Types of liquid fuels.

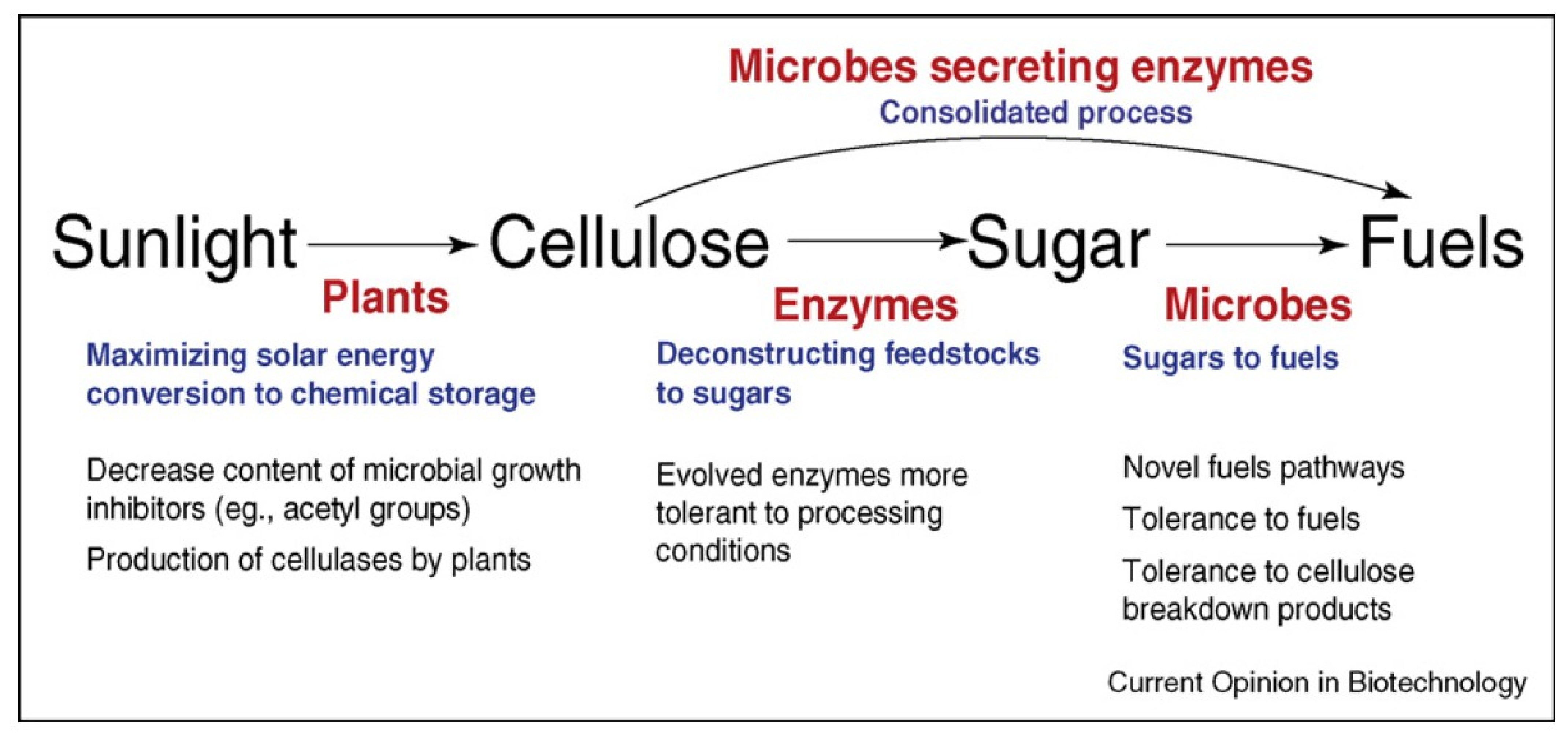
Fuel type	Major components	Important property	Biosynthetic alternatives
Gasoline	C_4–C_{12} hydrocarbons	Octane number[a]	Ethanol, *n*-butanol and *iso*-butanol
	Linear, branched, cyclic, aromatics	Energy content[b]	Short chain alcohols
	Anti-knock additives	Transportability	Short chain alkanes
Diesel	C_9–C_{23} (average C_{16})	Cetane number[c]	Biodiesel (FAMEs)
	Linear, branched, cyclic, aromatic	Low freezing temperature	Fatty alcohols, alkanes
	Anti-freeze additives	Low vapor pressure	Linear or cyclic isoprenoids
Jet fuel	C_8–C_{16} hydrocarbons	Very low freezing temperature	Alkanes
	Linear, branched, cyclic, aromatic	Net heat of combustion	Biodiesel
	Anti-freeze additives	Density	Linear or cyclic isoprenoids

[a] A measurement of its resistance to knocking. Knocking occurs when the fuel/air mixture spontaneously ignites before it reaches the optimum pressure and temperature for spark ignition.

[b] The amount of energy produced during combustion. The number of C–H and C–C bonds in a molecule is a good indication of how much energy a particular fuel will produce.

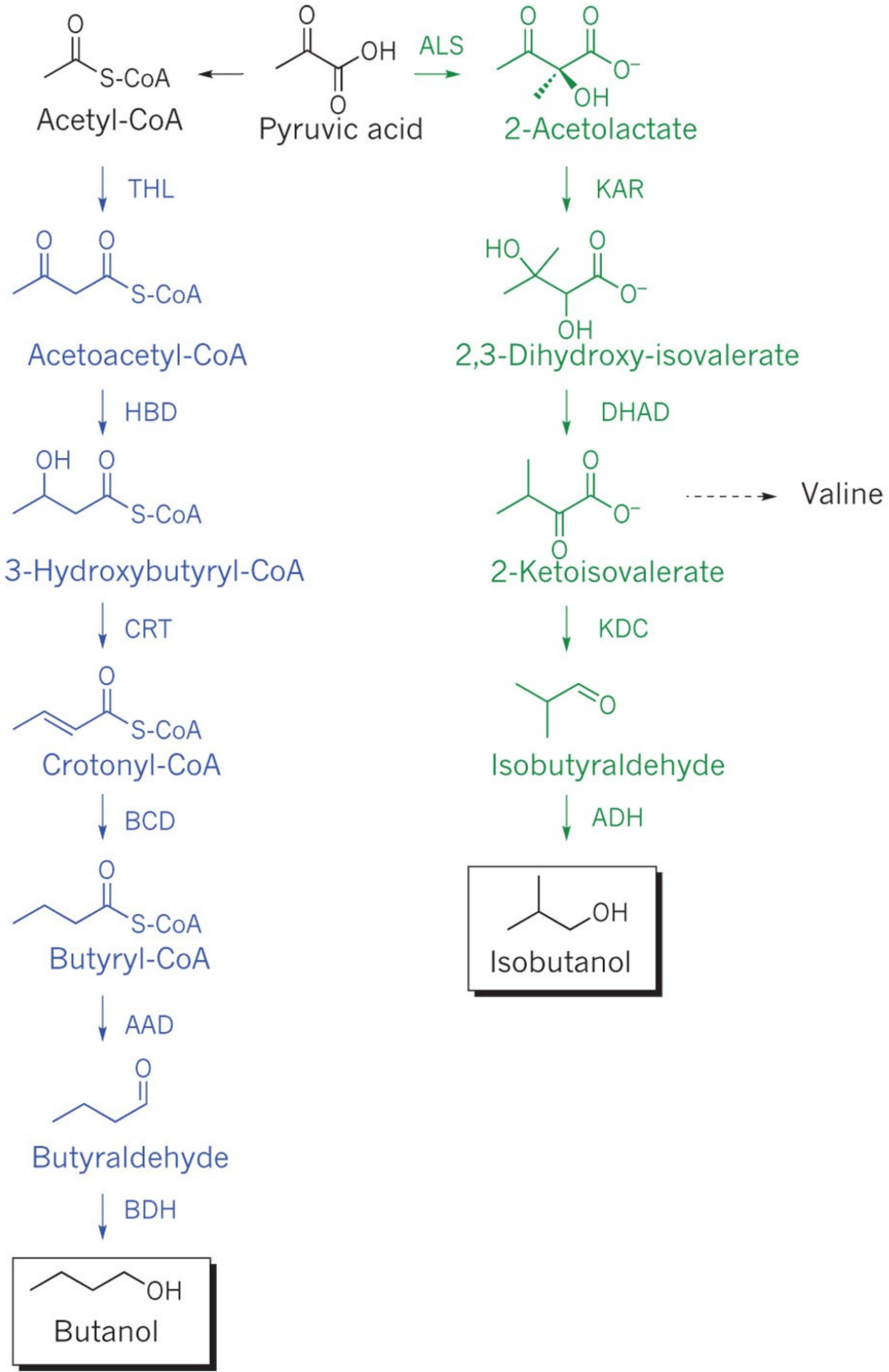
[c] A measurement of the combustion quality of diesel fuel during compression ignition. A shorter ignition delay, the time period between the start of injection and start of combustion of the fuel is preferred, and the ignition delay is indexed by the cetane number.

