## **On-line Supporting Information**

# A twin-track approach has optimised proton and hydride transfer by dynamically-coupled tunnelling during the evolution of protochlorophyllide oxidoreductase.

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#### **Supplementary tables**

**Table S1.** The rate constants and thermodynamic parameters for the hydride transfer step for the various POR enzymes in the presence of either *pro-S* NADPH or *S*-NADP<sup>2</sup>H (*S*-NADPD). All rate constants were measured at 25°C as described in the *Methods*. The enthalpies of activation,  $\Delta H^{\ddagger}$ , and the entropies of activation,  $\Delta S^{\ddagger}$ , have been calculated by fitting the temperature dependence data to the Eyring equation.

	Thermosyn. elongatus	Synechocystis sp. PCC6803	Gloeobacter violaceus	Arabidopsis POR B
$k_{\rm H}$ - (s <sup>-1</sup> x10 <sup>6</sup> )	$1.87 \pm 0.17$	$1.86 \pm 0.18$	$1.86 \pm 0.12$	$1.81 \pm 0.24$
$k_{\rm D}$ - (s <sup>-1</sup> x10 <sup>6</sup> )	$0.98 \pm 0.14$	$0.98 \pm 0.13$	$0.95 \pm 0.18$	$0.96 \pm 0.11$
KIE	$1.91 \pm 0.17$	$1.90 \pm 0.16$	$1.94 \pm 0.13$	$1.91 \pm 0.23$
$\Delta H^{\ddagger}$ (kJ mol <sup>-1</sup> )	$9.3 \pm 0.4$	$11.7 \pm 0.2$	$13.3 \pm 0.5$	$13.6 \pm 0.7$
(< -27°C)	$(27.2 \pm 0.5)$	$(35.0 \pm 1.0)$	$(33.1 \pm 1.0)$	$(33.7 \pm 1.0)$
$\Delta \Delta H^{\ddagger}$ (kJ mol <sup>-1</sup> )	$8.2 \pm 0.6$	$7.0 \pm 0.3$	$6.9 \pm 0.7$	$7.6 \pm 0.9$
(< -27°C)	$(0.4 \pm 1.0)$	$(0.4 \pm 1.5)$	$(0.5 \pm 1.2)$	$(0.3 \pm 1.2)$
$\Delta S^{\ddagger}$ (J mol <sup>-1</sup> K <sup>-1</sup> )	$-94.4 \pm 1.2$	$-85.9 \pm 0.5$	$-78.6 \pm 1.1$	$-79.4 \pm 1.7$
(< -27°C)	$(-21.8 \pm 0.3)$	$(10.0 \pm 0.2)$	$(0.3 \pm 0.1)$	$(2.8\pm0.1)$
ln A <sup>'</sup>	$12.4 \pm 0.2$	$13.4 \pm 0.1$	$14.3 \pm 0.2$	$14.2 \pm 0.3$
(< -27°C)	$(21.1 \pm 0.3)$	$(25.0 \pm 0.5)$	$(23.8\pm0.5)$	$(24.1 \pm 0.5)$
A' <sub>H</sub> /A' <sub>D</sub>	$0.08 \pm 0.02$	$0.11 \pm 0.01$	$0.15 \pm 0.05$	$0.08 \pm 0.04$
(< -27°C)	$(3.6 \pm 2.0)$	$(3.4 \pm 2.7)$	$(3.1 \pm 1.9)$	$(3.5 \pm 2.3)$

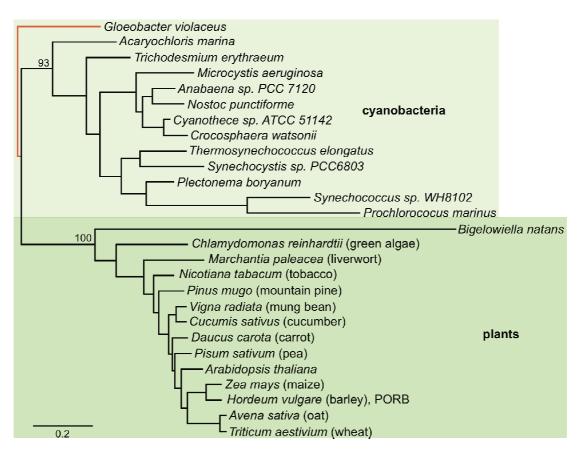
**Table S2.** The rate constants and thermodynamic parameters for the proton transfer step for the various POR enzymes in either H<sub>2</sub>O or <sup>2</sup>H <sub>2</sub>O (D<sub>2</sub>O) buffers. All rate constants were measured at 25°C as described in the *Methods*. The enthalpies of activation,  $\Delta H^{\ddagger}$ , and the entropies of activation,  $\Delta S^{\ddagger}$ , have been calculated by fitting the temperature dependence data to the Eyring equation.

	Thermosyn. elongatus	Synechocystis sp. PCC6803	Gloeobacter violaceus	Arabidopsis POR B
$k_{\rm H^+}  ({\rm s}^{-1}  {\rm x10}^3)$	$27.4 \pm 1.0$	$30.4 \pm 0.6$	$152.0 \pm 5.7$	$123.3 \pm 3.7$
$k_{\rm D}$ + (s <sup>-1</sup> x10 <sup>3</sup> )	$13.6 \pm 0.8$	$16.9 \pm 0.7$	$98.9 \pm 2.7$	$82.0 \pm 1.9$
SIE	$2.01 \pm 0.14$	$1.80 \pm 0.08$	$1.54\pm0.07$	$1.50\pm0.07$
$\Delta H^{\ddagger}$ (kJ mol <sup>-1</sup> )	$53.7 \pm 1.6$	52.1± 2.1	$43.9\pm0.8$	$36.7 \pm 1.3$
$\Delta \Delta H^{\ddagger}$ (kJ mol <sup>-1</sup> )	$15.6 \pm 3.1$	$17.6 \pm 3.7$	$2.6 \pm 2.4$	$1.0 \pm 1.9$
$\Delta S^{\ddagger} (\mathbf{J} \mathbf{mol}^{-1} \mathbf{K}^{-1})$	$19.4 \pm 0.5$	$14.4 \pm 0.5$	$1.7 \pm 0.1$	$-24.3 \pm 0.6$
$\ln A$	$26.1 \pm 0.6$	$25.5 \pm 0.8$	$24.0\pm0.3$	$20.8\pm0.5$
A' <sub>H</sub> /A' <sub>D</sub>	$0.004 \pm 0.005$	$0.002 \pm 0.003$	$0.55 \pm 0.57$	$0.90\pm0.70$

**Table S3**. Rate constants of the product release steps for the various POR enzymes. All values were measured at  $25^{\circ}$ C as described in the *Methods*. n/a means not applicable as no rate constant is measurable. Standard errors are within 5% of the measured values for the rate constants. These are approximate rate constants for each kinetic phase fitted by using a single exponential expression to each resolved phase as previously described (2), rather than fitting to a more complex sequential model. Data for *T. elongatus* is taken from (2).

Product release event	Thermosyn. elongatus	Synechocystis sp. PCC6803	Gloeobacter violaceus	Arabidopsis POR B
Conformational change	350 s <sup>-1</sup>	350 s <sup>-1</sup>	n/a	n/a
NADP <sup>+</sup> release	$45 \text{ s}^{-1}$	$45 \text{ s}^{-1}$	$10 \text{ s}^{-1}$	$65 \text{ s}^{-1}$
NADPH rebinding	16 s <sup>-1</sup>	n/a	1 s <sup>-1</sup>	11 s <sup>-1</sup>
Chlide release	1.7 s <sup>-1</sup>	0.2 s <sup>-1</sup>	0.04 s <sup>-1</sup>	$1.4 \text{ s}^{-1}$

## **Supplementary Figures**

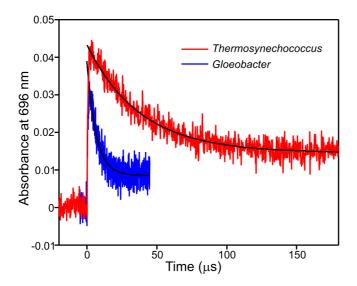


**Figure S1.** Inferred evolutionary history of plant and cyanobacteria PORs based on the alignment in panel B. The scale bar represents amino acid replacements per site. Numbers next to nodes correspond to % bootstrap replicates; only shown for the main cyanobacteria and plant clades.

