Supporting Information for:

Surveying labdane-related diterpenoid biosynthesis in the fungal genus *Aspergillus*

Meimei Xu, Matthew L. Hillwig,[†] Mollie S. Tiernan,[‡] and Reuben J. Peters*

Roy J. Carver Department of Biochemistry, Biophysics and Molecular Biology, Iowa State University, Ames, Iowa 50011 United States.

Table of Contents

Table S1: CPS-PS mutant summary.

Species (cyclase name)	PS_{inact} mutant	CPS_{inact} mutant
A. fumigatus (AfCPS-PS)	D651A	D311A/D313A/D314A
A. oryzae (AoCPS-PS)	D651A	D311A/D313A/D314A
A. niger (AnCPS-PS)	D667A	D327A/D329A/D330A
N. fischeri (NfCPS-PS)	D649A	D314A (middle Asp of Dx**D**D)

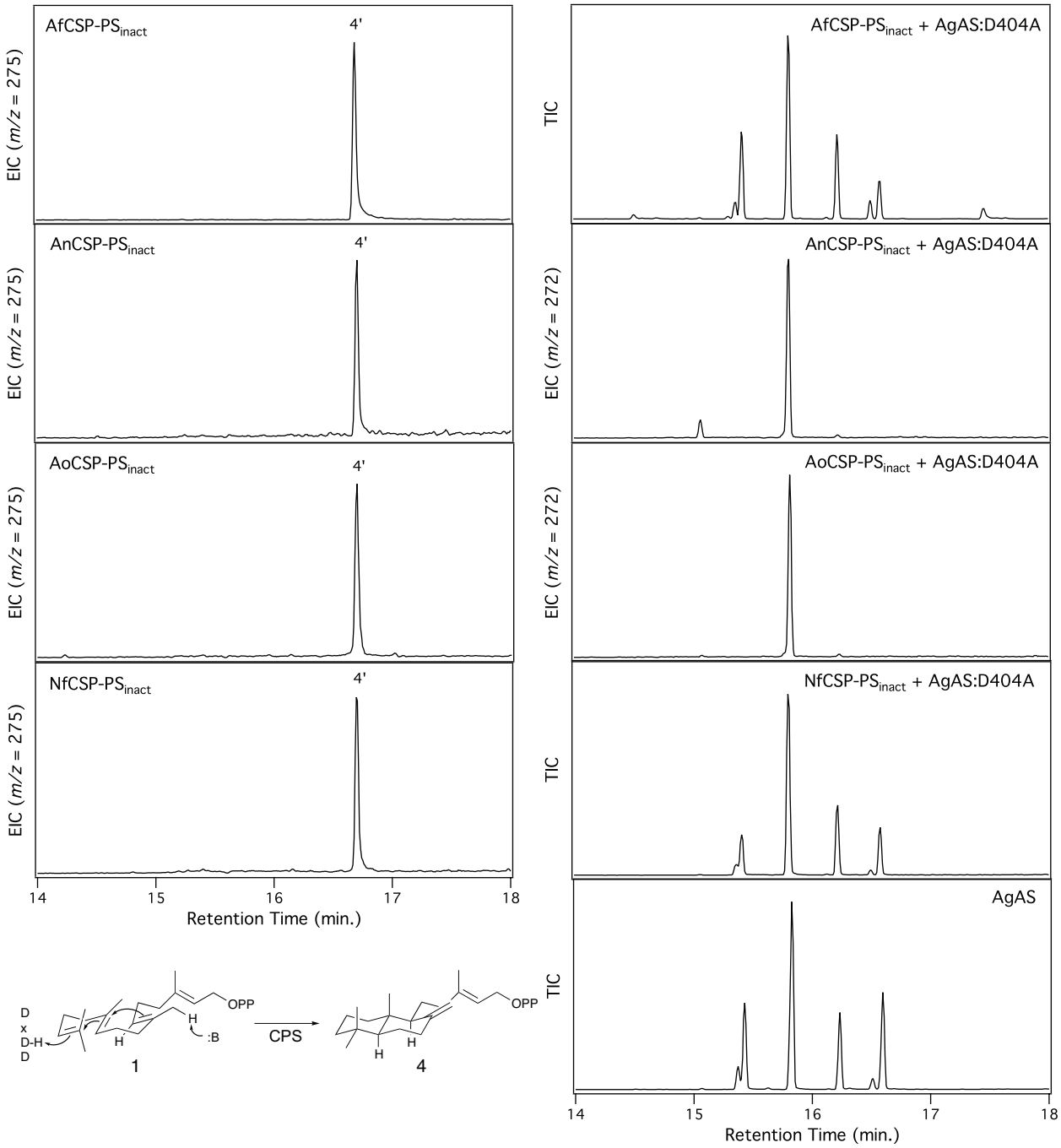

Figure S1: CPS activity of the fungal CPS-PS. GC-MS chromatograms for the PS$_{inact}$ mutants, either expressed alone or with class I diterpene synthases specific for CPP **4** (AtKS, data not shown) or *ent*-CPP **2** (i.e., AgAS:D404A) in *E. coli* engineered to produce **1**. The production of abietadiene (double bond isomers) observed upon co-expression with AgAS:D404A indicates the specific production of **4** by the CPS active site, by comparison to the product outcome mediated by the wild-type AgAS (note that single isomer seen in chromatograms for AnCPS-PS$_{inact}$ and AoCPS-PS$_{inact}$ result from use of 272 (*m/a*) ion extraction due to lower activity of these enzymes). Also shown is the reaction catalyzed by the CPS active sites of these fungal bifunctional enzymes.

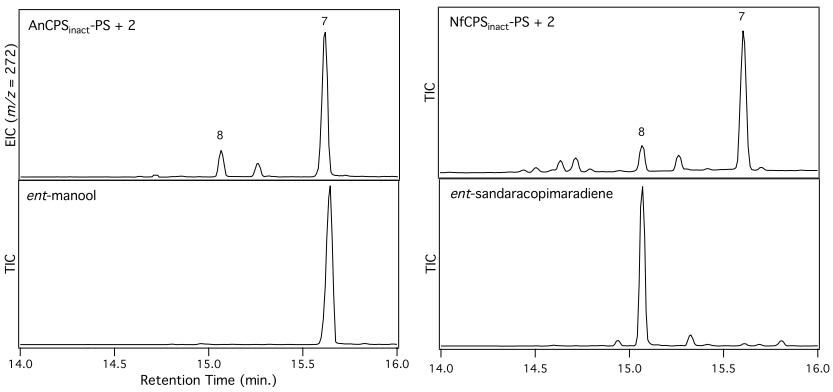

Figure S2: PS activity of fungal CPS-PS with *ent*-CPP **2**. GC-MS chromatograms for the CPS$_{inact}$ mutants when expressed in *E. coli* engineered to produce **2**, along with those of authentic standards.

