SCIENTIFIC REPORTS

Received: 28 October 2016 Accepted: 14 December 2016 Published: 24 January 2017

OPEN Allosteric Inhibition of **Phosphoenolpyruvate** Carboxylases is Determined by a Single Amino Acid Residue in Cyanobacteria

Masahiro Takeya¹, Masami Yokota Hirai² & Takashi Osanai^{1,2}

Phosphoenolpyruvate carboxylase (PEPC) is an important enzyme for CO₂ fixation and primary metabolism in photosynthetic organisms including cyanobacteria. The kinetics and allosteric regulation of PEPCs have been studied in many organisms, but the biochemical properties of PEPC in the unicellular, non-nitrogen-fixing cyanobacterium Synechocystis sp. PCC 6803 have not been clarified. In this study, biochemical analysis revealed that the optimum pH and temperature of Synechocystis 6803 PEPC proteins were 7.3 and 30 °C, respectively. Synechocystis 6803 PEPC was found to be tolerant to allosteric inhibition by several metabolic effectors such as malate, aspartate, and fumarate compared with other cyanobacterial PEPCs. Comparative sequence and biochemical analysis showed that substitution of the glutamate residue at position 954 with lysine altered the enzyme so that it was inhibited by malate, aspartate, and fumarate. PEPC of the nitrogen-fixing cyanobacterium Anabaena sp. PCC 7120 was purified, and its activity was inhibited in the presence of malate. Substitution of the lysine at position 946 (equivalent to position 954 in Synechocystis 6803) with glutamate made Anabaena 7120 PEPC tolerant to malate. These results demonstrate that the allosteric regulation of PEPC in cyanobacteria is determined by a single amino acid residue, a characteristic that is conserved in different orders.

Cyanobacteria are a group of bacteria that perform oxygenic photosynthesis and fix carbon dioxide. Ribulose-1,5-bisphosphate carboxylase/oxygenase (RubisCO) is the most famous CO2 fixing enzyme, which operates in the Calvin-Benson cycle^{1,2}. Besides RubisCO, metabolic flux analysis revealed that phosphoenolpyruvate carboxylase (PEPC) [EC 4.1.1.31] accounts for 25% of CO₂ fixation in the unicellular cyanobacterium Synechocystis sp. PCC 6803 (hereafter Synechocystis 6803)³. PEPC is a crucial branch point enzyme determining the type of carbon fixation in photosynthetic organisms⁴. PEPC catalyses an irreversible carboxylation of phosphoenolpyruvate (PEP) with bicarbonate (HCO₃⁻) to generate oxaloacetate and inorganic phosphate in the presence of Mg^{2+4} . PEPC is conserved among plants, algae, cyanobacteria, archaea, and heterotrophic bacteria, but not among animals, fungi, and yeasts⁵. Cyanobacterial PEPC also plays an anaplerotic role in energy storage and biosynthesis of various metabolites by replenishing oxaloacetate to the citric acid cycle5.

The kinetics of PEPCs are diverse among organisms. Higher plants can be classified as C3-type, C4-type, and crassulacean acid metabolism (CAM) plants. PEPC is responsible for the primary carbon fixation in C4-type and CAM plants^{6,7}. The affinity of PEPCs in C4-plants to bicarbonate is 10 times higher than that of PEPCs in C3-plants^{8.9}. Most PEPCs are allosterically regulated by various metabolic effectors. Maize PEPCs are inhibited by malate or aspartate, and activated by glucose-6-phosphate¹⁰. *Escherichia coli* PEPC is inhibited by malate or aspartate, and activated by acetyl-CoA¹¹. Cyanobacterial PEPCs are evolutionally diverse. One group has suggested that PEPCs of the orders Oscillatoriales and Nostocales (including the nitrogen-fixing cyanobacterium Anabaena sp. PCC 7120, hereafter Anabaena 7120) resemble C4-type PEPC because of the serine residue conserved among C4 plants at position 774¹². However, subsequent sequence analysis has revealed that most PEPCs contain the conserved serine residue; nevertheless the kinetic properties of cyanobacteria PEPCs are diverse¹². Therefore, there may be a different type of regulation in cyanobacterial PEPCs. Cyanobacterial PEPCs in the

