



Microbial engineering for renewable energy and sustainable manufacturing

José L. Avalos

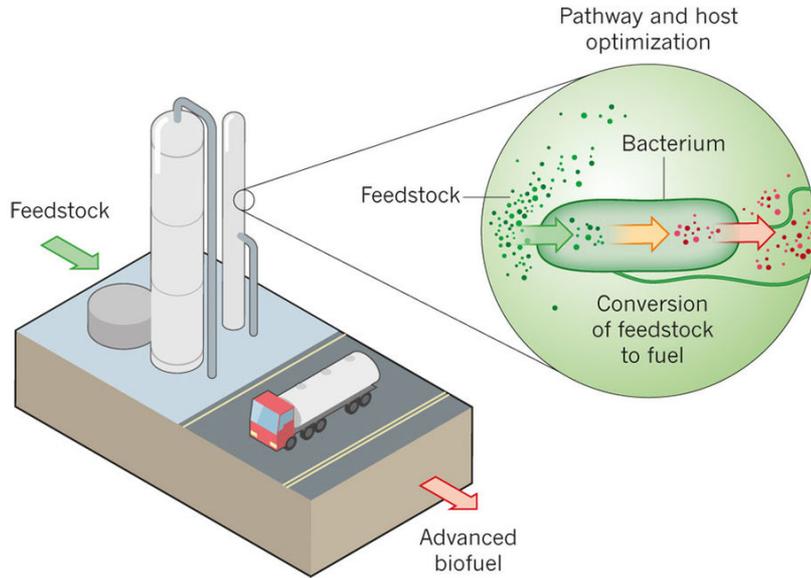
Chemical and Biological Engineering

Andlinger Center for Energy and the Environment

November 9th, 2018 Annual Meeting

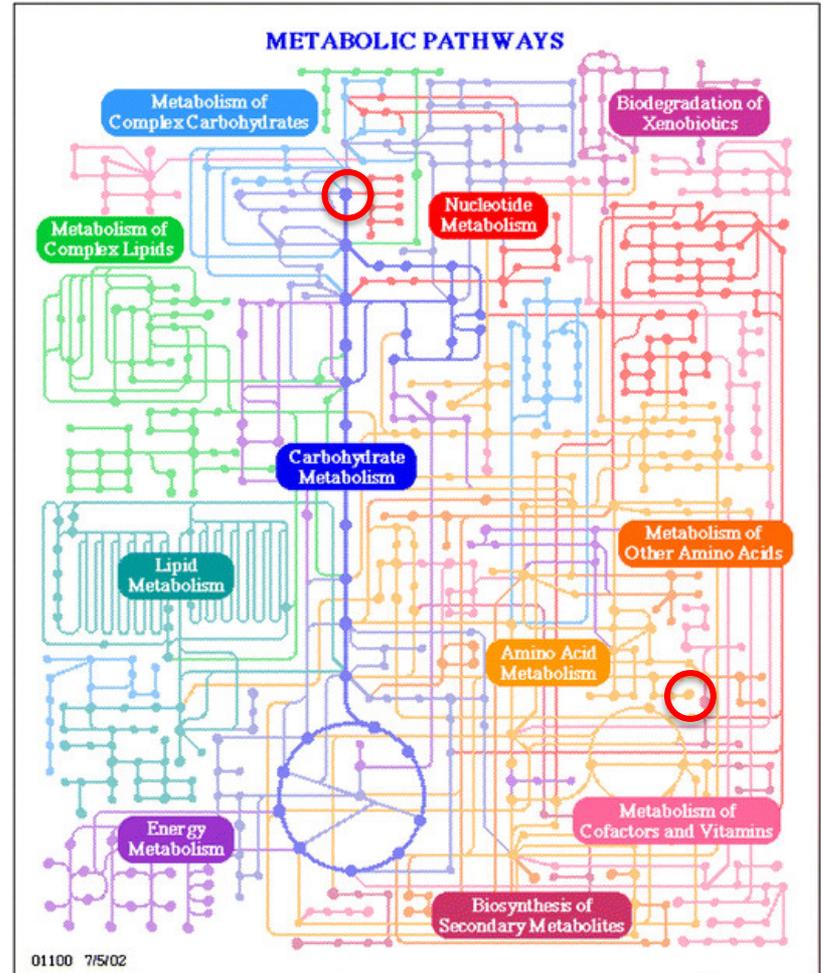


Microbial Engineering: Metabolic Engineering

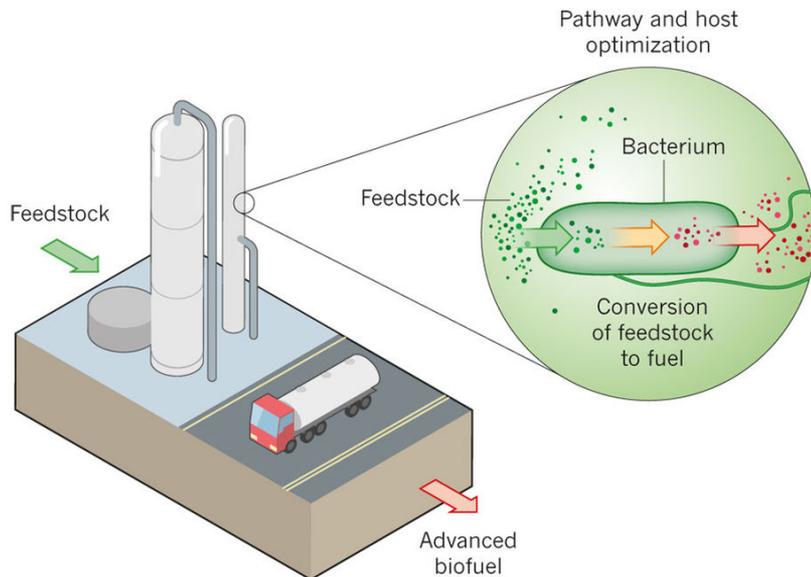


Nature **488**, 320-328 (16 August 2012)

- Biofuels
- Commodity chemicals
- Specialty chemicals
- Pharmaceuticals
- Food

