Development of Non-natural Carbon Conserving Biosynthetic Pathways

Presented at the Carbon-Optimized Bioconversion Workshop ARPA-E

By Harshal Chokhawala, CEO of ZymoChem

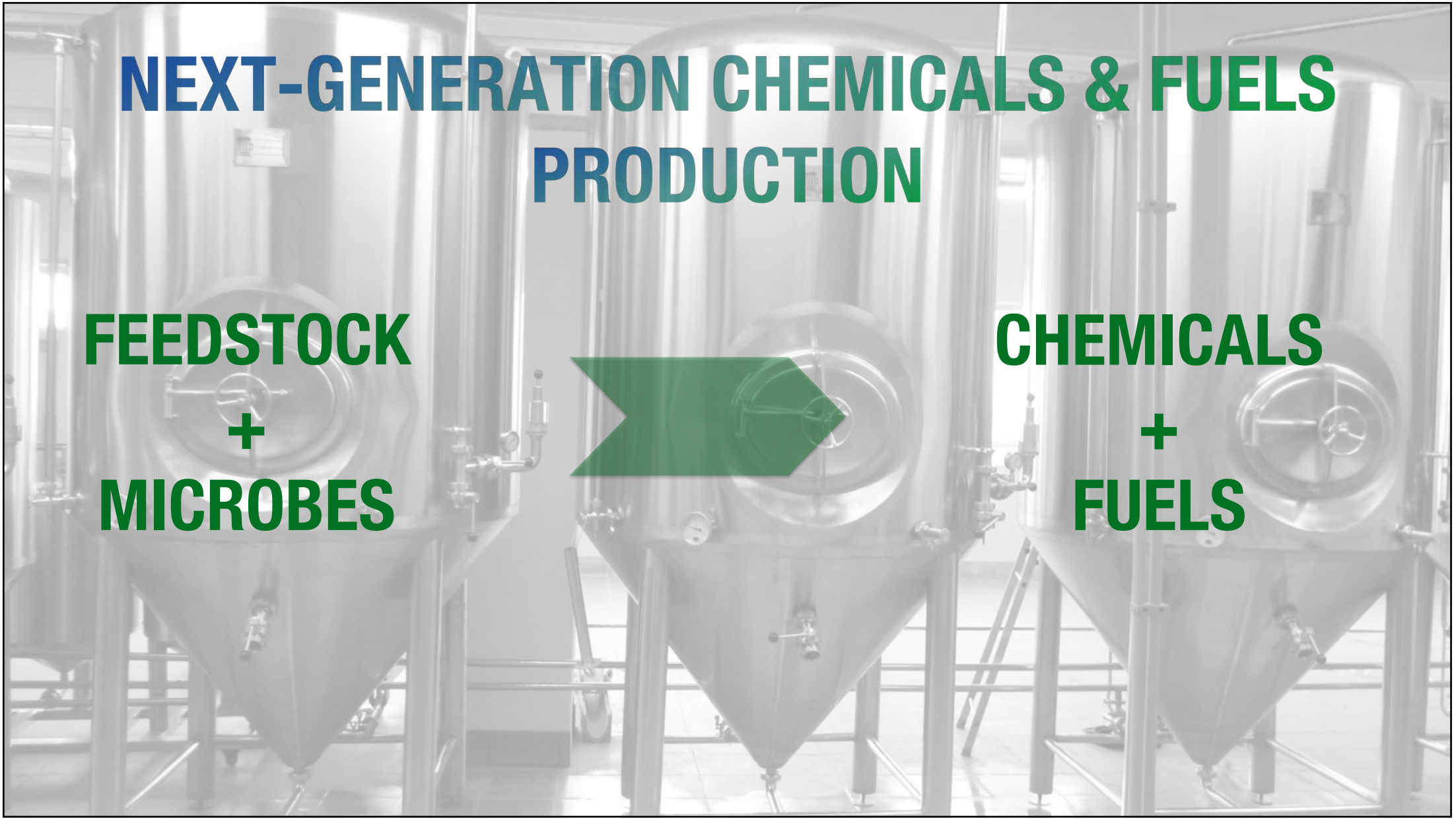
harshal@zymochem.com

ZYMOCHEM

ZYMOCHEM OVERVIEW

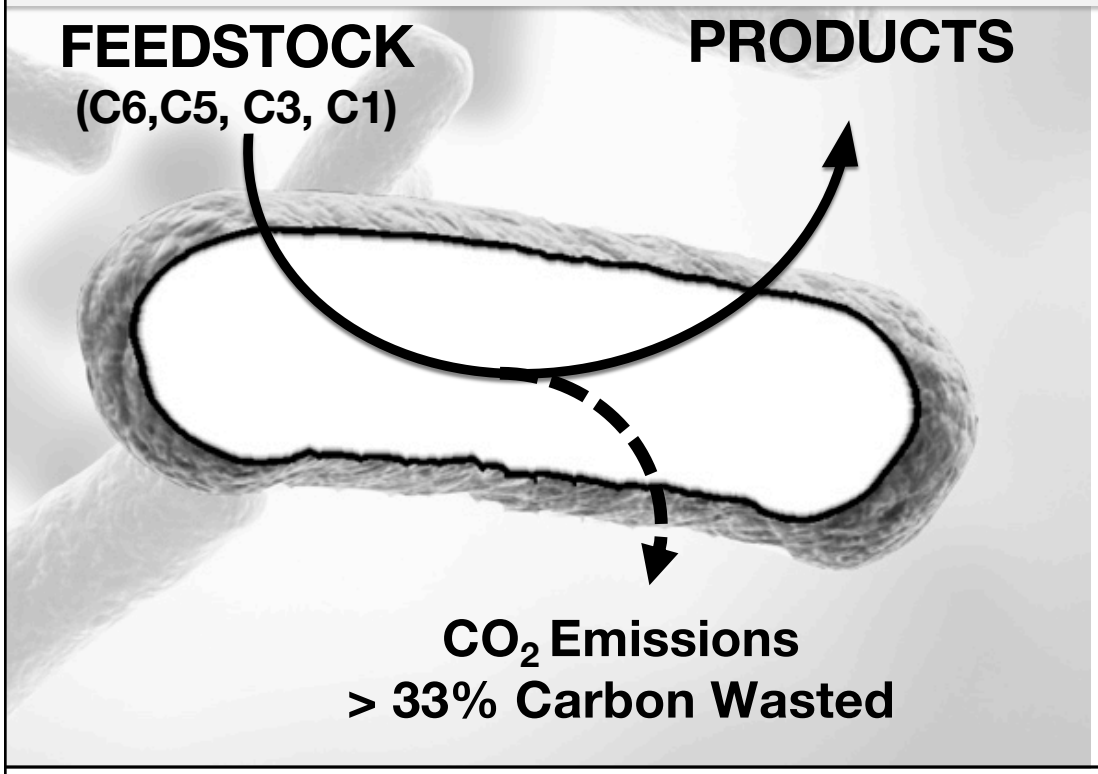
- ✓ Breakthrough Carbon Conservation (C2) technology platform enables low cost and scalable production of a wide range of chemicals, fuels, & materials
