

## Supplementary Information

### **Fusing $\alpha$ and $\beta$ subunits of the fungal fatty acid synthase leads to improved production of fatty acids**

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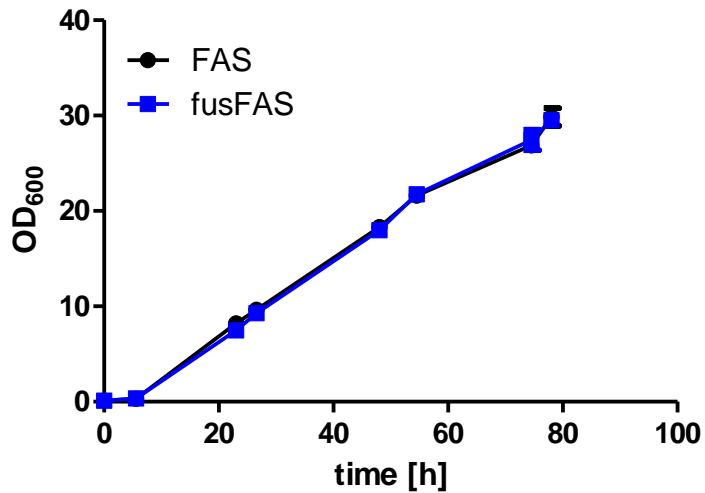
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**Supplementary Table S1 | Plasmids used in this study.** Under “description” the relevant genetic elements are listed. AmpR, Ampicillin resistance; prefixes “p” and “t” denote promoters and terminators, respectively; MCS, multiple cloning site. Other elements listed follow conventional nomenclature or (for FAS variants) the nomenclature used in the manuscript.