¹School of Agriculture, Meiji University, 1-1-1, Higashimita, Tama-ku, Kawasaki, Kanagawa 214-8571, Japan. ²RIKEN Center for Sustainable Resource Science, 1-7-22 Suehiro-cho, Tsurumi-ku, Yokohama, Kanagawa 230-0045, Japan. Correspondence and requests for materials should be addressed to T.O. (email: tosanai@meiji.ac.jp)



Figure 1. Biochemical analysis of *Synechocystis* 6803 phosphoenolpyruvate carboxylase (*SyPEPC*). (A) Purification of GST-tagged PEPC. Proteins were electrophoresed on an 8% SDS-PAGE gel, and stained with Instant Blue reagent. Arrowheads indicate the molecular weight. (B) Effect of temperature on *SyPEPC* activity. Data represent means of the values from three independent experiments. (C) Effect of pH on *SyPEPC* activity. Data represent relative values of means from three independent experiments. Four pmol (0.6μ g) of *SyPEPC* was used for the enzyme assay. One unit of PEPC activity was defined as the consumption of 1 µmol NADPH per minute.

order *Nostocales, Coccochloris peniocystis*, and *Thermosynechococcus vulcanus* are inhibited by either malate or aspartate¹²⁻¹⁵. Several effectors regulate cyanobacterial PEPCs, but their effects are dependent on the taxonomic order of the PEPCs¹². The biochemical properties, including V_{max} and K_m values, of several cyanobacterial PEPCs have been determined^{12,14,15}, although those of the PEPCs in *Synechocystis* 6803 have not. A comparison of cyanobacterial PEPCs including both phylogenetic and biochemical analyses has also been lacking until now.

Here, using the model cyanobacterium *Synechocystis* 6803, we performed biochemical analysis using purified PEPC proteins. Our analysis demonstrated that a single amino acid substitution between glutamate and lysine at position 954 was important for allosteric regulation.

Results

Measurement of the kinetic parameters of and inhibitor effects on *Synechocystis* **6803 PEPC.** *Synechocystis* **6**803 is one of the most studied cyanobacteria; nevertheless, the kinetic parameters of *Synechocystis* **6**803 PEPC (*SyPEPC*) have not been determined until now. Glutathione S-transferase (GST)-tagged *SyPEPC* proteins were expressed in *E. coli* and purified by affinity chromatography (Fig. 1A). The enzymatic activity of *SyPEPC* was highest at pH 7.3 and 30 °C (Fig. 1B and C). Biochemical analysis revealed the V_{max} value of *SyPEPC* was 1.74 units/mg, and the K_{m} values of *SyPEPC* for PEP and HCO₃⁻ were 0.34 and 0.80 mM, respectively (Fig. 2A).

We next examined the effects of various metabolic effectors on SyPEPC activity. The enzyme assay was performed at the optimal pH 7.3 and temperature 30 °C using a half-saturating concentration of PEP. Aspartate decreased the SyPEPC activity to 85.2% (Table 1). The tricarboxylic acid cycle (TCA) metabolites malate, fumarate, and citrate reduced the SyPEPC activity to 75–86% (Table 1). Both malate and fumarate increased the $V_{\rm max}$ and $K_{\rm m}$ values for PEP (Fig. 2B and C).

To strengthen the integrity of our results, we performed biochemical assays using commercially available PEPCs and cell extracts from other organisms. The purified PEPCs of *Acetobacter* and *Zea mays* were inhibited by both aspartate and malate (Fig. S1A). The activity of PEPCs in *Nostoc* sp. NIES-3756 and *E. coli* DH5 α extracts were decreased by both aspartate and malate (Fig. S1B). These results were consistent with previous results^{12,16,17}, confirming our data were reliable (Fig. S1C).