- ✓ C2 technology demonstrated >20 targets at lab scale
- ✓ Backed by ~$7M USD in funding from government + private investors
- ✓ Started operations in 2015 & located in Berkeley, CA, USA

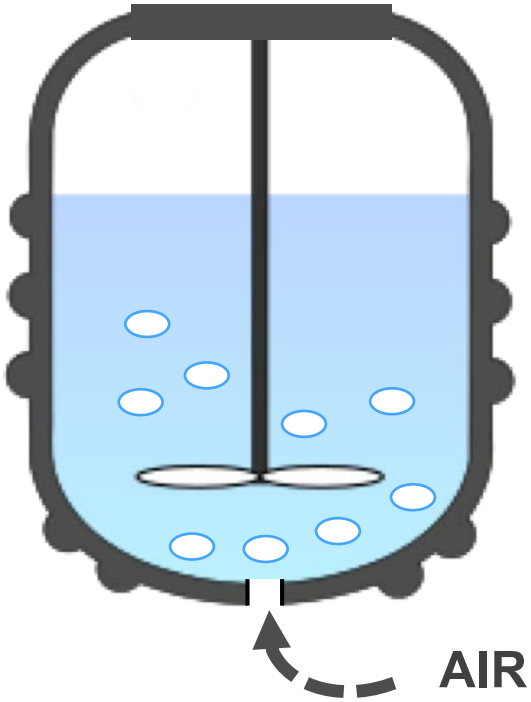
ZYMOCHEM


NEXT-GENERATION CHEMICALS & FUELS PRODUCTION
FEEDSTOCK + MICROBES
CHEMICALS + FUELS


BREWING CHEMICALS/FUELS IS COSTLY

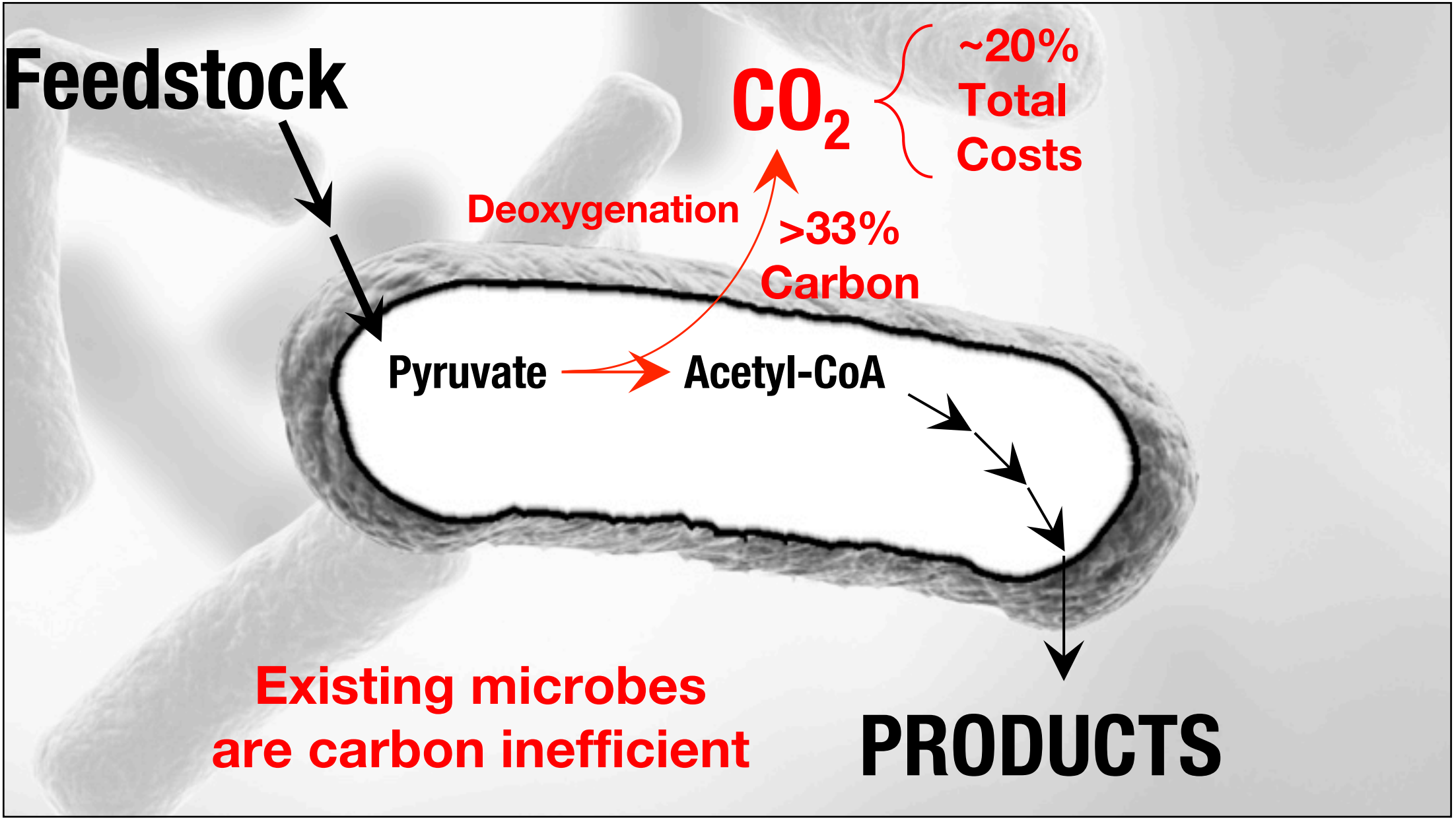
BREWING CHEMICALS IS COSTLY COMPARED TO PETOLEUM-BASED METHODS, PREVENTING ITS WIDE USE