Laboratory stock code	Plasmid name	Description	Used in Figure	Reference
ASB22	pRS62-H	<i>2μ</i> , AmpR, <i>HphNT1</i> , <i>pHXT7-MCS-tCYC1</i>	-	Farwick et al., 2014
ASB23	pRS62-K	<i>2μ</i> , AmpR, <i>kanMX4</i> , <i>pHXT7-MCS-tCYC1</i>	-	Farwick et al., 2014
SHV61	pRS315-FAS1 <sup>RK</sup> -FAS2	<i>CEN6/ARS4</i> , AmpR, <i>LEU2</i> , <i>pFAS1-FAS1<sup>R1834K</sup>-tFAS1</i> , <i>pFAS2-FAS2-tFAS2</i>	Fig. 2, S4	This study
FWV113	pRS315K-FAS1 <sup>RK</sup> -FAS2	<i>CEN6/ARS4</i> , AmpR, <i>kanMX4</i> , <i>pFAS1-FAS1<sup>R1834K</sup>-tFAS1</i> , <i>pFAS2-FAS2-tFAS2</i>	Fig. 4a,b; S5	This study
FWV124	pRS315K- FAS1 <sup>opt;RK</sup> -FAS2 <sup>opt</sup>	<i>CEN6/ARS4</i> , AmpR, <i>kanMX4</i> , <i>pFAS1-FAS1<sup>opt;R1834K</sup>-tFAS1</i> , <i>pFAS2-FAS2<sup>opt</sup>-tFAS2</i>	S5	This study
FWV125	pRS315K- fusFAS <sup>opt;RK</sup>	<i>CEN6/ARS4</i> , AmpR, <i>kanMX4</i> , <i>pFAS1-FAS1<sup>opt;R1834K</sup>-FAS2-tFAS2</i>	S5	This study
FWV128	pRS313K-fusFAS <sup>RK</sup>	<i>CEN6/ARS4</i> , AmpR, <i>kanMX4</i> , <i>pFAS1-FAS1<sup>R1834K</sup>-FAS2-tFAS2</i>	Fig. 4a,b; S5	This study
FWV129	pRS315K-FAS1-FAS2	<i>CEN6/ARS4</i> , AmpR, <i>kanMX4</i> , <i>pFAS1-FAS1-tFAS1</i> , <i>pFAS2-FAS2-tFAS2</i>	Fig. 4b; S3	This study
FWV132	pRS313H-fusFAS	<i>CEN6/ARS4</i> , AmpR, <i>HphNT1</i> , <i>pFAS1-FAS1-FAS2-tFAS2</i>	Fig. 4b; S3	This study
FWV133	pRS313H-fusFAS <sup>RK</sup>	<i>CEN6/ARS4</i> , AmpR, <i>HphNT1</i> , <i>pFAS1-FAS1<sup>R1834K</sup>-FAS2-tFAS2</i>	Fig. 4b	This study
FWV155	pRS315H-FAS1 <sup>RK</sup> -FAS2	<i>CEN6/ARS4</i> , AmpR, <i>hphNT1</i> , <i>pFAS1-FAS1<sup>R1834K</sup>-tFAS1</i> , <i>pFAS2-FAS2-tFAS2</i>	Fig. 4b	This study
SHV29	pRCC-N-kanMX4	<i>2μ</i> , AmpR, <i>natNT2</i> , <i>pROX3-opt.CAS9<sup>sp</sup>-tCYC1</i> , <i>pSNR52-gRNA[kanMX4]-tSUB4</i>	-	This study
SHV42	pRCC-N-faa2	<i>2μ</i> , AmpR, <i>natNT2</i> , <i>pROX3-opt.CAS9<sup>sp</sup>-tCYC1</i> , <i>pSNR52-gRNA[faa2]-tSUB4</i>	-	Henritzi et al., 2018
SHV69	pRS313-fusFAS	<i>CEN6/ARS4</i> , AmpR, <i>HIS3</i> , <i>pFAS1-FAS1-FAS2-tFAS2</i>	Fig. 2	This study
SHV70	pRS313-fusFAS <sup>RK</sup>	<i>CEN6/ARS4</i> , AmpR, <i>HIS3</i> , <i>pFAS1-FAS1<sup>R1834K</sup>-FAS2-tFAS2</i>	Fig. 2; Fig. 3; S4	This study
SHV72	pRS313-pHXT7-fusFAS <sup>RK</sup>	<i>CEN6/ARS4</i> , AmpR, <i>HIS3</i> , <i>pHXT7<sup>1-392</sup>-FAS1<sup>R1834K</sup>-FAS2-tFAS2</i>	Fig. 3	This study
SHV73	pRS313-pTEF1-fusFAS <sup>RK</sup>	<i>CEN6/ARS4</i> , AmpR, <i>HIS3</i> , <i>pTEF1-FAS1<sup>R1834K</sup>-FAS2-tFAS2</i>	Fig. 3	This study
SHV74	pRS313-pTDH3-fusFAS <sup>RK</sup>	<i>CEN6/ARS4</i> , AmpR, <i>HIS3</i> , <i>pTDH3-FAS1<sup>R1834K</sup>-FAS2-tFAS2</i>	Fig. 3	This study

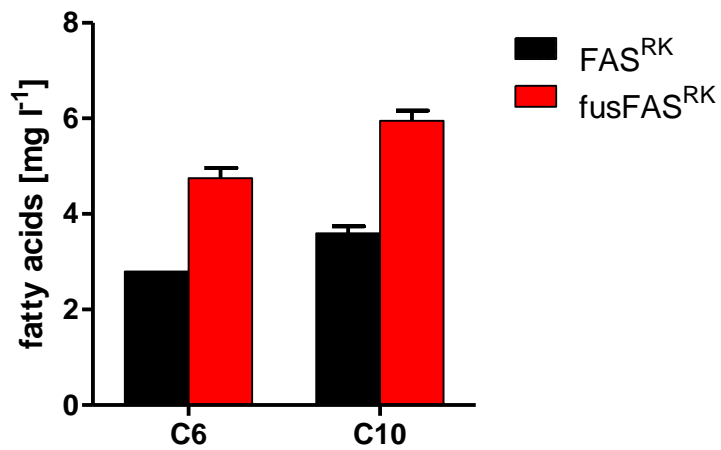
## Supplementary Table S2 | Oligonucleotides used in this study