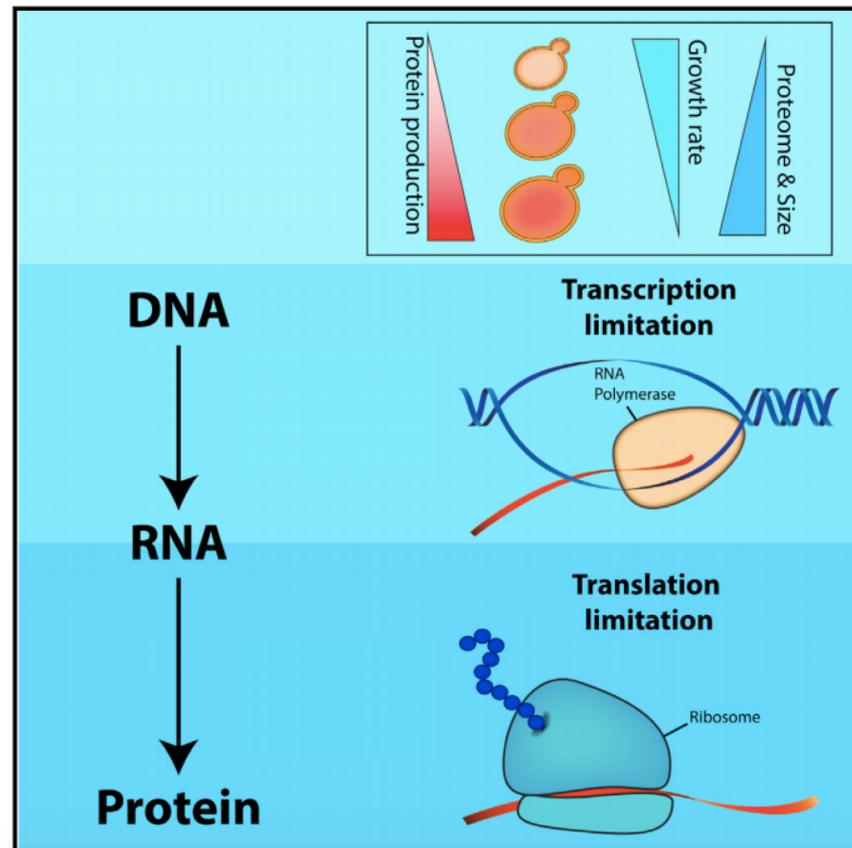


Microbial Engineering: Protein Production



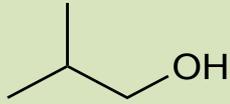
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- Biofuels
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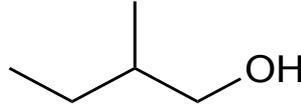


Adapted from Kafri, M. et.al. *Cell Reports* (2015)

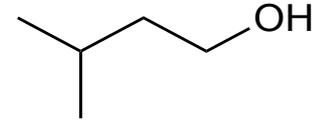
Advanced Biofuels: Branched-chain higher alcohols (BCHAs)



Isobutanol (C4)



2-methyl-1-butanol (C5)



3-methyl-1-butanol (C5)