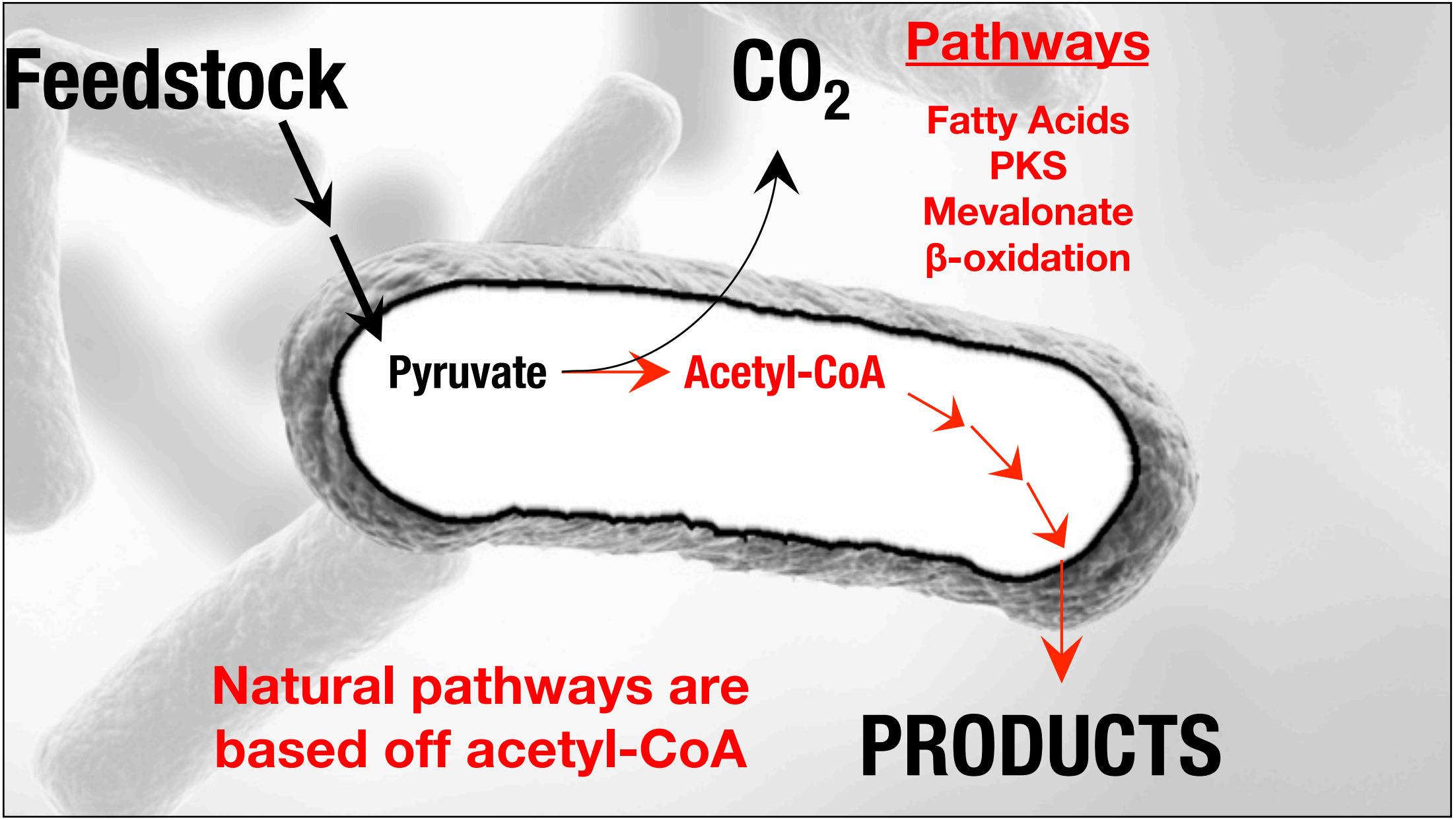




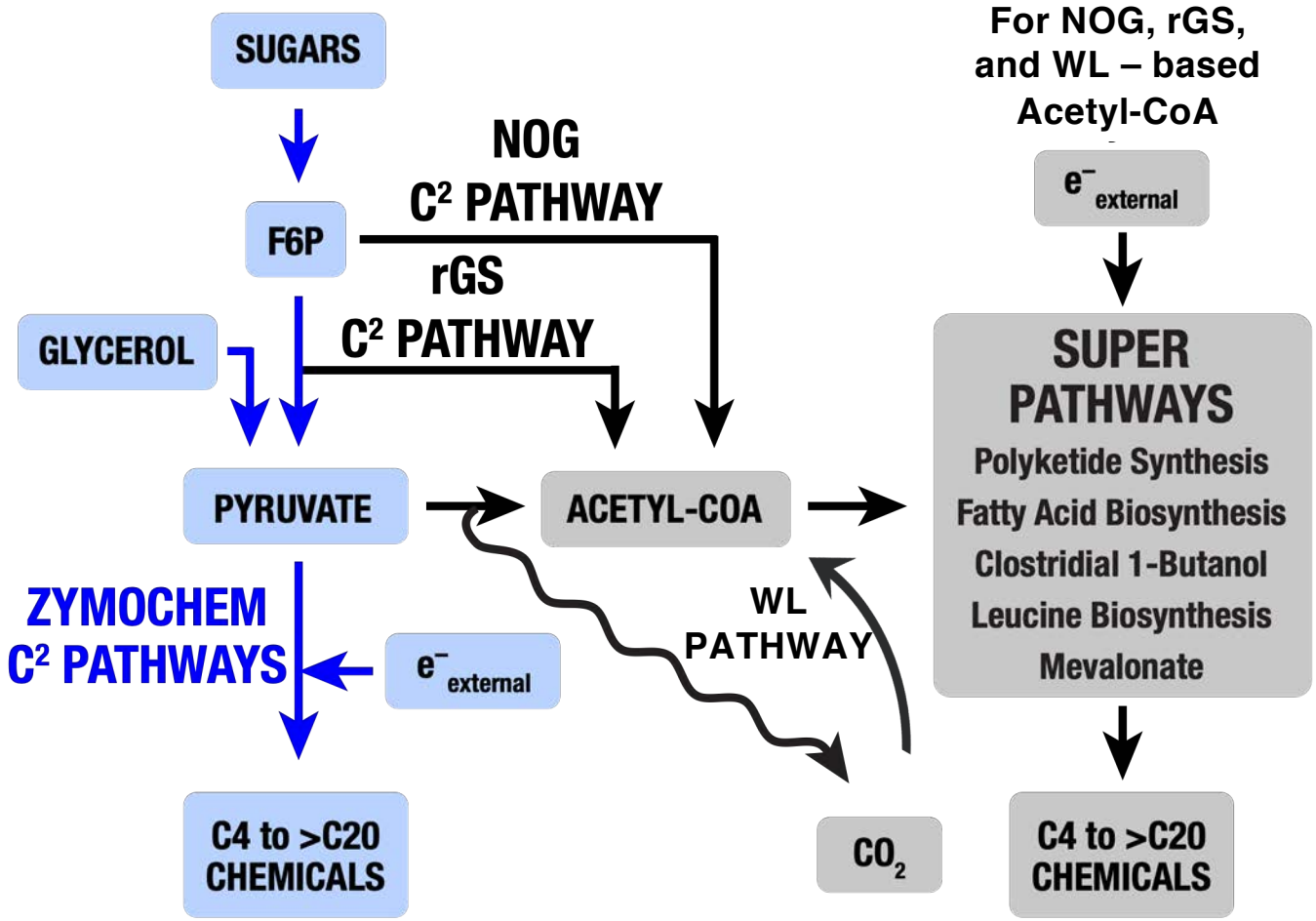
Inefficient microbes
Carbon loss: ~20% Total costs