Current Opinion in Biotechnology 19(6), 556–563 (2008)



Current Opinion in Biotechnology 19(6), 556–563 (2008)

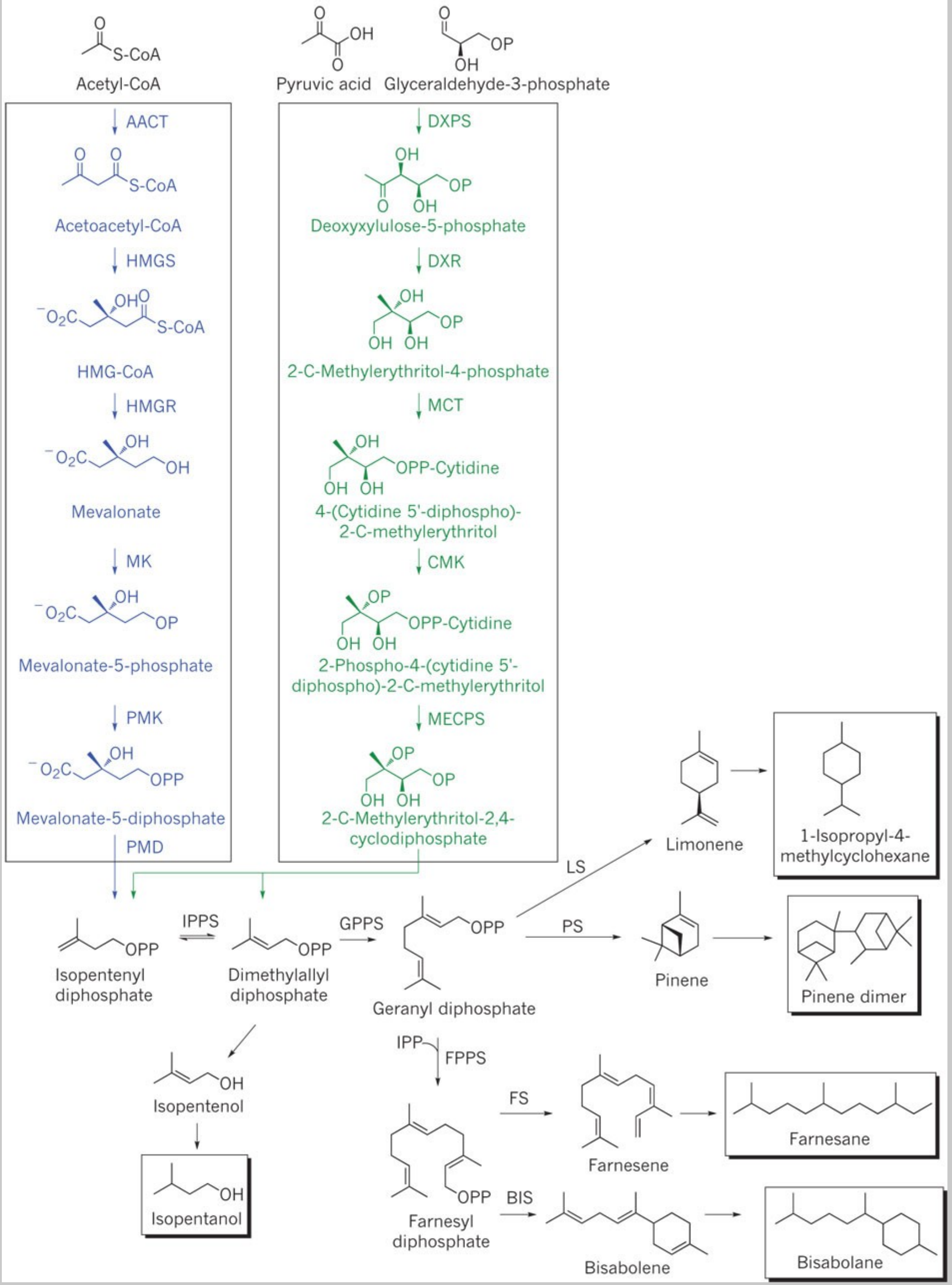
Butanolna pot pri klostridijih



Pot 2-keto kislin

Nature 488, 320–328 (2012)

Mevalonatna pot (modro) in
pot deoksiksiluloza-5-fosfata:
načini priprave izoprenoidnih goriv



Nature 488, 320–328 (2012)

