LYGOS

Engineering yeast to convert sugar into high-value chemicals

Jeffrey Dietrich, CTO and Co-Founder

BIOENERGY 2016

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Introduction to Lygos

Producing Malonic Acid Today

Scaling Integrated Process

- **Founded 2010**
- **15 Employees**
- **Berkeley, CA**

- **2013:** Innovative Biosynthetic Pathways to Advanced Biofuels
- **2015:** Small Business Voucher
- **2016:** Bioenergy Technologies Incubator 2

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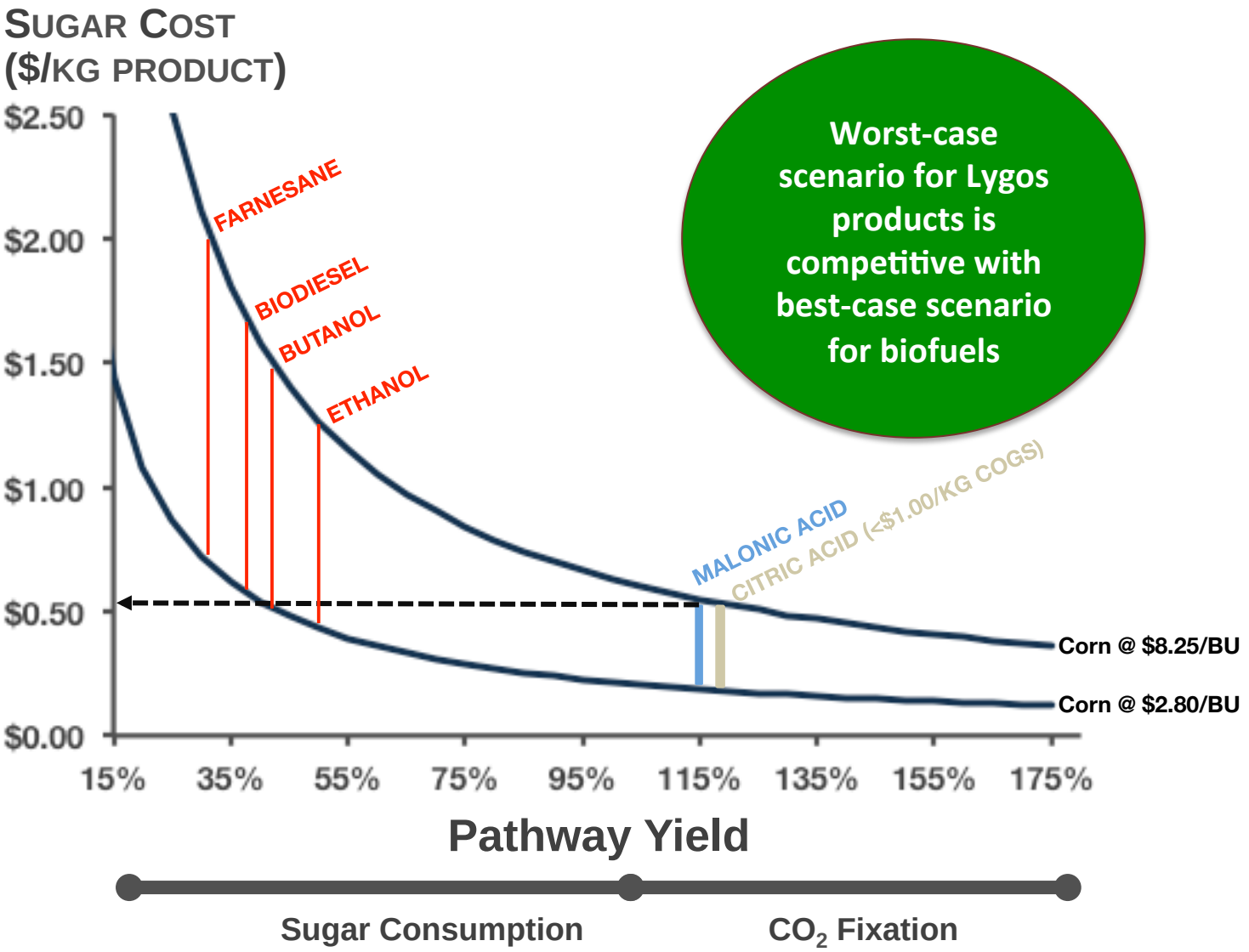
LS9
AMYRIS

Lygos Produces Bio-Advantaged Chemicals



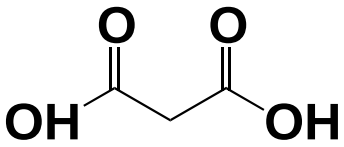
Worst-case scenario for Lygos products is competitive with best-case scenario for biofuels

Malonic Acid as a Bio-Advantaged Chemical

Lygos' Biological Process

SUGAR

Malonic Acid



Conventional Process

PETROLEUM CYANIDE

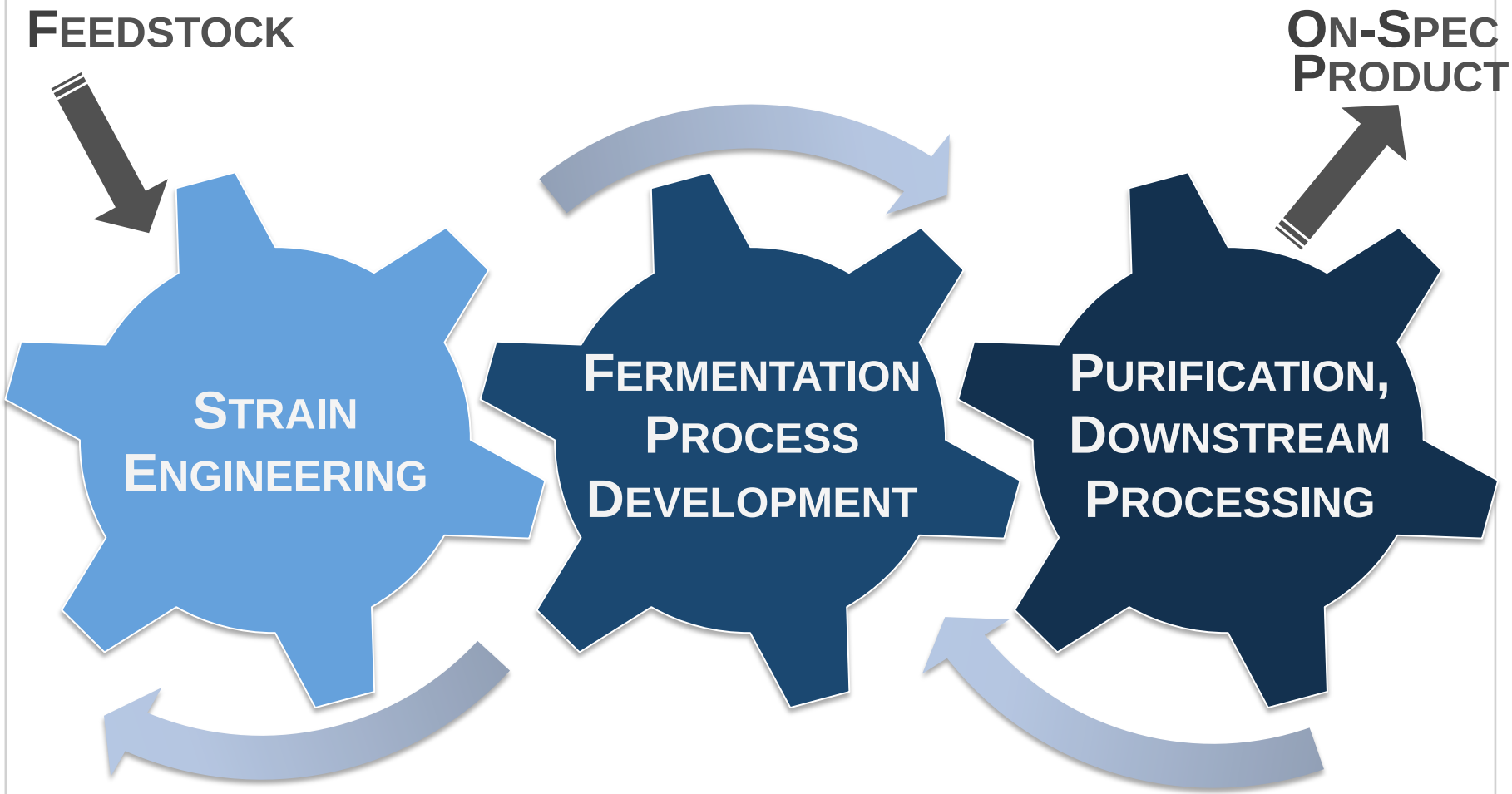
- ≈$250MM market today; $1B opportunity
- Bio-production is less expensive than petro raw materials cost
- Bio-tech provides higher quality, better performing product