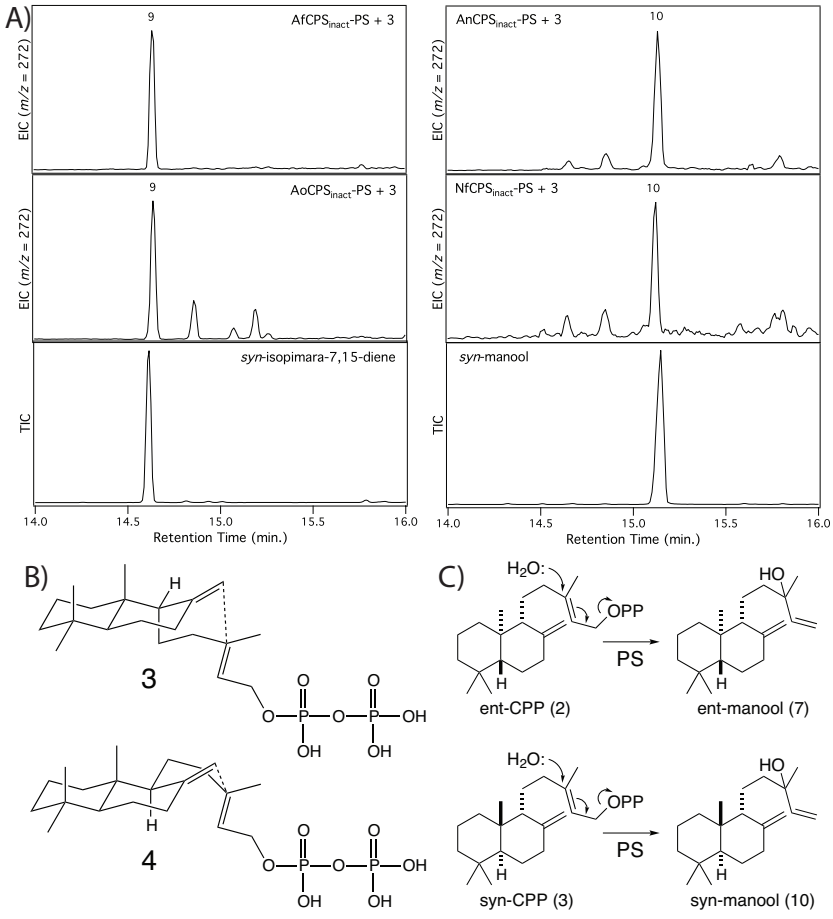

Figure S3: PS activity of fungal CPS-PS with *syn*-CPP **3**. A) GC-MS chromatograms for the CPS$_{inact}$ mutants when expressed in *E. coli* engineered to produce **3**. B) Comparison of the active site configurations of the native substrate **4** and alternative substrate **3** indicated by the observed production of **9** from **3** by both AfCPS-PS and AoCPS-PS. C) Indirect hydrolytic reactions catalyzed by both AnCPS-PS and NfCPS-PS with either **2** or **3** as alternative substrates.

Table S2: ^{1}H and ^{13}C NMR assignments for *syn*-isopimara-7,15-diene **9** in $CDCl_3$

***syn*-isopimara-7,15-diene 9**		
Position	**δ_C (ppm)**	**δ_H (ppm)**
1	37.04	1.141(m); 1.395(m)
2	19.95	1.276(m); 1.530(m)
3	46.80	1.116(m); 1.255(m)
4	35.16	
5	43.70	1.155(dt), *J*=3.4,12.5
6	23.94	1.811(m); 1.953(m)
7	119.78	5.265(bs)
8	137.06	
9	53.38	1.376(m)
10	35.39	
11	33.71	1.216(m); 1.704(m)
12	39.09	1.366(m); 1.374(m)
13	39.80	
14	49.87	1.686(d); 1.978(m), *J*=11.5
15	146.15	5.886(ddt), *J*= 1.8, 12.3, 17.9
16	111.13	4.910(m), 4.939(m)
17	22.41	0.978(s)
18	29.88	0.851(s)
19	22.96	0.878(s)
20	25.55	0.915(s)

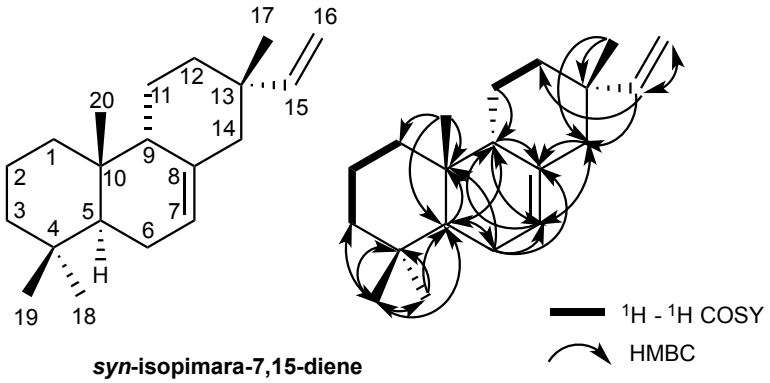

Figure S4: ^{1}H spectra obtained for *syn*-isopimara-7,15-diene **9**. Carbon numbering and HMBC correlations and COSY correlations used to verify the chemical structure. Note: All chiral centers were predetermined by the use of *syn*-CPP **4** as substrate with the exception of C13, which was assigned based on chemical shift differences and difference in GC-MS retention time compared to an authentic sample of *syn*-pimara-7,15-diene.