Metabolne poti za pripravo biogoriv na osnovi maščobnih kislin in poliketidov

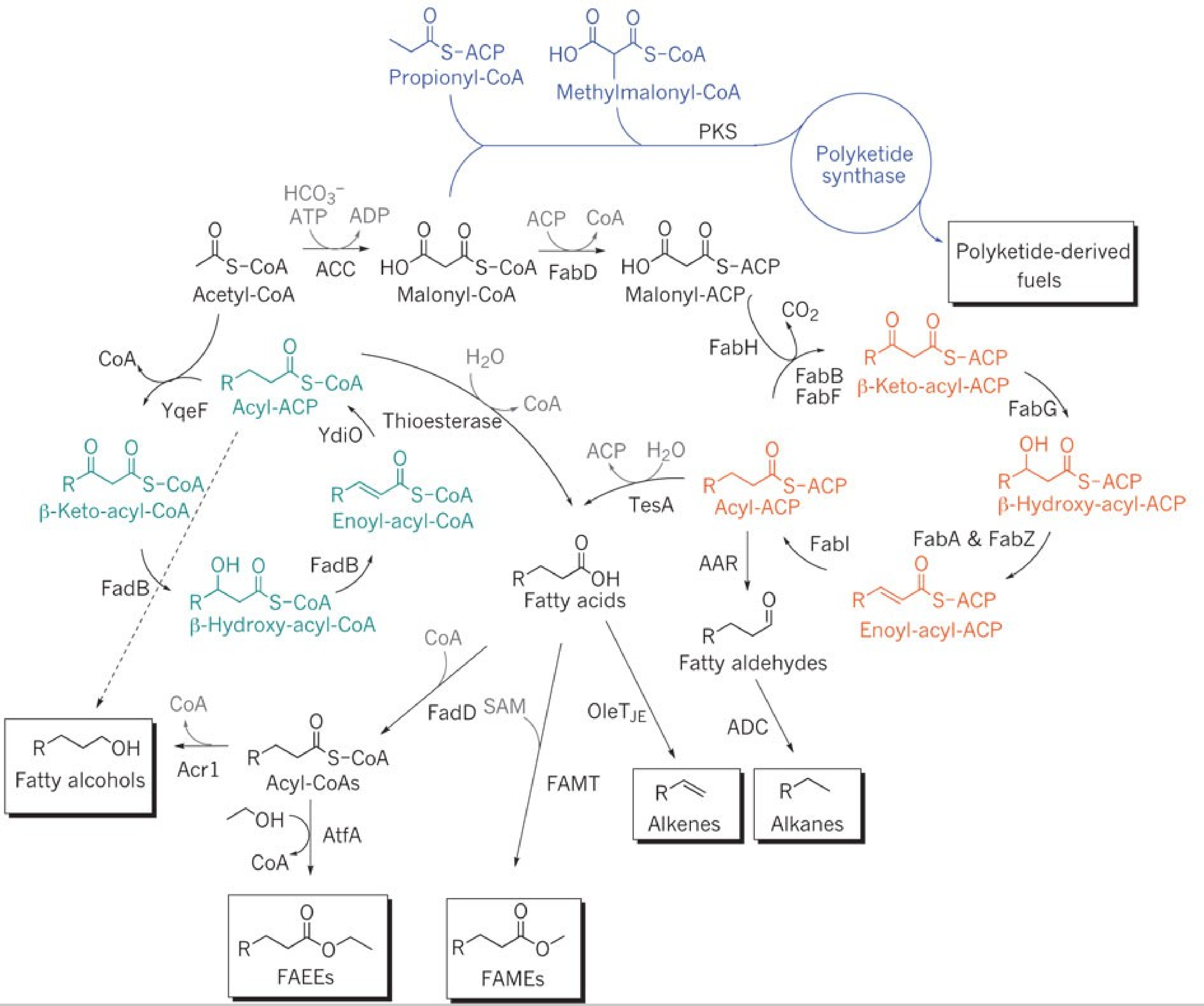


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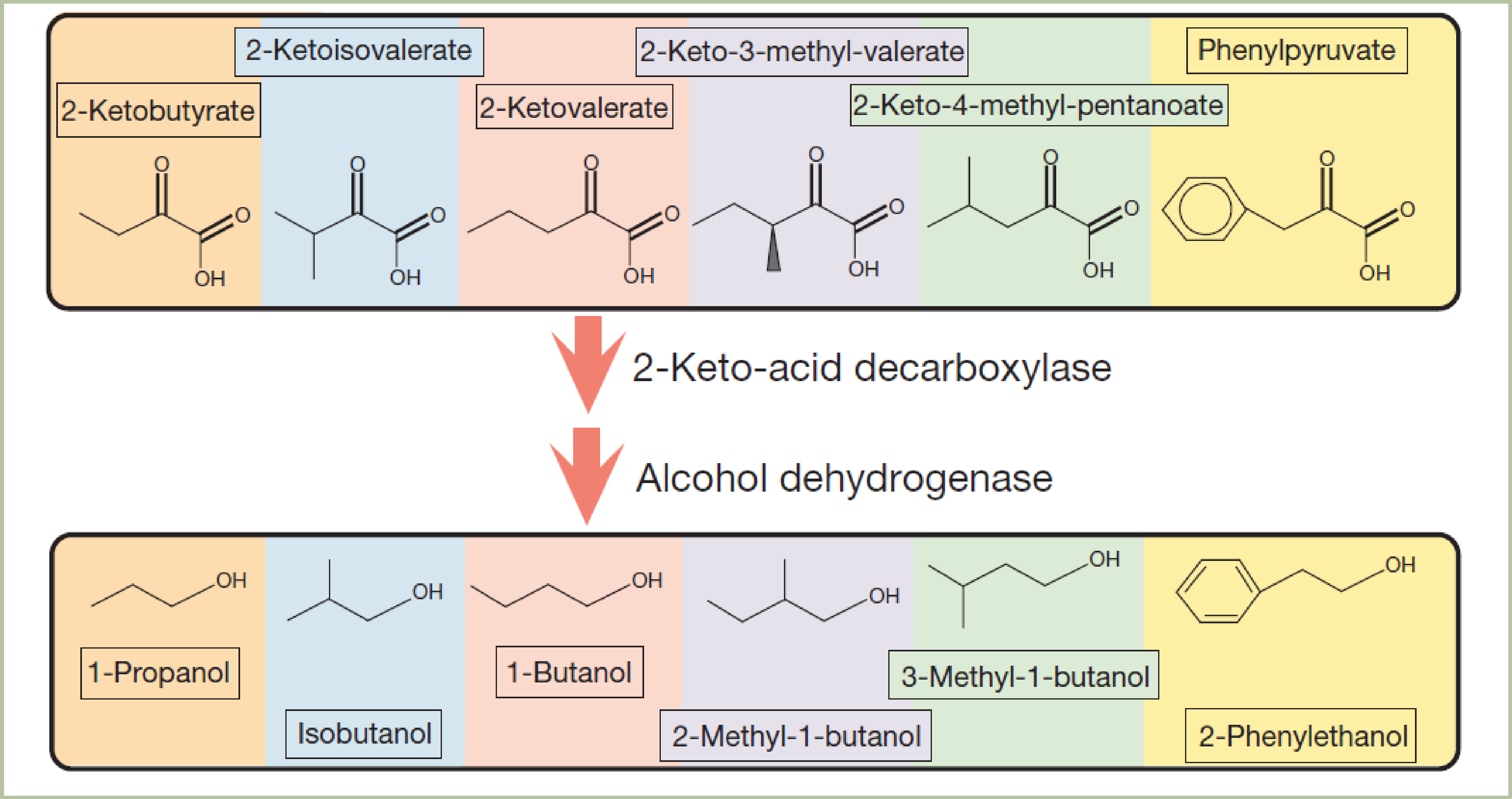
Table 2

Examples of different metabolic engineering strategies for increasing yields of various biofuels.

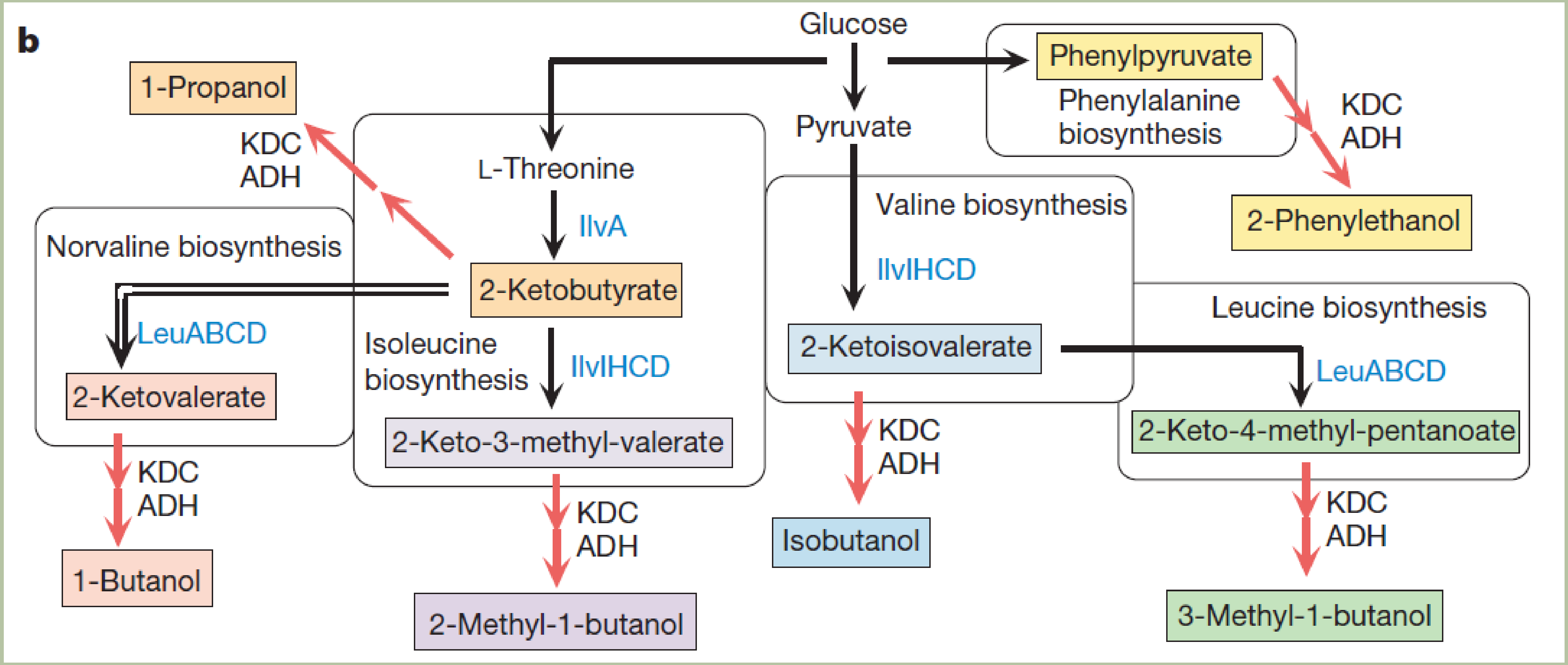
Biofuel	Strategy	Yield[a]	Reference
Ethanol	Engineering of phosphoketolase pathway to increase the availability of NAD^+ during xylose metabolism in *S. cerevisiae*	0.42	[29]
	Modulation of redox metabolism by modifying ammonium assimilation in order to increase xylose utilization by deleting GDH1 and overexpressing GDH2 in *S. cerevisiae*	0.34	[30]
	In silico gene insertion predicted that heterologous expression of *gapN* would increase ethanol yield and eliminate glycerol production in *S. cerevisiae* during growth on glucose and xylose	0.36	[48•]
	EM analysis directed knockout strategy optimized ethanol production from pentose and hexose and removed extraneous pathways in *E. coli*	0.36	[42]
Butanol	Expression of different gene combinations for butanol production in *E. coli* modeled after the *C. acetobutylicum* pathway; deletion of competing pathways; increased NADH availability	.0056	[18]
	Expression of different gene combinations for isobutanol production in *E. coli* modeled after the amino acid catabolic pathway; deletion of competing pathways; overexpression of valine biosynthetic genes	0.35	[4••]
Pentanol	Expression of different gene combinations for isopentanol production in *E. coli* modeled after the amino acid catabolic pathway; deletion of competing pathways; overexpression of leucine biosynthetic genes	0.11	[22]
Propanol	Expression of different gene combinations for propanol production in *E. coli* modeled after the *C. beijerinckii* pathway	0.14	[17]

[a] Reported yield [g biofuel/g carbon source].