Primer Name	Sequence 5'-3'	Application
FWP220	AGTTTATGTACAAATATCATAAAAAAAGAGAATC TTTCAGCGACATGGAGGCC	Amplification of <i>kanMX4</i> with overhangs for pRS315 backbone to replace <i>LEU2</i>
FWP221	TTCTCAACAAGTAATTGGTTGTTTGGCCGAGCGG TCTGACACTGGATGGCGGCG	
FWP263	CGGCATCAGAGCAGATTGTACTGAGAGTGCACCA TCGTCCCAAACCTTCTCAAG	Amplification of <i>hphNT1</i> with overhangs for pRS313 backbone to replace <i>HIS3</i>
FWP264	GCATCTGTGCGGTATTTACACCGCATATGATCC GCAGCGACATGGAGGC	
FWP275	GGCATCAGAGCAGATTGTACTGAGAGTGCACCAT AATTCCAGCGACATGGAGGCC	Amplification of <i>kanMX4</i> with overhangs for pRS313 backbone to replace <i>HIS3</i>
FWP276	TACGCATCTGTGCGGTATTTACACCGCATATGA TCCGTGACACTGGATGGCGGCG	
FWP312	ATAAAGTTTATGTACAAATATCATAAAAAAAGAG AATCTTTTCGTCCCAAACCTTCTC	Amplification of <i>hphNT1</i> with overhangs for pRS315 backbone to replace <i>LEU2</i>
FWP313	CTCTATTTCTCAACAAGTAATTGGTTGTTTGGCC GAGCGGTCTCAGCGACATGGAGG	
SHP100	ATGACCTTGATGATTAGCGAAGTAAGTCGACCTA GGTCTATCCGAACCTCCCTTTTTG	Amplification of pFAS2-FAS2-tFAS2 with overlaps to pRS315-FAS1-RK backbone
SHP101	CCCTCACTAAAGGGAACAAAAGCTGGGTACCGGG CATGCATAGAGCTGCTACGCGGAC	
SHP145	TGAATTGTAATACGACTCACTATAGGGCGAATTG GAGCTCCGCTCGTAGGAACAATTTTCG	Amplification of <i>pHXT7<sup>-1--392</sup></i> with overhangs for pRS313-fusFAS <sup>RK</sup> backbone to replace <i>pFAS1</i>
SHP26	GTGAGATAGGGTTAATGGTCTTGTGGAGTAAGCG TCCATTTTTTGGATTAAAATTAATAAACTTTTTG TTT	
SHP150	GAATTGTAATACGACTCACTATAGGGCGAATTGG AGCTCCACAGTTTATTCTGGCATCC	Amplification of <i>pTDH3</i> with overhangs for pRS313-fusFAS <sup>RK</sup> backbone to replace <i>pFAS1</i>
SHP151	ATAGGGTTAATGGTCTTGTGGAGTAAGCGTCCAT TTTGTGTTGTTTATGTGTGTTTATTCG	
SHP152	TGAATTGTAATACGACTCACTATAGGGCGAATTG GAGCTCCCTTGCCAACAGGGAGTTC	Amplification of <i>pTEF1</i> with overhangs for pRS313-fusFAS <sup>RK</sup> backbone to replace <i>pFAS1</i>
SHP153	GGGTTAATGGTCTTGTGGAGTAAGCGTCCATTTT GTAATTAATAACTTAGATTAGATTGCTATGC	
SHP78	CTCATGACGAGCTCCGTATGCTAAATGAATGTAC TTATGACGATTTGGAACACATTCAAA	Donor-DNA fragment for <i>faa2</i> deletion
SHP62	CCAAGGAAAAATATAAAAAAGTACATTGGGCCT TTTCATGGCGCCGACTGGTTTCTTAAGTGATTA TATAACCGTAAGAAATATTTAACTT	Donor-DNA fragment for <i>kanMX4</i> cassette deletion in <i>Δfas1</i> locus
SHP63	TTTTCACATGCTACCTCATTCCGCTCGTAACGTT ACGACCGGGCCCCCTGCGGCTCCGGTAAGAGAGC ACTACGTAGTCCCTCTTTTAATATGTAACGTGT	Donor-DNA fragment for <i>kanMX4</i> cassette deletion in <i>Δfas2</i> locus