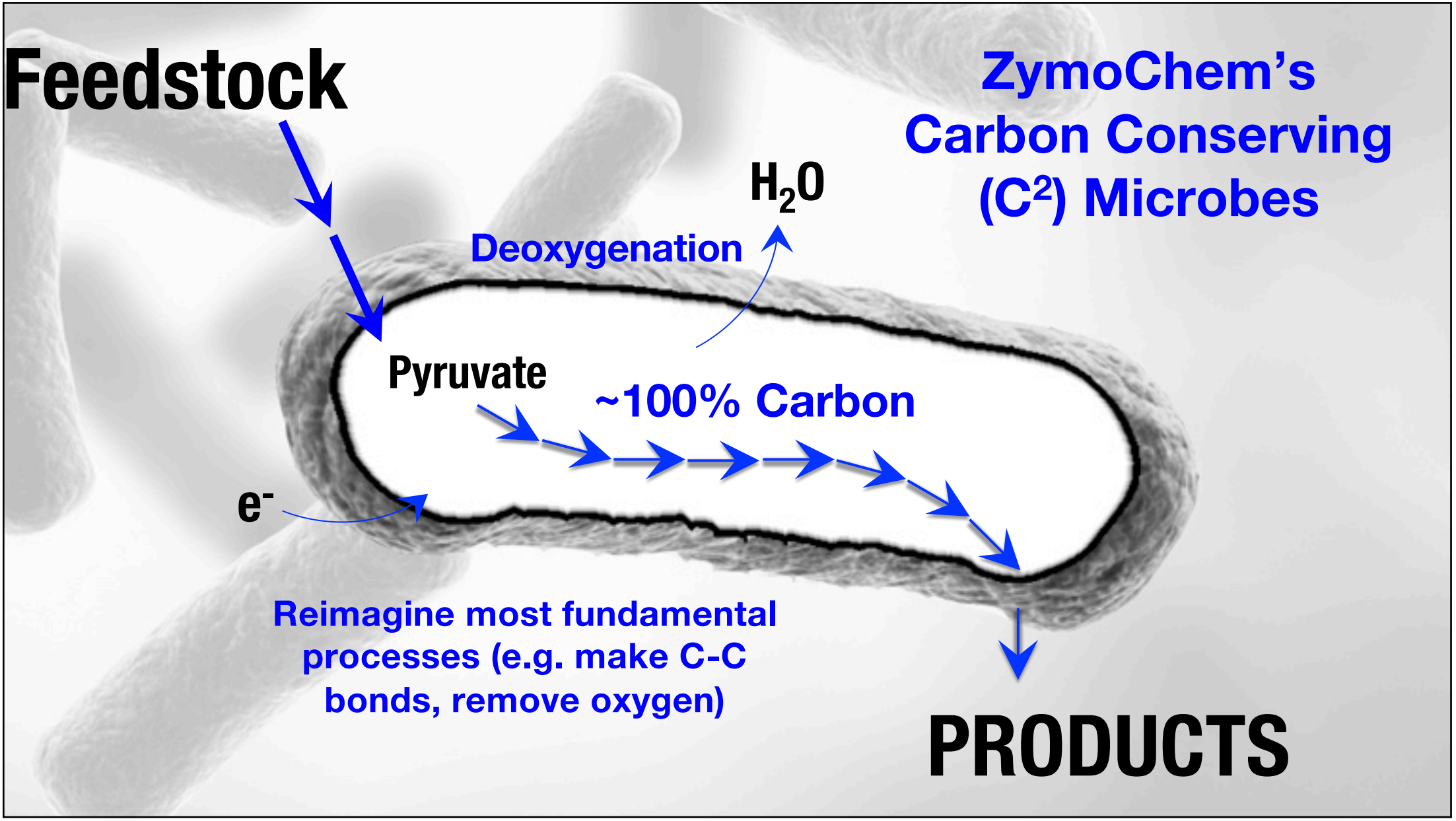
Aerobic processes
Difficulty scaling up
Increased OPEX/CAPEX