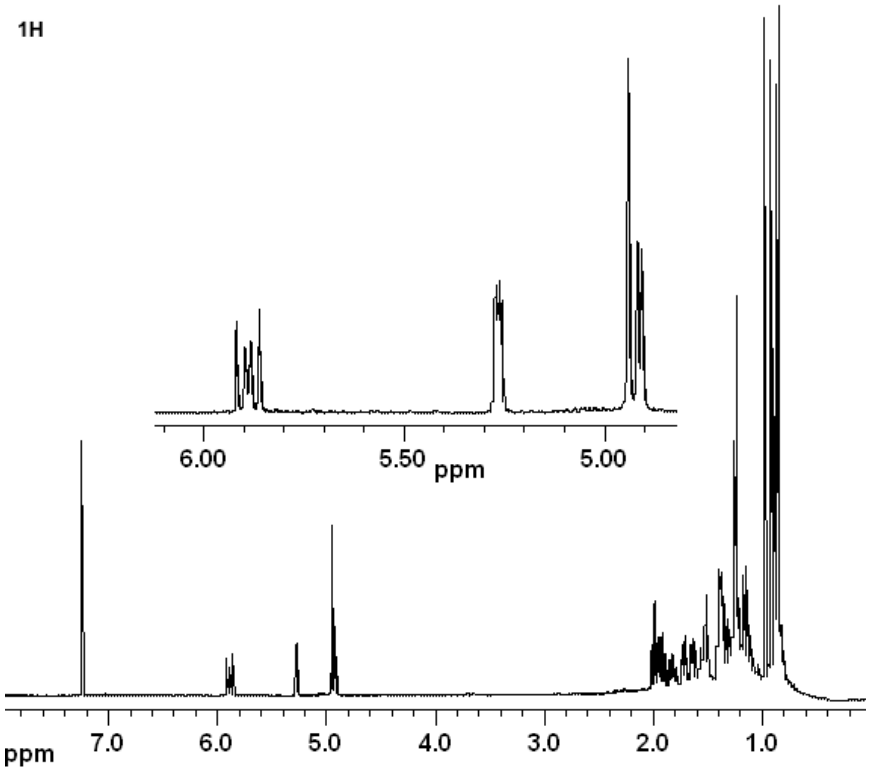

Figure S5: ^{1}H Spectrum of *syn*-isopimara-7,15-diene **9**. All spectra were acquired in $CDCl_3$ solvent.

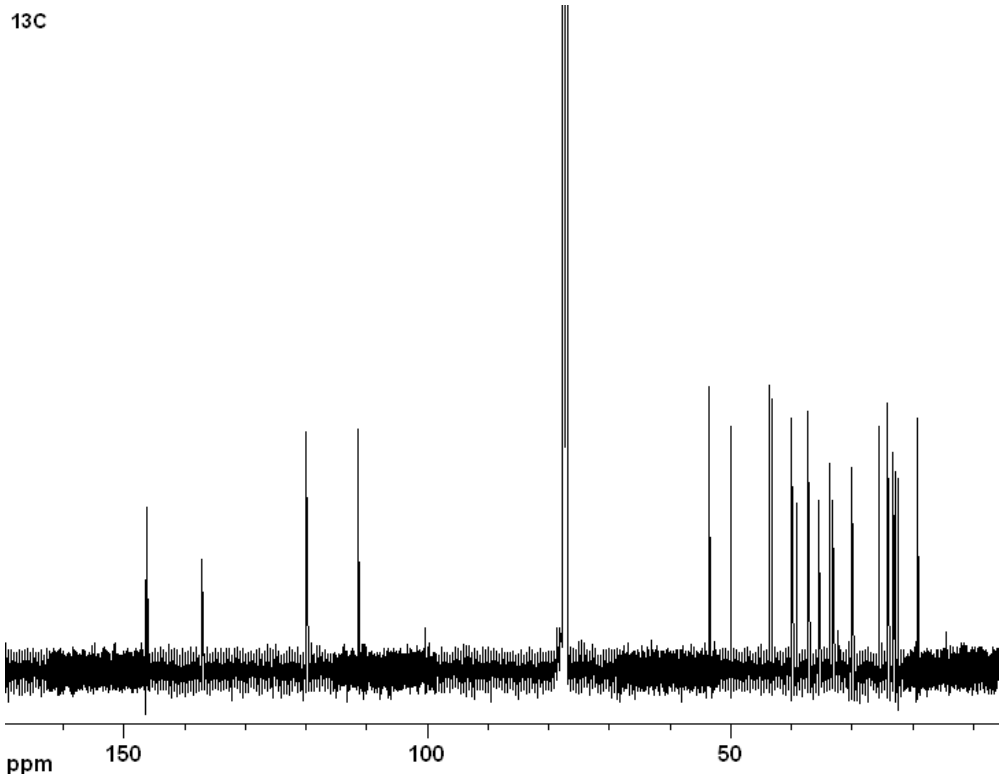

Figure S6: ^{13}C Spectrum of *syn*-isopimara-7,15-diene **9**.

Table S3: ^{1}H and ^{13}C NMR assignments for *syn*-manool **10** in $CDCl_3$

***syn*-manool 10**		
Position	**δ_C (ppm)**	**δ_H (ppm), *J* (Hz)**
1	36.98	1.086(m); 1.550(m)
2	19.44	1.428(m); 1.622(m)
3	42.85	1.165(m); 1.385(m)
4	33.47	
5	46.00	1.291(m)
6	23.92	1.289(m); 1.611(m)
7	31.93	2.067(m); 2.185(m)
8	149.44	
9	58.70	1.459(m)
10	38.33	
11	20.44	1.332(m); 1.590(m)
12	41.24	1.224(m), 1.428(m)
13	73.58	
14	145.50	5.899(dt), *J*=10.7, 17.4
15	111.72	5.048(d), *J*=10.7; 5.205(d), J=17.4
16	28.10	1.269(s)
17	109.64	4.539(t), *J*=1.7; 4.720(t), *J*=2.2
18	33.68	0.869(s)
19	22.63	0.802(s)
20	22.93	0.907(s)

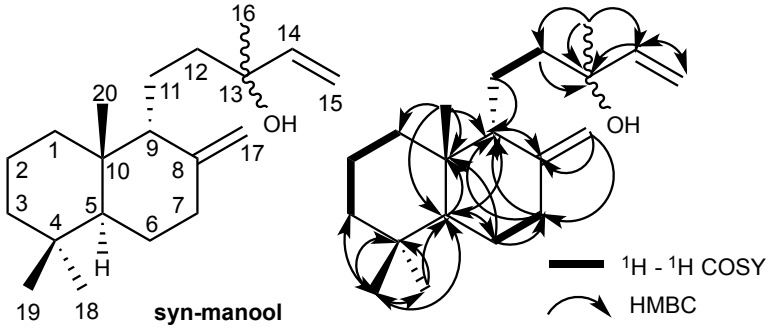

Figure S7: ^{1}H spectra obtained for *syn*-manool **10**. Carbon numbering and HMBC correlations and COSY correlations used to assign configurations.