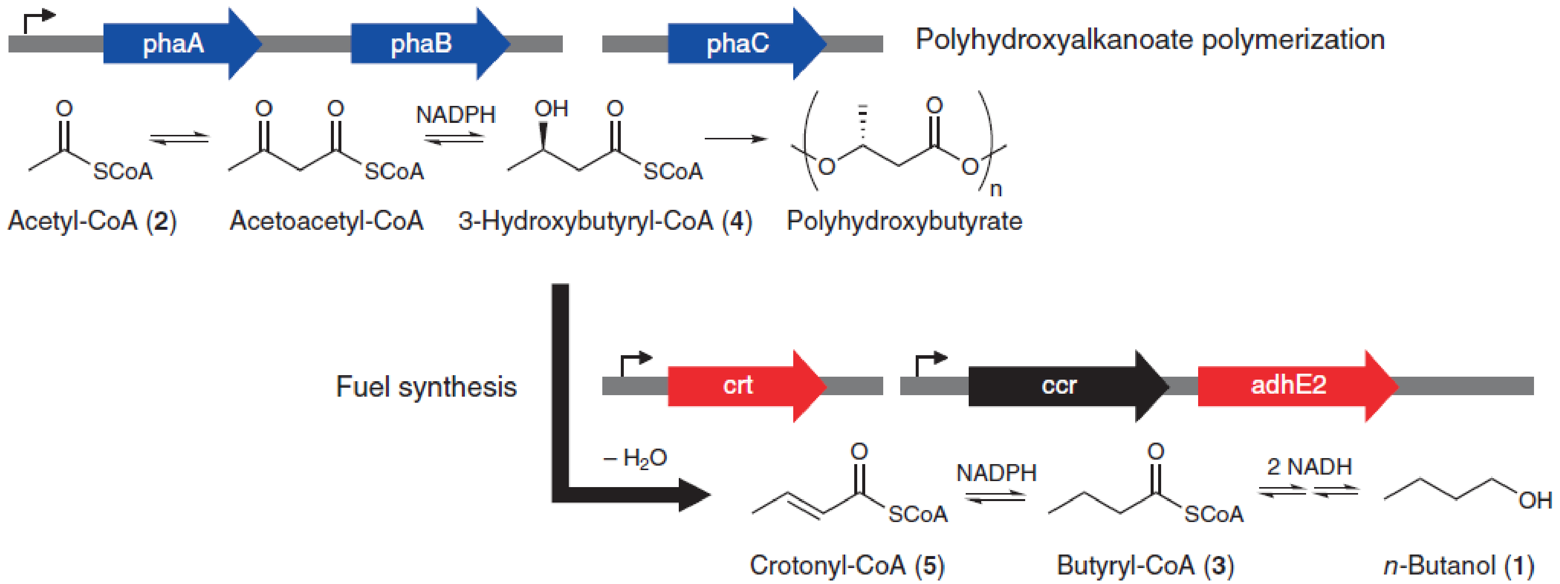


Nature 451, 86-90 (2008)

Preureditev biosintezne poti aminokislin v *E. coli* za prekomerno proizvodnjo višjih alkoholov



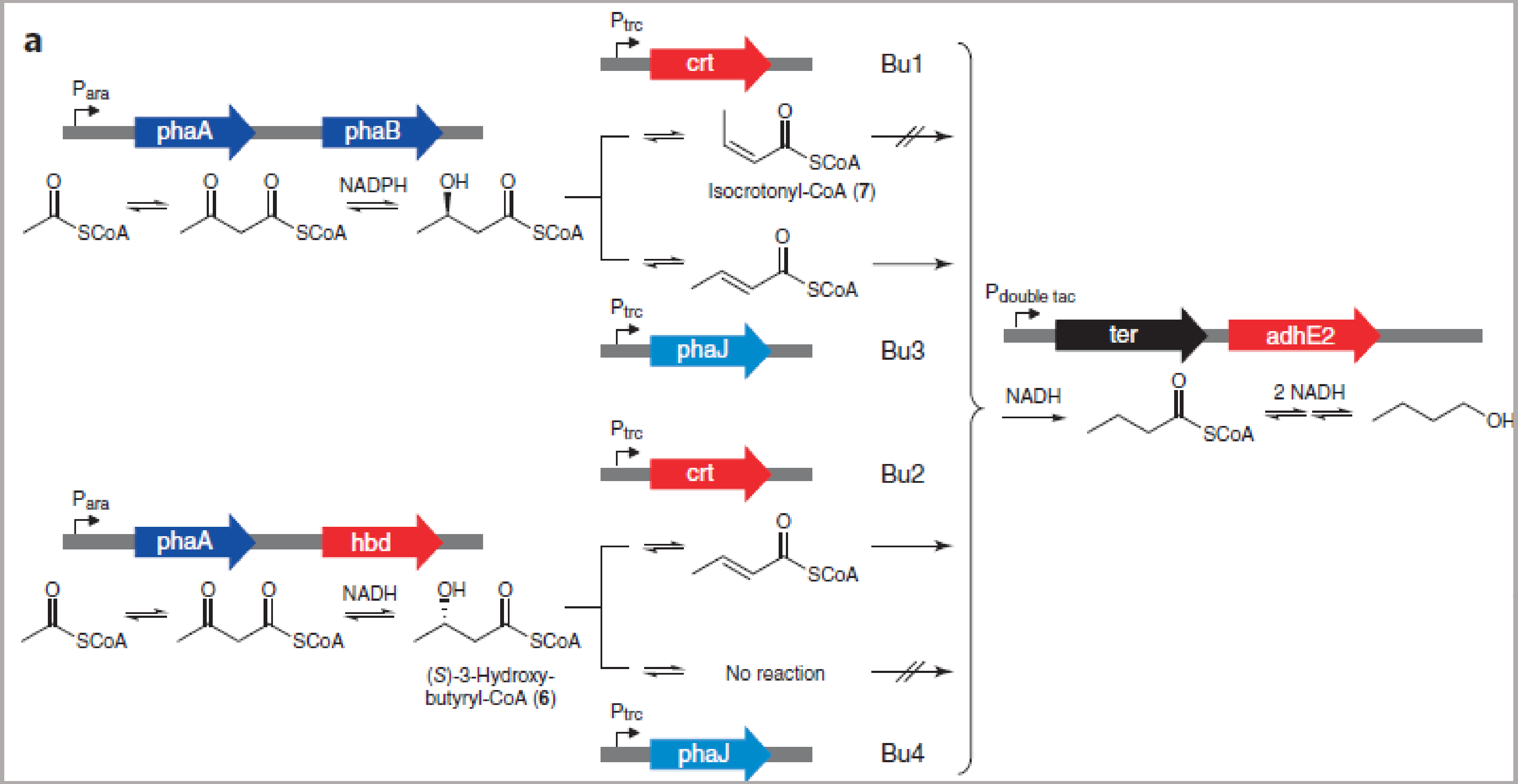
Nature 451, 86-90 (2008)