Lygos advantages: cheaper, better, proprietary route

Commercializing Malonic Acid Today

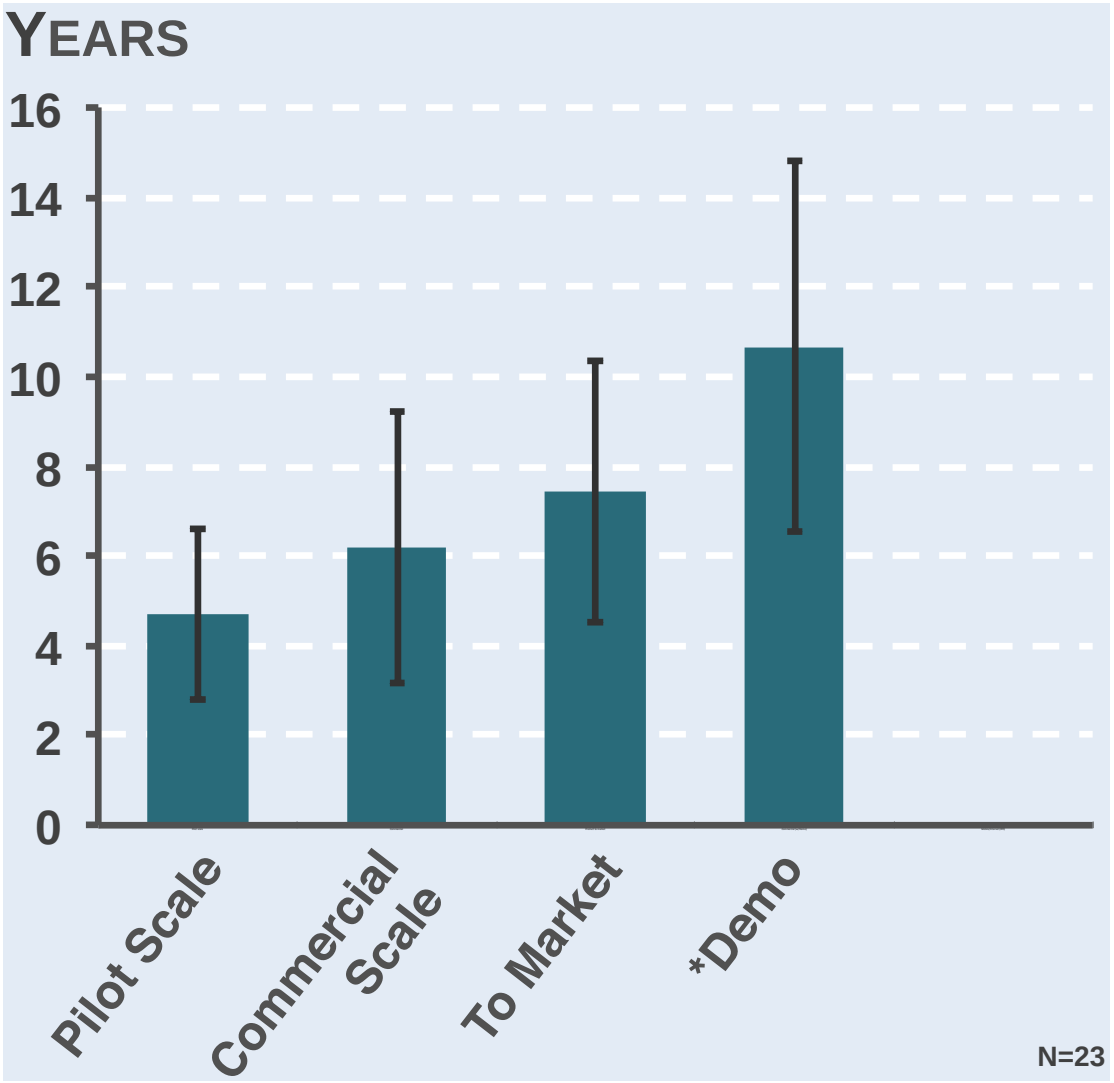
Q1-2016: Shipping kg samples of purified product (bench top scale)
2016: Scaling integrated process
Q4-2016: Goal of shipping 1 MT purified product by end of year

Design, Build, Test of the Integrated Process



Strain engineering needs to be examined in the context of an integrated process

DBTL Cycle Should Help Accelerate Commercialization



Average time for a bio-based material or chemical to get to market is 7.42 years

J. Allen, “Synthetic Biology: Applications and Lessons Learned in the Field of Bio-Based Materials and Chemicals.” Lux Research (04/2015)