We tested the inhibitory effects of aspartate and malate at alkaline pH, because the inhibitory effect on *Thermosynechococcus vulcanus* PEPC was stronger at alkaline pH than at neutral pH¹⁵. The inhibitory effects of malate and aspartate on *Sy*PEPC were enhanced at pH 9.0 compared with pH 7.3 (Fig. 3).

In silico prediction and biochemical assay identified a glutamate residue at position 954 as important for allosteric regulation. To understand the differences among cyanobacterial PEPCs, phylogenetic analysis was performed. The phylogenetic tree of PEPCs built using maximum likelihood methods showed a classification dependent on order; the PEPCs of *Synechocystis* 6803, *Thermosynechococcus vulcanus*, and *Coccochloris peniocystis*, all three of which belong to the order *Chroococcales*, were grouped in the same cluster, and were distinguished from *Anabaena* 7120 belonging to the order *Nostocales* (Fig. 4).



Figure 2. The V_{max} and K_{m} values for phosphoenolpyruvate (PEP) in the presence of various compounds. (A) Saturation curves of the activity of purified *Sy*PEPC. The graph shows the means of three independent experiments. The V_{max} and K_{m} values for PEP of GST-tagged *Sy*PEPC proteins are shown in (B) and (C), respectively. (B) Mean \pm SD V_{max} (units/pmol protein) values in the presence of various compounds, obtained from three independent experiments. (C) Mean \pm SD K_m values for PEP, obtained from three independent experiments. (C) Mean \pm SD K_m values for PEP, obtained from three independent experiments. Mock indicates the enzymatic activity in the absence of additional compounds. One unit of PEPC activity was defined as the consumption of 1 µmol NADPH per minute.

Compounds	SyPEPC activity (in vitro)
Mock	100 ± 5.2
GTP	101 ± 0.6
Acetyl-CoA	111 ± 14.0
Fructose-1,6-bisphophate	96.9±4.1
Aspartate	85.2 ± 10.7
Citrate	86.1±6.7
Malate	77.1±6.3
Fumarate	75.0±9.7
Succinate	124+12.3

Table 1. Effect of various metabolites on *SyPEPC* activity. Enzyme activities were measured at pH 7.3 and 30 °C in the presence of 0.5 mM PEP. The concentration of each metabolite was 1 mM, except for GTP (5 mM), acetyl-CoA (0.4 mM), and fructose-1,6-bisphosphate (2 mM). Mock indicates the enzymatic activity in the absence of additional compounds. Data represent means \pm SD from three independent assays. Mock was set at 100%.

A previous biochemical analysis showed that *Anabaena* 7120 PEPC (hereafter *An*PEPC) is sensitive to aspartate and malate¹², but *Sy*PEPC was less sensitive to these metabolites (Table 1). To reveal the cause of the difference among these cyanobacterial PEPCs, a multiple sequence alignment was performed with the software CLC sequence viewer 7.0 (Fig. 5). The carboxyl-terminal region, called region 5, is important for inhibitor binding in higher plants^{7,18}, and five conserved amino acid residues are important for aspartate inhibition¹¹ (Fig. 5). These amino acid residues were also conserved in cyanobacterial PEPCs (Fig. 5). Therefore, at least one other amino acid residue is responsible for the difference between cyanobacterial and higher plant PEPCs. We first looked for amino acid residues unique to *Sy*PEPC and found 28 (Fig. 5). Among them, we searched for amino acid







Figure 4. Phylogenetic analysis of the PEPCs from cyanobacteria, *Flaveria, Zea mays*, and *E. coli*. Protein sequences and accession numbers were obtained from GenBank. The protein sequences were aligned by the software CLC Sequence Viewer, and a maximum-likelihood tree based on 780 conserved amino acids was constructed using PHYML online (http://www.atgc-montpellier.fr/phyml/). The bootstrap values were obtained from 500 replications.