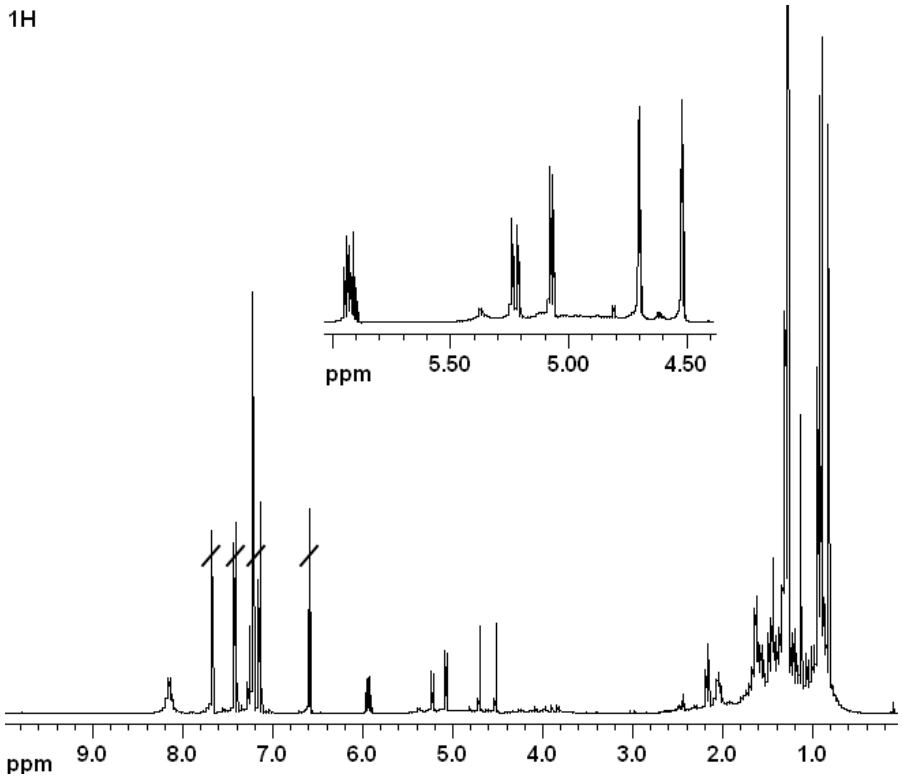

Figure S8: ^{1}H Spectrum of *syn*-manool **10**.

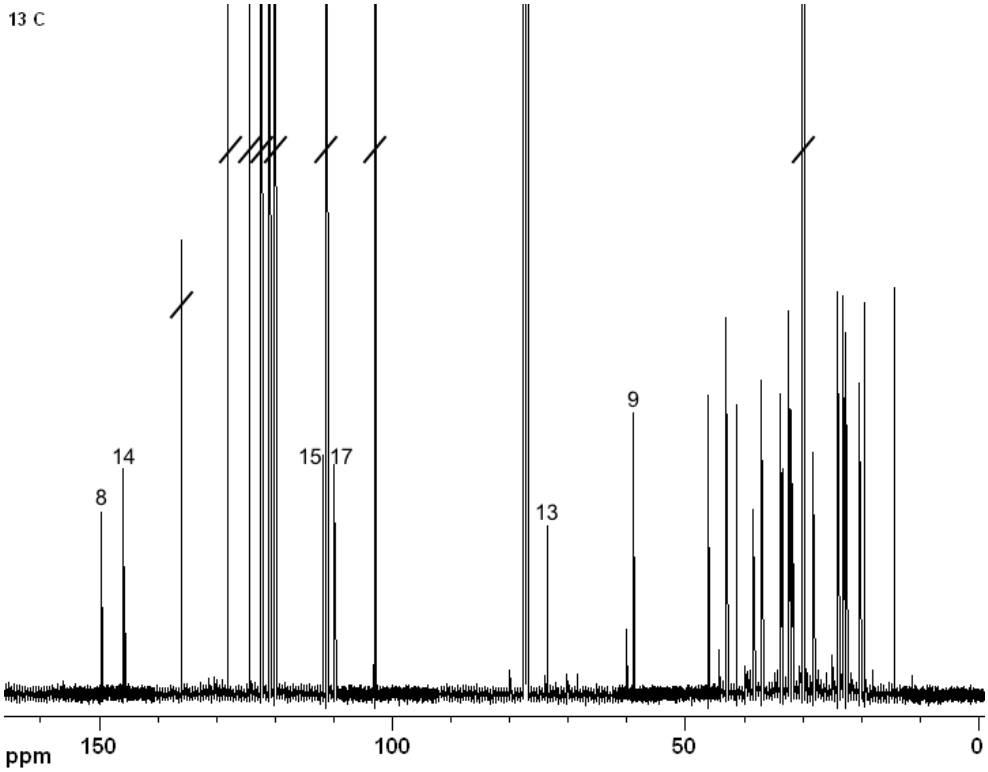

Figure S9: ^{13}C Spectrum of *syn*-manool **10**.

Table S4: Gene accessions.

Gene	Accession
AfCPS-PS	XP_753151
AoCPS-PS	XP_001820661
AnCPS-PS	XP_001398730
NfCPS-PS	XP_001264196
CYP503C1	XP_001398729
CYP503B4	XP_001264200
CYP58D2	XP_001820660
CYP58Dp	XP_753152
AoCPR	XP_001826472

Table S5: Primer sequences.