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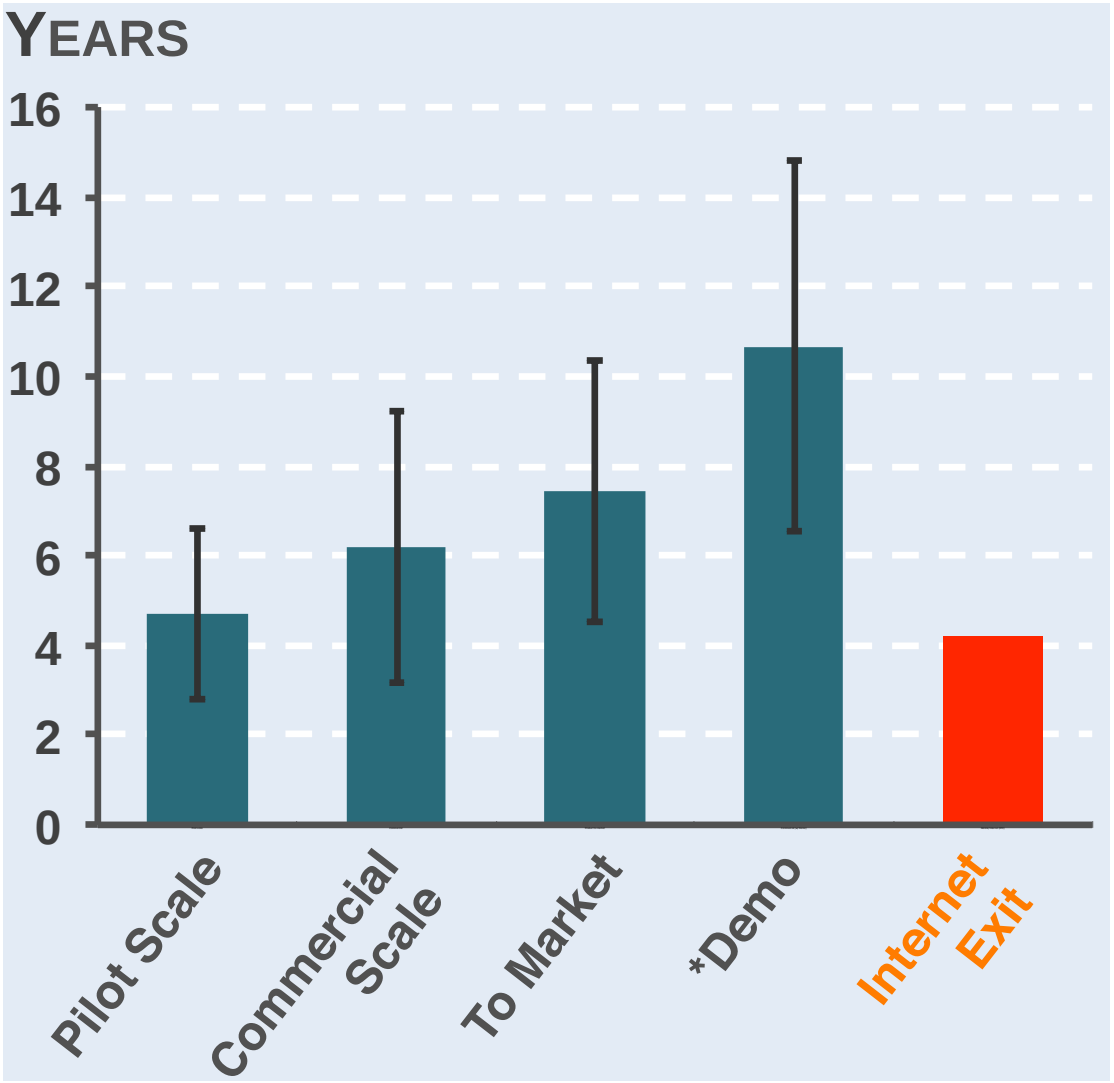
DBTL Cycle Should Help Accelerate Commercialization

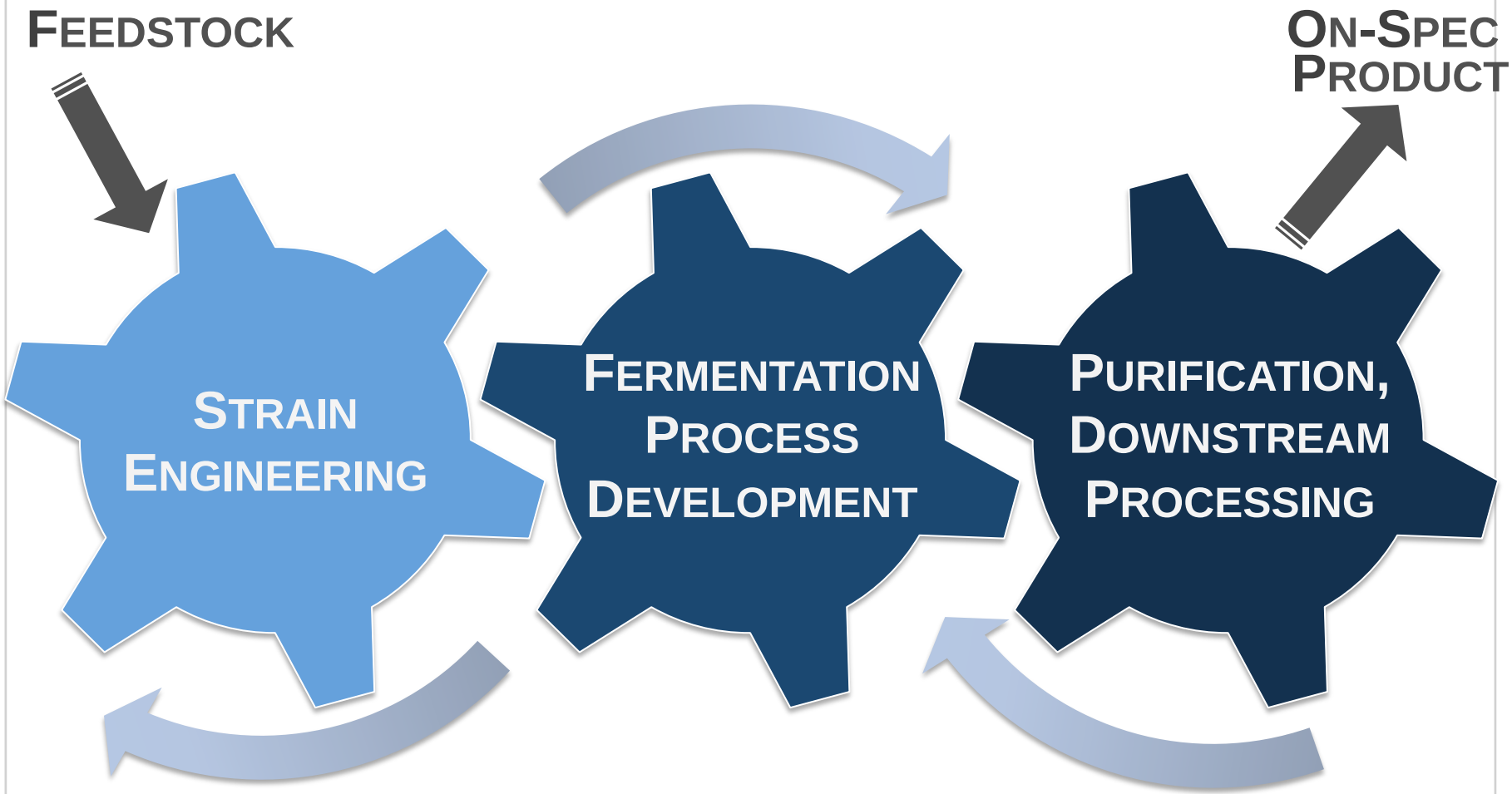


Average time for a bio-based material or chemical to get to market is 7.42 years

In 2013, the average time for an internet company to exit was 4.2 years

CB Insights Blog (November 7th, 2013)