residues that were highly conserved in the order *Nostocales* (*Nostoc/Anabaena*) but different from those in either *Oscillatoriales* or *Chroococcales* (including *Synechococcus* and *Synechocystis*). Consequently, we found two candidates—the amino acids at positions 954 and 967 in *SyPEPC*, which were glutamate and serine, respectively (Fig. 5).

| Anabaena variabilis Aloc 23413 | 702 HGRGGSVGRG GGPAHEA

 | LA QPGHSINGRI KITE | QGEVLA SKYSLLDLAL | YNLETITTAV IG
 | QASLLRTGF DD.
 | IEPWN EIMEE
 | ELAARS RQHYRGI | IYE QPDFIDFFHQ | VTPIEEISQL | QISSRPA-RR
 | PSGKKD LSSLRAIP | IV FSWTQTRFLI | . PSWYGVGTAL | 863 |

--
--|---|---|--
--
--
--|---|--
---|--|---|---
--|--|
| Anabanea sp. PCC 7120 | 705 HGRGGSVGRG GGPAHEA

 | LA QPGHSINGRI KITE | QGEVLA SKYSLLDLAL | YNLETITTAV IC
 | QASLLRTGF DD
 | IEPWN EIMER
 | ELAARS RQHYRGI | IYE QPDFIDFFHQ | VTPIEEISQL | QISSRPA-RR
 | PSGKKD LSSLRAIP | V FSWTQTRFLI | . PSWYGVGTAL | 866 |
| Nostoc sp. NIES 3756 | 704 HGRGGSVGRG GGPAHEA

 | LA QPGHSINGRI KITE | QGEVLA SKYSLLDLAL | YNLETITTAV IG
 | QASLLRTGF DD
 | IEPWN EIMER
 | ELAARS RQHYRNI | IYE QPDFIDFFHQ | VTPIEEISQL | QISSRPA-RR
 | PSGKKD LSSLRAIP | V FSWTQTRFLI | . PSWYGVGTAL | 865 |
| Nostoc sp. PCC 7524 | 705 HGRGGSVGRG GGPAHEA

 | LA QPGHSINGRI KITE | QGEVLA SKYSLLDLAL | YNLETITTAV IG
 | QASLLRTGF DD
 | IEPWN EIMER
 | ELAARS RQHYRAI | IYE QPDFIDFFHQ | VTPIEEISQL | QISSRPA-RR
 | PSGKKD LSSLRAIP | IV FSWTQTRFLI | , PSWYGVGTAL | 866 |
| Nostoc sp. PCC 7107 | 695 HGRGGSVGRG GGPAYEA

 | LA QPGHSINGRI KITE | QGEVLA SKYSLVDLAL | YNLETVTTAV IG
 | QASLLRTGF DD
 | IEPWN EIMER
 | ELAARS RQHYRAI | IYE QPDFIDFFNQ | VTPIEEISQL | QISSRPA-RR
 | PSGKKD LSSLRAIP | V FSWTQTRVLI | , PSWYGMGTAL | 856 |
| Nostoc piscinale CENA 21 | 696 HGRGGSVGRG GGPAYEA

 | LA QPGHSINGRI KITE | QGEVLA SKYSLVDLAL | YNLETVTTAV IG
 | QASLLRTGF DD
 | IEPWN EIMER
 | ELAVRS RQHYRAI | IYE QPDFIDFFNQ | VTPIEEISQL | QISSRPA-RR
 | PSGKKD LSSLRAIP | V FSWTQTRVLI | . PSWYGVGTAL | 857 |
| Nostoc punctiforme PCC 73102 | 716 HGRGGSVGRG GGPAYEA