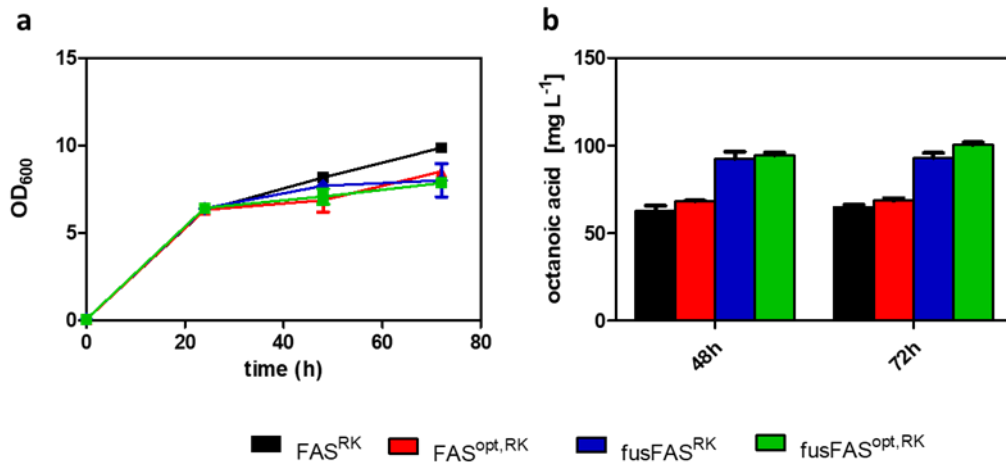


**Supplementary Figure S3 | Complementation of FAS deficiency by FAS constructs.**

The wildtype split FAS (FAS) and fused FAS (fusFAS) were expressed in the strain SHY34 ( $\Delta fas1 \Delta fas2 \Delta faa2$ ) cultivated in buffered YPD medium. The growth was assessed by measuring OD<sub>600</sub> over time. Mean values and standard deviations of biological duplicates are shown. Error bars may be smaller than the symbols.



**Supplementary Figure S4 | Production of other SMCFA by FAS constructs.** The production of hexanoic acid (C6) and decanoic acid (C10) by two gene encoded FAS (FAS<sup>RK</sup>) and fused FAS (fusFAS<sup>RK</sup>) was quantified in the same samples (at 48 h) as shown in Fig. 2b in the main manuscript. Mean values and standard deviations of biological duplicates are shown.



**Supplementary Figure S5 | Codon-optimization of FAS-constructs.** Mutated two gene encoded FAS (FAS<sup>RK</sup>) and fused FAS (fusFAS<sup>RK</sup>) were expressed in strain SHY34 ( $\Delta fas1 \Delta fas2 \Delta faa2$ ) as codon optimized (opt.) or non-optimized variants. Comparison of (a) growth) and octanoic acid production (b) in buffered YPD medium over a time of 72h. For plasmid maintenance hygromycin (100 mg l<sup>-1</sup>) was used. Mean values and standard deviations of biological duplicates are shown.

**Sequences of promoters and FAS constructs.** Sequences of promoters used in Figure 3 are listed. The online tool JCat (<http://www.jcat.de>) was used to codon-optimize the nucleotide sequence and calculate the codon adaptation index (CAI) of FAS ORFs. The change in CAI resulting from optimization is indicated, where appropriate. To introduce the R1834K mutation, the respective native codon “AGA” in *FAS1* was replaced by “AAA”.