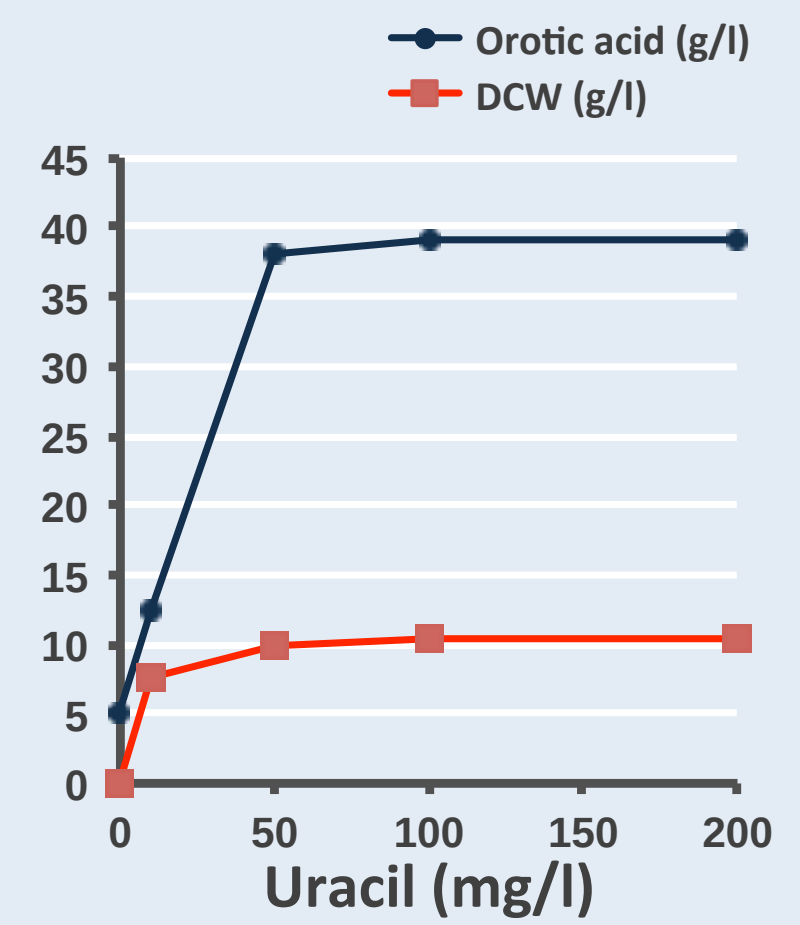
Design, Build, Test of the Integrated Process

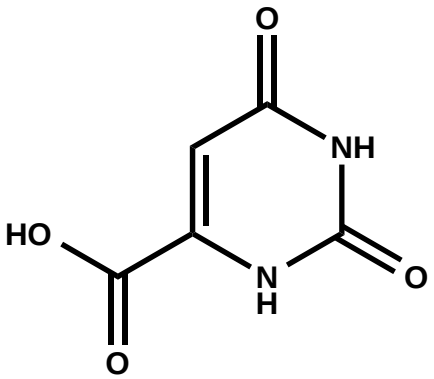


Strain engineering needs to be examined in the context of an integrated process

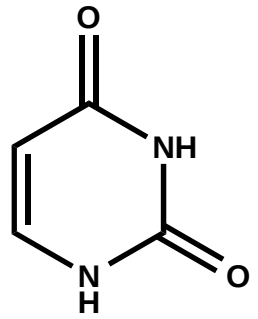
Strain Engineering Strategy: Small Genotypic Changes with Large Phenotypic Outcomes

Example: one gene deletion (ura3) leads to uracil auxotrophy and orotic acid hyperproduction