 | LA QPGHSINGRI KITE | QGEVLA SKYSLLDLAL | YHMETITTAV IG
 | QASLLRTGF DD
 | IEPWN EIMEE
 | ELAARS RQHYRAI | IYE QPDFVDFFHQ | VTPIEEISQL | QISSRPA-RR
 | PSGKKD LSSLRAIP | V FSWTQTRFLI | , PSWYGVGTAL | 877 |
| Anabaena sp. PCC 7108 | 698 HGRGGSVGRG GGPAYEA

 | LA QPGHSINGRI KITE | QGEVLA SKYSLVDLAL | YHVETITTAV VQ
 | QASLLRTGF DD
 | IQPWN EIMEE
 | ELSVRS RQHYRAI | IYE QPDFIDFFHQ | VTPIEEISQL | QISSRPA-RR
 | PSGKKD LSSLRAIP | V FSWTQTRILI | , PSWYGIGTAL | 859 |
| Anabaena cylindrica PCC 7122 | 688 HGRGGSVGRG GGPAYEA

 | LA QPGHSINGRI KITE | QGEVLA SKYSLLDLAL | YHVETITSAV IC
 | QASLLRTGF DD
 | IEPWN EIMER
 | ELSMRS RQHYRAI | IYE QPDFIDFFHQ | VTPIEEISQL | QISSRPA-RR
 | PSGKKD LSSLRAIP | V FSWTQTRFLI | . PSWYGIGTAL | 849 |
| Anabaena sp. 90 | 693 HGRGGSVGRG GGPAHEA

 | LA QPGHSISGRI KITE | QGEVLA SKYSLLDLAL | YHLETITTAV IG
 | QASLLGTGF DD
 | IEPWN EIMER
 | ELSHAS RQHYRNI | IYE QPDFIDFFHQ | VTPIEEISQL | QISSRPA-RR
 | PSGKKD LSSLRAIP | V FSWTQTRFLI | . PSWYGIGTAL | 854 |
| Anabaena sp. wa 102 | 693 HGRGGSVGRG GGPAHEA

 | LA QPGHSISGRI KITE | QGEVLA SKYSLLDLAL | YHLETITTAV IG
 | QASLLGTGF DD
 | IEPWN EIMER
 | ELSHAS RQHYRNI | IYE QPDFIDFFHQ | VTPIEEISQL | QISSRPA-RR
 | PSGKKD LSSLRAIP | V FSWTQTRFLI | . PSWYGIGTAL | 854 |
| Phormidium sp. OSCR | 683 HGRGGSVGRG GGPAYEA

 | LA QPGRTIDGRI KITE | QGEVLA SKYSLPELAL | YHLETVTSAV IC
 | QSSLLGSGF DD
 | IQPWN ETMER
 | ELAHKS RQHYRSI | VYE EPDFVDFFMQ | VTPIEEISQL | QISSRPS-RR
 | RQGKKD IGSLRAIP | V FSWTQSRFLI | , PAWYGVGTAL | 844 |
| Phormidium willei BDU 130791 | 683 HGRGGSVGRG GGPAYEA

 | LA QPGRTIDGRI KITE | QGEVLA SKYSLSELAL | YHLETVTSAV IG
 | QSSLLGSGF DD
 | IQPWN ETMER
 | ELAHKS RQHYRSI | VYE EPDFIDFFMQ | VTPIEEISQL | QISSRPS-RR
 | RQGKKD IGSLRAIP | IV FSWTQSRFLI | . PAWYGVGTAL | 844 |
| Oscillatoria acuminata PCC 6304 | 694 HGRGGSVGRG GGPAYEA

 | LA QPGRSINGRI KITE | QGEVLA SKYTLPELAL | YNLETIASAV VQ
 | QSSLLGSGF DD
 | IEAWN QIMEE
 | ELADCS RQHYRAI | IYE QPDFIDFFHE | VTPIDEISKL | QISSRPA-RR
 | SSGKRD LGSLRAIP | V FSWTQTRFLI | , PAWYGVGTAL | 855 |
| Oscillatoria sp. PCC 10802 | 711 HGRGGSVGRG GGPAYEA