Butamax™
Advanced
Biofuels LLC

A joint venture between BP and DuPont



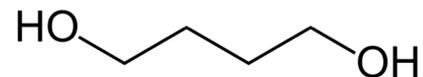
gevo®



Commodity Chemicals: Diols



1,3-Propanediol



1,4-Butanediol

Polyurethanes



Unsaturated polyester resins



Heat-transfer fluids



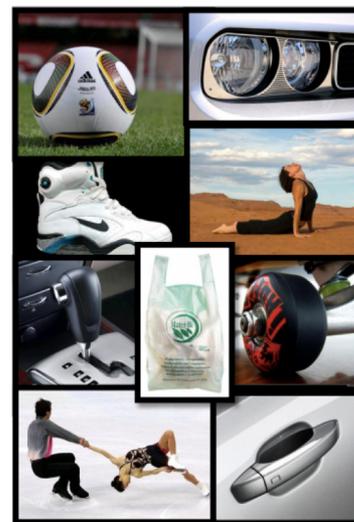
Solar and Geothermal systems



Low-temperature, food-safe fluids



Engine coolants



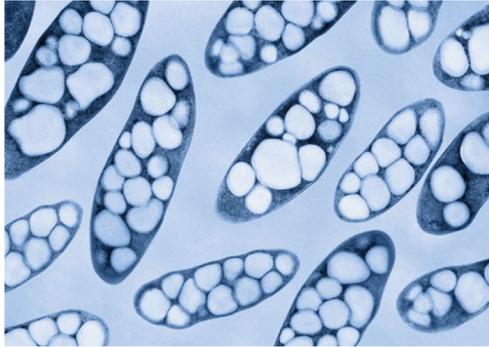
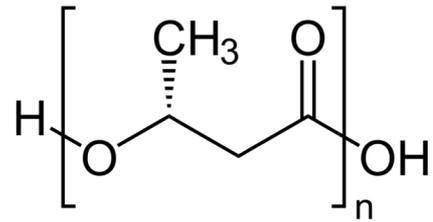
Deicing fluids



Bio-based Chemicals



Bioplastics: Polyhydroxyalkanoates (PHAs)



Biodegradable fibers: Polyhydroxyalkanoates (PHAs)



Bolt
Threads



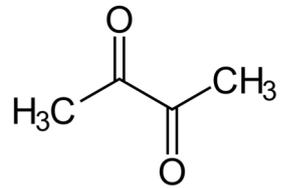
Animal substitutes: Food and materials



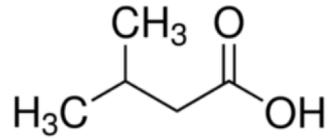
**Leather as you like it.
Just no cow.**



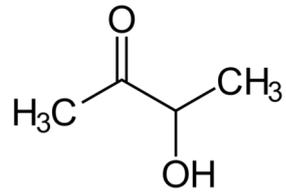
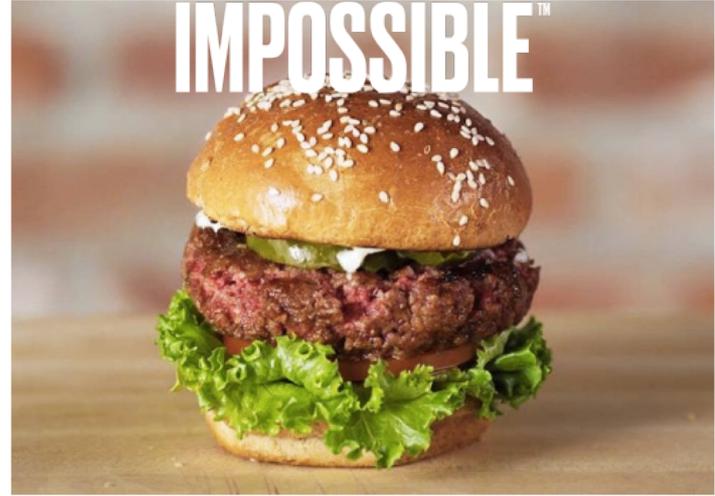
Flavors



