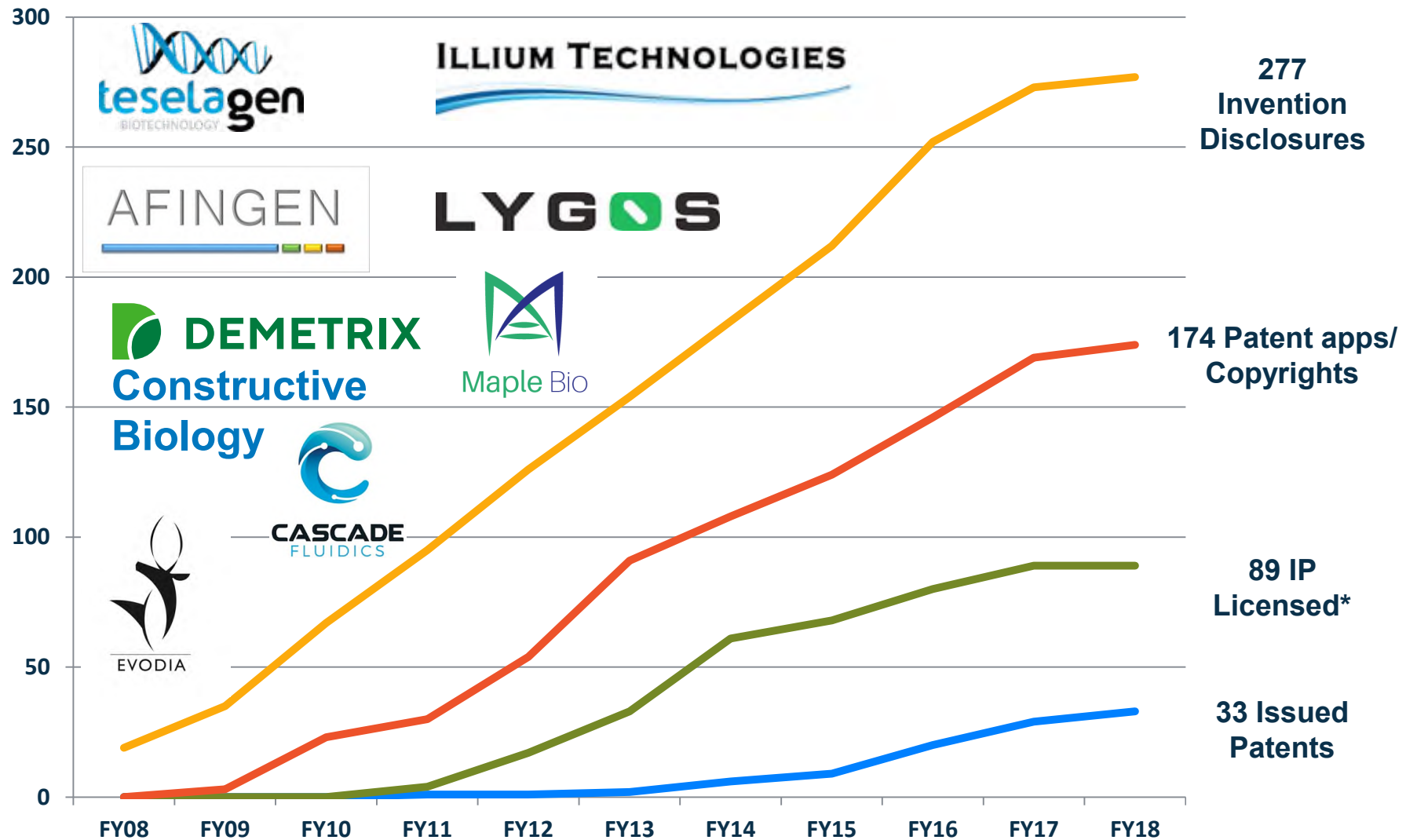
# Target bioproducts



# Biodegradable and recyclable plastics



# JBEI's Commercial Impact



\*Licensed IP that Includes patents, patent applications, foreign patent applications and copyright  
 Plus: one JBEI affiliated invention disclosure and agreement; not included here

As of  
 12/31/2017

# JBEI interactions with industry





# Technology maturation: State of California Matching Funds

- \$3M project awarded by the State of California to JBEI as cost share
- Partnership with Aemetis
- Deployment and demonstration of an IL-based process for production of an advanced biofuel
- Using California wild type woody biomass feedstocks



AEMETIS



Thanks to ...

## The JBEI Team



DOE for funding