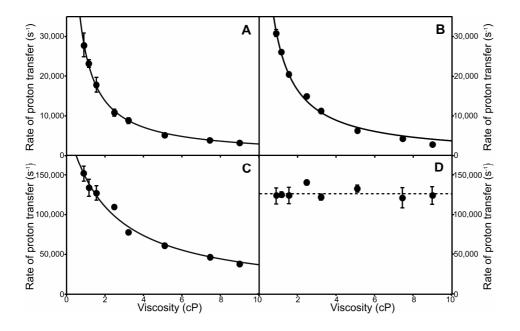
Nicotiana	ATTPAVNQSTSEQKKTLRKGNVIITGASSGLGLATAKAIGETGEWHVIMACRDFLKAEKAAK
Cucumis	– – – – – TESPAVNKATPDGKKTLRKGSVVITGASSGLGLATAKALAETGKWHVIMACRDFLKAERAAK
Pisum	– – – – – – PATPAVNKSSSEGKKTLRKGNVVITGASSGLGLA <mark>TAKALAES</mark> GKW <mark>HVI</mark> MACRD <mark>YLKAARA</mark> AK
Pinus	VAAPVETKDAPASKKTDRKGNVIITGASSGLGLATAKALGESGKWHIIMACRDFLKAERMAR
Marchantia	
	VTAPAETMNKPSSKKTATKSTCIITGASSGLGLATAKALADTGEWHVIMACRDFLKAERAAR
Vigna	– – – – – – ATTPGVTKASPEGKKTLRKGSVI I TGAS <mark>SGLGLAT</mark> AKA <b>LAET</b> GKW <mark>HVIMAG</mark> RDFLK <mark>AERA</mark> AK
Daucus	– – – – – – ATTPS VNRATGEGKKTLRKGS VI I TGAS <mark>S GL</mark> GL <mark>ATAKALAETG</mark> KW <mark>H VI M</mark> ACRDFLKAERAAK
Arabidopsis-thaliana	– – – – – – T S T P S V T K S S L D R K K T L R K G N V V T G A S S G L G L A TA K A L A E T G K WH V I MA G R D F L K A E R A A Q
Hordeum	VSAPTATPASPAGKKTVRTGNAIITGASSGLGL <mark>AT</mark> AKALAESGKWHVIMACRDYLKTARAAR
Zea	VSSPSVTPASPSGKKTLRKGTAVITGASSGLGLATAKALAETGKWHVIMACRDFLKASRAAK
Triticum	TTSPGSATAKPSGKKTLRQGVVVITGASSGLGLAAAKALAETGKWHVVMACRDFLKASKAAK
Avena	<u> </u>
Gloeobacter	NAEQTVIITGASSCVGLHAADSLAQSGRWHVVMACRDKAKAQNAAA
Acaryochloris	CMEQHQKQTVVVTGASSGVGLYAAKALALTGKWHVIMACRNFLKAETAAQ
Trichodesmium	AKENHKSTVVITGASSGVGLHAAKALAKTGEWYVVMACRDISKAEKVAQ
Microcystis	MIQDKKPTVIITGTTSGVGLYAAKSLAQRG-WFVVMACRDIPKMEQAAK
Nostoc	MVQDRKSTVVITGASSGVGLYAAKALAERG-WYVYMACRDVAKAQLAAQ
	WVQDRKSTVVTTGASSGVGLTAARALAERG-WTVVMACRDVARAQLAAQ
Crocosphaera	AC
Synechocystis	<b>U</b> MEQPMKP <b>TV</b> II <b>TG</b> AS <mark>SGVGLYGAKALIDKG</mark> -WHVIMACRNLDKTQKVAD
Thermo	WSDQPRP <b>TV</b> II <b>TG</b> AS <mark>SGVGLYATKALANRG</mark> -WHVIMACRNLEKAEQAAK
Plectonema	WAQDQKP <b>TV</b> VI <b>TG</b> AS <mark>SGVGLYAAKALVKRG-WHVVMA</mark> CRNLEKADSAAK
Synechococcus	WSTPGTVLITGTT SGVGLNATCALVKRG-WTVITANR SPQRAAAAAD
Cyanothece	MGVSIHMVENHKSTVIITGASSGVGLYAAKALADRG-WYVVMACRNQPKAHQAAQ
Anabaena	
Prochlorococus	
Nicotiana	VG I P KE - NYT VMHLDLASLESVRQEVDT - FRRSGR PLDALVCNAAVYLPTAKEPT FTADGFELSV
Cucumis	AGITKE-NYTYMHLDLASLDSVROFYDN-FROSGRPLDVLVCNAAVYLPTAKEPTFTAEGFELSV
Pisum	AGLAKE-NYTIM-LDLASLDSVRQFVDN-FRRSEMPLDVLINNAAVYFPTAKEPSFTADGFEISV
Pinus	VG I P KE - NY S VMHL D LASE B S V ROF VDN - FR S G R P LD V L T NNAA VIFFTA KE P S FTAD G FE I S V VG I P KE - NY S VMHL D LASE E S V ROF AD N - FR R S G R P LD V L V C NAA I YL P T A KL P T Y T A EGFE LS V
	VGIPKE-NTSVMHEDLASLESVRUFADN-FRKSGRPEDVLVCNAATYLPTAKEPTTTAEGFELSV
Marchantia	VGIPKD-SYTVI <mark>H</mark> CDLASFDSVRAFVDN-FRRTERQLDVLVCNAAVYFPTDKEPKFSAEGFELSV
Vigna	SG I S – – – K E – NY T VMHL D L A S L D S V R Q F V D N – F <mark>R</mark> Q S G R P L D V L V C N A A V Y L P T A S E P T H T <mark>A D G</mark> F E L S V
Daucus	AGMP KE - NYT I MHLD LASLD SVRQF VET - FR SERPLD VLVC NAAVYF PT AKE PT YT ADG FELSV
Arabidopsis-thaliana	AGMP KD - SYT VMHLD LASLD SV RQF VDN - FR RAEMPLDVLVCNAAVYQPTANQPT FTAEG FELSV
Hordeum	AGMPKG-SYTIYHLDLASLDSVROLVKN-VROLDMPIDVVVCNAAVMOPTAKEPSFTADGFEMSV
	AGMDKD-SFTVVHLDLASLDSVRQFVRN-VRQLKNPIDVVVCNAAVYQPTAKEPSYTADGFEMSV
Zea	
Triticum	AGMADG-SYTVMHLDLASLDSVRQEVDA-ERRAEMPLDVLVCNAAIYRPTARTPTETADGHEMSV
Avena	AGMA – – – DG – SYT VM <mark>II LD LA S</mark> LD <mark>SVRQF VDA – FRRAEMP LDVLVCNAA I YRPT</mark> ARK PT FTAEGVEMSV
Gloeobacter	<u> </u>
Acaryochloris	VGIPRD-SYTVIHLDLACFESIHRFVKD-FREMGRSLDALVCNAAIYMPLLKKPLHTAEGYELNV
Trichodesmium	VGMTQD-SYTVMHLDLASLEVVKRFVKT-FRESGRSLEALVCNAAVYLPLLKEPMRSIDGYEISV
Microcystis	LNIPRD-NYCIEFIDLGSLDSVRRFVKN-FRALGRSLTALVCNAAIYLPLLKEPLRSPDGYELSM
Nostoc	VGIPHQGSYTIMHIDLGSLDSVRQFVKN-FRASGHSLDALYCNAAIYMPLIKEPLRSPEGYELTV
Crocosphaera	LGIALD-AYTVMHIDLGNLDSVRQFAQD-FRATGKTLDALVCNAAIYMPLLKEPLRSPEGYELSM
Synechocystis	LGFP KD - SYTIIKLDLGYLDSVRRFVAQ - FRELGRPLKALVCNAAVYFPLLDEPLWSADDYELSV
Thermo	LQIPPE-AYTILHL <mark>DLSSLASVRGFVES-FRALNRPLRALVCNAA</mark> VYY <mark>P</mark> LLKE <b>PIYSVDGYE</b> ITV
Plectonema	LGMS PD - SYTLMH I DLGSLDSVRKFVTQ - FRESGKSLDALVCNAAVHMPLLKE PMRSPEGYELSV
Svnechococcus	
	MDLP KE - RLQHVLMDLGDLDSVRRAVD ALPDRLDAVYCNAAVYK PKLKQPERSPQGYE I SM
Cyanothece	MDLPKE-RLQHVLM <mark>DLGDLDSVRRAVDALPDRLDAVVCNAA</mark> VYK <mark>P</mark> KLKQPERSPQGYEISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALVCNAAIYMPLLKEPLRSPEGYELSM
Cyanothece Anabaena	MDLPKE-RLQHVLMDLGDLDSVRRAVDALPDRLDAVYCNAAVYKPKLKQPERSPQGYEISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALVCNAAIYMPLLKEPLRSPEGYELSM VGIPKD-SYSIIHIDLGSLDSVRQFVMD-FRATGKSLDALLCNAAIYMPLIKEPLRSPEGYELTM
Cyanothece Anabaena	MDLPKE-RLQHVLM <mark>DLGDLDSVRRAVDALPDRLDAVVCNAA</mark> VYK <mark>P</mark> KLKQPERSPQGYEISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALVCNAAIYMPLLKEPLRSPEGYELSM
Cyanothece Anabaena Prochlorococus	MDLPKE-RLQHVLMDLGDLDSVRRAVDALPDRLDAVYCNAAVYKPKLKQPERSPQGYEISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALVCNAAIYMPLLKEPLRSPEGYELSM VGIPKD-SYSIIHIDLGSLDSVRQFVND-FRATGKSLDALLCNAAIYMPLIKEPLRSPEGYELTM LGLPFRCPK-QLQHISIDLSDLDSVSKGVKDLLDKLDEPLDALVCNAAVYMPRLSKPRRSPQGYELSM
Cyanothece Anabaena Prochlorococus Nicotiana	MDLPKE-RLQHVLMDLGDLDSVRRAYDALPDRLDAVYCNAAVYKPKLKQPERSPQGYEISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALVCNAAIYMPLLKEPLRSPEGYELSM VGIPKD-SYSIIHIDLGSLDSVRQFVKD-FRATGKSLDALLCNAAIYMPLIKEPLRSPEGYELSM LGLPFRCPK-QLQHISIDLSDSVSKGVKDLLDKLDEPLDALVCNAAVYMPRLSKPRRSPQGYELSM TNHLGHFLLSRLLDDLKQSDYPQKRLIVGSITGNTNTLAGNVPPKANLGDLRGL
Cyanothece Anabaena Prochlorococus Nicotiana	MDLPKE-RLQHVLMDLGDLDSVRRAVDALPDRLDAVYCNAAVYKPKLKQPERSPQGYEISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALVCNAAIYMPLLKEPLRSPEGYELSM VGIPKD-SYSIIHIDLGSLDSVRQFVND-FRATGKSLDALLCNAAIYMPLIKEPLRSPEGYELTM LGLPFRCPK-QLQHISIDLSDLDSVSKGVKDLLDKLDEPLDALVCNAAVYMPRLSKPRRSPQGYELSM
Cyanothece Anabaena Prochlorococus Nicotiana Cucumis	MDLPKE-RLQHVLMDLGDLDSVRRAYDALPDRLDAVYCNAAVYKPKLKQPERSPQGYEISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALLVCNAAIYMPLLKEPLRSPEGYELSM UGIPKD-SYSIIHIDLGSLDSVRQFVKD-FRATGKSLDALLCNAAIYMPLIKEPLRSPEGYELSM LGLPFRCPK-QLQHISIDLGSLDSVRGVKDLLDKLDEPLDALVCNAAVYMPRLSKPRRSPQGYELSM INHLGHFLLSRLLLDDLKQSDYPQKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLDDLKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL
Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum	MDLPKE-RLQHVLMDLGDLDSVRRAVDALPDRLDAVVCNAAVYKPKLKQPERSPQGYEISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALVCNAAIYMPLIKEPLRSPEGYELSM VGIPKD-SYSIIHIDLGSLDSVRQFVND-FRATGKSLDALLCNAAIYMPLIKEPLRSPEGYELSM LGLPFRCPK-QLQHISIDLSDLDSVSKGVKDLLDKLDEPLDALVCNAAVYMPRLSKPRRSPQGYELSM TNHLGHFLLSRLLLDDLKQSDYPQKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL
Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus	MDLPKE-RLQHVLMDLGDLDSVRRAYDALPDRLDAVYCNAAVYKPKLKQPERSPQGYEISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALVCNAAIYMPLLKEPLRSPEGYELSM VGIPKD-SYSIIHDLGSLDSVRQFVKD-FRATGKSLDALLCNAAIYMPLIKEPLRSPEGYELSM LGLPFRCPK-QLQHISIDLSDLDSVSKGVKDLLDKLDEPLDALVCNAAVYMPRLSKPRRSPQGYELSM TNHLGHFLLSRLLLDDLKQSDYPQKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLNKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL
Ċyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia	MDLPKE-RLQHVLMDLGDLDSVRRAYDALPDRLDAVYCNAAVYKPKLKQPERSPQGYEISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALLVCNAAVYKPKLKQPERSPEGYELSM LGLPFRCPK-QLQHISIDLGSLDSVRQFVKD-FRATGKSLDALLVCNAAVYMPLIKEPLRSPEGYELSM TNHLGHFLLSRLLLDDLKQSDYPQKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL
Ċyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna	MDLPKE-RLQHVLMDLGDLDSVRRAYDALPDRLDAVYCNAAVYKPKLKQPERSPQGYEISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALLCNAAIYMPLLKEPLRSPEGYELSM UGIPKD-SYSIIHIDLGSLDSVRQFVKD-FRATGKSLDALLCNAAIYMPLIKEPLRSPEGYELSM LGLPFRCPK-QLQHISIDLSDLDSVSKGVKDLLDKLDEPLDALVCNAAVYMPRLSKPRRSPQGYELSM TNHLGHFLLSRLLLEDLNKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLNKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYP
Ċyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna	MDLPKE-RLQHVLMDLGDLDSVRRAYDALPDRLDAVYCNAAVYKPKLKQPERSPQGYEISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALLCNAAIYMPLLKEPLRSPEGYELSM UGIPKD-SYSIIHIDLGSLDSVRQFVKD-FRATGKSLDALLCNAAIYMPLIKEPLRSPEGYELSM LGLPFRCPK-QLQHISIDLSDLDSVSKGVKDLLDKLDEPLDALVCNAAVYMPRLSKPRRSPQGYELSM TNHLGHFLLSRLLLEDLKSSYPQKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLNKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIVGSITGNTNTLAGNVPPKANLGDLRGL
Ċyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus	MDLPKE-RLQHVLMDLGDLDSVRRAYDALPDRLDAVYCNAAVYK PKLKQPERSPQGY EISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALLVCNAAIYMPLIKEPLRSPEGYELSM UGIPKD-SYSIIHIDLGSLDSVRQFVKD-FRATGKSLDALLVCNAAIYMPLIKEPLRSPEGYELSM LGLPFRCPK-QLQHISIDLSSVRQFVKDLLDKLDEPLDALVCNAAVYMPRLSKPRRSPQGYELSM TNHLGHFLLSRLLLEDLKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIIVGSITGNTNTLAGNVPPKANLGDLRGL
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Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana Hordeum Zea Triticum Avena Gloeobacter Acaryochloris Trichodesmium Microcystis Nostoc Crocosphaera Synechocystis	MDLPKE-RLQHVLMDLGDLDSVRAYDALPDRLDAVYCNAAVYKPKLKQPERSPQGYEISM VGIPLD-SYTYMQIDLGSLDSVRQFVKD-FRATGKSLDALVCNAAIYMPLLKEPLRSPEGYELSM VGIPKD-SYSIIHIDLGSLDSVRQFVKD-FRATGKSLDALLCNAAIYMPLLKEPLRSPEGYELSM LGLPFRCPK-QLQHISIDLSDLDSVSKGVKDLLDKLDEPLDALVCNAAYYMPRLSKPRRSPQGYELSM TNHLGHFLLSRLLLDDLKQSDYPQKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSSYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKKSDYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSDYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHGHFLLSRLLLEDLKSDYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHGHFLLSRLLLEDLKSDYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHGHFLLSRLLLDDLKSDYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL VNHGHFLLSRLLLDDLKSDYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL VNHGHFLLSRLLLDDLKSDYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL VNHGHFLLSRLLLDLKSSDYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL VNHGHFLLSRLLLDLKSSDYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL VNHGHFLLSRLLLDLKSSSPPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL VNHGHFLLSRLLLDLKSSSPP