>pFAS1

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TGCGGTCTCGTCCTCTACGAATATGGCTATTTGCCTTCGTATATACCTTTCTATACCAAG
TAATGAATGTCTTGAGGGCCCGTATGGCCGCGCGAAGGCTTAGTTAAGATGTTTCAGCAA
ACGGCAGCATGTGAAAAAACCCGTAGAAAGGTCCGCATCAGCCTTCCATGCCCCGTGCACCC
ACGGCTCCTCGGAGGCCGGGTTATAGCAGCGTCTGCTCCGCATCACGATACACGAGGTGC
AGGCACGGTTCACTACTCCCCTGGCCTCCAACAAACGACGGCCAAAACTTCACATGCCG
CCCAGCCAAGCATAATTACGCAACAGCGATCTTTCCGTCGCACAAGTTAAAAGAAATTGT
TGAAAAATACAAATAATCGCGAACAATACGTTGTTGCTATTTAACGCTTTTGGTCTGACA
GTAAGTGTGCCTTTCCCAATCACCGAAAAGTGTGAACGATTCACTGCGACAATAATCAG
AGATTACAGTCGGCATTGTTGGCATTGTTGGCATACTTTTATCGATTGAACCATCTTCTC
CAAACACTTTTCTTTTCTTTCTATTCTGCAGGACCAACTAAAACCTGGGTATATATATC
ATTATCTATATATATAAACGGCTTTCAACAAAAGTTATAGGGGAAAACTAAAAATATAAGA
AAAAAAAAGGTATTGATTGATAAGGAAAAAGAACCAAGGGAAAAATATAAAAAAGTACAT
TGGGCCTTTTCATACTTGTATCACTTACATTACAAAGAAGAACAACAACCTTTTTTAAA
CGAATTTTCTTTCTTTCTTTTCAATTTATTAATTCTTTTTTTCCATAACAATTCAAGGTC
AAATATATTCTTATATGCTCTTTGAATATTTCTGAAAAATATATAAAGAAAAGAACTAC
AAGAACATCATCCGGAAAATCAGATTATAGACTAGGATTCCGCTCTTTTTTAGTATATTTA
TTCGCCACACCTAACTGCTCTATTATTTCGCTCATT
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>pFAS2

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TTCTATCCGAACTCCCCTTTTGTATATCAATATATCTTAATACTTTTCGCCTATTCTTTAC
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GGACGTGTATTTAGTTTAGCCAAGCAATATTTAAATATCACTCTTCTAAAAATACATTG
GGCATTACCCGCAAACCTAACCCATCGCTTAGCAAAATCCAACCATTTTTTTTTTATCTCC
CGCGTTTTCACATGCTACCTCATTCGCTCGTAACGTTACGACCGAAATCTCACTAAGGC
ACGGTTTTGTTGGGAGTTACAGATGTTGGATAACCAGTTGTTTCTAAACGGTTATGCCT
CATATATAACTTGTAACTGAAGGTTACACAAGACCACATCACCCTGTCGTGCTTTTCT
AATAACCGCTATATTAGACGTTTAAAGGGCTACAGCAACACCAATTGAAATACCATCATT
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>pTDH3

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ACAGTTTATTCTCGGCATCCACTAAATATAATGGAGCCCGCTTTTTTAAGCTGGCATCCAG
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CCATTCTCTTAGCGCAACTACAGAGAACAGGGGCACAAACAGGCCAAAAACGGGCACAAC
CTCAATGGAGTGATGCAACCTGCCTGGAGTAAATGATGACACAAGGCAATTGACCCACGC
ATGTATCTATCTCATTTTCTTACACCTTCTATTACCTTCTGCTCTCTGATTTGGAAAA
AGCTGAAAAAAAAGGTTGAAACCAGTTCCTGAAATATTCCCTACTTGACTAATAAGT
ATATAAAGACGGTAGGTATTGATTGTAATTCTGTAAATCTATTTCTTAAACTTCTTAAAT
TCTACTTTTATAGTTAGTCTTTTTTTTTTAGTTTTTAAACACCAAGAACTTAGTTTCGAATA
AACACACATAAACAAACAAA
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>pTEF1