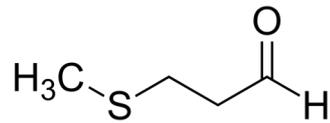
Diacetyl



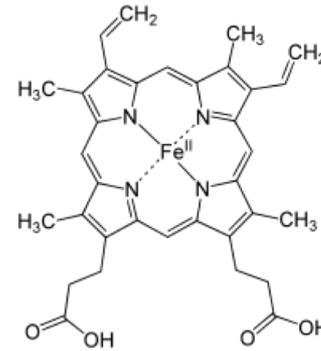
Isovaleric acid



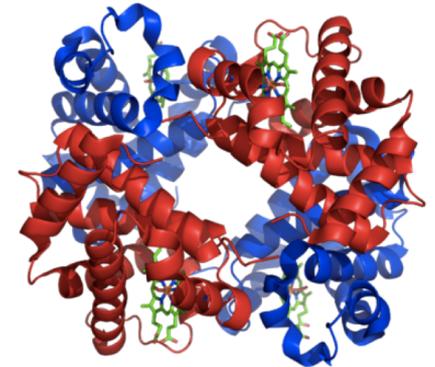
Acetoin



Methional

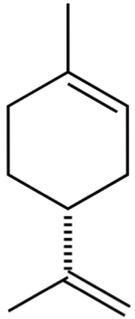


Heme

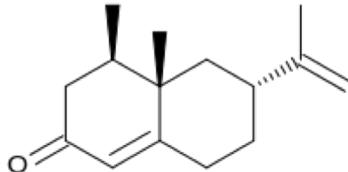


Hemoglobin

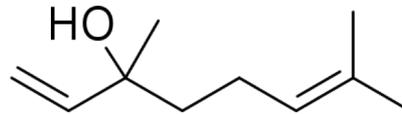
Fragrances



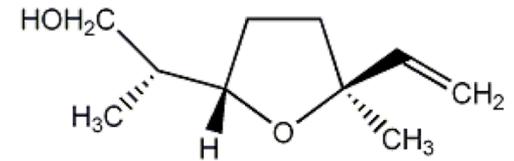
Limonene



Nootkatone



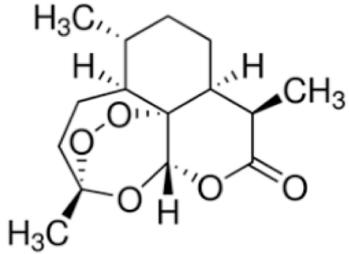
Linalool



Lilac alcohol

Pharmaceuticals

Artemisinin



Artemisia annua

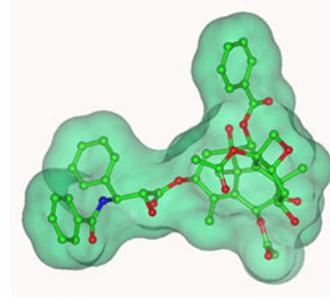


Tu Youyou



2015

Taxol

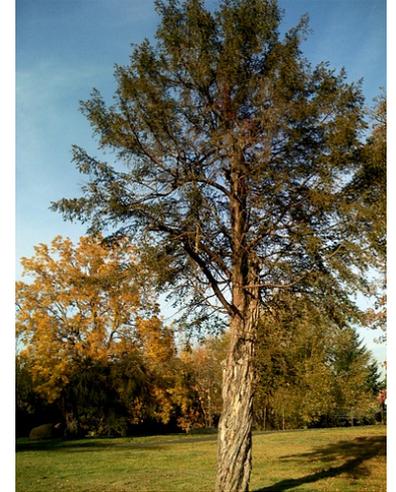


2-4, 100 year-old trees
to treat 1 patient

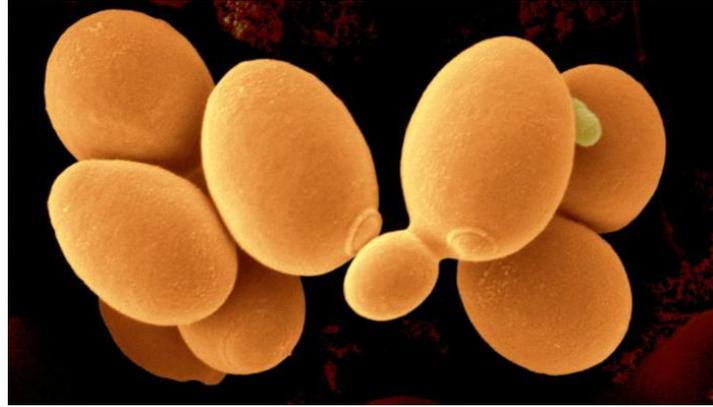


\$13,000 - \$20,000 / week

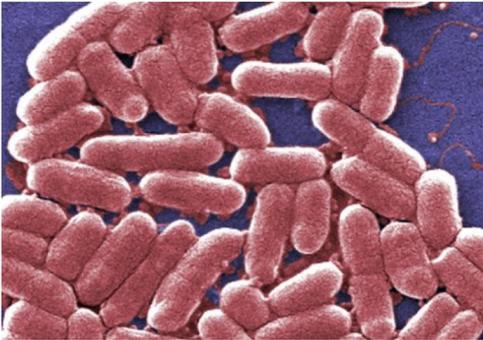
Pacific Yew



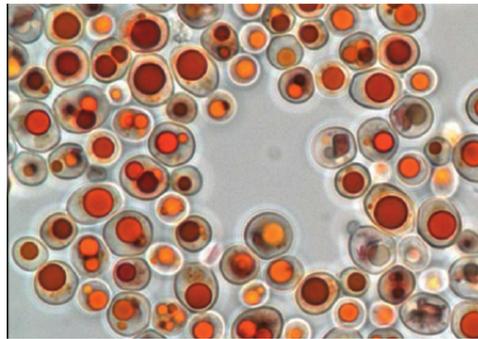
Spatial and temporal control of metabolic pathways to boost production