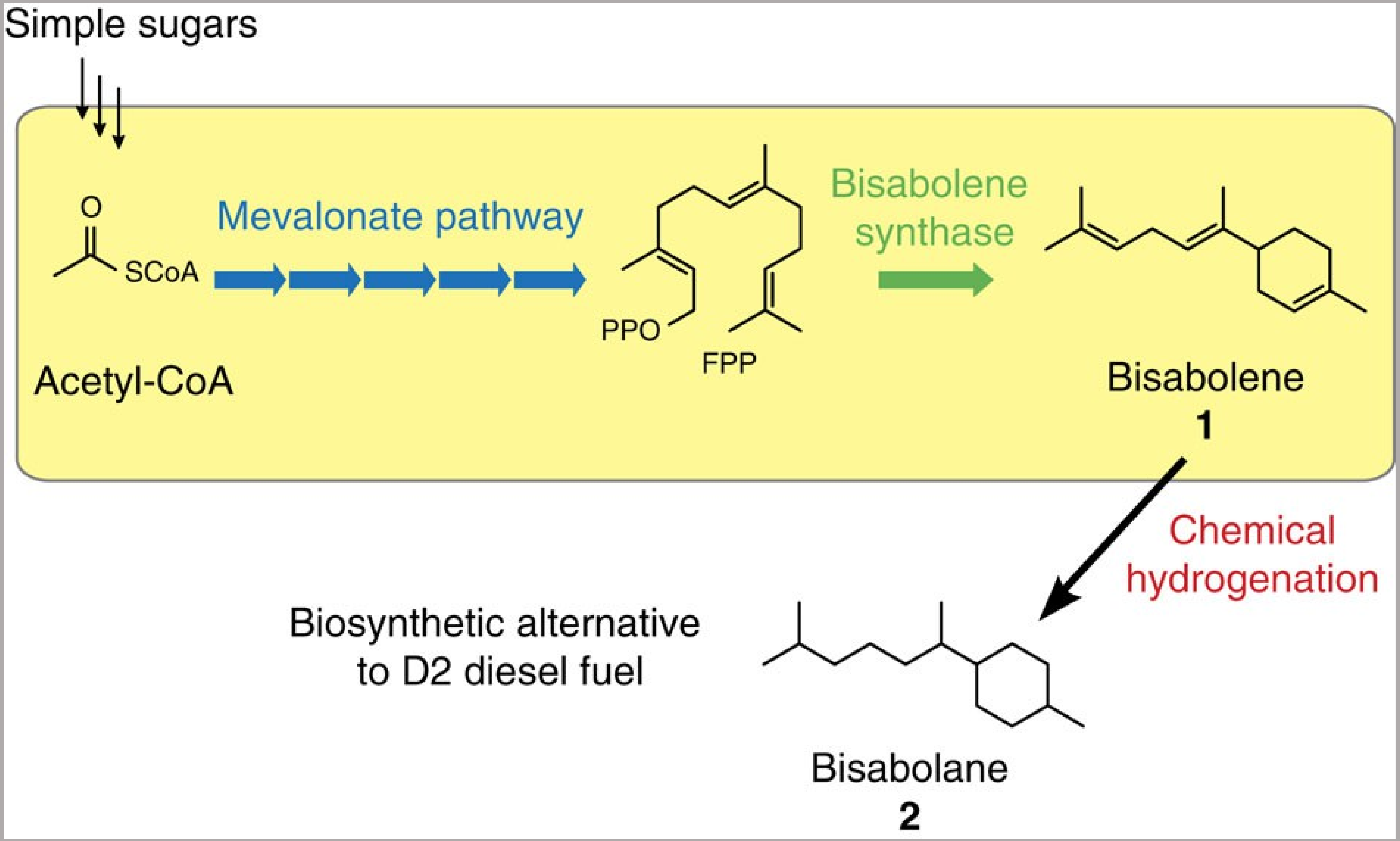
Scheme 1 | Comparison of a high-yielding pathway for production of polyhydroxyalkanoates (PHAs) to the design of a chimeric pathway for fuel synthesis derived from three different organisms. Blue, *R. eutrophus*; red, *C. acetobutylicum*; black, *S. collinus*; *phaA*, acetoacetyl-CoA thiolase/synthase; *phaB*, 3-hydroxybutyryl-CoA dehydrogenase; *phaC*, PHA synthase; *crt*, crotonase; *ccr*, crotonyl-CoA reductase; *adhE2*, bifunctional butyraldehyde and butanol dehydrogenase.

Nature Chemical Biology 7, 222–227 (2011)

Optimizacija biosintezne poti n-butanola s posredovanjem trans-enoil-CoA reduktaze (ter): identifikacija ozkih grl



Nature Chemical Biology 7, 222–227 (2011)



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dizel

metilna estra
mašč. kislin

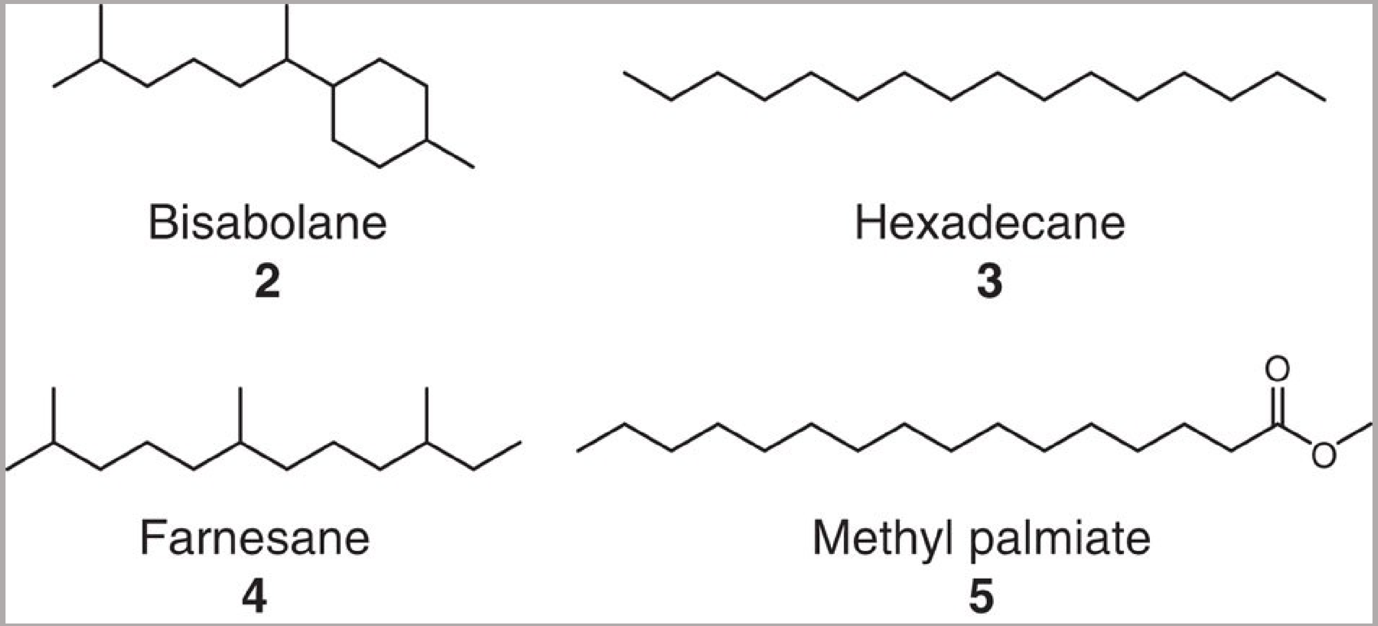

Table 1 | Fuel properties of D2 diesel fuel and biosynthetic alternatives.

Properties	D2 Diesel fuel*	Biodiesel†	Hydrogenated commercial bisabolene‡
Density ($g\,ml^{-1}$)	0.85	0.88	0.82
API Gravity	35.0	29.3	41.1
Flash point (°C)	60–80	100–170	111
Kinetic viscosity ($mm^2\,s^{-1}$)	1.3–4.1	4.0–6.0	2.91
Boiling point (°C)	180–340	315–350	267
Cloud point (°C)	−35 to 5	−3 to 15	< −78
Cetane number	40–55	48–65	41.9

*Biodiesel Handling and Use Guide, National Renewable Energy Laboratories[15].

†Biodiesel: Fatty acid methyl esters. Biodiesel Handling and Use Guide, National Renewable Energy Laboratories[15].

‡Hydrogenated commercial bisabolene: bisabolane: ~50%, farnesane: ~20%, partially hydrogenated bisabolene: ~20%, and aromatized bisabolene: ~7% (Fig 3b).

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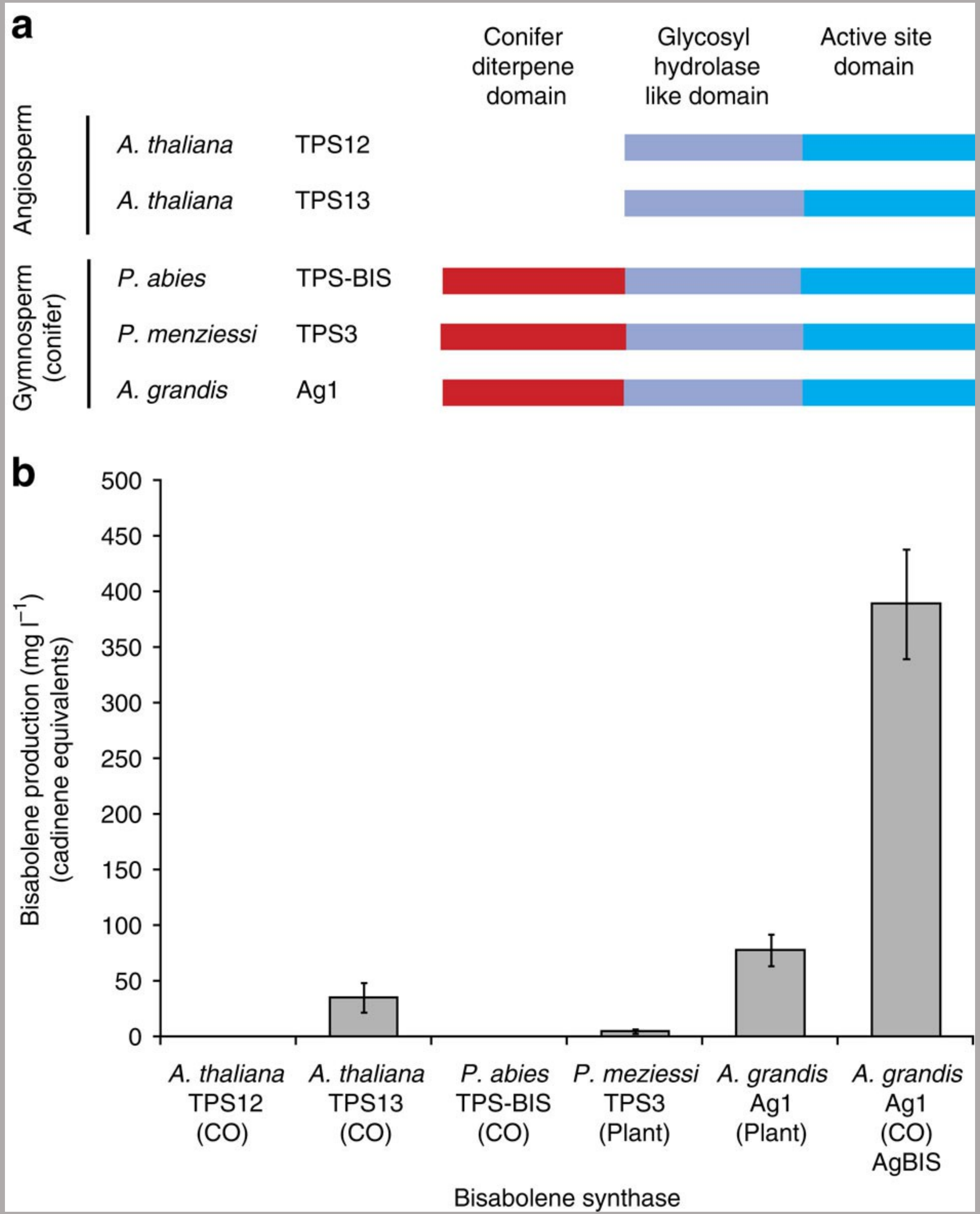
Genska struktura in aktivnost bisabolen sintaz