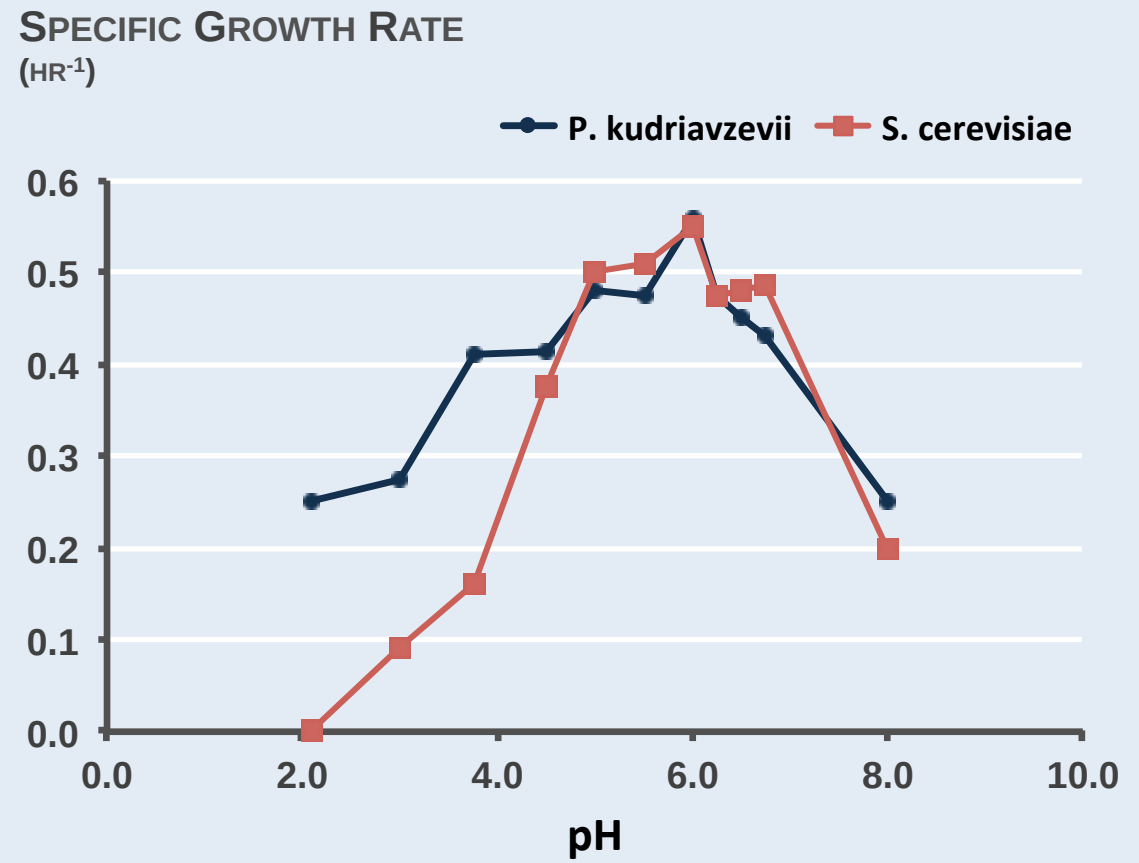
Orotic acid



Uracil

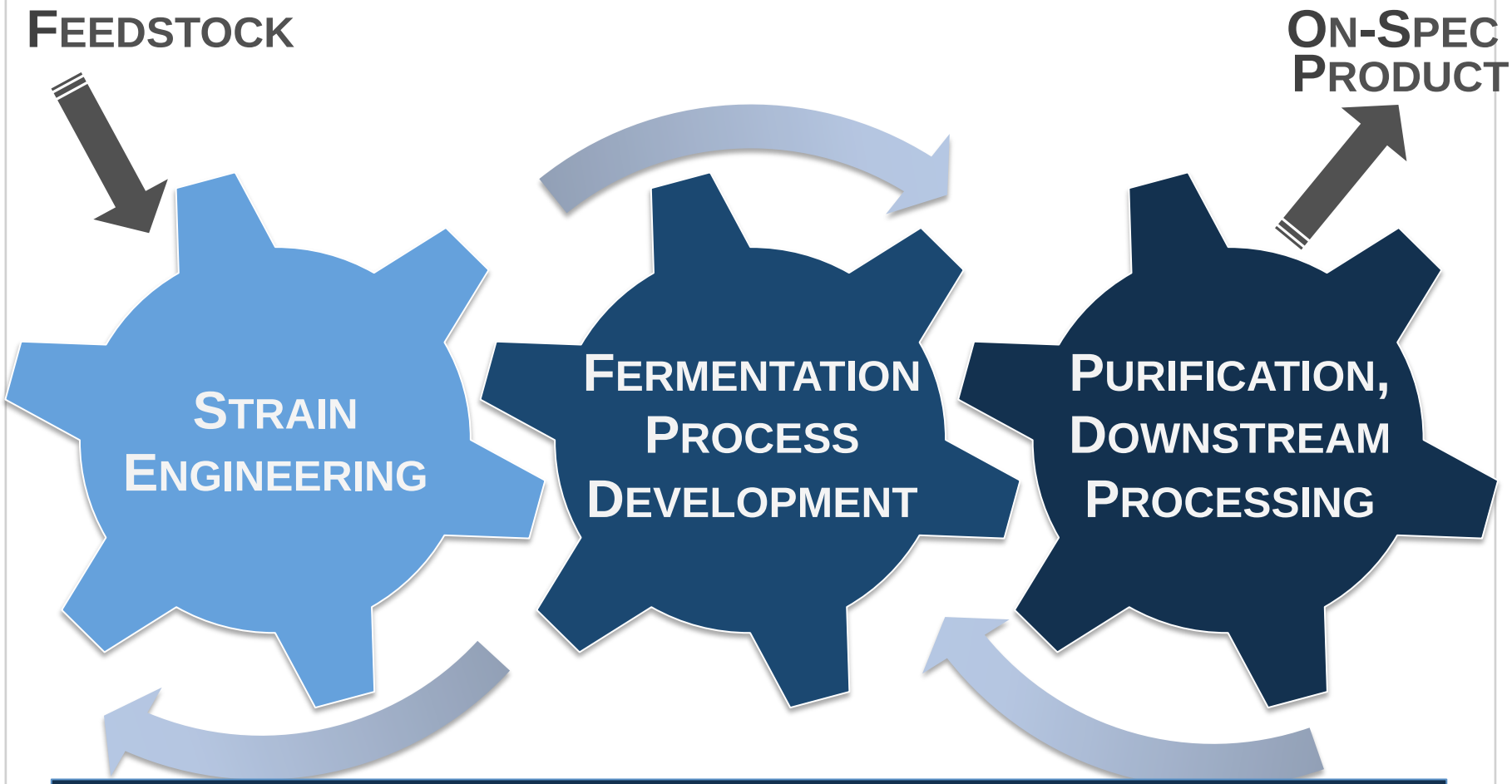
Adapted from Asahi, S et al. *BioSci. Biotech. Biochem.* 57:6 (1993)

Fermentation Process Development: Use Production Hosts that Fit Into an Integrated Process