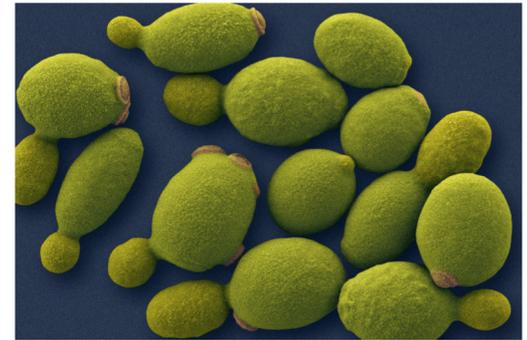
Saccharomyces cerevisiae



Escherichia coli



Yarrowia lipolytica

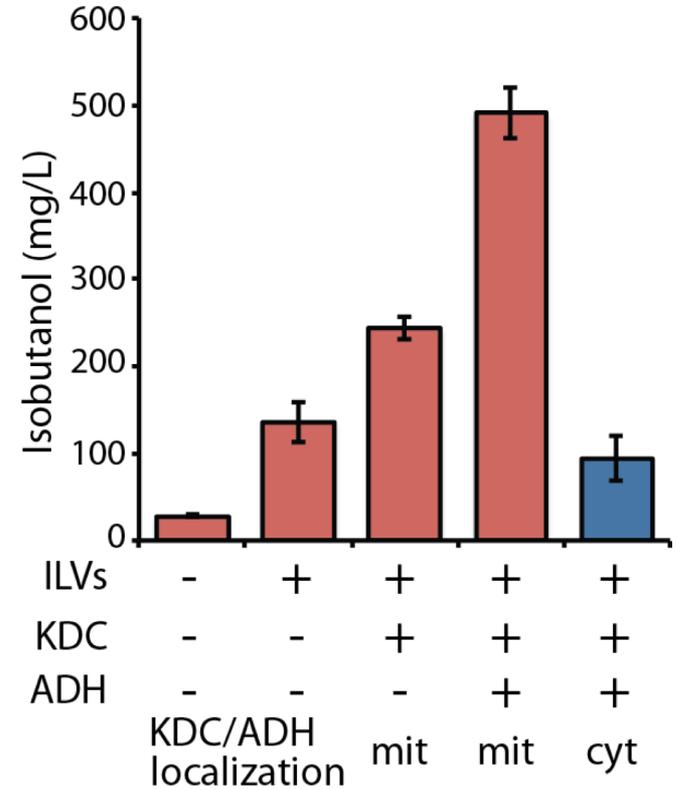


Pichia pastoris

Organelle compartmentalization: Mitochondria