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CCTTGCCAACAGGGAGTTCTTCAGAGACATGGAGGCTCAAAACGAAATTATTGACAGCCT
AGACATCAATAGTCATACAACAGAAAGCGACCACCAACTTTGGCTGATAATAGCGTATA
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TATAATACATATCACATAGGAAGCAACAGGCGCGTTGGACTTTTAATTTTCGAGGACCGC
GAATCCTTACATCACACCCAATCCCCACAAGTGTATCCCCACACACCATAGCTTCAAAA
TGTTTCTACTCTTTTTTACTCTTCCAGATTTTTCTCGGACTCCGCGCATCGCCGTACCAT
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AATTACCCGTAATAAGGTTTGGAAAAGAAAAAGACACCGCCTCGTTTCTTTTTCTTCG
TCGAAAAAGGCAATAAAAATTTTTATCACGTTTCTTTTTCTTGAAAATTTTTTTTTTTGA
TTTTTTTTCTTTTCGATGACCTCCCATTTGATATTTAAGTTAATAAACGGTCATCAATTTT
TCAAGTTTCAGTTTCATTTTTCTTGTCTATTACAACCTTTTTTTACTTCTTGCTCATTAG
AAAGAAAGCATAGCAATCTAATCTAAGTTTTTAATTACAAA
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>pHXT7<sup>-1-392</sup>

GCTCGTAGGAACAATTTTCGGGCCCCCTGCGTGTTCTTCTGAGGTTTCATCTTTTACATTTGC  
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AAGGAAAAATCCCCACCATCTTTTCGAGATCCCCTGTAACCTTATTGGCAACTGAAAGAATG  
AAAAGGAGGAAAAATACAAAATATACTAGAACTGAAAAAAGTATAAATAGAGACGA  
TATATGCCAATACTTCACAATGTTTCGAATCTATTCTTCATTTGCAGCTATTGTAAAATAA  
TAAAACATCAAGAACAACAAGCTCAACTTGTCTTTTCTAAGAACAAGAATAAACACAA  
AAACAAAAAGTTTTTTTAATTTAATCAAAAA