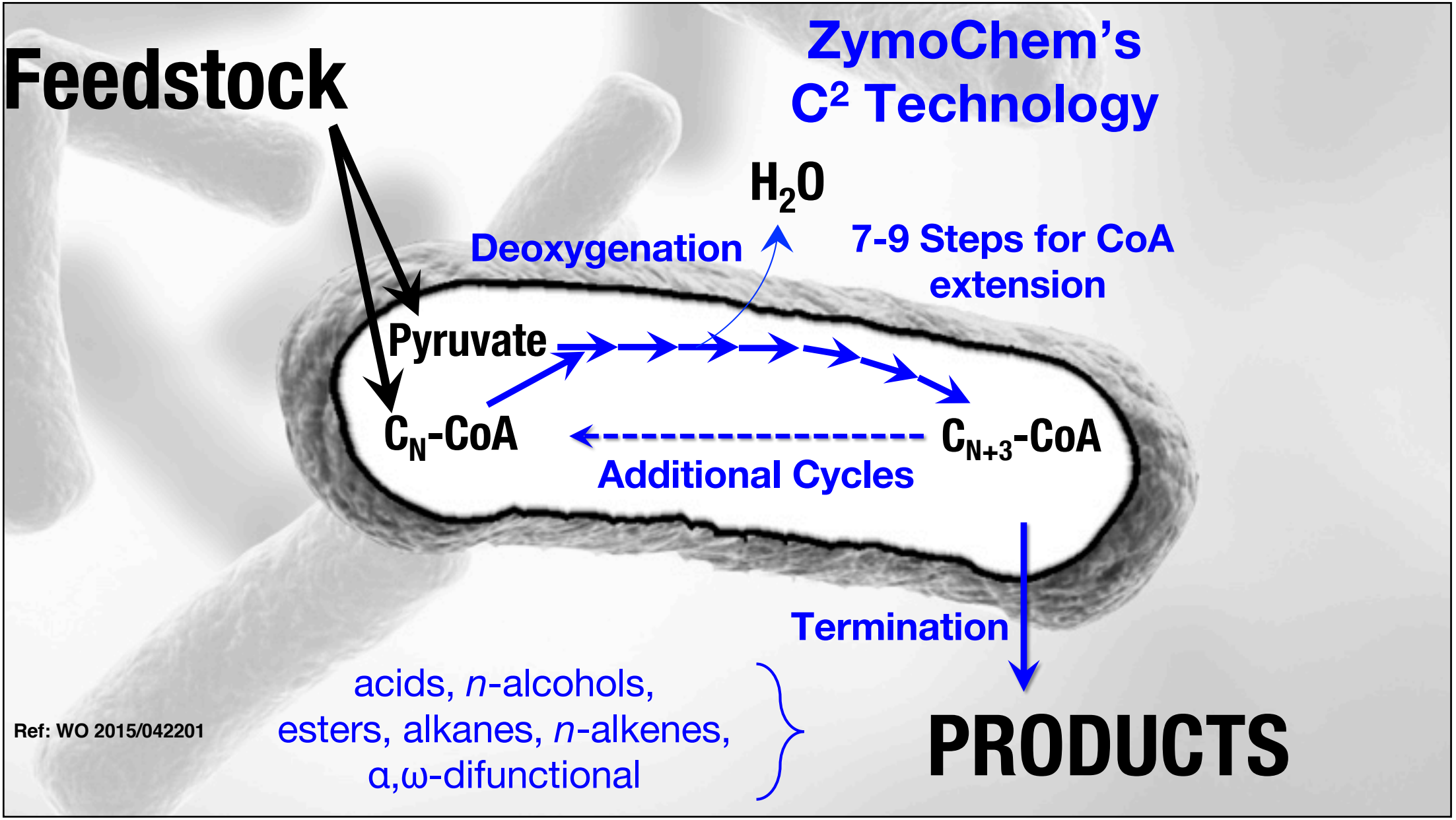

Feedstock
CO_2
~20%
Total
Costs
Deoxygenation
>33%
Carbon
Pyruvate
Acetyl-CoA
Existing microbes
are carbon inefficient
PRODUCTS


Feedstock
CO_2
Pathways
Fatty Acids
PKS
Mevalonate
β-oxidation
Pyruvate
Acetyl-CoA
Natural pathways are based off acetyl-CoA
PRODUCTS

DIFFERENT APPROACHES TO SOLVING CARBON LOSS PROBLEM

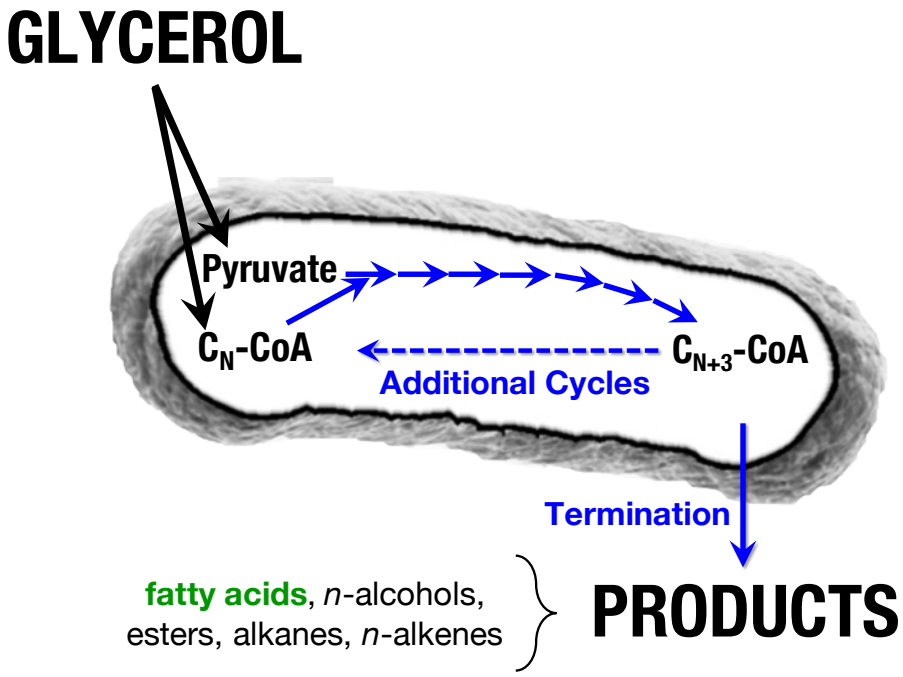



Feedstock
ZymoChem's
Carbon Conserving
(C²) Microbes
H2O
Deoxygenation
Pyruvate
~100% Carbon
e-
Reimagine most fundamental
processes (e.g. make C-C
bonds, remove oxygen)
PRODUCTS


Feedstock
ZymoChem's
C² Technology
H₂O
Deoxygenation
7-9 Steps for CoA
extension
Pyruvate
C_N-CoA
C_N+3-CoA
Additional Cycles
Termination
acids, n-alcohols,
esters, alkanes, n-alkenes,
α,ω-difunctional
PRODUCTS
Ref: WO 2015/042201