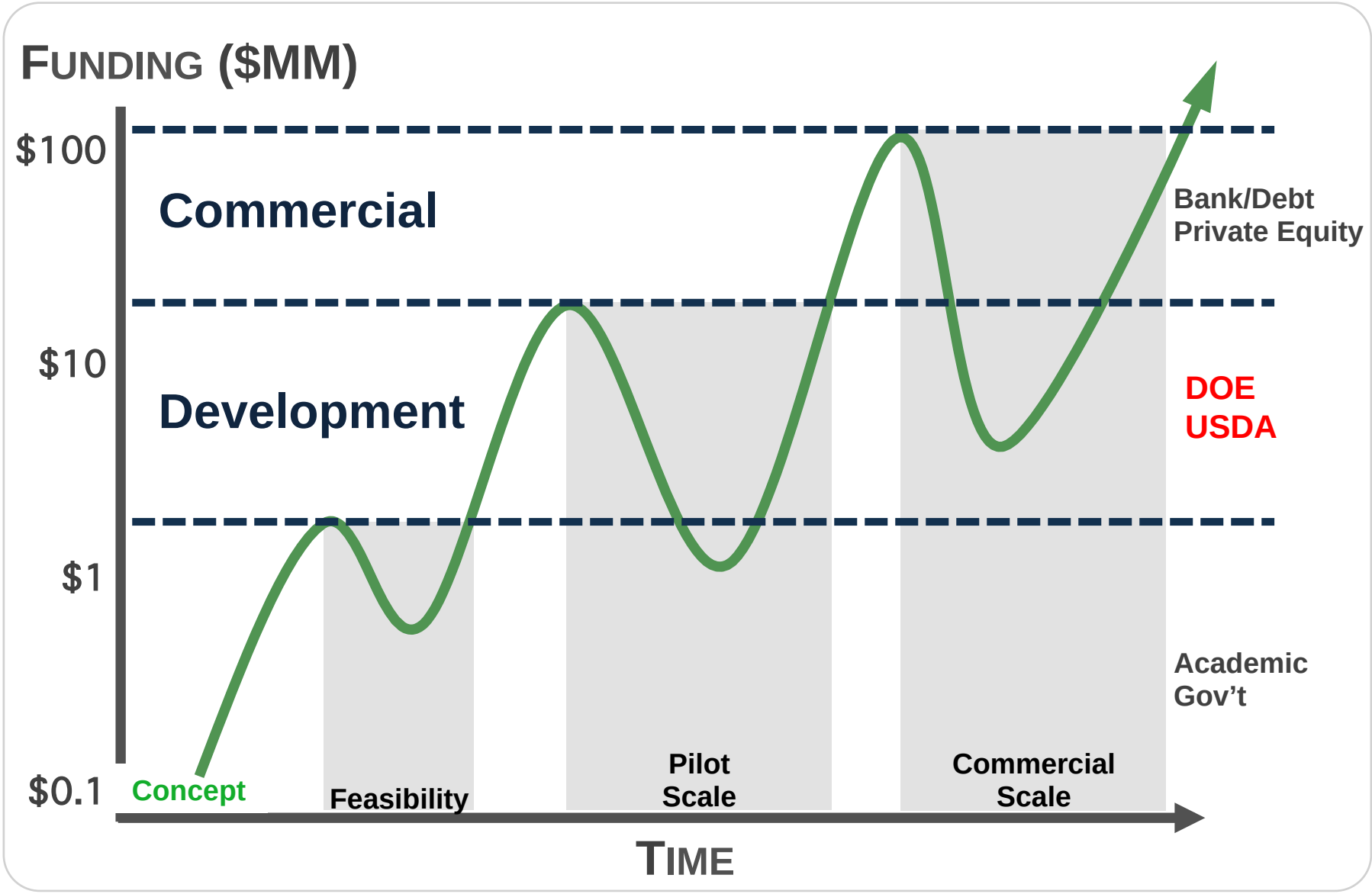


- *P. kudriavzevii* exhibits better pH tolerance than *S. cerevisiae*
- Reduces the amount of base required in a fermentation

Design, Build, Test of the Integrated Process



Industrial BioTech Faces Three “Valleys of Death”