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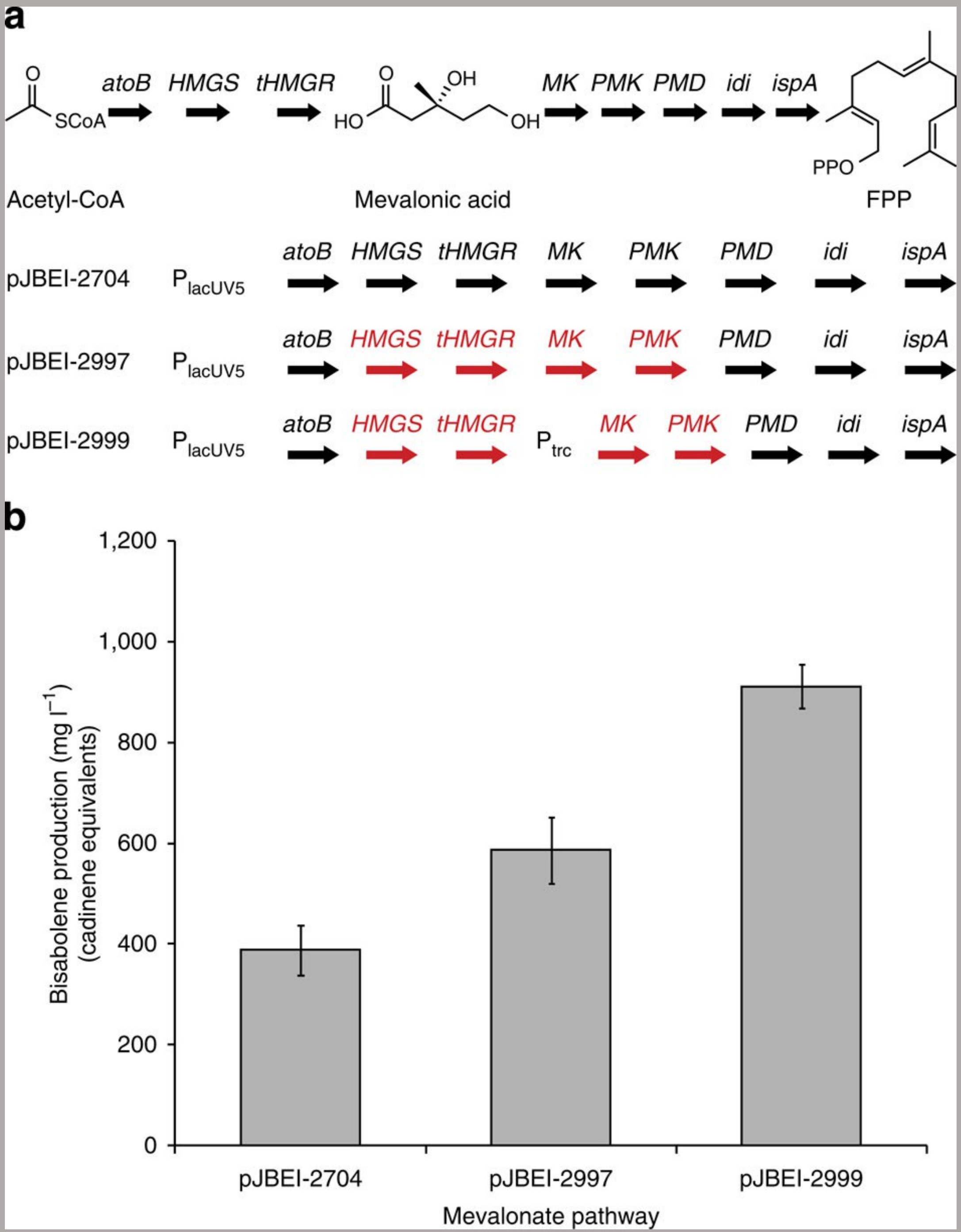

Izboljšave mevalonatne poti za pretvorbo Ac-CoA v farnezildifosfat (FPP)

geni iz *S.c.* (velike črke) in *E. coli* (male črke), sintezni geni s prilagojeno rabo kodona za *E. coli* (rdeče)

Biosinteza bisabolena ob uporabi sintaze AgBIS v *E. coli*

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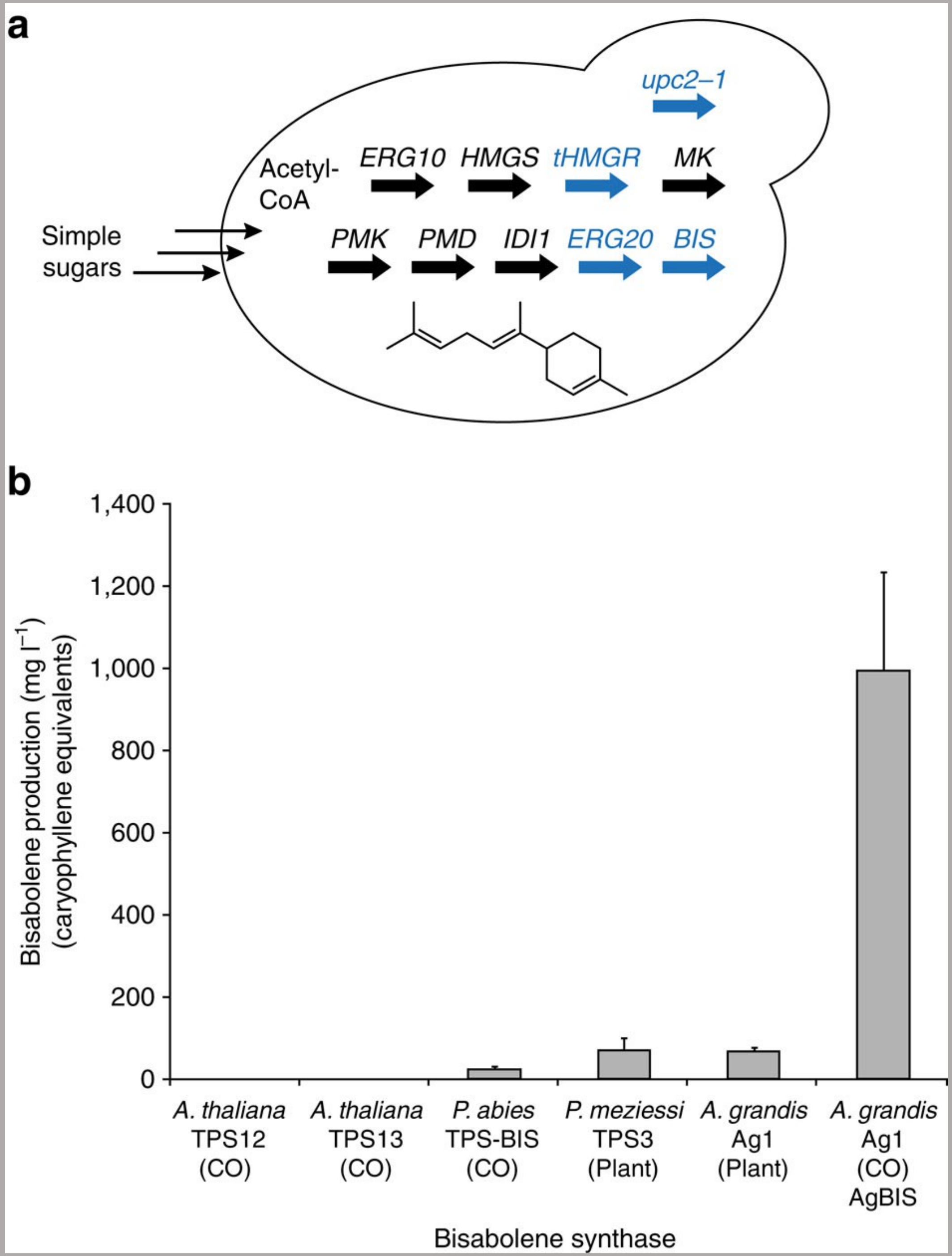