Gene	Purpose		Sequence
AfCPS-PS	cloning	F	CACCATGATTGGCAATCCAGGAGCGT
		R	GGCTCTACCACAGCGATGTGA
	PS_{inact}	F	ATTGGTTTGTTTCAAGAAGCTGACTTGATGGAGAGGTCG
		R	CGACCTCTCCATCAAGTCAGCTTCTTGAAACAAACCAAT
	CPS_{inact}	F	AATGCATGTGCTGCTGCCGCTGCTACAGCCAAGGCGTTA
		R	TAACGCCTTGGCTGTAGCAGCGGCAGCAGCACATGCATT
AoCPS-PS	cloning	F	CACCATGAAAGATAACCCGGTGGGCGTTC
		R	ATTTGGTAGCACGACGGCGACGTAA
	PS_{inact}	F	ATTGGTATCTTTCAGGAAGCTGAACTGATGGAAAAAAG
		R	CTTTTTTCCATCAGTTCAGCTTCCTGAAAGATACCAAT
	CPS_{inact}	F	AAAGCGTGCCCGGCTGCCGCTGCTACCGCAAAAGCCCTG
		R	CAGGGCTTTTGCGGTAGCAGCGGCAGCCGGGCACGCTTT
AnCPS-PS	cloning	F	CACCATGACTGTTGTGAAAAAAATAAAGCTGA
		R	ATTCAGCCGCCAAAGTCGTCCTGA
	PS_{inact}	F	TACTCAACTATCAGGTAGCTGAGTATATGGAGTCGGTT
		R	AACCGACTCCATATACTCAGCTACCTGATAGTTGAGTAA
	CPS_{inact}	F	GGCTTTGTGCCTGCTGCCGCTGCTACTGCGCGGGCTCTT
		R	AAGAGCCCGCGCAGTAGCAGCGGCAGCAGGCACAAAGCC
NfCPS-PS	cloning	F	CACCATGACCCGCCCGAACGCAACC
		R	GCGATATCGCCACCCGTATGTAA
	PS_{inact}	F	CTGAACTATCAGGCGGCTGAATTCATGGAAGCC
		R	GGCTTCCATGAATTCAGCCGCCTGATAGTTCAG
	CPS_{inact}	F	ATCCAGGCCGATGCAGCTGATACCGCGAAAGCC
		R	GGCTTTCGCGGTATCAGCTGCATCGGCCTGGAT
CYP503C1	cloning	NdeI-F	AAAAACATATGGTGAACGATACCGAACTGT
		XhoI-R	AAGCGAATGTCTGCAGCTGTAACTCGAGTTTTT
	N-term. mod.	Δ45-F	CACCATGGCTAAAAAAACCAGCAGCAAAGGTAAACTGCCGATCTTTGGCACCAAA
CYP503B4	cloning	NdeI-F	AAAAACATATGGATAACTATACGCTGCTGA
		XhoI-R	CCCCGGAAATTGTGCTGGTTTAACTCGAGTTTTT
	N-term. mod.	Δ54-F	CACCATGGCTAAAAAAACCAGCAGCAAAGGTAAACCGTTTGTGGGCTTCCGCTC
CYP58D2	cloning	NdeI-F	AAAAACATATGGGCGTGATCAGCGTGGTTA
		XhoI-R	GGTTGGTATTCGCAAAGATTAACTCGAGTTTTT
	N-term. mod.	Δ48-F	CACCATGGCGAAAAAAACCAGCAGCAAAGGTAAACTGCCGCCGGGTCCGAAACTGGCGGC
CYP58Dp	Cloning	F	ATGGATTTTATGTCTCCTGCCGCAATTTTG
		R	GCTTTGCCAATACTTTGGTCTGT
AoCPR	cloning	NcoI-F	AAAAACCATGGTTACCCCGCCGTGGCCGCT
		NotI-R	AAATGGCAGGAAGATGTGTGGTAAGCGGCCGCAAAAA
Modified CYPs	cloning	NdeI-F	AAAACATATGGCTAAAAAAACCAG

Sequences of synthetic genes

>AoCPS-PS

atgaaagataacccggtgggcgttctggtggatatgaaagaacgtagcctgttcaaatctttcgataaaagttaccatccgacctacggc
ctgggtacgatgagcggcaatatctatgataccgcgtggattgcgatggtgcgcaaaccgatcgagggtaaatctgtgtgggcgtttccg
accgcattccaggcgctgctgcagcagcagagccattgcggttcttggggcggcaccacgagcgaactggattctatcgcgagtaccctg
gcagcactgctggcactgcagcgtcacgcagaagatagctatgatgccgatcgtcaggatctgaactctcgcattctgaaagccaaagc
atttctggatgcagcgctgaaaggcctgaatggtctgctgcgtacctgtacgctgcctgtgagcctggaactgcgtctgccggcaatcctg
gatctgctggaagcagaaggccatacctttgatttcgatcgcacgtacctgaacaaaatccagagtaaaaaactgagcaaaatcaatct
ggataccatttttagcggcccgcagagctctctgctgcatagtctggaagccctggttggcaaaattgatttcaaaggtctggcacactac
aaagtgctgggtagcatgctggcaagtccgagcgcaaccgcagcatatctgatgtacaacccggtttgggatgatgaagcggaagaata
tattcagcgtgcgatctctaatggtgcaggtcacggcagtggtctggtggcggcaggctacccgaccacggtttttgaatgggcctgggtg
accacgaacctgattcgtcatggcatcgaaccgagtagccgcctgaaagaagttggtaaacagattgaaagcgaaatcgaactgcacg
gcgtggttggtttcgtgccgaaagcgtgcccggatgccgatgataccgcaaaagccctggcagcactggcactgcagggtgcacagtat
agcccgcaggttctggtggatcgttttgaacgcgaaaaacatttcaccacgtatctgtacgaaacccacacgtctattagtaccaacgca
aatgttctgacggcgctggtgctgctgagcgccgatgatcgttatcagccgcagattgaaaaatgcatccgctacctgtgtgatgcatggt
ttcagtgcgatcgtatggtgaaagataaatggaatatcagcccgtattacccgaccatgctgatgtgtgaagcgctgatgagctatattca
gcgctggtctgaaggtcatctggccgcactgccggatgatctgatgaaatttcagctgccgatcaccctgttccagagcctgattcgtaccc
tgcgcacgcagaaccaggatggcagttggggttctagtaatagcgcagaagaaaccgcatacgcggttctgatcctgaaaagtgtggcg
ccgtttagcttcacgaacatgattagtgccgaaatcaaagatgcaattaatcgtggcgttcagtttattctgaccaagggtcagcgcagcc
agacggatgatcagctgtggctggataaaaccctgtatgcgatcccgaccgtgagcgattcttacattatggcggccctgcaggcagaag
ataccatcgataaactggcggaaattccgcacatgctggcgaacgttagcaccgcgatggtgctgaaaatgacggaatatttttctcgtct
gccgagtcagatggaaaccccgaaatgggttattcaggcatctgtgattgaagcgatcctgtttggctaccgcctgaaaaccctggatgtt
ttcagtacgggcggtgcgctgggcgaaaaatatatcaaatacggtgcctgcttctggaccctggcaaacaatagctctccggaatatctg
ctgtctacgtgggtggtttactctatgattgaactgagtattggtatctttcaggaagatgaactgatggaaaaaagtctggtgaacctgcc
ggatttcaccacggatatgatcgcggattatattgatgaactgtgcaatgaaaccgccctgtgtaaagatagtagcctgcatggccactct
agtcgtacgaacatcagcgatgttaatgaagaaaccctgacgcgtctgaaatctatccgcgaaaatattggcacctggtttcgcttcgtgc
tggatgataacctgaaagcgaatacgagtccgtatcatcgtcgcgatctgcagaaagaactggaaatgagcaccctggcagcgacgca
gcaggccaaagcacatcgttctctgaacaatcgtctgccgcacagtggcaccgaatgcgcaaccgttagcacgggtcagacctttatac
gtggctgcataccagcgcggttcacgatgtgaaatctgccgttgttagtaaaagcctggtttgtaaaattggcaacggcggtgatgtgtttc
cgaccgcgcgcgaaaaatacctggccgaaaaactgtggcgtcagatctctgtggaaggccgcctgtggaacgatttcggtagtattgaa
cgtgatcgcctggcgagcaacctgaacagcgttaattttccggaatttagcagcccgcagagcctgctgctggatggtgatgtgggcacc
cagctgctgcagctggccgaatatgaacataaatgcaccctgtcttgtctgaatgatctgacgcagatcctggatagtaccggccgtcag
acgattagcctgtacctgcagatgtattaccgctgctgtgttatctacagtgaaacctgtgtgaaatacgcatttggtagcacgacggcga
cgtaa