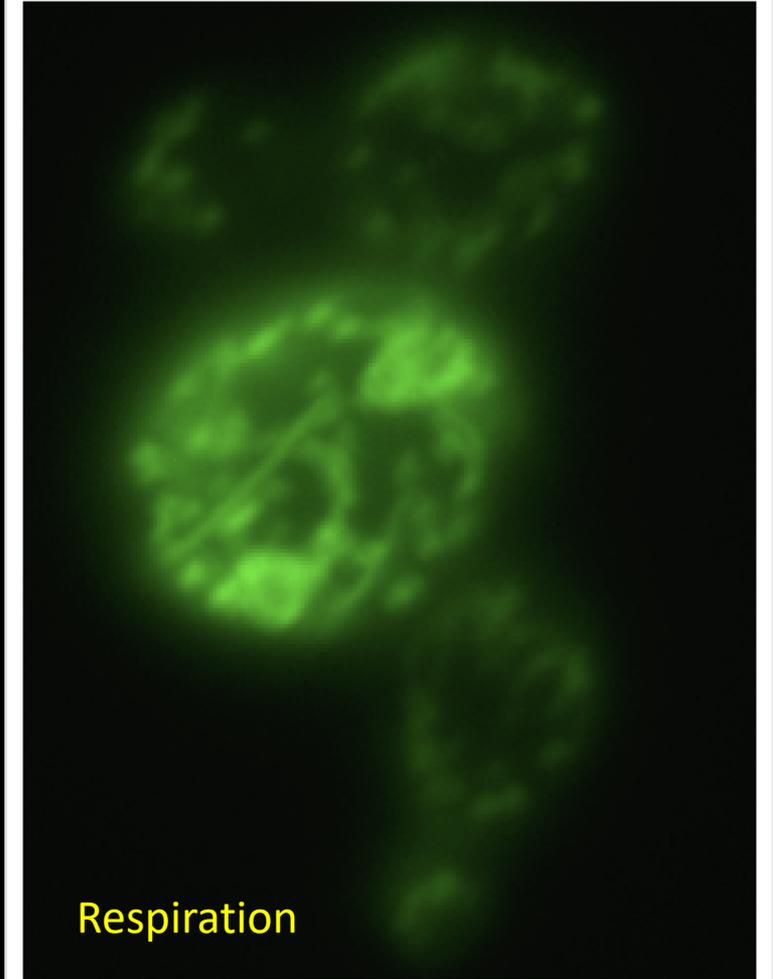
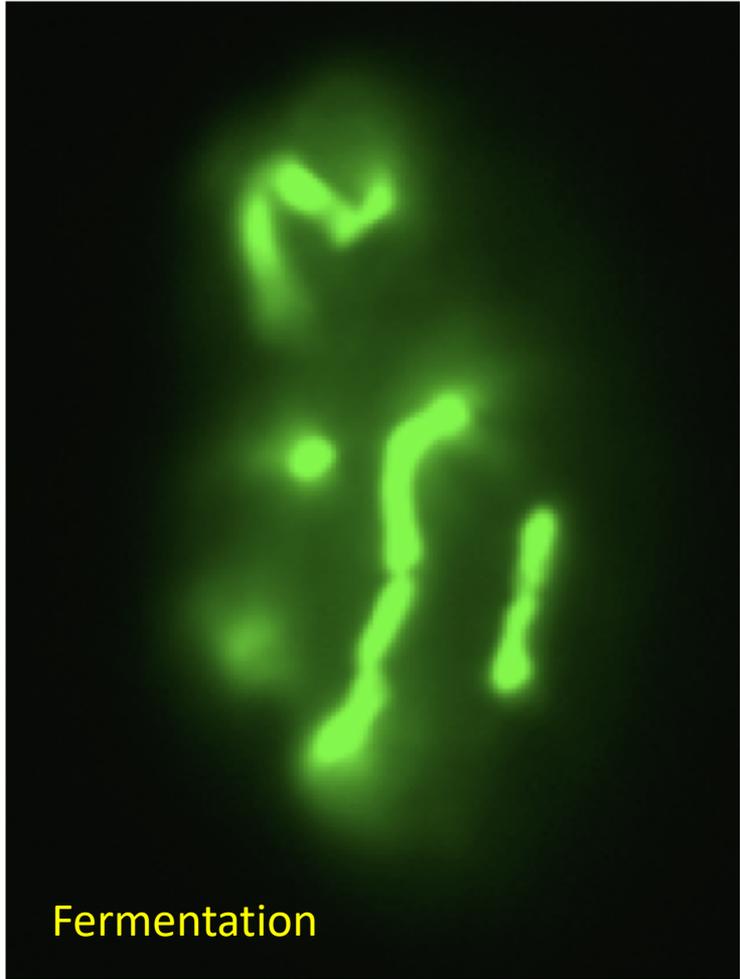


Image: flickr.com/col_and_tasha;National Botanic Garden of Wales

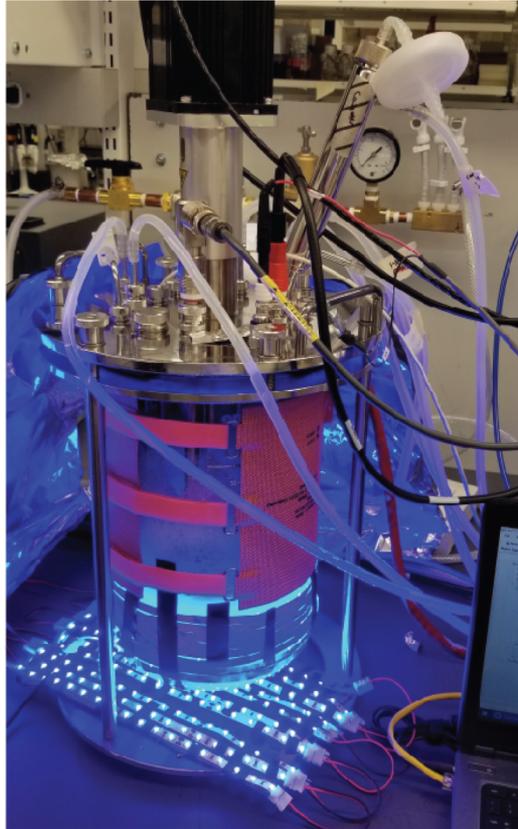


Avalos J.L. et.al., *Nature Biotech* (2013)