>codon optimized FAS1, CAI change: 0.27 > 0.98

ATGGACGCTTACTCTACTAGACCATTGACTTTTGTCTCACGGTTCTTTGGAACACGTTTTG  
TTGGTTCCAACACTGCTTCTTTCTTCATCGCTTCTCAATTGCAAGAACAATTCAACAAGATC  
TTGCCAGAACCAACTGAAGGTTTCGCTGCTGACGACGAACCAACTACTCCAGCTGAATTG  
GTTGGTAAGTTCTTGGGTTACGTTTCTTCTTTGGTTGAACCATCTAAGGTTGGTCAATTC  
GACCAAGTTTTGAACTTGTGTTGACTGAATTCGAAAACCTGTTACTTGAAGGTAACGAC  
ATCCACGCTTTGGCTGCTAAGTTGTTGCAAGAAAACGACACTACTTTGGTTAAGACTAAG  
GAATTGATCAAGAATACTACTGCTAGAAATCATGGCTAAGAGACCATTGACAAGAAG  
TCTAACTCTGCTTTGTTTCAGAGCTGTTGGTGAAGGTAACGCTCAATTGGTTGCTATCTTC  
GGTGGTCAAGGTAACACTGACGACTACTTTCGAAGAATTGAGAGACTTGTACCAAACCTTAC  
CACGTTTTGGTTGGTGACTTGTATCAAGTTCTCTGCTGAAAACCTTTGTCTGAATTGATCAGA  
ACTACTTTGGACGCTGAAAAGGTTTTCACTCAAGGTTTGAACATCTTGAATGGTTGGAA  
AACCCATCTAACACTCCAGACAAGGACTACTTGTGTCTATCCCAATCTCTTGTCCATTG  
ATCGGTGTTATCCAATTGGCTCACTACGTTGTTACTGCTAAGTTGTTGGGTTTCACTCCA  
GGTGAATTGAGATCTTACTTGAAGGGTGCTACTGGTCACTCTCAAGGTTTGGTTACTGCT  
GTTGCTATCGCTGAAACTGACTCTTGGGAATCTTTCTTCGTTTCTGTTAGAAAGGCTATC  
ACTGTTTTGTTCTTCATCGGTGTTAGATGTTACGAAGCTTACCCAAACACTTCTTTGCCA  
CCATCTATCTTGAAGACTCTTTGGAAAACAACGAAGGTGTTCCATCTCCAATGTTGTCT  
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GACACTTTCGACGGTCTGACTTGAGAGTTTTGTCTGGTCTATCTCTGAAAGAATCGTT  
GACTGTATCATCAGATTGCCAGTTAAGTGGGAAACTACTACTCAATTCAAGGCTACTCAC  
ATCTTGGACTTCCGTTCCAGGTGGTGTCTTGGTTTGGGTGTTTTGACTCACAGAAACAAG  
GACGGTACTGGTGTAGAGTTATCGTTGCTGGTACTTTGGACATCAACCCAGACGACGAC  
TACGGTTTTCAAGCAAGAAATCTTCGACGTTACTTCTAACGGTTTTGAAGAAGAACCCAAAC  
TGTTTGAAGAATACCACCCAAAGTTGATCAAGAACAAGTCTGGTAAGATCTTTCGTTGAA  
ACTAAGTTCTCTAAGTTGATCGGTAGACCACCATTTGTTGGTTCCAGGTATGACTCCATGT  
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GAAGCTGTTGTTGACCAAGACGTTCAAAGAAGCTTGTATCTTGCACGGTCCAGTTGCTGCT  
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AGAATCAAGGAAATGTAAGTTGTGGATCGACGAACCATTCAACTTGGACTTCGAC  
CCAAGAGACGTTATCAAGGGTAAGGACTTCGAAATCACTGCTAAGGAAGTTTACGACTTC  
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AACACTGTTGACGGTGACTTGTGGAAGTTGGTTCACTTGTCTAACGGTTACAAGATGATC  
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GTTTTGGACTCTTACACTCCACTACTAACAACCCATACGCTAGAGTTTCTGGTGACTTG  
AACCCAATCCACTTTCTAGACACTTCGCTTCTTACGCTAACTTGGCAGGTACTATCACT  
CACGGTATGTTCTTCTGCTTCTGTTAGAGCTTTGATCGAAAACGGGCTGCTGACTCT  
GTTTTCTTCTAGAGTTAGAGGTTACACTTGTCAATTCGTTGACATGGTTTTTGCAAAACACT  
GCTTTGAAGACTTCTATCCAACACGTTGGTATGATCAACGGTAGAAAAGTTGATCAAGTTC  
GAACTAGAAAACGAAGACGACGTTGTTGTTTTGACTGGTGAAGCTGAAATCGAACAACCA  
GTTACTACTTTTCTGTTTCTACTGGTCAAGGTTCTCAAGAACAAGGATGGGTATGGACTTG  
TACAAGACTTCTAAGGCTGCTCAAGACGTTTGGAACAGAGCTGACAACCCTTCAAGGAC  
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TTCGGTGGTAAAAGGGTAAGAGAATCAGAGAAAACACTCTGCTATGATCTTTCGAAACT  
ATCGTTGACGGTAAGTTGAAGACTGAAAAGATCTTCAAGGAAATCAACGAACACTCTACT  
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>codon optimized FAS2, CAI change: 0.32 > 0.98

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>fusFAS based on native FAS1 and FAS2 ORFs

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### **Supplementary Information - References**

Henritzi, S., Fischer, M., Grininger, M., Oreb, M., and Boles, E. (2018). An engineered fatty acid synthase combined with a carboxylic acid reductase enables de novo production of 1-octanol in *Saccharomyces cerevisiae*. *Biotechnol. Biofuels* 11, 150. doi:10.1016/j.jtrangeo.2006.11.008

Farwick A, Bruder S, Schadeweg V, Oreb M, Boles E (2014) Engineering of yeast hexose transporters to transport D-xylose without inhibition by D-glucose. *Proc. Natl. Acad. Sci. USA* 111: 5159–5164. doi:10.1073/pnas.1323464111