 | LA QPSESVNGRI KITE | QGEVLA SNYTLPDLAI | YNLENIATAV IG
 | QSSLLGTGF DD
 | IEPWK EIMEF
 | ELADRS RAHYRAI | IYE QPDFIEFFHQ | VTPIDEISQL | QISSRPA-RR
 | RTGKKD LGTLRAIP | V FSWTQTRFLI | . PSWYGVGTAV | 872 |
| Synechococcus elongatus PCC 7942 | 696 HGRGGSVGRG GGPAYEA

 | LA QPGRTTDGRI KITE | QGEVLA SWYALPELAL | YNLETITTAV IC
 | QSSLLGSGF DD.
 | IEPWN QIMEE
 | ELAARS RRHYRAI | VYE QPDLVDFFNQ | VTPIEEISKL | QISSRPA-RR
 | KTGKRD LGSLRAIP | IV FSWTQSRFLI | . PSWYGVGTAL | 857 |
| Synechococcus elongatus PCC6301 | 732 HGRGGSVGRG GGPAYEA

 | LA QPGRTTDGRI KITE | QGEVLA SKYALPELAL | YNLETITTAV IC
 | QSSLLGSGF DD.
 | IEPWN QIMEE
 | ELAARS RRHYRAI | VYE QPDLVDFFNQ | VTPIEEISKL | QISSRPA-RR
 | KTGKRD LGSLRAIP | V FSWTQSRFLI | . PSWYGVGTAL | 893 |
| Thermosynechococcus vulcanus | 691 HGRGGSVGRG GGPAYAA

 | LA QPAQTIKGRI KITE | QGEVLA SKYSLPELAL | FNLETVATAV IC
 | QASLLRSSI DE
 | IEPWH EIMER
 | ELATRS RQCYRHI | IYE QPEFIEFFNE | VTPIQEISQL | QISSRPT-RR
 | -GGKKT LESLRAIP | V FSWTQTRFLI | . PAWYGVGTAL | 851 |
| Myxosarcina sp. GI1 | 709 HGRGGSVGRG GGPAYSAV

 | 'LA QPTDTIQGRI KITE | QGEVLA SKYSLPELAL | YNLETITTAV IG
 | QSSLLGSGF DR
 | VEPWH EVMEE
 | ELAARS RTVYRAI | IYE QPDFVDFFHS | VTPIDVIGKL. | QIGSRPS-KR
 | PGKGGGKKKD MSGLRAIP | IV FSWTQSRFLI | , PAWYGVGSAL | 874 |
| Synechocystis sp. PCC 6803 | 713 HGRGGSVGRG GGPAYKA

 | LA QPAGTVDGRI KITE | QGEVLA SKYSLPELAL | YNLETLTTAV 19
 | QASLLKSSF DF.
 | IEPWN RIMEE
 | ELACTA RRAYRSI | IYE EPDFLDFFLT | VTPIPEISEL | QISSRPA-RR
 | KGGKAD LSSLRAIP | V FSWIQTRFLI | . PAWYGVGTAL | 874 |
| Flaveria trinervia | 633 HGRGGTVGRG GGPTHLAI

 | LS QPPDTINGSL RVTV | QGEVIE QSFGEEHLCF | RTLQRFCAAT LE
 | EHGMN PP.
 | ISPRPEWR ELMIN
 | QMAVVA TEEYRS) | VFK EPRFVEYFRL | ATPELEFGRM | NIGSRPSKRK
 | PSGG IESLRAIP | 1 FSWTQTRFHI | , PVWLGFGAAF | 792 |
| Flaveria pringlei | 633 HGRGGTVGRG GGPTHLA