Prilagoditev kvasovke za proizvodnjo bisabolena

celice so predhodno optizimirali za proizvodnjo amorfadiena (→ artemizinska kislina)
encimi označeni z modro so bili prekomerno izraženi

Biosinteza bisabolena ob uporabi različnih sintaz v *S. c.*

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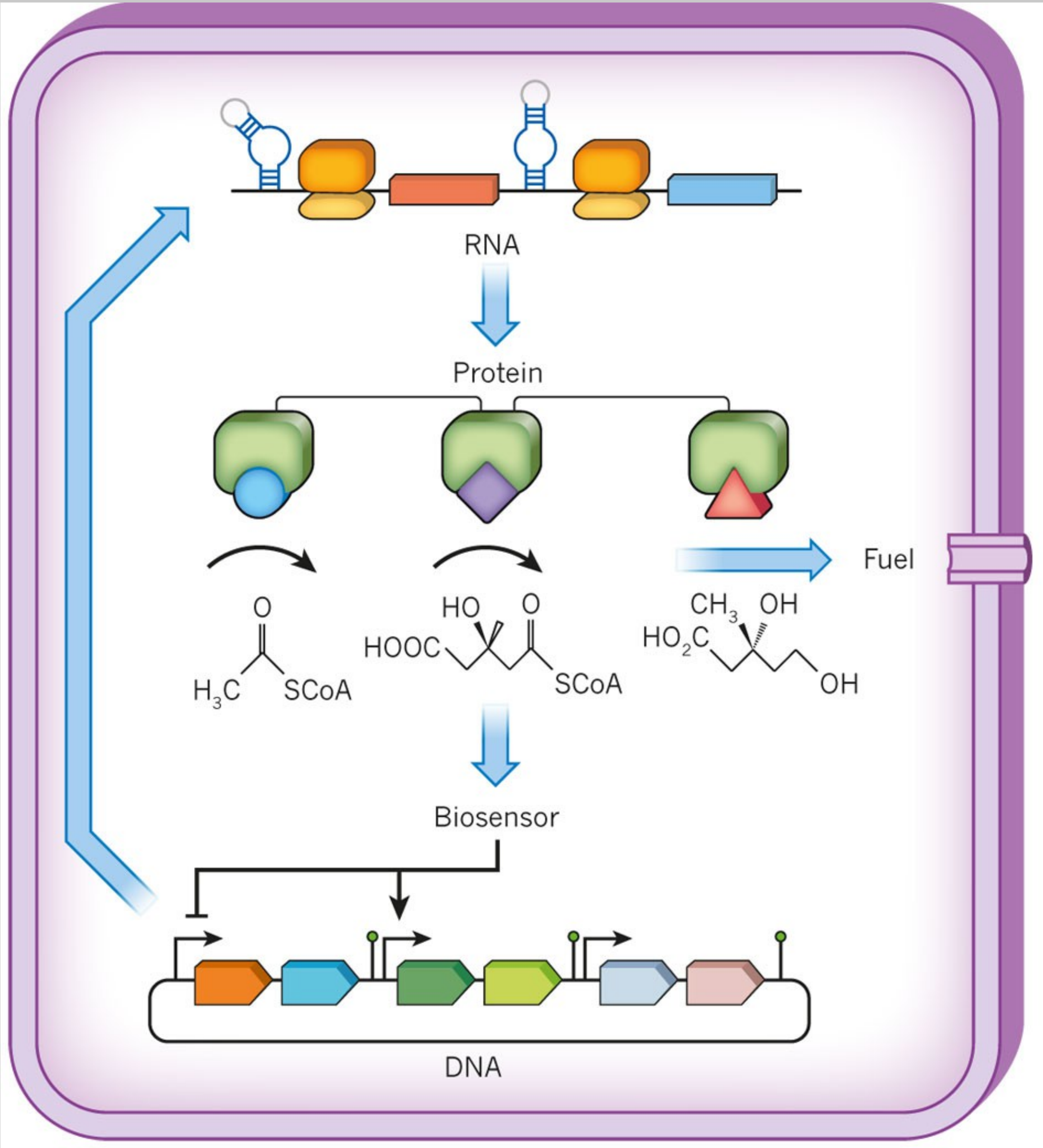
Sinteznobiološki pristop k proizvodnji biogoriv



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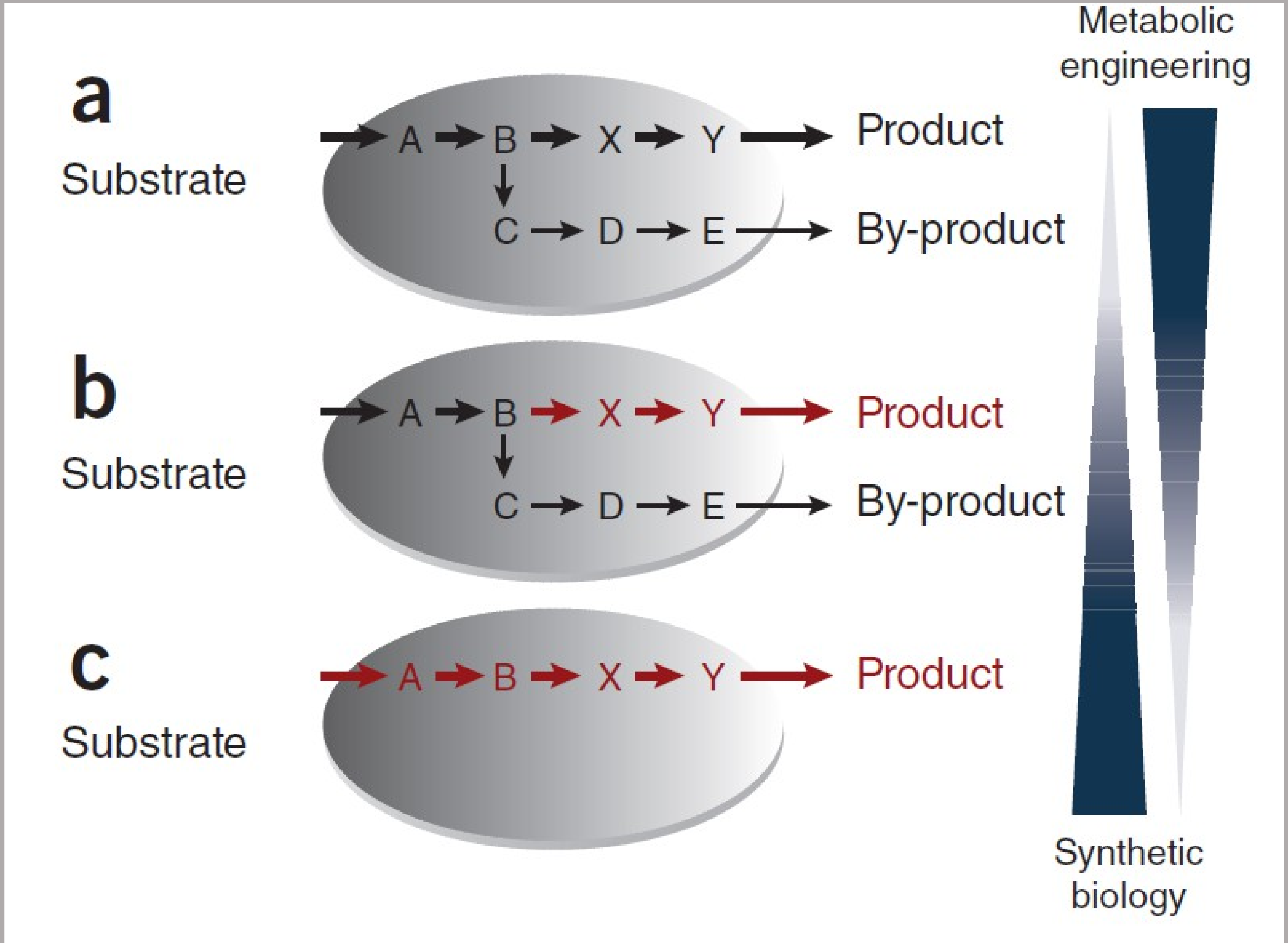
Sinergija med sintezno biologijo in metaboličnim inženirstvom