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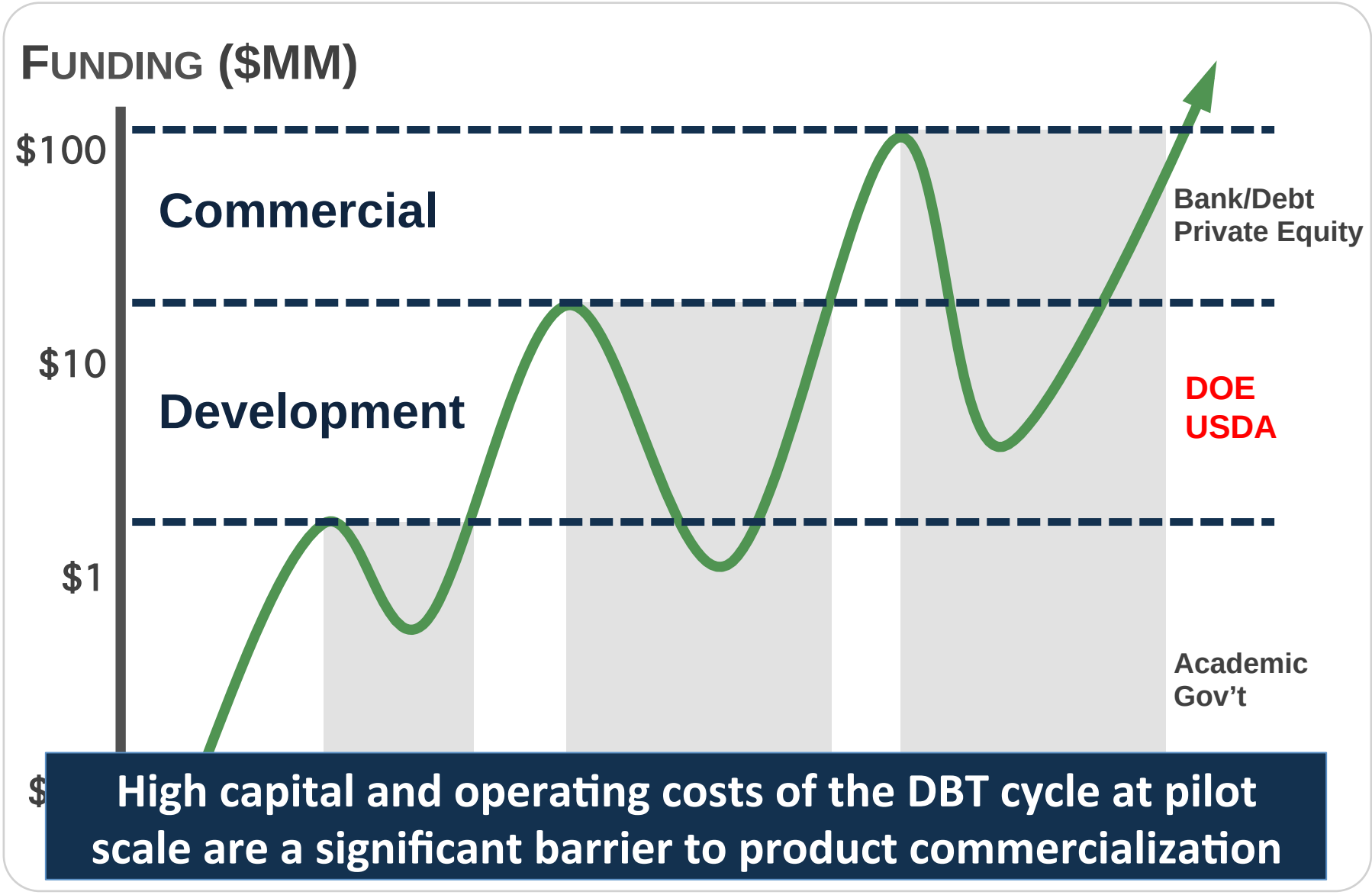
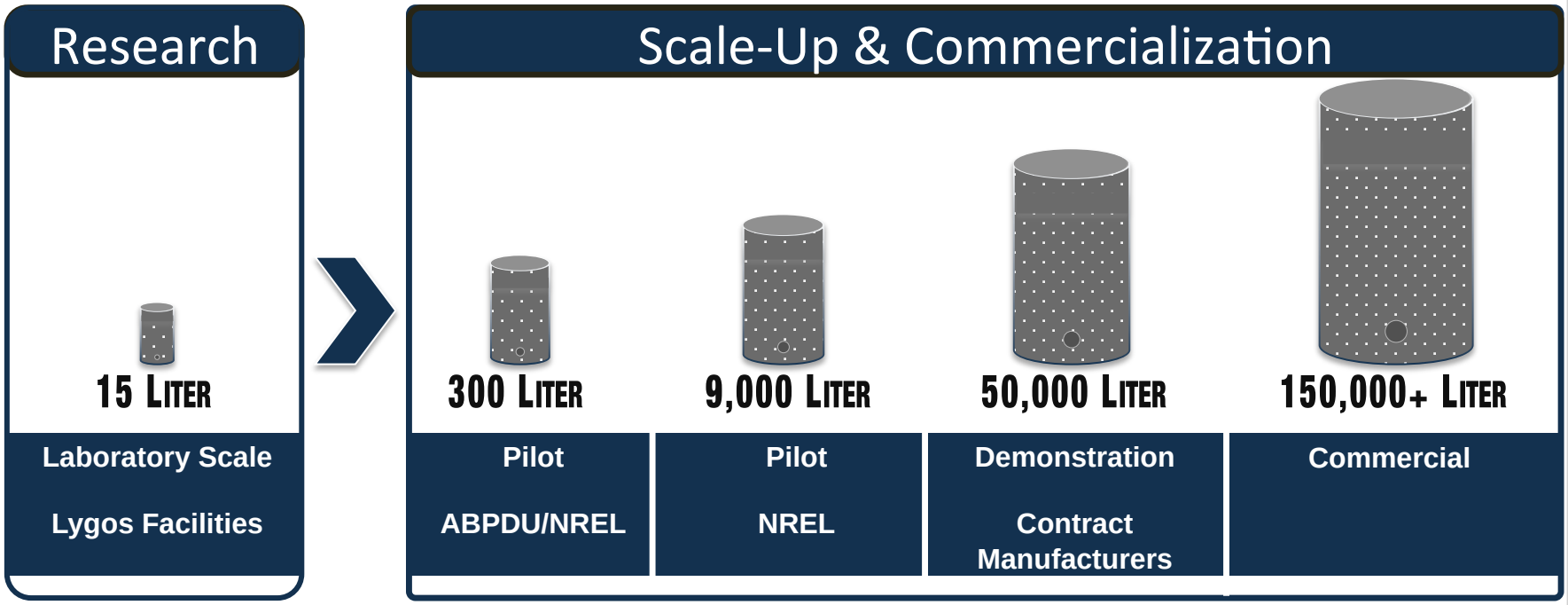
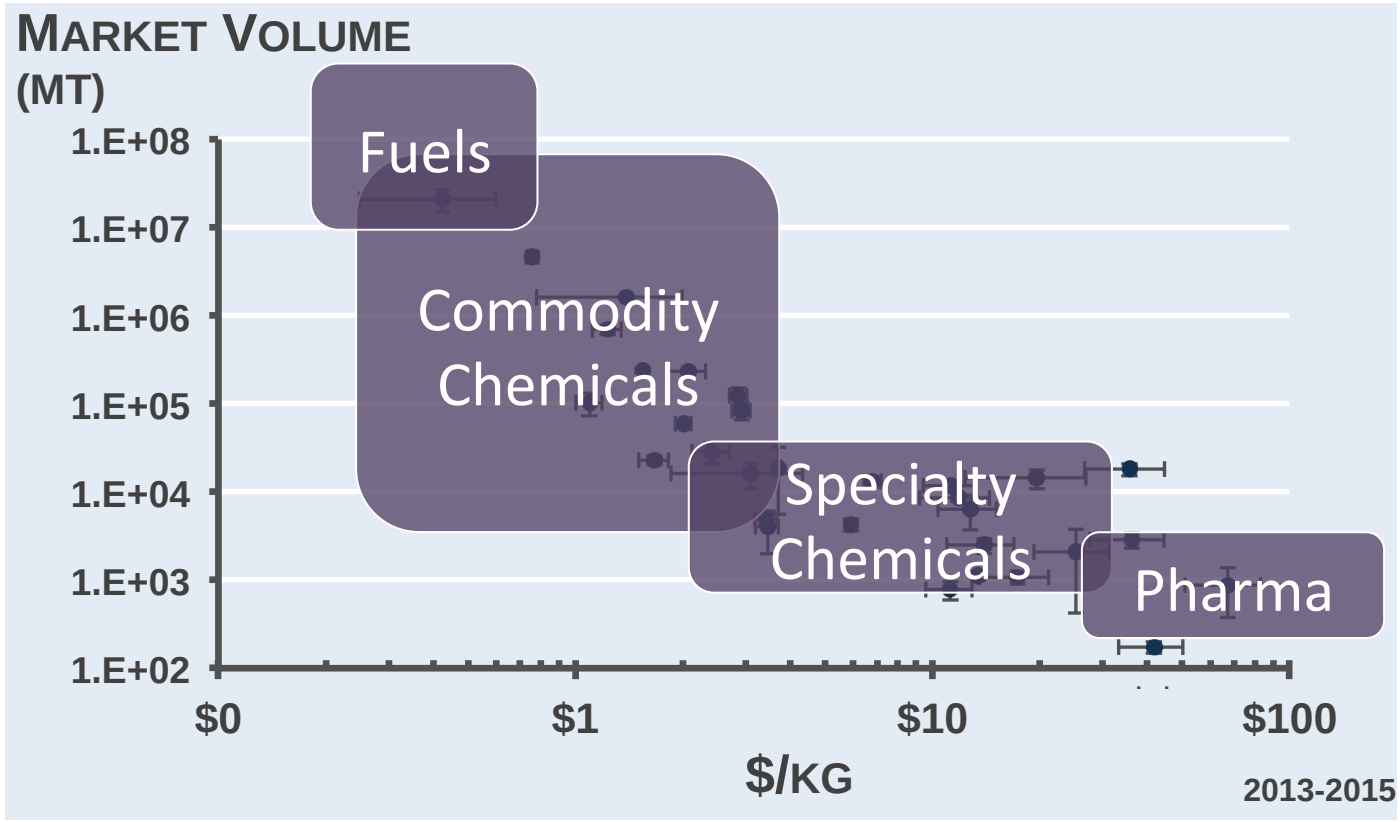