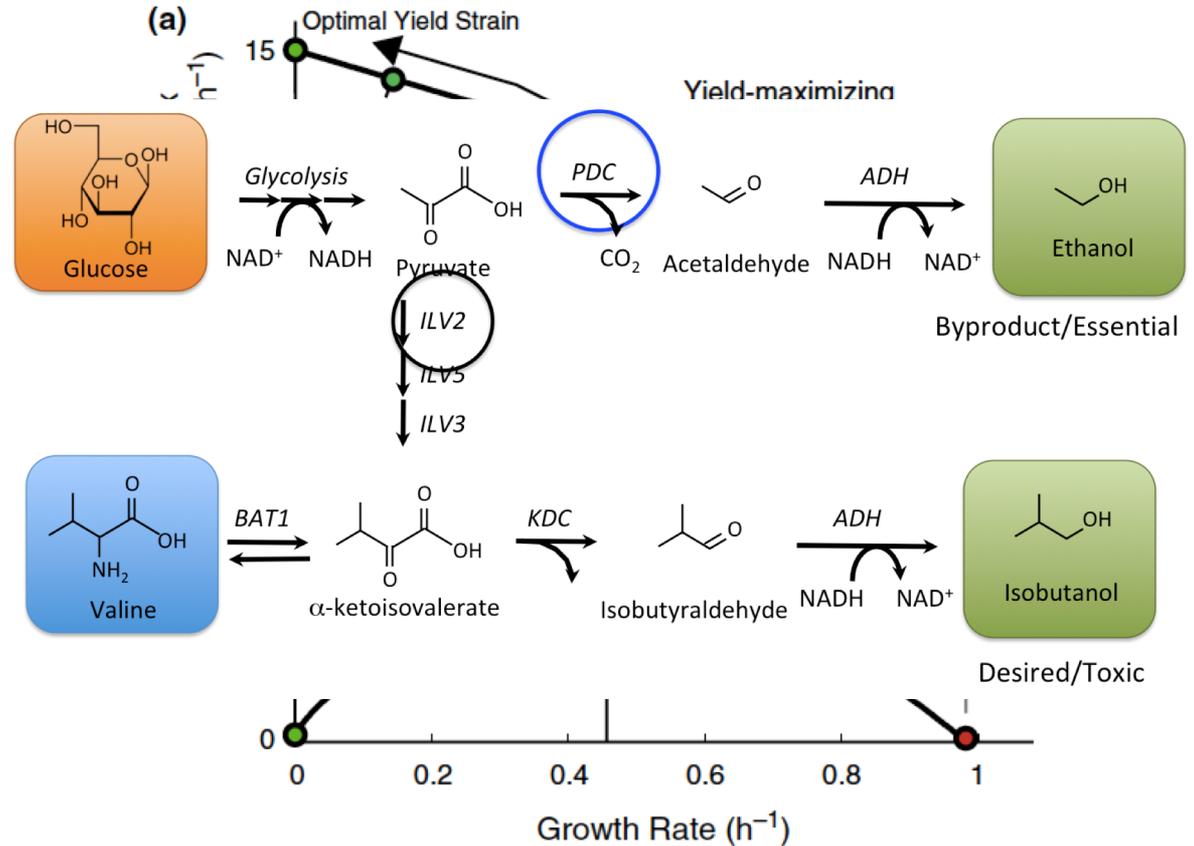
Mitochondrial morphology and dynamics



Dynamic control: Optogenetics



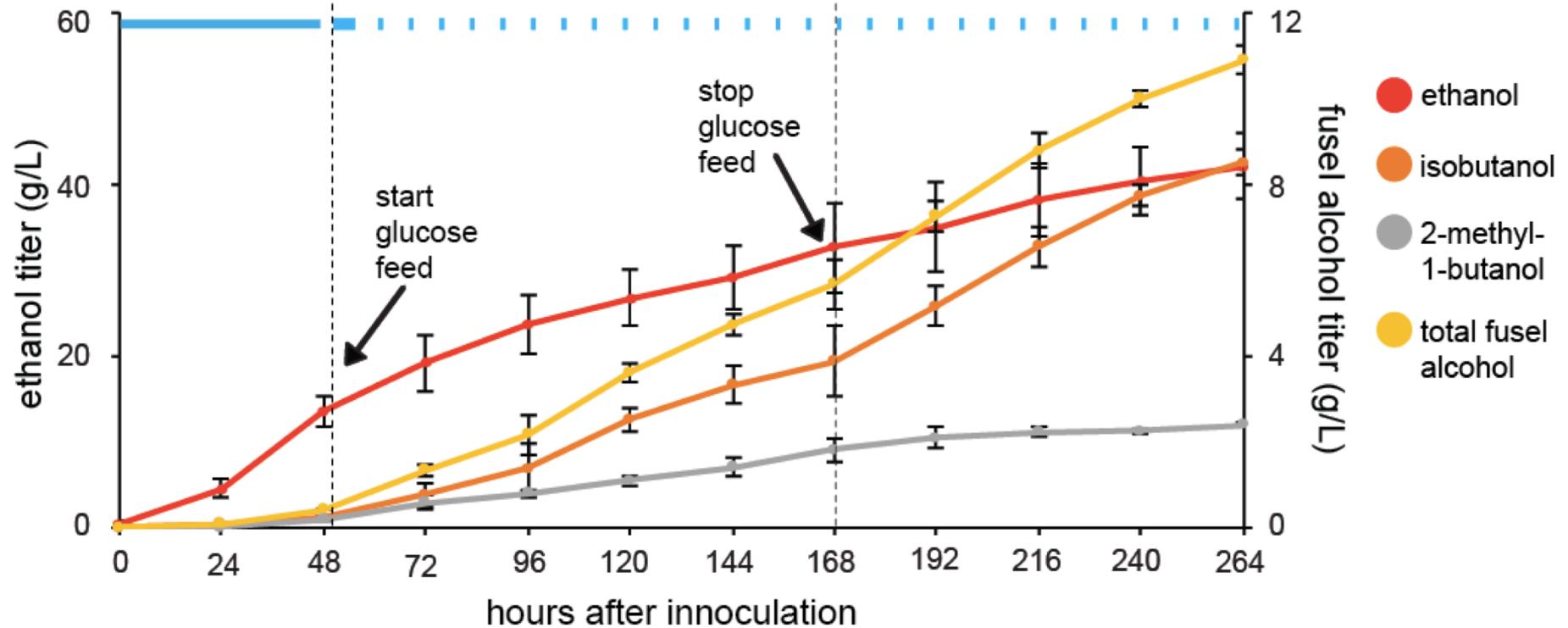
Zhao, E. et.al. *Nature* (2018)



Current Opinion in Biotechnology

Venayak, N. et.al. *Curr.Opin.Biotech* (2015)

Fed-batch bioreactor operated with periodic light pulses