>NfCPS-PS

atgacccgcccgaacgcaaccgatctgtgcacgcaggcgtgtcagctggtgcagcagctgcgtacgaaagatggcgaactgggttttat
gtctccggcagtttatgataccgcgtgggttagcatggtgaagaaaaccacgccggaaggtccgcagtggctgctgccggaatgcttcga
atatattctgcgcacccagctggaagatggcggttgggaaacgtacgcgtgtgatattgatggtatcctgaatacggcggccagcctgct
ggccctggaaattcatgcagaatctcgtatcgcacgtaccgatccgccggtggcagaaattaaagaacgtatcggtcgtgcccgcgcagc
actgagccgtgaactgcaggcgtgggatgttaaagataccgtgcatgttggttttgaaatgatcctgccggcactgctgcgtctgctgcgt
aaaaaaggccacgaatttgaattcgatggtcgtgcggaactggaacgcctgaaccgtattaaactgagcaaattccgcccggaatatct
gtacagtgcacgtaccacggcgctgcatagcctggaagcatttgtgggcatgatcgatttcgataaagtggcgcaccagaaagttaacg
gtagctttatgttctctccgagctctaccgccgcatttctgatgttcgccagtagctgggatgatgattgcgaacagtatctgcgcctggttc

tgcagaatggtgccggctgtggttctggcggtatgccgagtgcatatccgagcaaatactttgaagttagttgggttctgaccacgctgct
ggataacggctacagtccgagcgatctgggtattgaagataccgattctctgggcgaaatgctgcgtaatgccctggtgaaaggcggtgg
cattgttggtttcgcaccgagtatccaggccgatgcagatgataccgcgaaagccctgatgacggtgtctctgctggataaaccgctgagt
gcgcagggcctgatcgatgaatttgaaggtccgacccatttccgcacgtatcacggcgaacgtgatccgagctttacggccaactgcaat
gtgctgatggcactgctgaattctccggatgccagtacctttgcaccgcagattgaaaaaaccacggcattcctgtgtgatgtttggtgga
ccgcggatagcgaaatcggtgataaatggaacctgagtccgtattacccgagcatgctgatggcagaagcgtttggcaaactgctgcaa
gtgtggtctaatgacggtctgaaaagtatttctagtcagttcatccgtgatcgcgtgagcatttgccagtatcaggcgctggttcgcaccct
gcagagccagaacgaagatggctcttggggttctcatagtcacgaagaaaccgcctacgcaattctgacgatcgcgcatgcctgtcagct
gccggtggttaaccagctgtggaccaatgtgcagagtgcagttagccgtggccgcaaatttctgcagaatagcgcgggtgaaaaaccgg
aatatctgtgggtggaaaaagttacctacggctctattctgctgagcaaatcttatgtgctggcggccctgaaagttagctgcgaacgctc
ttacccggcgtgtctggccgaactgtttaacattagcaaaaaacgcgtgatggaatttgcgcgtttcaatagtatgctgccgctgttcagcg
gcatggaaccgtggaaaatccgtgcagcggtggttgaaggttatctgctgctgccgcagctgcgtgatcgtcgtctggccgtttttccgcgt
accggcatggaagaagataaatacttcgaatacatcccgttcacctggacgctgtgcaacaatcgtcgcaacaccttcctgtctacgaaa
agtctggtggaaatgatggttatcagctttctgaactatcaggcggatgaattcatggaagccgtggttggtcgcctgaatagctctcagc
gcagtatggcgcgtagctgtattgatgaaatctttctggatctgaaagataacaccgaaatgaacgaaaaaatgcagccggatacggaa
accacggataaaaacggctataaaaccctgccgcaggtgaaacgcaccaaaacgggttctcgtctgccgagtgaagtggccaccgttct
gagtgcatttgtgcatcacgttatgaatcatccgagcgtggaagccgcagcgccgctggaatacaaacgtgttaaagatgaactgaaaa
tttttctgctgagtcacatcaaacaggcggatgataacggtcgtttcgcagcacagccggaaagcacccgtgataattttgaaacggccc
gcagtagcttctatcgttgggtgtacagcacctctagtgatcatacgagctgcccgtattcttttgcgttctaccagtgtctgctgggttctga
acacgccagctctgatgcggcctgctttcgcacgtgtgaagaaaaatatgtggcagaagcgatgtgccgccacctggccgttacctgtcg
tatgtataacgattacggcagcctggcacgtgatcgcgatgagaaaaacctgaattgcgtgaattttccggaattcgccccggcaggtcc
gaaaagcgatgcggttcgtcagaaacagctgtttagcctggcccagttcgaacgctctaatgtggaacgtggcctggaagttctgaccga
aatggcagcgcaggatcgtgcgcgcatgcgtgtgctggaaaaagttcagatgttttgtgatgtgacggatctgtatggtcagatttacgtt
gcgcgcgatatcgccacccgtatgtaa