Using Contract Manufacturing For Scaleup



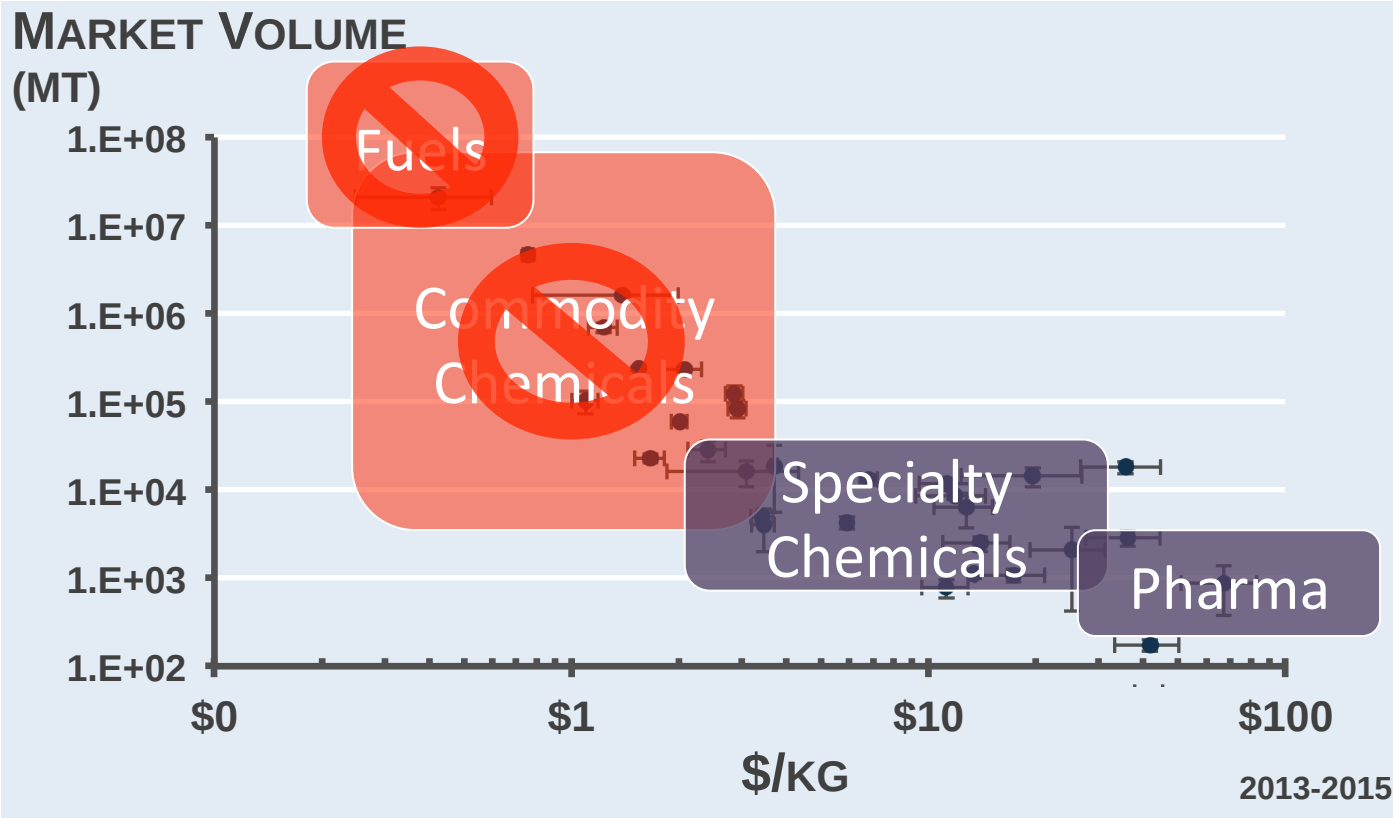
- DOE small business voucher facilitates pilot scaleup to 9,000 liter fermenters
- High malonic acid price points allow for contract manufacturing and break-even economics

Using Contract Manufacturing to Bridge Valley of Death



High contract manufacturing costs preclude break-even production of fuels and commodity chemicals

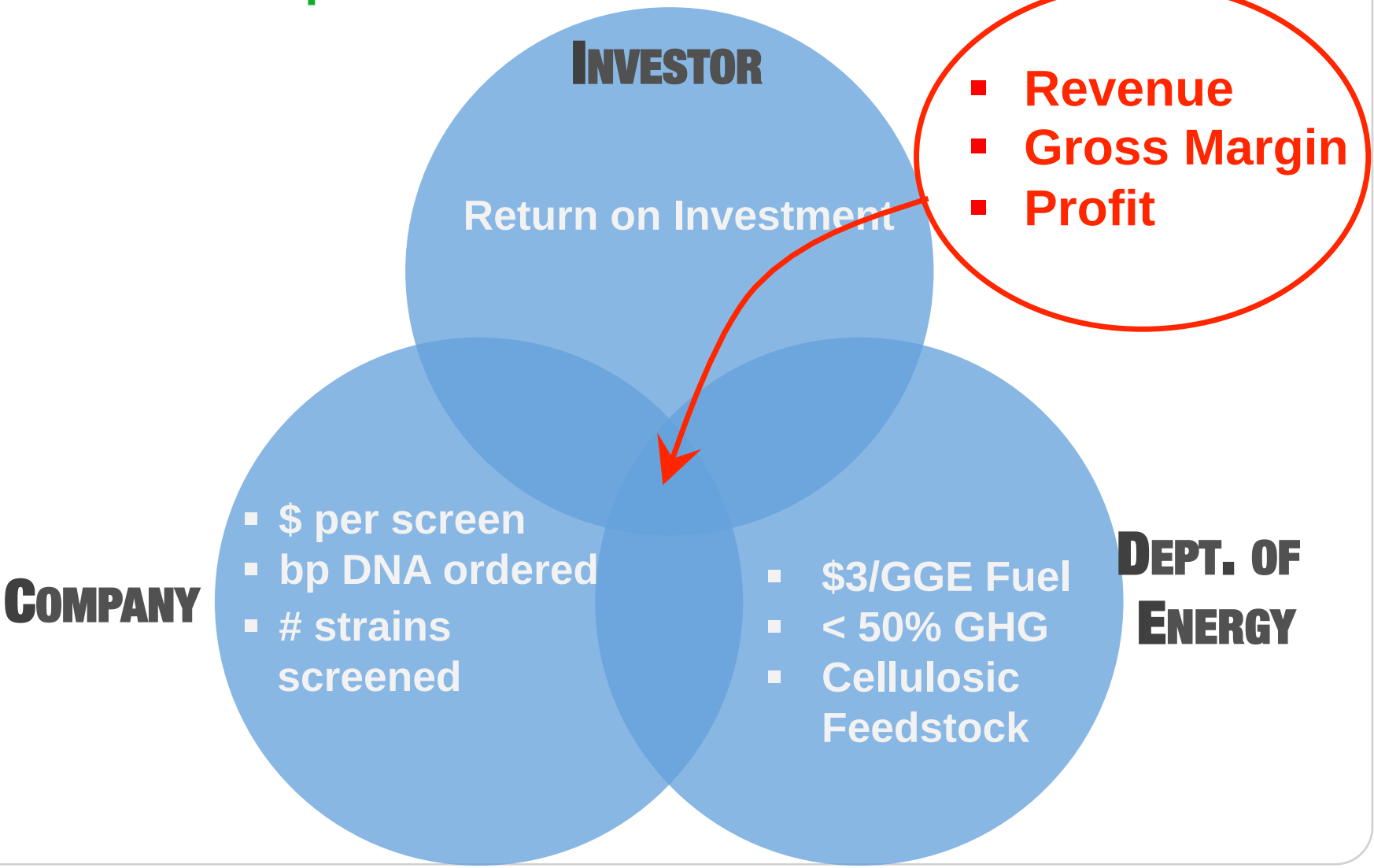
Using Contract Manufacturing to Bridge Valley of Death



Commercialization of fuels and commodity chemicals becomes more costly, time consuming, and difficult

DBTL Cycles: Need to Align Stakeholder Incentives

Representative Stakeholder Metrics



Thank You

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