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Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana Hordeum Zea Triticum Avena Gloeobacter Acaryochloris Trichodesmium Microcystis Nostoc Crocosphaera Synechocystis Thermo Plectonema	MDLPKE-RLQHVLMDLGDLDSVRAYDALPDRLDAVYCNAAVYKPKLKQPERSPQGYEISM VGIPLD-SYTVMQIDLGSLDSVRQFVKD-FRATGKSLDALUCNAAIYMPLLKEPLRSPEGYELSM UGIPKD-SYSIIHIDLGSLDSVRQFVKD-FRATGKSLDALUCNAAIYMPLLKEPLRSPEGYELSM LGLPFRCPK-QLQHISIDLGSLDSVRQFVKD-FRATGKSLDALUCNAAIYMPLKEPLRSPEGYELSM TNHLGHFLLSRLLLDDLKQSDYPQKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSSYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSYPSKRLIIVGSIIGNTNTLAGNVPPKANLGDLRGL TNHLGHFLLSRLLLEDLKSYP
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Nicotiana	GGLNSLNCSPMIDGGE-FDGAKAYKDSKVCNMLTMQEFHRRFHEETGIAFASLYPGCIAETGLFRNHIP
Cucumis	GGLNGLK-SSMIDGGE-FDGAKAYKDSKVCNMLTMQEFHKRYHEETGITFASLYPGCIATTGLFREHIP
Pisum	GGLTGLNS SAMIDGGD - FDGAKAYKDSKVCNMLTMQFFHRRYHEETGITFASLYPGCIATTGLFREHIP
Pinus	GGLNGVN I S PM I DGGE – FDGA KAYKD S KVCNMLTMQ F F HRRYHE ETG I T F AS LY PGCI AT TGL F R E H I P
Marchantia	GGLNGVNSSSMIDGGE – FDGAKAYKDSKVCNMFTMQEFHRRYHAETGITFSSLYPGCIAETGLFRNHVT
Vigna	GCLNGLNTSAMIDGGS-FDGAKAYKDSKVCNMLTMQEFHRRYHEETGITFASLYPGCLATTGLFREHIP
Daucus	GGLNGMNSSAMIDGAE-FDGAKAYKDSKVCNMLTMQEFHRRYHEETGITFASLYPGCIATTGLFREHIF
Arabidopsis-thaliana	GGUNGLNSSAMIDGGD-FYGAKAYKDSKVCNMLTMQEFHRRFHEDTGITFASLYPGCIATTGLFREHIP
Hordeum	A G <mark>L NG VG SAAM I DG</mark> A E – <mark>FD</mark> GA KAYKD SK <mark>V</mark> C N <mark>M LTMQE FH R RYH E E TG VT FAS</mark> LYPGC I A TTG L F R EH I P
Zea	GGLNGVGSSVMIDGGE – FDGAKAYKDSKVCNMLTMQEFHRRYHEETGVTFASLYPGCIATTGLFREHIP
Triticum	GGLSGASGSAMIDGDESFDGAKAYKDSKVCNMLTMQEFHRRYHEETGITFSSLYPGCIATTGLFREHIP
Avena	GGLTGASGSAMIDGDESFDGAKAYKDSKVCNMLTMQEFHRRYHEDTGITFSSLYPGCIATTGLFREHIP
Gloeobacter	QGFK APHTMIDGKA-YNPVKAYKDSKVCNLLTMRELHRRFHTSHKITFSALYPGCVATSGLFRESPR
Acaryochloris	AGFK APVSMINGKK - FKPGKAYKDSKLCNMLTMRELHRRFHESTGITFSALYPGCVATTGLFRNHFA
Trichodesmium	QGFK TPISMINAKK - FKSGKAYKDSKLCNVLTMRELHRRYYKSTGIVFSSLYPGCVADTPLFRNHYP
Microcystis	KGFK EPITMADGKK - FESVKAYKDSKVCNVLTMRELHKRYHQSTGITFTSLYPGCVADTPLFRNHYP
Nostoc	ECFKEPISMIDGKK-FEPVKAYKDSKVCNVLTMRELHQRYHESTGIVFNSLYPCCVAETPLFRNHYP
	DGFK EPISMVDGKN-FEPVKAYKDSKVCNVLTMRELDRRYHESTGIVFTSLYPGCVADTPLFRNHYP
Crocosphaera	
Synechocystis	AGFK KPIAMINNKK - FKSGKAYKDSKLCNMLTTRELHRRFHQETGIVFNSLYPGCVADTPLFRNHYS
Thermo	K G F K – – K P I AM I N G K P – F K S G K A Y K D S K L C NM L T A R E L H R R F H E S T G I V F N S L Y P G C V A D T P L F R H H F P
Plectonema	A G F K – A P I A M I D G K P – F K A G K A Y K D S K L C NM I T S R E L H R R Y H D S T G I V F N T L Y P G C V A D T P L F R N S L P
Synechococcus	A G F K – – Y P V A M A S G K P – F K P G K A Y K D S K L C N M I S T Q E L H R R L H G E S G I T F T S L Y P G C V A D T P L F R N T P K
Cyanothece	DGFK EPVSMIDGKK -FEPVKAYKDSKVCNVLTMRELHRRYHDNTGIVFTSLYPGCVADTPLFRNHYP
Anabaena	QGFK PPISMIDCKK -FEPVKAYKDSKVCNVLTMRFLHRRYHESTGITFTSLYPGCVAETPLFRNHYP
Prochlorococus	EGFLDPICMASGKR-FKPGKAYKDSKLCNMITIQELHRRFK-DSSVVFSSLYPGCVANTKLFRNTPK
Nicotiana	LFRALFPPFQKYITKGYVSEABAGKRLAQVVRDPSLSKSGVYWSWNNTSS-SFENQLSKEASDAE
Cucumis	LFRILFPPFQKFITQCYVSEDEAGKRLAQVVSEPSLTKSCVYWSWNKNSA-SFENQLSQEASDAE
Pisum	L F R T L F P P F Q K Y I T K G Y V S E E E S G K R L A Q V V S D P S L T K S G V Y W S W N N A S A - S F E N Q L S Q E A S D A E
Pinus	LFRLLFPPFQKYITKGFVSEELAGKRLAQVVSNPSLTKSGVYWSWNNNSG-SFENQLSELASDPE
Marchantia	
Vigna	L F R L F P P F Q K F I T K G F V S E D E S G K R L A Q V V S D P S L T K S G V Y W S W N K A S A - S F E N Q L S Q E A S D A D
Daucus	L F R T L F P P F Q K Y I T K G Y V S E A E S G K R L A Q V V S E P S L T K S G V Y W S W N K D S A - S F E N Q L S E E A S D V E
Arabidopsis-thaliana	LFRTLFPPFQKYITKGYVSESEAGKRLAQVVADPSLTKSGVYWSWNKTSA-SFENQLSQEASDVE
Hordeum	LFRLLFPPFQKYITKGYVSEELAGKRLAQVVSEPSLTKSGVYWSWNKNSA-SFENQLSEEASDTE
Zea	LFRLLFPPFQKYITKGYVSEEEAGKRLAQVVSDPSLTKSGVYWSWNKNSA-SFENQLSEEASDAD
Triticum	LFRTLFPPFQKFVTKGFVSEAESGKRLAQVVAEPSLTKSGVYWSWNKDSA-SFENQLSQEASDPE
Avena	L <u>ERTLFPFQKFVTKGFV</u> SEAE <u>SGKRLAQVVGEPSLTKSGVYWSWNKDSA-SFENQLSQ</u> EAS <u>DFE</u>
Gloeobacter	EFQILFPVFQKYVTGGFVSEAEAGGRVAALVDDPAYSRSGVYWSWGNRQKKDGK-SFIQDVSTEASDED
Acaryochloris	L F R F L F P K F Q R F I T G G F V T E E L A G T R V A Q V V S D P L F G K S G V Y W S W G N R Q K E G R P - S F E Q E M S N E S L D D T
Trichodesmium	L F Q K L F P L F Q K N I T G G Y V S Q D L A G E R V A A V V K D P E Y K E S G I Y W S W G N R Q K K D R K - S F V Q E V S D E A S D D D
Microcystis	F F Q Q F F PWF Q K N I T G G Y V S Q E L A G E R V A M V Y A D P E Y R Q S G A Y W S W G N R Q K K E G K - S F V Q R V S P Q A R D D E
Microcystis Nostoc	F FQQF F PWFQKN I TGGYVSQE LAGER VAMVVAD PEYRQSGAYWSWGNRQK KEGK - S F VQRVS PQARDDE L FQK I F P L FQKY I TKGYVSQE LAGER VAAVVAD PEYNQSGVYWSWGNRQK EDGK - S F VQKVS PQARDDD
Nostoc	L FQK I F P L FQKY I T K GY V S Q E L A G E R V A A V V A D P E Y NQ S G V Y W S W G N R Q K E D G K - S F V Q K V S P Q A R D D D
Nostoc Crocosphaera	L FQK I F P L FQKY I T K GY V SQE L A G E R V A A V V A D P E Y NQ S G V Y W SWG N R Q K E D G K - S F V Q K V S PQ A R D D D L FQK I F P W F Q K N V T G G Y V SQE L A G E R V A D V V T K P E Y G E S G S Y W SWG N R Q K K D R Q A A F V Q N V S PQ A Q D E A
Nostoc Crocosphaera Synechocystis	L FQK I F PU FQK Y I T K G Y VSQE L AG E R V AA V VA D P E Y NQ SG Y W SWG NR QK ED GK - S F V Q K Y S PQA RDDD L FQK I F PW FQ K N V T GG Y VSQE L AG E R V AD V Y T K P E Y G E S G S Y W SWG NR QK KD RQAA F VQ NY S PQA QD EA L F R T I F PW FQ K N V T KG Y VSQE L AG E R V AM V AD DK F KD S G V HW SWG NR QQ AG R E - A F VQ E L S E QG SDAQ
Nostoc Crocosphaera Synechocystis Thermo	L FQK I F P L F Q K Y I T K G Y VSQE L AG E R V A A V Y A D P E Y NQS G Y Y WSW G N R Q K E D G K – S F V Q K V S PQ A R D D L F Q K I F P W F Q K N V T G G Y VSQE L AG E R V A D V Y T K P E Y G E S G S Y WSW G N R Q K AD R Q A A F V Q N S PQ A Q D E A L F R T I F P W F Q K N V T K G Y VSQE L AG E R V A M V V A D D K F R D S G Y H WSW G N R Q Q AG R E – A F V Q E L S E Q G S D A Q L F Q K L F P L F Q K K I T G G Y VSQE L AG E R V A M V A D D K F R D S G Y H WSW G N R Q A G R K – A F VQ E L S E A G S D A Q L F Q K L F P L F Q K K I T G G Y VSQE L AG E R V A M V A D P E F R Q S C Y H WSW G N R Q K E G K K – A F VQ E L S A E A S D E Q
Nostoc Crocosphaera Synechocystis Thermo Plectonema	L FQK I F P L FQKY I T KGY VSQE L AG E R VAAV VAD P E YNQS G VYWSWGNRQK EDGK - S F VQK VS PQARDDD L FQK I F PWFQKNVTGGY VSQE L AG E R VAD VYTK P E Y GESGSYWSWGNRQK KD RQAAF VQN YS PQAQD EA L F R T I F PWFQKNVTKGY VSQE L AG E R VAM V VADD K F KD S G YHWSWGNRQK EGRK - AF VQE L S E G S D AQ L F QK L F P L F QKK I TGGY VSQE L AG E R YAM V VAD P E F RQS G YHWSWGNRQK EGRK - AF VQE L S E A S D EQ V F QK V F PWFQKNI TGGY VSQE L AG E R T AQ V VAD P E F KQS G YHWSWGNRQK EGRE - S F VQ E L S E K YT DDA
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus	L FQK I F PU FQKY I T KGY VSQELAGE R VAAV VAD PE YNQSGYW SWGNRQK EDGK - S F VQKY S PQA RDDD L FQK I F PW FQKNV T GGY VSQELAGE R VAD V Y T KPE YGE S G S YW SWGNRQK KDRQAAF VQNV S PQA QD EA L FRT I F PW FQKNV T KGY VSQELAGE R VAM V VAD DK FRD S G VHW SWGNRQK GGRE - A F VQEL S EQG S D AQ L FQK L F PL FQK N T KGY VSQELAGE R VAM V VAD PE FRQ SG VHW SWGNRQK EGRK - A F VQEL S AEA S D EQ V FQK V F PW FQK N I T GG Y VSQELAGE R T AQ V VAD PE FRQ SG VHW SWGNRQK EGRK - S F VQE L S AEA S D EQ A FQT I F PW FQK N I T GG Y VSQELAGE R T AQ V VAD PE FRQ SG VHW SWGNRQK EGRE - S F VQE L S AEA S D EQ
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece	L FQK I F PU FQKY I T KGY VSQE L AGE R V AA V VAD P E YNQSGY WSWGNRQK EDGK - S F VO KY S PQA RDDD L FQK I F PW FQK N V T GGY VSQE L AGE R V AD V VT KP E YGE SG S YW SWG NRQK KDRQAAF VQN V S PQAQD EA L F R TI F PW FQK N V T KGY VSQE L AGE R V AM V VAD DK FRD SG V HW SWG NRQQ AGR E - AF VQE L S EQG SDAQ L F QK L F P L FQ KK I T GG Y VSQE L AGE R V AM V VAD DF FRQ SG V HW SWG NRQK EGRK - AF VQE L S AE AS D EQ V FQK V F PW FQK N I T GG Y VSQE L AGE R V AM V VAD P E FRQ SG V HW SWG NRQK EGRK - AF VQE L S AE AS D EQ V FQK V F PW FQK N I T GG Y VSQE L AGE R V AM V VAD P E FRQ SG V HW SWG NRQK EGRK - S F VQE L S E K YT DDA AFQT I F PW FQK N I T GG Y VSQA L AGE R V AM V VAH PD FAE SG V HW SWG NRQK KDRQ - Q F SQE L S D KAT D PD L FQK I F PW FQK N I T GG Y VSQE L AGE R V AM V Y H PD FAE SG Y HW SWG NRQK KDR KAR KAR AV QK Y S PQAQD EA