ZYMOCHEM'S C2 TECHNOLOGY FOR FATTY ACIDS PRODUCTION

FATTY ACYL-COA ELONGATION / TERMINATION ("FACE/T") PATHWAY

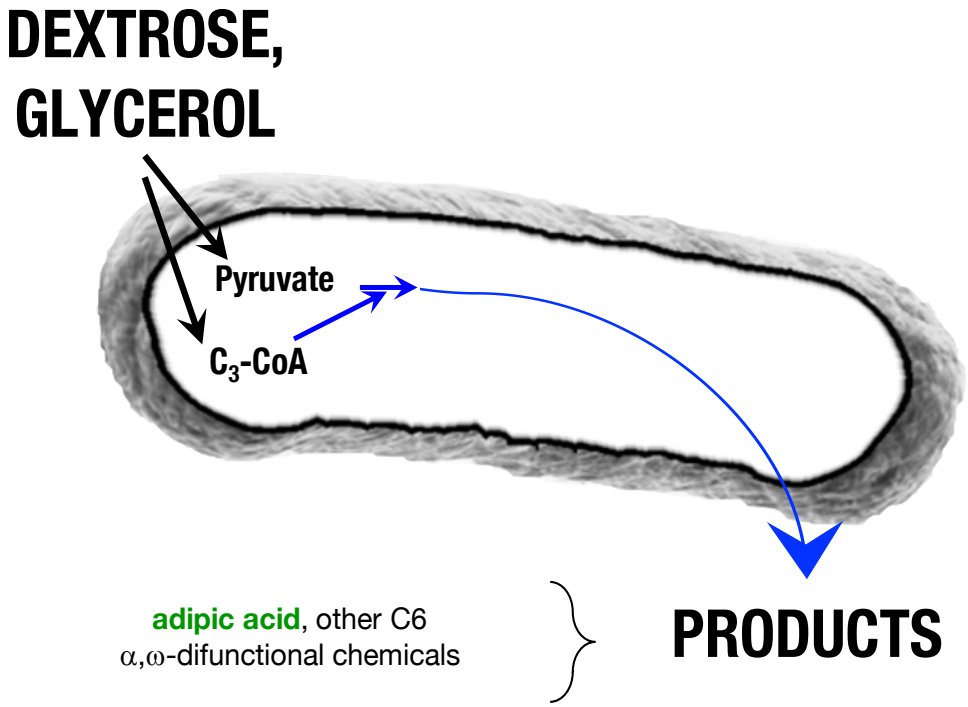


		Traditional FAB Pathway	ZymoChem's FACE/T Pathway	
Fatty Acid	**Feed-stock**	**Theoretical Yield** (g acid/ g feed)	**Extra NADH Needed** (mol/mol)	**Theoretical Yield** (g acid/ g feed)
Pentanoic Acid	Glucose	0.49	1	0.57
	Glycerol	0.49	0	0.55
Hexanoic Acid	Glucose	0.43	4	0.64
	Glycerol	0.42	2	0.63
Octanoic Acid	Glucose	0.40	4	0.53
	Glycerol	0.39	1	0.52

Demonstrated lab scale production of various fatty acids

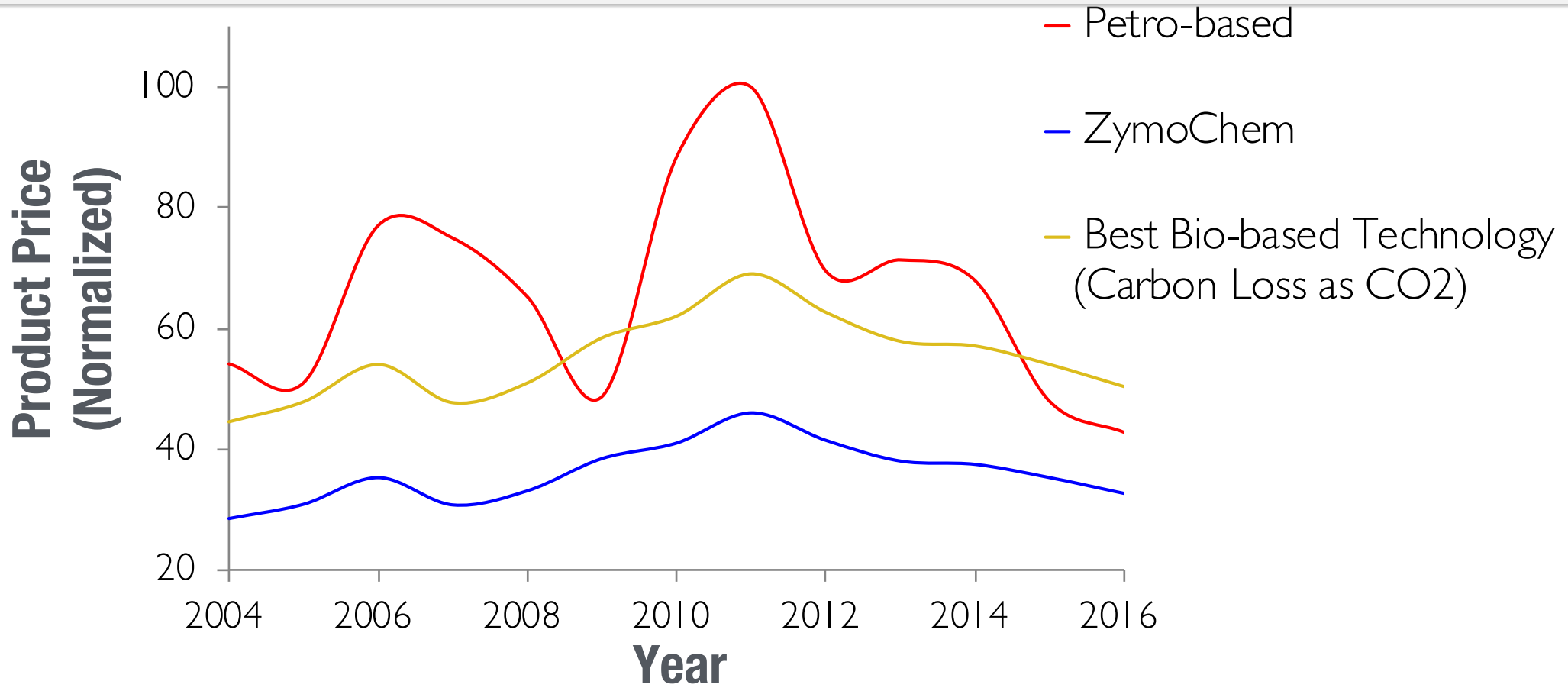
ZYMOCHEM'S C2 TECHNOLOGY FOR ADIPIC ACID PRODUCTION