 | LS QPPDTIHGSL RVTV | QGEVIE QSFGEEHLCF | RTLQRFCAAT LE
 | EHGMN PP
 | ISPRPEWR ELMD
 | QMAVVA TEEYRS | VFK EPRFVEYFRL | ATPELEYGRM | NIGSRPSKRK
 | PSGG IESLRAIP | I FAWTQTRFHI | , PVWLGFGAAF | 792 |
| Zea mays | 579 HGRGGTVGRG GGPTHLA

 | LS QPPDTINGSI RVTV | QGEVIE FOFGEEHLCF | QTLQRFTAAT LE
 | EHGMH PP
 | VSPKPEWR KLMDE
 | EMAVVA TEEYRS | VVK EARFVEYFRS | ATPETEYGRM | NIGSRPAKRR
 | PGGG ITTLRAIP | I FSWTQTRFHI | . PVWLGVGAAF | 798 |
| Escherichia coli | 639 HGRGGSIGKG GAPAHAAI

 | LS QPPGSLKGGL RVTE | QGEMIR FWYGLPEITV | SSLSLYTGAI LE
 | EANLL PPI
 | PEPKESWR RIMDE
 | ELSVIS CDLYRG | VRE NKDFVPYFRS | ATPEQELGKL | PLGSRPAKRR
 | PTGG VESLRAIP | I FINTQNRLMI | , PAWLGAGTAL | 738 |
| PEP/asr | artate binding

 | Dogion 5 | Aspartate b | inding
 |
 |
 | | | |
 | S/ | 1 99774 | | |
| | 9

 | Region 5 | • | 0
 |
 |
 | | | |
 | | | | |
| |

 | | |
 |
 |
 | | | |
 | | | | |
| |

 | | |
 |
 |
 | | | |
 | | | | |
| |

 | | |
 |
 |
 | | | |
 | | | | |
| |

 | | |
 |
 |
 | | | |
 | | | | |
| |

 | | |
 |
 |
 | | | |
 | | | | |
| |

 | | |
 |
 |
 | | | |
 | | | | |
| |

 | | |
 |
 |
 | | | |
 | | | | |
| |

 | | |
 |
 |
 | | | |
 | | | | |
| |

 | | |
 |
 |
 | | | |
 | | | | |
| Anabaena variabilis ATCC 29413 | 874 HLKLMRYFYV KWPFFKMV

 | IS KVEMTLANVD MQMAG | GHYVQE LSDPEDKSRF | EKVFEQIANE YY
 | YLTRDLVLK ITE
 | DHSRLLDG DFVLQ
 | RSVQL RNGTIVF | .GF IQVSLLKRLR | QSKNNNATSG | VIHSRYSKG-
 | | L LRGALLTING | IAAGMENTG | 1023 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120 | 874 HLKLMRYFYV KWPFFKMV
877 HLKLMRYFYV KWPFFKMV

 | IS KVEMTLANVD MQMAG
IS KVEMTLANVD MQMAG | GHYVQE LSDPEDKSRF
GHYVQE LSDPEDKPRF | EKVFEQIANE YY
EKVFEQIANE YY
 | YLTRDLVLK ITE
YLTRDLVLK ITE
 | DHSRLLDG DPVLQ
 | RSVQL RNGTIVF | .GF IQVSLLKRLR
.GF IQVSLLKRLR | QSKNNNATSG
QSKNNTATSG | VIHSRYSKG-
VIHSRYSKG-
 | | L LRGALLTING
L LRGALLTING | IAAGMENTG :
IAAGMENTG : | 1023 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NIES 3756 | 874 HLKLMRYFYV KWPFFKMV
877 HLKLMRYFYV KWPFFKMV
876 HLKLMRYFYV KWPFFKMV