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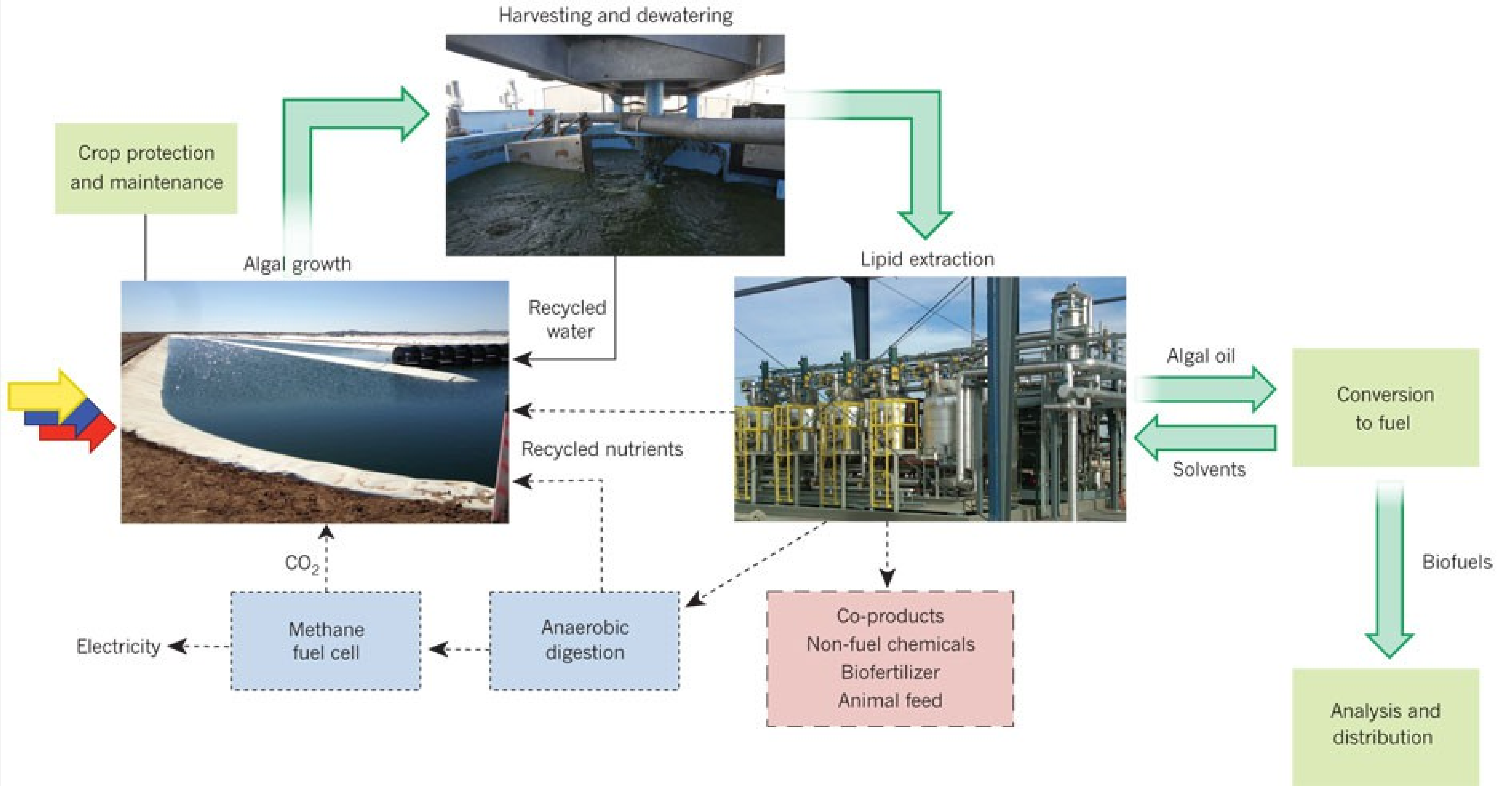

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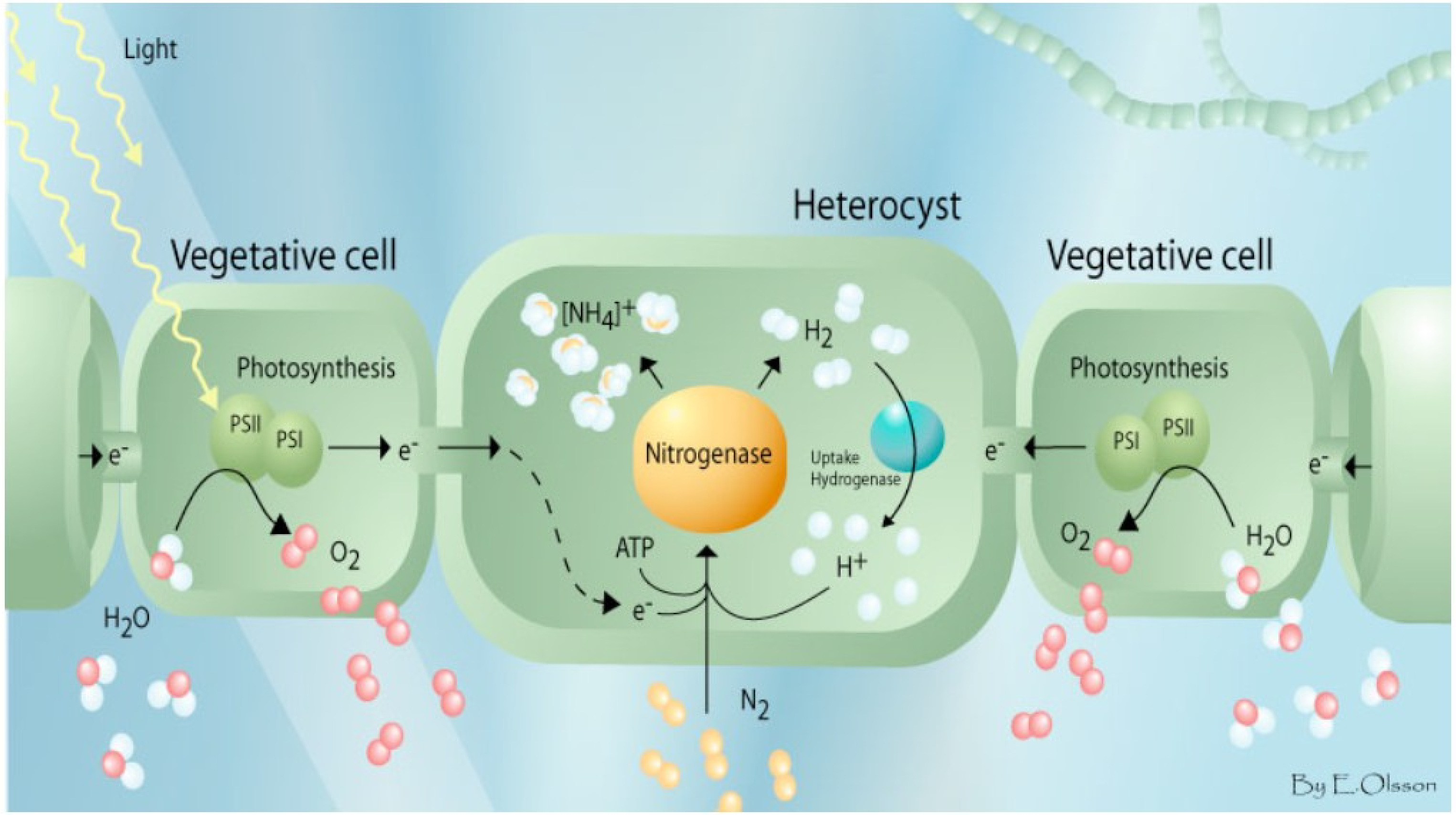
Hydrogen production by heterocystous cyanobacteria



By **nitrogenase** catalysed reaction:

$$N_2 + 8\,H^+ + 8\,e^- + 16\,ATP \xrightarrow{\text{nitrogenase}} 2\,[NH_4]^+ + H_2 + 16\,ADP + 16\,P_i$$

uptake hydrogenase

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