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena	L FQK I F P L FQKY I T K GY V SQE L AG E R V A A V Y A D P E Y NQS G V Y W SWG N R Q K E D G K - S F V Q K V S PQ A R D D L FQK I F P W FQ K N V T G G Y V SQE L AG E R V A M V Y A D D K FR D S G Y W SWG N R Q K G R Q A A F V Q N S PQ A Q D E A L F R T I F P W FQ K N V T K G Y V SQE L AG E R V A M V Y A D D K FR D S G Y HW SWG N R Q AG R E - A F V Q E L S E Q S D A Q L F Q K L F P L F Q K K I T G G Y V SQE L AG E R V A M V Y A D D F F R Q S C Y HW SWG N R Q AG R E - A F V Q E L S E A S D E Q V F Q K V F P W FQ K N I T G G Y V SQE L AG E R V A M V Y A D P E F R Q S C Y HW SWG N R Q K E G R K - A F V Q E L S E K Y T D D A A F Q T I F P W FQ K N I T G G Y V SQE L AG E R V A D V A H P D F A E S C Y HW SWG N R Q K K G G R - S F V Q E L S E K Y T D D A A F Q T I F P W FQ K N I T G G Y V SQE L AG E R V A D V Y A H P D F A E S C Y HW SWG N R Q K K D G A - Q F S Q E L S D K AT D P D L F Q K I F P W FQ K N I T G G Y V SQE L AG E R V A D Y T K P E Y G Q S C S Y W SWG N R Q K K D R K A K P K V K V S P Q A Q D E A L F Q K I F P W FQ K N I T G G Y V S Q E L AG E R V A D Y T K P E Y G Q S C S Y W SWG N R Q K K D G K - S F V Q K V S P Q A R D E
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece	L FQK I F PU FQKY I T KGY VSQE L AGE R V AA V VAD P E YNQSGY WSWGNRQK EDGK - S F VO KY S PQA RDDD L FQK I F PW FQK N V T GGY VSQE L AGE R V AD V VT KP E YGE SG S YW SWG NRQK KDRQAAF VQN V S PQAQD EA L F R TI F PW FQK N V T KGY VSQE L AGE R V AM V VAD DK FRD SG V HW SWG NRQQ AGR E - AF VQE L S EQG SDAQ L F QK L F P L FQ KK I T GG Y VSQE L AGE R V AM V VAD DF FRQ SG V HW SWG NRQK EGRK - AF VQE L S AE AS D EQ V FQK V F PW FQK N I T GG Y VSQE L AGE R V AM V VAD P E FRQ SG V HW SWG NRQK EGRK - AF VQE L S AE AS D EQ V FQK V F PW FQK N I T GG Y VSQE L AGE R V AM V VAD P E FRQ SG V HW SWG NRQK EGRK - S F VQE L S E K YT DDA AFQT I F PW FQK N I T GG Y VSQA L AGE R V AM V VAH PD FAE SG V HW SWG NRQK KDRQ - Q F SQE L S D KAT D PD L FQK I F PW FQK N I T GG Y VSQE L AGE R V AM V Y H PD FAE SG Y HW SWG NRQK KDR KAR KAR AV QK Y S PQAQD EA
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus	L FQK I F PU FQKY I T K GY VSQE L AG ER V AAV VAD P E YNQS GY WSWGNRQK EDGK - S F VO K VS PQA RDDD L FQK I F PW FQKNVT GGY VSQE L AG ER V AD V VT K P E YGES G S YW SWGNRQK KDRQAAF YQNV S PQAQD EA L FRT I F PW FQKNVT KGY VSQE L AG ER V AM V VAD DK FKD S C VHW SWGNRQK KDRQAAF YQNV S PQAQD EA L FRT I F PW FQKNIT GGY VSQE L AG ER V AM V VAD DK FRQ S C VHW SWGNRQK EGRK - AF VQE L S E G S DAQ L FQK L F P L FQKNIT GGY VSQE L AG ER V AM V VAD P E FRQ S C VHW SWG NRQK EGRK - AF VQE L S A E A S D EQ V FQK VF PW FQKNIT GGY VSQE L AG ER V AM V VAD P E FRQ S C VHW SWG NRQK EGRK - AF VQE L S A E A S D EQ V FQK VF PW FQK NIT GGY VSQE L AG ER V AM V VAD P E FRQ S C VHW SWG NRQK KDG - QF S C L S D K AT D PD L FQK I F PW FQK NIT GGY VSQE L AG ER V AD V V K P E YGQ S C S YW SWG NRQK KDG - QF S C L S D K AT D PD L FQK I F PW FQK NIT GGY VSQE L AG ER V AD V T K P E YGQ S C S YW SWG NRQK KDG K AAF Y Q K VS PQAQD EA L FQK I F PL FQK Y I T GGY VSQE L AG ER V AD V T K P E YGQ S C S YW SWG NRQK KDG K AAF Y Q K VS PQAQD EA L FQK I F PL FQK Y I T GGY V SQE L AG ER V AD V T K P E YGQ S C S YW SWG NRQK KDG K S S F V O K VS PQA RDD E I FQWL FP L FQ K Y I T GGY V SQE L AG ER V AD V Y S S P E FG I S C V HW SWG NRQK K KDG K - S F V O K VS PQA RDD E I FQWL FP L FQ R Y I T GG F V SQP L AG G R V AQ V Y S S P E FG I S C V HW SWG NRQ K KDG K - G F S O K L S ER I T D P E
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana	L FQK I F PL FQKY I T KGY VSQELAGER VAAV VAD PE YNQSGYYWSWGNRQK EDGK - S F VQKVS PQARDDD LFQK I F PWFQKNVT KGY VSQELAGER VAD V VT KPEYGESGSYWSWGNRQK KDRQAAF VQNYS PQAQD EA LFRT I F PWFQKNVT KGY VSQELAGER VAD V VAD DK FRDSGY HWSWGNRQK EGRK - AF VQELS EQGSDAQ LFQK LF PL FQKK I TGGY VSQELAGER VAM V VAD PE FRQSGY HWSWGNRQK EGRK - AF VQELS EASD EQ VFQK VF PWFQKNI TGGY VSQELAGER VAM V VAD PE FRQSGY HWSWGNRQK EGRK - AF VQELS EKYTDDA AFQT I F PWFQKNI TGGY VSQELAGER VAD V VAH PD FAESGY HWSWGNRQK KDGQ - QF SQELS EKYTDDA LFQK I F PWFQKNI TGGY VSQELAGER VAD V VAH PD FAESGY HWSWGNRQK KDGK - SF VQELS EKYTDDA LFQK I F PWFQKNI TGGY VSQELAGER VAD V VAH PD FAESGY HWSWGNRQK KDGK - SF VQKVS PQAQD EA LFQK I F PWFQKNI TGGY VSQELAGER VAD V VAH PD FAESGY HWSWGNRQK KDGK - SF VQKVS PQAQD EA LFQK I F PL FQKY I TGGY VSQELAGER VAD V YAH PD FAESGY HWSWGNRQK KDGK - SF VQKVS PQAQD EA LFQK I F PL FQKY I TGGY VSQELAGER VAD VY SF PEFG I SGY WSWGNRQK KDGK - SF VQKVS PQARDDE I FQWL FP LFQR FV I GGF VSQPLAGKR VAQ VYSSP EFG I SGY HWSWGNRQK KNGE - QF SQK LSER I TD PE
Nostoć Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis	L FQK I F PU FQKY I T KGY VSQE L AGER V AAV VAD PE YNQSGY WSWGNRQK EDGK - S F V OKVS PQA RDDD L FQK I F PW FQKN V T GGY VSQE L AGER V AD V V T K PE YGES GSY WSWGNRQK KDRQAAF YQN VS PQA QD EA L FRI I F PW FQKN V T KGY VSQE L AGER V AD V VAD DK FRQSG V HWSWGNRQK KDRQAAF YQN VS PQA QD EA L FRI I F PW FQKN I T GGY VSQE L AGER V AD V VAD DE FRQSG V HWSWGNRQK EGRK - AF VQE L S EA AS DE Q V FQK V F PW FQKN I T GGY VSQE L AGER T AQ V VAD PE FRQSG V HWSWGNRQK EGRK - AF VQE L S EA AS DE Q V FQK V F PW FQKN I T GGY VSQE L AGER T AQ V VAD PE FRQSG V HWSWGNRQK EGRK - AF VQE L S EA AS DE Q V FQK V F PW FQKN I T GGY VSQE L AGER V AD V VAD PE FRQSG V HWSWGNRQK KDGQ - QF SQE L S DKAT D PD L FQK I F PW FQKN I T GGY VSQE L AGER V AD V V H PD FFASS C V HWSWGNRQK KDGQ - QF SQE L SDKAT D PD L FQK I F PW FQKN I T GGY VSQE L AGER V AD V V H PD FFASS C V HWSWGNRQK KDGK - S F VQK VS PQAQ D EA L FQK I F PL FQK Y I T GGY VSQE L AGER V AD V V K PE YGQSG SY WSWGNRQK KDGK - S F VQK VS PQAQ D EA L FQK I F PL FQK Y I T GGY VSQE L AGER V AD V Y S PE FG I SG V HWSWGNRQK KDGK - S F VQK VS PQAR D EA L FQK I F PL FQK Y I T GG Y SQE L AGER V AD V Y S PE FG I SG V HWSWGNRQK KDGK - G F SQE L SDK X S PQAR D EA L FQK I F PL FQR F V I GG F V SQP L AG KR V AQ V Y S S PE FG I SG V HWSWGNRQK KDGK - G F SQ K L S ER I T D PE KAR KL WW Y S EK L Y GE A
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum	L FQK I F PU FQKY I T KGY VSQE L AGER V AA V VAD PE YNQSGYW SWGNRQK EDGK - S F V O KYS PQA RDDD L FQK I F PW FQKN V T GGY VSQE L AGER V AD V VT KP EYGES G S YW SWGNRQK KDRQAAF VQN VS PQAQD EA L FR TI FPW FQKN VT KGY VSQE L AGER V AD V VAD DK FKD S C VHW SWGNRQK KDRQAAF VQN VS PQAQD EA L FR TI FPW FQKN VT KGY VSQE L AGER V AM V VAD DE FRQS G VHW SWGNRQK EGRK - AF VQE L S EAG SD AQ V FQK VF PW FQKN I T GGY VSQE L AGER V AM V VAD PE FRQS G VHW SWGNRQK EGRK - AF VQE L S EAS D EQ V FQK VF PW FQKN I T GGY VSQE L AGER V AM V VAD PE FRQS G VHW SWGNRQK EGRK - AF VQE L S EK VT DDA AF QT I F PW FQKN I T GGY VSQE L AGER V AD V VAH PD FFRQS G VHW SWGNRQK KDG - QF S Q E L SDK AT D PD L FQK I F PW FQKN I T GGY VSQE L AGER V AD V V K PE YGQS G S YW SWGNRQK KDG - QF S Q E L SDK AT D PD L FQK I F PW FQKN I T GGY VSQE L AGER V AD V T K PE YGQS G S YW SWGNRQK KDG X G S Y S PQAQD EA L FQK I F PW FQKN I T GGY VSQE L AGER V AD V T K PE YGQS G S YW SWGNRQK KDG K AAF Y Q K VS PQAQD EA L FQK I F PL FQK FY T GGY VSQE L AGER V AD V Y K PE YGQS G S YW SWGNRQK KDG K G S S F V O K YS PQAQD EA L FQK I F PL FQK FY T GGY VSQE L AGER V AD V Y K PE YGQS G S YW SWGNRQK KDG K G S S F V O K YS PQAQD EA L FQK I F PL FQK FY T GGY VSQE L AGER V AD V Y K PE YGGS G YW SWGNRQK K NG K S S F V O K YS PQAQD EA L FQK I F PL FQK FY T GGY VSQE L AGER V AD V YS S PE FG I S G VHW SWGNRQK K NG E - QF S O K L S ER I T D PE KARK L WE YS EK L V G L A
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus	LFQKIFPLFQKYITKGYVSQELAGERVAAVVADPEYNQSGYYWSWGNRQKEDGK-SFVQKVSPQARDDD LFQKIFPWFQKNVTKGYVSQELAGERVADVVTKPEYGESGSYWSWGNRQKKDRQAAFVQNVSPQAQDEA LFRTIFPWFQKNVTKGYVSQELAGERVADVVADDKFRDSGVHWSWGNRQKGQRE-AFVQELSGGSDAQ LFQKLFPLFQKKITGGYVSQELAGERVAMVVADDFFRQSGVHWSWGNRQKEGRK-AFVQELSAEASDEQ VFQKVPPWFQKNITGGYVSQELAGERVADVVADPEFRQSGVHWSWGNRQKEGRE-SFVQELSEKVTDDA AFQTIFPWFQKNITGGYVSQELAGERVADVVAHPDFAESGVHWSWGNRQKEGRE-SFVQELSEKVTDDA LFQKIFPWFQKNITGGYVSQELAGERVADVVAHPDFAESGVHWSWGNRQKKDGQ-QFSQELSDKATDPD LFQKIFPWFQKNITGGYVSQELAGERVADVVAHPDFAESGVHWSWGNRQKKDGK-SFVQKVSPQAQDEA LFQKIFPLFQKNITGGYVSQELAGERVADVVAHPDFAESGVHWSWGNRQKKDGK-SFVQKVSPQAQDEA LFQKIFPLFQKNITGGYVSQELAGERVADVVSPFGISGVHWSWGNRQKKDGK-SFVQKVSPQARDDE IFQWLFPLFQKVITGGVSQELAGERVADVVSSPFGISGVHWSWGNRQKKDGK-SFVQKVSPQARDDE IFQWLFPLFQKVITGGFVSQFLAGERVADVVSSPFGISGVHWSWGNRQKKNGE-QFSQKLSERITDPE KARKLWEVSEKLVGLA
Nostoć Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia	L FQK I F PU FQK Y I T KGY VSQE L AGER V AAV VAD PE YNQSGY WSWGNRQK EDGK - S F V G KY S PQA RDDD L FQK I F PW FQ KN V T GG Y VSQE L AGER V AD V Y K PE YGES G S Y WSWGNRQK KDRQAAF YQ NY S PQA QD EA L FR TI FPW FQ KN T KGY VSQE L AGER V AD V YAD DK FRQSG Y HWSWGNRQK KDRQAAF YQ NY S PQAQD EA L FR TI FPW FQ KN T TGG Y VSQE L AGER Y AD V YAD DE FRQSG Y HWSWGNRQK EGRK - A F YQ E L S AEAS D EQ V FQ K Y FPW FQ KN T TGG Y VSQE L AGER T AQ V YAD DE FRQSG Y HWSWGNRQK EGRK - A F YQ E L S AEAS D EQ V FQ K Y FPW FQ KN T TGG Y VSQE L AGER T AQ V YAD PE FRQSG Y HWSWGNRQK EGRK - A F YQ E L S AEAS D EQ V FQ K Y FPW FQ KN T TGG Y VSQE L AGER Y AD Y YAD PE FRQSG Y HWSWGNRQK KDGQ - QF SQ E L SD KAT D PD L FQ K I F PW FQ KN T TGG Y VSQE L AGER Y AD Y YAH PD FFAES C Y HWSWGNRQK KDGQ - QF SQ E L SD KAT D PD L FQ K I F PU FQ KN T TGG Y VSQE L AGER Y AD Y Y K PE YGQSG S Y WSWG NRQK KDG K - S F YQ K Y S PQ AQ D EA L FQ K I F PL FQ KY T TGG Y VSQE L AGER Y AD Y Y K PE YGQSG S Y WSWG NRQ K KDG K - S F YQ K Y S PQ AR D DE I FQ W I F PL FQ KY T TGG Y VSQE L AGER Y AD Y Y K PE YGQSG S Y WSWG NRQ K KDG K - S F YQ K Y S PQ AR D DE I FQ W I F PL FQ KY T GG F V SQP L AG KR Y AQ Y Y S S PE FG T S C Y HWSWG NRQ K KDG K - S F YQ K Y S PQ AR D DE I FQ W F Y Y G K L YG L A