POLYMER PRECURSOR ("POP") PATHWAY



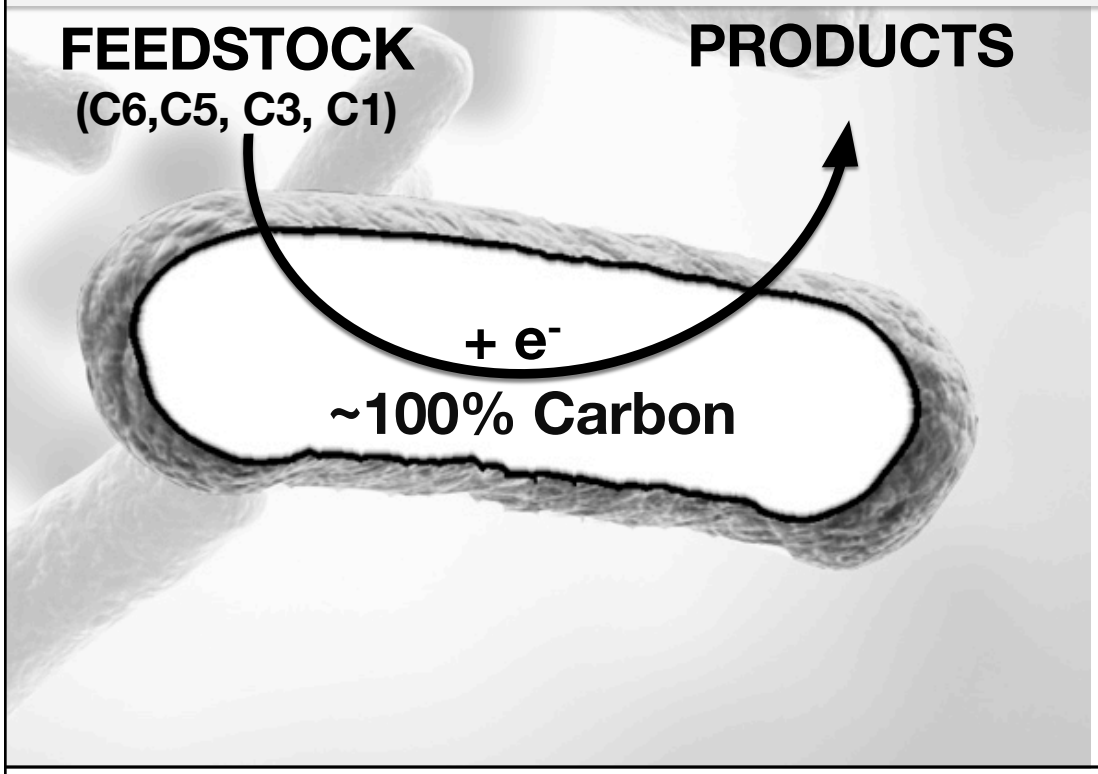
Demonstrated lab scale production of adipic acid

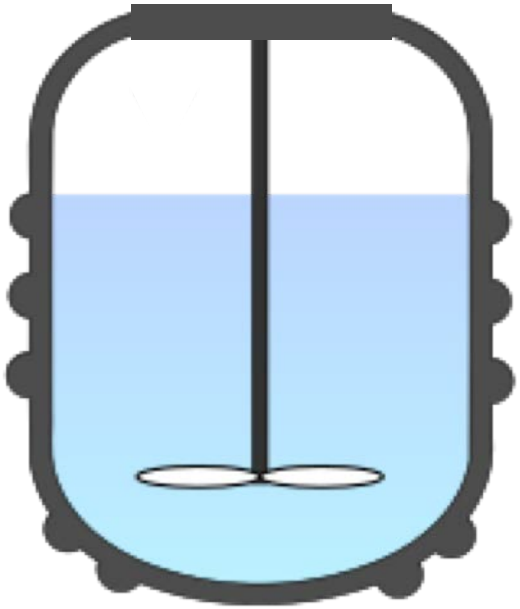
ZYMOCHEM'S C2 TECHNOLOGY CAN ENABLE COST-ADVANTAGED PRODUCTION OF A ADIPIC ACID COMPARED TO PETROLEUM-BASED PRODUCTION



** Calculated using techno-economic models assuming the bio-based processes were commercial since 2004. Cost increase in Best Bio-based Technology only due to carbon loss as CO2.*

ZYMOCHEM'S CARBON CONSERVING (C2) TECHNOLOGY CAN ENABLE COST-ADVANTAGED BREWING OF MANY PRODUCTS EVEN AT TODAY'S OIL PRICES





~3 story tall fermenter

Anaerobic
(No oxygen)

ZymoChem's microbes
Up to 50% increase in carbon yield compared to state of the art

Anaerobic processes
Lower scale up risk
Lower OPEX/CAPEX

ZYMOCHEM TEAM

HARSHAL CHOKHAWALA

JON KUCHENREUTHER

MURTHY KONDA

JORGE ALONSO-GUTIERREZ

TIM DUMMER