>AoCPR
atgaccccgccgtggccgctgccgctgaacattccgccggatgcgctgcaggaactgtctaaaaccctgacgccgaccggtattgccgat
tatagcgcactgacgatcttttctgtggcagcagcaacctatctgagccgcggctacctgtgggatcagccggacccgtatcagcatctgg
tttacgaacgtccgcagctgaaaaacggcggtgcggccggttctgcgacgaaagaaacccgcaatattgccaaaaaactggaagaaag
tcgtaaagatatggtggttttctggggctctcagagtggcaccgccgaaggctttgccaaccgtctggcacgcgaaattagtctgcgcttc
ggtctgagcgcgatgacggccgatctgagcgattatgatccggaaaccatcgcagaagtgccgcagagtaaactggttggctttctgctg
agcacgtacggcgaaggtgatccgtctgataacaccgcggaactgtgggattgggtgaataaaacgaaagatcagggtcagctgctga
gctctgttcgttattttgcgttcggcctgggtaaccgtaattacaaatattacaatcgcgtggttgatgtggttgtggaagccctggataaac
tgggcgcgaaagccgtgatgccggttggtaaagcagatgatgcggaaggcgccacgcaggaagattttatgacctggaaagaaagcct
gttcgccgtgctgaaaggcctgggttttcaggaacatgaagtgcagtatatgccgaccctgtctgttcaggaagatgaaagtctggaacc
gattgatctgcacaacggtgaaccggatggcggtagcctgaaagcgcagtgctctccgattcgtccgctggcaatcagcgcgtctcgcga
actgttcaatagtagcgatcgtcattgtctgcacattgatctggatctgaccagtcagccggaatttacgtacaaaaccggtgatcatctgg
caatctggccgggtaacccggatagcgaagtggaacgtctgctgcaggcgctgggtctgtctagtcgtcgcgatgtgccgattacgatca
aatctctggatagtgccaccaaagttaaaattccgagcccgaccacggtggcaaccgttttccgctattacctggaaatctgcggtccggt
gaaccgtgataatgttctgggtctggcacagtttgcaccgaccccggatgcaaaagcgtatctgcagcagctgggtcaggataaagcca
gctacgcagcgtttattaacaaaaatcacgtgaacctgggccgtctgctgcagcaggcaagtacggaaacctggaatatcccgctgagct
atctggttgaaaccctgccgctgatgcagccgcgctattacagcattagctctagtagcgtgatcagcccgcgtaaagcgtctattaccgtt
gtggttagcaccacgccggttccggaaaacggtgatgaactgattcatggcgtgacgtctaactatctgctggcagttagtgaaaatctgc
gtagcgcaccgcatccggaaggtctgacctaccacctgaatggcccgagtgatagcctgcagggcggtaaagtgctgtctcacctgcgta

aaagtaaattcaaactgccgaccctggcgaaatgcccgctgattatggttgcagcaggcacgggtctggcaccgtttcgtgcattcatcgc
cgaacgtcgccagctgcagcagattggtcgtgaaatcggcgaaatgctgctgattttcggttgtcgtcgccacgatgaagattttatctatc
gtgatgaactggaagaaatgacctctgtgctgggcgaaaaactgcgtattgttacggcctatagtcgcgaagataaaaaacagtacgtg
caggataaaatcagcgaagtgggcgatgatgtttatcgcctgattgatgaaggtgcgaattttttacatctgtggcaaagcagaaatggcg
cgtgaagttgaaaaagccgtggcaggtgttatgagccagaaaggccaggatgaagcgaacgaatggcgtacccgcatgaaacgtcgc
aataaatggcaggaagatgtgtggtaa

>CYP503B4
atggataactatacgctgctgagcctgcacaccggcaatctgaaaccgccggatagctctagtagcatcgatcgcagccagctgtatctg
ggcgtgatcggtgttctgtctgtgatttacctgctgcagacgctggttgcctgcaccaaaagctttaaagcaccgtttgtgggcttccgctct
agttttgaaccgaaatggctggttggcctgcgtttctctcagggtgcactggcgcaggtgaacgaaggttacgaaaaatacaaaaacgcg
atgttcaaaattgcccgcaatgatagcgatattctggttatcccgaacaaatatgtggaagaactgcgttctctgccggatgaaaaaatta
gtgccatccgcgcacacatcaaaaatctgctgggcaaatacagtaccacgctgattctgctggaaagcgatctgcatacccgtatgctgc
agacgaaactgaccccgaacctgggtagctttattgaagtgatcgaatctgaactgcatttcgcgatggaaaaagaaatcccggccgat
ctgcacgattggcagaatgtgaacgtttttcatattgttctgcgcatcgtggcacgtatttctgcgcgcgttttcctgggtgtgccggcctgtc
gcaacgaagaatggctgcagacgagtattcactataccgaaaatgtttttgcaaccgtgatgctgctgcgtcgcttcccgaaatggatgc
atccgatcgttggccacctgctgccgagctactgggcaattcattctaacctgcgtacggcgaaacgcattatcagcccgatggtgcgtca
gcgtcgtgcagaagaagccaaaggtgatccgacctatgaaaaaccgaatgatctgctgcagtggatgatggatggcgcgaatgaaaac
gatggtcagccggataaactggcacaccgtcagctgctgctgagcctggcctctattcataccacgacgatggcggcggcgcactgctttt
atgatctgtgtcagcatccggaatacttcgaaccgctgcgtgaagaaatcaacgatgttattgcgcaggatggcggttggaagaaaacc
accctgaataaaatgcgtaaactggattcttttctgaaagaaagtcagcgtatcaacccgccgagcctgctggcattcaatcgtattgtta
gtgaagatctgacgctgagcgatggcaccctgctgccgaaaggcacccattttagtatgccgagcgcggccatcctgcaggataacgca
gtggaaccggatgcggatcagtttgatgccttccgttattacaaaaaacgcctgaatccggaagaagcaaacaaacaccagtttgcgat
gaccgataacaataacctgcatttcggccacggtaaatattcttgcccgggccgctttttcgcaagtaacgaaatcaaaatcatcatggcg
catctgctgacggattatgaatttaaatacccgccgggtgccagtcgcccgcgtaatctgaccgcagatgaaaacctgtacccggacccg
agcgcacgtctgctgatgcgccgtcgtatggtggcagagggtcaggcacagatcaccccggaaattgtgctggtttaa