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna	L FQK I F PU FQKY I T KGY VSQE L AGER V AA V VAD PE YNQSGYWSWGNRQK EDGK - SF V G KYS PQA RDDD L FQK I F PWFQKNVT KGY VSQE L AGER V AD V VT KP EYGES G SYWSWGNRQK KDRQAAF VON VS PQAQD EA L FR TI FPWFQKNVT KGY VSQE L AGER V AD V VAD DK FKDS G VHWSWGNRQK KDRQAAF VON VS PQAQD EA L FR TI FPWFQKNVT KGY VSQE L AGER V AD V VAD DE FRQS G VHWSWGNRQK EGRK - AF VQE L S EAG SD AQ V FQK VF PWFQKNI T GGY VSQE L AGER V AD V VAD DE FRQS G VHWSWGNRQK EGRK - AF VQE L S EAS D EQ V FQK VF PWFQKNI T GGY VSQE L AGER V AD V VAD PE FRQS G VHWSWGNRQK EGRK - AF VQE L S EK VT DDA AF QT I F PWFQKNI T GGY VSQE L AGER V AD V VAH PD FFRQS G VHWSWGNRQK KDG - QF S Q E L SDK AT D PD L FQK I F PWFQKNI T GGY VSQE L AGER V AD V VT KP EYGQS G SYWSWGNRQK KDG - QF S Q E L SDK AT D PD L FQK I F PWFQKNI T GGY VSQE L AGER V AD V VT KP EYGQS G SYWSWGNRQK KDG A G S E L SDK AT D PD L FQK I F PWFQKNI T GGY VSQE L AGER V AD V T KP EYGQS G SYWSWGNRQK KDG C G S F V G KY S PQAQD EA L FQK I F PU FQK Y I T GGY VSQE L AGER V AD V YK PE YGQS G SYWSWGNRQK KDG C G S S PO G S S S S S S S S S S S S S S S S S S
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus	L FQK I F PUFQKY I TKGY VSQE L AGER V AA V VAD PEYNQSGYY WSWGNRQK EDGK - SF V O KYS PQARDDD L FQK I F PWFQKNV T KGY VSQE L AGER V AD V VT KP EYGES GS YW SWGNRQK KDRQAAF VQNV S PQAQD EA L FR TI F PWFQKNV T KGY VSQE L AGER V AD V VAD DK FKD SC VHW SWGNRQK KDRQAAF VQNV S PQAQD EA L FR L F PUFQKNI TGGY VSQE L AGER V AM V VAD DF FRQS C VHW SWGNRQK EGRK - AF VC EL S AEAS D EQ V FQK VF PWFQKNI TGGY VSQE L AGER V AD V VAD PE FRQS C VHW SWGNRQK EGRK - AF VC EL S AEAS D EQ V FQK VF PWFQKNI TGGY VSQE L AGER V AD V VAD PE FRQS C VHW SWGNRQK EGRK - AF VC EL S AEAS D EQ V FQK VF PWFQKNI TGGY VSQE L AGER V AD V VAD PE FRQS C VHW SWGNRQK EGRK - SF V Q EL S EK VT DD A AFQT I F PWFQK NI TGGY VSQE L AGER V AD V VAH PD FFRQS C VHW SWGNRQK KDGQ - QF SQ EL S DKAT D PD L FQK I F PWFQK NI TGGY VSQE L AGER V AD V TK PEYGQ SC S YW SWGNRQK KDGK - SF V Q KV S PQAQ D EA L FQK I F PLFQ KY I TGGY VSQE L AGER V AD V TK PEYGQ SC S YW SWGNRQK KDGK - SF V Q KV S PQAQ D EA L FQK I F PLFQ KY I TGGY VSQE L AGER V AD V V K PEYGQ SC S YW SWGNRQK KDGK - SF V Q KV S PQAQ D EA L FQK I F PLFQ KY I TGGY VSQE L AGER V AD V V K S PEFG I S C VHW SWGNRQK KNGE - QF SQ KL S ER I TD PE KARK LWE Y S EK L Y G L A
Nostoć Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana	L FQK I F PLFQKY I T KGY VSQE L AGER V AAV VAD PEYNQSGY WSWGNRQK EDGK - SF V G KY S PQA RDDD L FQK I F PWFQ KNY T GGY VSQE L AGER V AD V Y K PEYGESG SY WSWGNRQK KDRQAAF VQ NY S PQA QD EA L FR II F PWFQ KNY T KGY VSQE L AGER V AD V VAD DK FRQSG V HWSWGNRQK KDRQAAF VQ NY S PQAQD EA L FQK L F PLFQ KKI T GGY VSQE L AGER T AQ V VAD DE FRQSG V HWSWGNRQK EGRK - AF VQ E L S AEAS D EQ V FQK V F PWFQ KNI T GGY VSQE L AGER T AQ V VAD PE FRQSG V HWSWGNRQK EGRK - AF VQ E L S AEAS D EQ V FQK V F PWFQ KNI T GGY VSQE L AGER T AQ V VAD PE FRQSG V HWSWGNRQK EGRK - AF VQ E L S AEAS D EQ V FQK V F PWFQ KNI T GGY VSQE L AGER V AQ V VAD PE FRQSG V HWSWGNRQK KDGQ - QF SQ E L S DKAT D PD L FQK I F PWFQ KNI T GGY VSQE L AGER V AD V VAH PD FF AGSG V HWSWGNRQK KDGQ - QF SQ E L S DKAT D PD L FQK I F PU FQ KNI T GGY VSQE L AGER V AD V V K PE YGQSG SY WSWG NRQK KDGK - S F VQ K V S PQAQD EA L FQK I F PL FQ KY I T GGY VSQE L AGER V AD V V K PE YGQSG SY WSWG NRQK KDGK - S F VQ K V S PQAQD EA L FQK I F PL FQ KY I T GGY VSQE L AGER V AD V V K S PE FG I SG V HWSWG NRQK KDGK - S F VQ K V S PQAQD EA L FQK I F PL FQ KY I T GG Y SQE L AGER V AD V Y S S PE FG I SG V HWSWG NRQK KDGK - S F VQ K V S PQAR D DE I FQ WL P L FQ R F V I GG F V SQP L AG K R V AQ V Y S S PE FG I SG V HWSWG NRQK K NG E - Q F SQ K L S ER I T D PE KARK VW L S E K L VG L A
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana Hordeum	L FQK I F PUF CAXY I TKGY VSQE L AGER V AA V VAD PEYNQSGY WSWGNRQK EDGK - SF V CXY S PQARDDD L FQK I F PWF QKNV TKGY VSQE L AGER V AD V VTKP EYGESG SY WSWGNRQK KDRQAAF VON VS PQAQD EA L FR TI PWF QKNV TKGY VSQE L AGER V AD V VAD DK FKD SC VHWSWGNRQK KDRQAAF VON VS PQAQD EA L FQK L FP L FQKKI TGGY VSQE L AGER V AM V VAD DK FKD SC VHWSWGNRQK EGRK - AF V QE L S EQS D AQ V FQK VF PWF QKNI TGGY VSQE L AGER V AM V VAD DE FRQSG VHWSWGNRQK EGRK - AF VQE L S EASD EQ V FQK VF PWF QKNI TGGY VSQE L AGER V AD V VAD PE FRQSC VHWSWGNRQK EGRK - AF VQE L S EK VT DDA AF QT I FPWF QKNI TGGY VSQA L AGER V AD V VAH PD FFRQSC VHWSWGNRQK KDG - QF S QE L S DKAT D PD L FQK I F PWF QKNI TGGY VSQA L AGER V AD V V K PEYGQSG SY WSWGNRQK KDG - QF S QE L S CKAT D PD L FQK I F PWF QKNI TGGY VSQE L AGER V AD V V K PEYGQSG SY WSWGNRQK KDG - QF S Q E L S Q KAT D PD L FQK I F PWF QKNI TGGY VSQE L AGER V AD V V K PEYGQSG SY WSWGNRQK KDG - QF S Q K VS PQAQD EA L FQK I F PUF QKNI TGGY VSQE L AGER V AD V V K PEYGQSG SY WSWGNRQK KDG C G F S Q K VS PQAQD EA L FQK I F PUF QKNI TGGY VSQE L AGER V AD V Y K PEYGQSG SY WSWGNRQK KNG K S F V C K VS PQAQD EA L FQK I F PUF QKNI TGGY VSQE L AGER V AD V Y K PEYGQSG SY WSWGNRQK K KDG C G F S Q K VS PQAQD EA L FQK I F PUF QKNI TGGY VSQE L AGER V AD V Y S S PEFG I S G V HWSWGNRQ K KDG C G F S Q K VS PQAQD EA L FQK I F PL FQ K V TGG F V S Q L AG G R V AQ V Y S S PEFG I S G V HWSWGNRQ K KNG E - Q F S Q K L S ER I T D PE K ARK VW L S E K L V G L A
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana Hordeum Zea	L FQK I F PUFQKY I TKGY VSQE L AGER V AA V VAD PEYNQSGY WSWGNRQK EDGK-SF V GKYS PQA RDDD L FQK I F PUFQKNY TGGY VSQE L AGER V AD V YTKPEYGESG SY WSWGNRQK KDRQAAF VQNV S PQA RDD L FRI I F PUFQKNY TKGY VSQE L AGER V AM V VAD PE FRQSG V HWSWGNRQK EGRK-AF VQE L S EGSDAQ L FQK I F PUFQKNI TGGY VSQE L AGER V AM V VAD PE FRQSG V HWSWGNRQK EGRK-AF VQE L S AEAS DEQ V FQKY F PWFQKNI TGGY VSQE L AGER TAQ V VAD PE FRQSG V HWSWGNRQK EGRK-AF VQE L S AEAS DEQ V FQKY F PWFQKNI TGGY VSQE L AGER V AM V VAD PE FRQSG V HWSWGNRQK EGRK-AF VQE L S AEAS DEQ V FQKY F PWFQKNI TGGY VSQE L AGER V AM V VAD PE FRQSG V HWSWGNRQK KDGQ -QF SQE L S DKAT D PD L FQK I F PWFQKNI TGGY VSQE L AGER V AD V V H PD FFAGSG V HWSWGNRQK KDGQ -QF SQE L S DKAT D PD L FQK I F PUFQKNI TGGY VSQE L AGER V AD V V H PD FFAGSG V WSWGNRQK KDG SAF V KVS PQAQD EA L FQK I F PUFQKNI TGGY VSQE L AGER V AD V YK PEYGQ SGAY WSWGNRQK KDG SAF V KVS PQAQD EA L FQK I F PUFQKNI TGGY VSQE L AGER V AD V YK PEYGQ SGAY WSWGNRQK KDG SAF V KVS PQAQD EA L FQK I F PUFQKNI TGGY VSQE L AGER V AD V YK SPEFG I SG V HWSWGNRQK KNG SAF V KVS PQAQD EA L FQK I F PUFQKNI TGGY VSQE L AGER V AD V YS SPEFG I SG V HWSWGNRQK KNG SAF V KVS PQAQD EA L FQK I F PUFQKNI TGGY VSQE L AGER V AD V YS SPEFG I SG V HWSWGNRQK KNG SAF V KVS PQAR DDE I FQWL F P L FQK Y I TGGY VSQE L AGER V AD V YS SPEFG I SG V HWSWGNRQK KNG SAF V KVS PQAR DDE KARKLWE VS SG KL VG L A
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana Hordeum Zea Triticum	L FQK I F PLFQKY I TKGY VSQE L AGER V AAV VAD PEYNQSGY WSWGNRQK EDGK-SF V GKY S PQA RDDD L FQK I F PWFQKNV TGGY VSQE L AGER V AD V VT KPEYGESGS Y WSWGNRQK KDRQAAF VQNV S PQAQD EA L FRI I F PWFQKNV TKGY VSQE L AGER V AD V VAD DK FRQSG V HWSWGNRQK EGRK-AF V QE L S EGS D AQ L FQK L F PLFQKN T GGY VSQE L AGER T AQ V VAD DE FRQSG V HWSWGNRQK EGRK-AF VQE L S EAS DE Q V FQK V F PWFQKN T GGY VSQE L AGER T AQ V VAD PE FRQSG V HWSWGNRQK EGRK-AF VQE L S EAK SD EQ V FQK V F PWFQKN T GGY VSQE L AGER V AQ V VAD PE FRQSG V HWSWGNRQK KDGQ-QF S QL S EK VT DDA AF QT I F PWFQKN T GGY VSQE L AGER V AQ V VAD PE FRQSG V HWSWGNRQK KDGQ-QF S QL S EK XT D PD L FQK I F PUFQKN T GGY VSQE L AGER V AQ V VAD PE FRQSG V HWSWGNRQK KDGQ-QF S QL S DKATD PD L FQK I F PUFQKN T GGY VSQE L AGER V AQ V V AD PE FRQSG V HWSWGNRQK KDGQ-QF S QL S DKATD PD L FQK I F PLFQKY T GGY VSQE L AGER V AQ V V S PE FG I S G V HWSWGNRQK KDGK-S F V G X V S PQAQD EA L FQK I F PLFQKY T GGY VSQE L AGER V AQ V Y S PE FG I S G V HWSWGNRQK KDGK-S F V G X V S PQAR DD E I FQW L P L FQR Y T GG F V SQP L AG KR V AQ V Y S PE FG I S G V HWSWGNRQK K DGK-S F V G X V S PQAR DD E I FQW L P L FQR Y V G L A
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana Hordeum Zea Triticum Avena	L FQK I F PU F Q K Y T K G Y VSQE L AG E R V A V VA D P E Y NQ S G Y W SWG N RQ K ED GK - S F V C K Y S PQ A RD DD L FQK I F PW FQ K N Y T GG Y VSQE L AG E R V A V V X D P E F RQ S G Y W SWG N RQ K KD RQ A A F VO N Y S PQ AQD E A L F R T I PW FQ K N Y T KG Y VSQE L AG E R V A V V AD D K F RD S G Y W SWG N RQ K AG RE - A F V G EL S G G D AQ L F Q K L F P L F Q K K T T G G Y VSQE L AG E R V A W V AD D E F RQ S G Y H SWG N RQ K EG R K - A F V G EL S A E A S D E Q V F Q K V F PW FQ K N T T G G Y VSQE L AG E R V A W V AD D E F RQ S G Y H SWG N RQ K EG R E - S F VG E L S A K AT D PD L F Q K I F P W FQ K N T T G G Y VSQE L AG E R V A D V V H P D F F RQ S G Y H SWG N RQ K KDG P - Q F S C E L S D K AT D PD L F Q K I F P W FQ K N T T G G Y VSQE L AG E R V A D V Y K P E Y G Q S G S Y W SWG N RQ K KDG R- Q F S C E L S D K AT D PD L F Q K I F P W FQ K N T T G G Y VSQE L AG E R V A D V Y K P E Y G Q S G S Y W SWG N RQ K KDG R- Q F S C E L S D K AT D PD L F Q K I F P W FQ K N T T G G Y VSQE L AG E R V A D V Y K P E Y G Q S G S Y W SWG N RQ K KDG R- Q F S C E L S D K AT D PD L F Q K I F P U F Q K Y T T G G Y VSQE L AG E R V A D V Y K P E Y G Q S G S Y W SWG N RQ K KDG R- Q F S Q A Q D E A L F Q K I F P L F Q K Y T G G F Y SQP L AG K R V A Q V Y S S P E F G T S G V H W SWG N RQ K KD G K - S F V O K Y S PQ A R D D E I F Q W L F P L F Q K Y G L A