Isobutanol titer: 8.49 ± 0.31 g/L

Isobutanol yield: 53.5 ± 8.4 mg/g

2-methyl-1-butanol titer: 2.38 ± 0.06 g/L

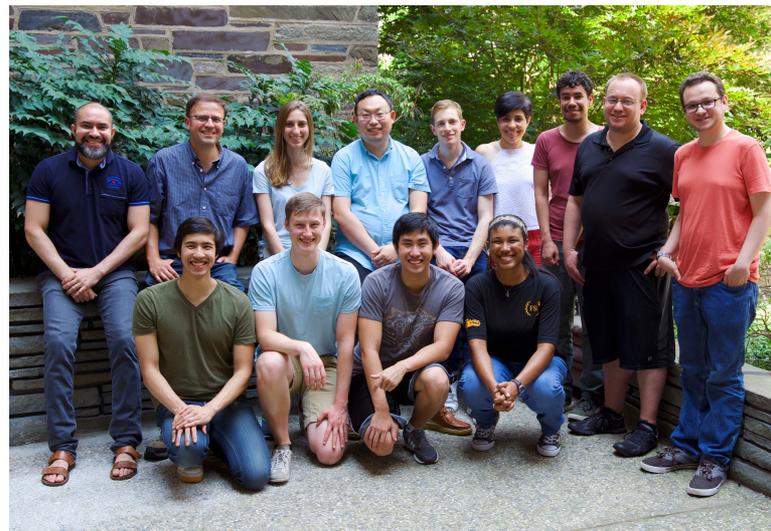
% Theoretical Isobutanol yield: 13%

Total fusel alcohol titer: 10.87 ± 0.06 g/L

Acknowledgements

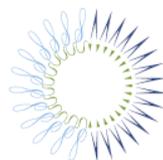


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