>CYP503C1
atggtgaacgataccgaactgtggacgctggtgaccacggcgcatccgtttccggttgaaagcattcactggacctatacgctgctgttcc
tggcggttggcgcctactgctgtagtatcttttggagccagattttcggctataaactgccgatctttggcaccaaatctccgtgggaaccg
gtgattatcagtaacttccgtttctttcatcacgcagaacaggttctgcagcagggttacaacgaatgcaaaaaccgcatcttccagttccg
tcgcgcggataccgatatgctggtgctgccgccgaaatacgttgatgaaatccgtcgcctgccgaatcatattgcgagtccgaccctggcc
catgtgcacaacctgatgggcagccgtatcaacatgcatatcatcctgcgtaacaatctgcactttcgcaccctgcaggttaaactgacgc
cgaacctgaatagcattaccctgccgatgcaggaagaagtgaactacgcgatcgaaaaagatttcacgaaatctgaagatgaatgggtt
accatcaaaccgtaccacacgattctggatctggtgtctcgtgttagtgcccgcattttcctgggccagccgctgtgtcgtaacccgcagtg
gctggaactgagcacccagtttacggaaaatgtgttcgtttctctggtgtttctgcgcctgttcccgatgtggacccacggcctgctgacgt
ggtttatgccgagctcttatcgtggtagcgcatacatccgccaggcgaaaaaactgctggttccggaaattaaccgtcgccgtaaactgg
cctctgaaggtatcgaagaaccggcagaaaacaaacacaatctgctgagttggatgatggaaattgccaccccggaagaatctgatccg
gcaagtctggcgcatctggaagtggttctgagtctggcggccatccatacgagccagatgaatgcagtgcacgttctgtatgatctgctgg
tgcatccggaatacctggaaccgattcgtgatgaaatccgcaccacgattctggaaaacggcccgtggatgacctgggaaaaaagcgcg
ttttctaaactgcgtaaactggatagcttcatgcgtgaatctcagcgcgtgaatccgccgaccctgctgagtatgcaccgtgtgctgctgca
ggaagttaccctgagtgatagcacgcgcctgccgaaaggtgcacatatctctatggccgtgaacgcaattcagaatgatccggaagttac
cacgaacccggaaaccctttgatggcttccgttattacaaactgcgtcagcgcgaaggtgaagcccatctgcaccagttcagcaccacgca

ggatcgcattctgaacttcggtcatggcgcaaatgcatgcccgggtcgtttctttgcagcgctggaaatcaaaattatcctggtgcgcctgc
tgatggattttgaatggaaactgaaagaaccgggtaaacgcccggaaaacctgcatgcgcacgaatttatcttcccgaatccggatgcg
gaaattctgatgcgccgtcgcccggcaagcgaatgtctgcagctgtaa

>CYP58D2
atgggcgtgatcagcgtggttacctttctggcctctgcaaaagaacatttcatcatctctatcctgctgctgtttccgattgcgctgatcctgc
gtacgatttatcgcctgtacatcgatccgctgcatcacattccgggtccgaaactggcggccatcagccatctgtatgaatttaccacgat
gtggttcgcggcggtctgtttatttgggaaatcgaaaaaatgcatcaggaatatggcccgattgtgcgtatcaacccgcgcgaagttcaca
tcaaagatccgtatttctacgatgaactgtacgcgccggcgcatggctggcgtgataaagatgcgaaaagcgttgaaatttttagctctcc
gaatgccctggtgtctaccgttgatcatcacacgcaccgtatgcgtcgcaaactgctgaccagctttttctctcgtcgcagtattgaacgca
tcgaaccggtgattcatgaaagtctgagcaaatttctggatagtctgatcaccgcgtatgaagaagatagcgtggttgaactgattgatcg
cctgcaggccctgaccggccatgttatcacgcagtatgcatacggcgaagattacggtctgcacgaaccgcagaacattggcaaaggta
tcgtgaaagtggttcaggaaggcaccgaacagatccatctgcaccgtttctttccgctgattcagcgtttcctgcgcctgatcccgagctttt
tcatgacccagctgtttccggcccgtgcagcgatgtatgatctgctgcacggcgttcgtaaaaaatctattgaagtgctgcagcagaaaga
tgtttgcaccccgacggaacgtaccacgatgtttcatgccctgaccgcaccggaagttccgccggaagaacgtacgctgcagcgcctgga
agatgaaggcctggtgctgttcgcagcaggcaccgaaaccacggcaaccacgctgggtgtggccatttttcacatcctgagcgatccgat
ggttctgacgaaactgcgtaaagaactggaacaggtgatgccgaccccggaaggtctggcaacgtggcgtgaactggaaaaactgccg
tatctgaatggcgttattcatgaagcactgcgtttctctggtctggcgatgcgtcagcagcgcgtgagtccgaccgaagttatcaaataca
aagattacgcaatcccgccgggcacccctgtgagtatgctgcagtattttctgcacaccgatccggcactgtttagcgatccggaaaaatt
ctacccggaacgttggatgctggcagcagaacgtaaagaatctctgagtcgctttctggtgaccttcggcaagggtacgcgtagctgtatt
ggtatgaacctggcgtatgcggaactgcataccgccctggcagcgatcgttcgtcgcttcgatctggaactgtacgaaaccacggcagaa
gatattcgttttgtgcgcgataaactgctgccgcgtgcgaaaaatggcccgtggcgtgtgcgcgttaaagtggttggtattcgcaaagatt
aa