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana Hordeum Zea Triticum	L FQK I F PUFQKY I TKGY VSQE L AGER V AA V VAD PEYNQSGY WSWGNRQK EDGK-SF V GKYS PQA RDDD L FQK I F PUFQKNV TGGY VSQE L AGER V AD V VTKPEYGESGS YWSWGNRQK KDRQAAF VQNVS PQAQD EA L FR TI FPWFQKNV TKGY VSQE L AGER V AM V VAD DK FRQSG VHWSWGNRQK EGRK-AF VQE L S EGSDAQ L FQK L FPLFQKN T TGGY VSQE L AGER V AM V VAD DE FRQSG VHWSWGNRQK EGRK-AF VQE L SAEAS DE Q V FQK V FPWFQKNI TGGY VSQE L AGER TAQ V VAD PE FRQSG VHWSWGNRQK EGRK-AF VQE L SAEAS DE Q V FQK V FPWFQKNI TGGY VSQE L AGER V AM V VAD PE FRQSG VHWSWGNRQK EGRK-AF VQE L SAEAS DE Q V FQK V FPWFQKNI TGGY VSQE L AGER V AM V VAD PE FRQSG VHWSWGNRQK KDGQ-QF SQE L SDKAT D PD L FQK I FPWFQKNI TGGY VSQE L AGER V AD V VAH PD FFAGSG VHWSWGNRQK KDGQ-QF SQE L SDKAT D PD L FQK I FPWFQKNI TGGY VSQE L AGER V AD V VAH PD FFAGSG VWSWGNRQK KDGA ST SQE L SDKAT D PD L FQK I FPWFQKNI TGGY VSQE L AGER V AD V VAH PD FFAGSG VWSWGNRQK KDGA ST SQE L SDKAT D PD L FQK I FPWFQKNI TGGY VSQE L AGER V AD V VAH PD FFAGSG VWSWGNRQK KDGA ST SQE L SDKAT D PD L FQK I FPUFQKYI TGGY VSQE L AGER V AD V V SP FG I SG V WSWGNRQK KDGA ST SF SG V SY SQA QD EA L FQK I FP L FQKYI TGGY VSQE L AGER V AD V Y SP FG I SG V HWSWGNRQK KDGA SF SF SG V SY SQA QD EA L FQK I FP L FQKYI TGGY SQE L AGER V AD V Y SP FG I SG V HWSWGNRQK KDGA SF SF SG X SY SY SG SG SF SG S S S S S S S S S S S S S S
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana Hordeum Zea Triticum Avena Gloeobacter Acaryochloris	L FQK I F PLFQKY I TKGY VSQE LAGER VAAV VAD PEYNQSGY WSWGNRQK EDGK-SF V GKYS PQARDDD L FQK I F PWFQKNV TKGY VSQE LAGER VAD V VT KPEYGESGS YWSWGNRQK KDRQAAF VQNVS PQAQD EA L FRI I FPWFQKNV TKGY VSQE LAGER VAD V VAD DK FRQSG VHWSWGNRQK EGRK-AF V GELS GAGSDAQ L FQK L FPLFQKKI TGGY VSQE LAGER VAD V VAD DE FRQSG VHWSWGNRQK EGRK-AF V GELS AEASD EQ V FQK V FPWFQKNI TGGY VSQE LAGER VAD V VAD PE FRQSG VHWSWGNRQK KDGQ-QF SG LLS AKATD PD L FQK I FPWFQKNI TGGY VSQE LAGER VAD V VAD PE FRQSG VHWSWGNRQK KDGQ-QF SG LLS BKATD PD L FQK I FPWFQKNI TGGY VSQE LAGER VAD V VAD PE FRQSG VHWSWGNRQK KDGQ-QF SG LLS BKATD PD L FQK I FPLFQKYI TGGY VSQE LAGER VAD V VAD PE FRQSG VHWSWGNRQK KDGQ-QF SG LLS BKATD PD L FQK I FPLFQKYI TGGY VSQE LAGER VAD V VAD PE FRQSG VHWSWGNRQK KDGQ-QF SG LLS BKATD PD L FQK I FPLFQKYI TGGY VSQE LAGER VAD V VAD PE FRQSG VHWSWGNRQK KDGQ-QF SG LLS BKATD PD L FQK I FPLFQKYI TGGY VSQE LAGER VAD V VK PE YGQSG SY WSWGNRQK KDGQ - QF SG LLS BKATD PD L FQK I FPLFQKYI TGGY VSQE LAGER VAD V VX SP FFG IS G VHWSWGNRQK KDGK - SF VG KV SPQAQD EA L FQK I FPLFQKY I TGGY VSQE LAGER VAD V YS SP FFG IS G VHWSWGNRQK KDGK - SF VG KV SPQARD DE I FQW L PL L FQRFV I GG F VSQP LAGK R VAQ VYS SP EFG IS G VHWSWGNRQK KNGG - QF SG KLS ER I TD PE KARKVW L S EK L VG L A
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana Hordeum Zea Triticum Avena Gloeobacter	L FQK I F PLFQKY I TKGY VSQE LAGER VAAV VAD PEYNQSGYWSWGNRQK EDGK - SF VGKYS PQARDDD L FQK I F PWFQKNV TKGY VSQE LAGER VAD V VTKPEYGESGSYWSWGNRQKKDRQAAF VON VS PQAQD EA L FR TI PWFQKNV TKGY VSQE LAGER VAD V VAD VATK FEYGESGSYWSWGNRQK KDRQAAF VON VS PQAQD EA L FQK I F PLFQKKI TGGY VSQE LAGER VAD V VAD VAD PEFRQSGVHWSWGNRQK EGRK - AF VGE LS SAEASD EQ V FQK VF PWFQKNI TGGY VSQE LAGER VAD V VAD PEFRQSGVHWSWGNRQK EGRK - AF VGE LS SAEASD EQ V FQK VF PWFQKNI TGGY VSQE LAGER VAD V VAD PEFRQSGVHWSWGNRQK EGRK - AF VGE LS SAKATD PD L FQK I F PWFQKNI TGGY VSQA LAGER VAD V VAH PD FAESGVHWSWGNRQK KDG - QF SGE LS DKATD PD L FQK I F PWFQKNI TGGY VSQE LAGER VAD V VAH PD FAESGVHWSWGNRQK KDG - QF SGE LS DKATD PD L FQK I F PWFQKNI TGGY VSQE LAGER VAD V VAH PD FAESGVHWSWGNRQK KDG - QF SGE LS DKATD PD L FQK I F PWFQKNI TGGY VSQE LAGER VAD V VAH PD FAESGVHWSWGNRQK KDG - QF SGE LS DKATD PD L FQK I F PUFQKNI TGGY VSQE LAGER VAD V VAH PD FAESGVHWSWGNRQK KNGG - QF SGE LS DKATD PD KARK VW L YS EK L VGL A
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Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana Hordeum Zea Triticum Avena Gleeobacter Acaryochloris Trichodesmium Microcystis Nostoc Crocosphaera Synechocystis Thermo Plectonema	L FQK I FPUFQKY I TKGY VSQE L AGER V AA V VAD PEYNQSGY WSWGNRQK EDGK-SF V GKYS PQARDDD L FQK I FPWFQKNV T KGY VSQE L AGER V AA V VAD V TKPEYGESG SY WSWGNRQK KDRQAAF VQNV S PQAQD EA L FR TI FPWFQKNV T KGY VSQE L AGER V AM V VAD DE FRQSG V HWSWGNRQK EGRE-AF VQE L SAEASD EQ V FQK V FPWFQKNI T GGY VSQE L AGER TAQ V VAD PE FRQSG V HWSWGNRQK EGRE-AF VQE L SAEASD EQ V FQK V FPWFQKNI T GGY VSQE L AGER TAQ V VAD PE FRQSG V HWSWGNRQK EGRE-SF VQE L SAEASD EQ V FQK V FPWFQKNI T GGY VSQE L AGER TAQ V VAD PE FRQSG V HWSWGNRQK KDQQ-QF SQE L SDKATD PD L FQK I FPWFQKNI T GGY VSQE L AGER V AD V VAH PD FFRQSG V HWSWGNRQK KDGQ-QF SQE L SDKATD PD L FQK I FPWFQKNI T GGY VSQE L AGER V AD V VAH PD FFRQSG V WSWGNRQK KDG C GF SQE L SDKATD PD L FQK I FPWFQKNI T GGY VSQE L AGER V AD V Y TKPEYGQ SG Y WSWGNRQK KDG C GF SQE L SDKATD PD L FQK I FP L FQK VI T GGY VSQE L AGER V AD V Y K PEYGQ SG Y WSWGNRQK KDG C GF SQE L SDKATD PD L FQK I FP L FQK VI T GGY VSQE L AGER V AD V Y TKPEYGQ SG Y WSWGNRQK KDG C GF SQE L SDKATD PD L FQK I FP L FQK VI T GG F VSQP L AGK R V AQ V V SS PE FG I S C V WSWG NRQK KNG E - QF SQ K L S ER I TD PE KARK LWE V S EK L VG L A
Nostoć Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana Hordeum Zea Triticum Avena Gleeobacter Acaryochloris Trichodesmium Microcyslis Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococus	LFQKIFPUFQKNITGGYVSQELAGERVAAVVADPEYQQSGYWSWGNRQKEDGK-SFVQKVSPQARDDD LFQKIFPWFQKNVTGGYVSQELAGERVAAVVADDKFKDSGYWSWGNRQKADRQAAFVQNYSPQAQDEA LFRIFPWFQKNVTGGYVSQELAGERVAAVVADDKFKDSGYWSWGNRQAGRCA-AFVQELSEQGSDAQ LFQKIFPUFQKNITGGYVSQELAGERVAAVVADDFFRQSGYWSWGNRQKEGRK-AFVQELSEQGSDAQ AFQTIFPWFQKNITGGYVSQELAGERVAAVVADDFFRQSGYWSWGNRQKEGRK-AFVQELSEQGSDAQ LFQKIFPWFQKNITGGYVSQELAGERVAAVVADDFFRQSGYWSWGNRQKKDGQ-QFSQELSEKYDDA AFQTIFPWFQKNITGGYVSQELAGERVADVYAHPDFAESGYWSWGNRQKKDGQ-QFSQELSEKYDDA AFQTIFPWFQKNITGGYVSQELAGERVADVYTKPEYQQSGSYWSWGNRQKKDGQ-QFSQELSDKATDPD LFQKIFPUFQKVITGGYVSQELAGERVADVYTKPEYQQSGSYWSWGNRQKKDGK-SFVQKYSPQAQDEA LFQKIFPUFQKVITGGYVSQELAGERVADVYTKPEYGQSGYWSWGNRQKKDGK-SFVQKYSPQAQDEA LFQKIFPUFQKVITGGYVSQELAGERVADVYSSPEFGISGYWSWGNRQKKDGK-SFVQKYSPQAQDEA LFQKIFPUFQKVITGGYVSQELAGERVADVYSSPEFGISGYHWSWGNRQKKDGK-SFVQKYSPQAQDEA LFQKIFPLFQKYITGGYVSQELAGERVADVYSSPEFGISGYHWSWGNRQKKDGK-SFVQKYSPQAQDEA LFQKIFPLFQKYITGGYVSQELAGERVADVYSSPEFGISGYHWSWGNRQKKDGK-SFVQKYSPQAQDEA LFQKIFPLFQKYITGGYVSQELAGENVADVYSSPEFGISGYHWSWGNRQKKDGK-SFVQKYSPQARDDE TQWFFFVGKNITGGYYSQELAGENVADVYSSPEFGISGYHWSWGNRQKKDGK-SFVQKYSPQARDDE TQWFFFVGKNUTGGYSGKUVGYSSPEFGISGYHWSWGNRQKKDGK-SFVQKYSPQARDDE KARKLWEVSEKLVGLA
Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana Hordeum Zea Triticum Avena Gloeobacter Acaryochloris Trichodesmium Microcystis Thichodesmium Microcystis Thermo Plectonema Synechococcus Cyanothece	L FQK I FP U FQK Y I TKG Y VSQE L AGE R V AA V VAD PE YNQS G Y WSWGNRQK EDGK - SF VQK YS PQARD DD L FQK I FP WFQKNV TGG Y VSQE L AGE R V AM V VADD K FRDS G Y WSWGNRQKADRQAAF VQN S PQAQD EA L FR I I FP WFQKNV TGG Y VSQE L AGE R V AM V VADD K FRDS G Y HWSWGNRQAGRE - AF VQE L S EQG D AQ L FQK I FP U FQK NI TGG Y VSQE L AGE R V AM V VAD DE FRQS G Y HWSWGNRQ KEGR E - AF VQE L S EQG D AQ L FQK I FP WFQK NI TGG Y VSQE L AGE R V AM V AD DE FRQS G Y HWSWGNRQ KEGR E - SF YQE L S EX KY D DA AFQT I FP WFQK NI TGG Y VSQE L AGE R V AD V YAD PE FRQS G Y HWSWGNRQ KEGR E - SF YQE L S EK YT D DA AFQT I FP WFQK NI TGG Y VSQE L AGE R V AD V YAD PE FRQS G Y HWSWGNRQ KEGR E - SF YQE L S EK YT D DA L FQK I FP WFQK NI TGG Y VSQE L AGE R V AD V YK PE YGQ S G YWSWGNRQ KKDG C A SF YO KY S PQAQD EA L FQK I FP U FQK YI TGG Y VSQE L AGE R V AD V YK PE YGQ S G YWSWGNRQ KKDR KAAF YQ KY S PQAQD EA L FQK I FP L FQK YI TGG Y VSQE L AGE R V AD V YK PE YGQ S G YWSWGNRQ KKDG K AG K SF Y V XY S PQAQD EA L FQK I FP L FQK YI TGG Y SQE L AGE R V AD V YK PE YGQ S G YWSWGNRQ KKDR C KKDG C S F Y V XY S PQAQD EA L FQK I FP L FQK YI TGG Y SQE L AGE R V AD V YK PE YGQ S G YWSWGNRQ KKDR C KKDG C S SF V XY SPAARD DE I FQW L FP L FQ R F Y TGG F YSQ PLAGK R V AQ Y YSS PE FG I SG Y HWSWGNRQ KKNG E - G F SQ KL S ER I TD PE KARKYWE YS EKL YG I A
Nostoć Crocosphaera Synechocystis Thermo Plectonema Synechococcus Cyanothece Anabaena Prochlorococus Nicotiana Cucumis Pisum Pinus Marchantia Vigna Daucus Arabidopsis-thaliana Hordeum Zea Triticum Avena Gleeobacter Acaryochloris Trichodesmium Microcyslis Nostoc Crocosphaera Synechocystis Thermo Plectonema Synechococus	LFQKIFPUFQKNITGGYVSQELAGERVAAVVADPEYQQSGYWSWGNRQKEDGK-SFVQKVSPQARDDD LFQKIFPWFQKNVTGGYVSQELAGERVAAVVADDKFKDSGYWSWGNRQKADRQAAFVQNYSPQAQDEA LFRIFPWFQKNVTGGYVSQELAGERVAAVVADDKFKDSGYWSWGNRQAGRCA-AFVQELSEQGSDAQ LFQKIFPUFQKNITGGYVSQELAGERVAAVVADDFFRQSGYWSWGNRQKEGRK-AFVQELSEQGSDAQ AFQTIFPWFQKNITGGYVSQELAGERVAAVVADDFFRQSGYWSWGNRQKEGRK-AFVQELSEQGSDAQ LFQKIFPWFQKNITGGYVSQELAGERVAAVVADDFFRQSGYWSWGNRQKKDGQ-QFSQELSEKYDDA AFQTIFPWFQKNITGGYVSQELAGERVADVYAHPDFAESGYWSWGNRQKKDGQ-QFSQELSEKYDDA AFQTIFPWFQKNITGGYVSQELAGERVADVYTKPEYQQSGSYWSWGNRQKKDGQ-QFSQELSDKATDPD LFQKIFPUFQKVITGGYVSQELAGERVADVYTKPEYQQSGSYWSWGNRQKKDGK-SFVQKYSPQAQDEA LFQKIFPUFQKVITGGYVSQELAGERVADVYTKPEYGQSGYWSWGNRQKKDGK-SFVQKYSPQAQDEA LFQKIFPUFQKVITGGYVSQELAGERVADVYSSPEFGISGYWSWGNRQKKDGK-SFVQKYSPQAQDEA LFQKIFPUFQKVITGGYVSQELAGERVADVYSSPEFGISGYHWSWGNRQKKDGK-SFVQKYSPQAQDEA LFQKIFPLFQKYITGGYVSQELAGERVADVYSSPEFGISGYHWSWGNRQKKDGK-SFVQKYSPQAQDEA LFQKIFPLFQKYITGGYVSQELAGERVADVYSSPEFGISGYHWSWGNRQKKDGK-SFVQKYSPQAQDEA LFQKIFPLFQKYITGGYVSQELAGENVADVYSSPEFGISGYHWSWGNRQKKDGK-SFVQKYSPQARDDE TQWFFFVGKNITGGYYSQELAGENVADVYSSPEFGISGYHWSWGNRQKKDGK-SFVQKYSPQARDDE TQWFFFVGKNUTGGYSGKUVGYSSPEFGISGYHWSWGNRQKKDGK-SFVQKYSPQARDDE KARKLWEVSEKLVGLA

**Figure S2.** Sequence alignment highlighting total conservation (pink) and differential conservation in the cyanobacterial (green) and plant PORs (red). *Gloeobacter violaceus* (black box) shows a mixture of conservation of features relating to both groups of POR. Species 'Thermo' represents the sequence from *Thermosynechococcus elongatus*. The bracket indicates the additional 4 residues at position 281 (numbering in *T. elongatus* POR) in the cyanobacteria PORs referred to in the main manuscript.



**Figure S3.** Kinetic transients showing the absorbance changes at 696 nm for POR from *Thermosynechococcus elongatus* and *Gloeobacter violaceus* following laser photoexcitation at 450 nm. The initial increase in absorbance represents hydride transfer (1) and the slower decrease in absorbance represents the proton transfer step (1). Transients were collected at 25°C as described in the *Materials and Methods*.



**Figure S4.** The viscosity-dependence of the proton transfer reaction. The viscosity dependence of the rate constant for the decrease in absorbance at 696 nm, representing proton transfer, is shown for POR from *Thermosynechococcus elongatus* (**A**), *Synechocystis* sp. PCC6803 (**B**), *Gloeobacter violaceus* (**C**) and *Arabidopsis thaliana* POR B (**D**). All measurements were recorded over a range of timescales as described in the *Methods*. The error bars were calculated from the average of at least 3 traces.

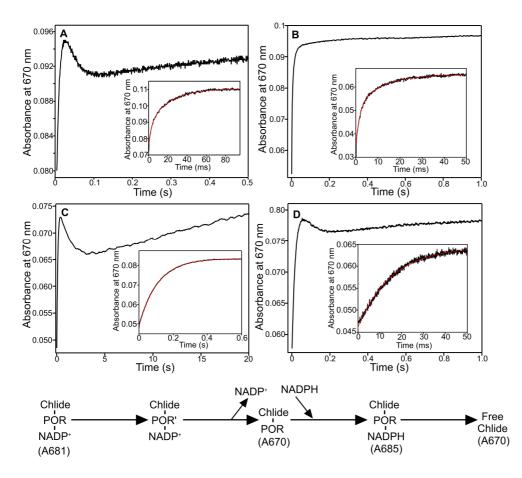


Figure S5. Kinetic transients showing product release steps following laser photoexcitation at 450 nm. Transients, showing all three spectroscopic changes associated with the product release and NADPH re-binding events, were measured at 670 nm for POR from *Thermosynechococcus elongatus* (A), *Synechocystis* sp. PCC6803 (B), *Gloeobacter violaceus* (C) and *Arabidopsis thaliana* POR B (D) (2). All measurements were recorded over a range of timescales at 25°C as described in the *Methods*. A scheme of the product release steps is shown at the bottom to indicate the spectral change associated with each phase (2). The rates of each product release step are shown in Table S3. Panel A is taken from (2).

#### **Supplementary References**

- Heyes, D. J., Sakuma, M., De Visser, S. & Scrutton, N. S. (2009) Nuclear quantum tunneling in the light-activated enzyme protochlorophyllide oxidoreductase. *J. Biol. Chem.* 284: 3762-3767.
- Heyes, D. J., Sakuma, M. & Scrutton, N. S. (2007) Laser excitation studies of the product release steps in the catalytic cycle of the light-driven enzyme, protochlorophyllide oxidoreductase. *J. Biol. Chem.* 282: 32015–32020.