 | IS KVEMTLANVD MQMAG
IS KVEMTLANVD MQMAG
VS KVEMTLANVD MQMAG | GHYVQE LSDPEDKSRF
GHYVQE LSDPEDKPRF
GHYVQE LSDPEDKPRF | EKVFEQIANE YY
EKVFEQIANE YY
DKVFEQIANE YY
 | YLTRDLVLK ITT
YLTRDLVLN ITT
YLTRDLVLN ITT
 | HSRLLDG DPVLQ
HGRLLDG DPVLQ
HSRLLDG DPVLQ
 | RSVQL RNGTIVF
RSVQL RNGTIVF
RSVQL RNGTIVF | .GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR | QSKNNNATSG
QSKNNTATSG
QSKNNTATSG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
 | | L LRGALLTING
L LRGALLTING
L LRGALLTING | IAAGMENTG
IAAGMENTG
IAAGMENTG | 1023
1026
1025 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NLES 3756
Nostoc sp. PCC 7524 | 874 HLKLMRYFYV KWPFFKMV
877 HLKLMRYFYV KWPFFKMV
876 HLKLMRYFYV KWPFFKMV
877 HLKLLRYFYV KWPFFKMV

 | IS KVEMTLAKVD NQMA
IS KVEMTLAKVD NQMA
VS KVEMTLAKVD NQMA
IS KAEMTLAKVD NQMAI | CHYVQE LSDPEDKSRF
CHYVQE LSDPEDKPRF
CHYVQE LSDPEDKPRF
RHYVQE LSNPEDKARF | EKVFEQIANE YY
EKVFEQIANE YY
DKVFEQIANE YY
EKVFEQIASE FY
 | YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDLVLK ITT
 | DHSRLLDG DPVLQ
DHGRLLDG DPVLQ
DHSRLLDG DPVLQ
DHIRLLDG DPVLQ
 | RSVQL RNGTIVF
RSVQL RNGTIVF
RSVQL RNGTIVF
RSVQL RNGTIVF | LGF IQVSLLKRLR
LGF IQVSLLKRLR
LGF IQVSLLKRLR
LGF IQVSLLKRLR | QSKNNNATSG
QSKNNTATSG
QSKNNTATSG
QSKN-IATSG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
 | | L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING | IAAGME TG
IAAGME TG
IAAGME TG
IAAGME TG | 1023
1026
1025
1025 |
| Anabæena varisbilis ATCC 29413
Anabæena sp. PCC 7120
Nostoc sp. NES 3756
Nostoc sp. PCC 7524
Nostoc sp. PCC 7107 | 874 HLKLMRYFYV KWPFFKMV 877 HLKLMRYFYV KWPFFKMV 876 HLKLMRYFYV KWPFFKMV 877 HLKLLRYFYV KWPFFKMV 867 HLKLLRYFYM KWPFFKMV

 | IS KVEMTLAKVD MQMAA
IS KVEMTLAKVD MQMAQ
VS KVEMTLAKVD MQMAQ
IS KAEMTLAKVD MQMAQ
IS KAEMTLAKVD MQMAQ | CHYVQE LSDPEDKSRF
CHYVQE LSDPEDKPRF
CHYVQE LSDPEDKPRF
RHYVQE LSNPEDKARF
RHYVQE LSNPEDKARF | EKVFEQIANE YY
EKVFEQIANE YY
DKVFEQIANE YY
EKVFEQIASE FY
DKVFEQIASE YY
 | YLTROLVLK ITT
YLTROLVLK ITT
YLTROLVLK ITT
YLTROLVLK ITT
YLTROFVLK ITT
 | DHSRLLDG DFVLQ
DHGRLLDG DFVLQ
DHSRLLDG DFVLQ
DHHRLLDG DFVLQ
SHNRLLDG DFVLQ
 | RSVQL RNGTIVF
RSVQL RNGTIVF
RSVQL RNGTIVF
RSVQL RNGTIVF
RSVQL RNGTIVF | LGF IQVSLLKRLR
LGF IQVSLLKRLR
LGF IQVSLLKRLR
LGF IQVSLLKRLR
LGF IQVSLLKRLR | QSKNNNATSG
QSKNNTATSG
QSKNNTATSG
QSKN-IATSG
QAKNTTATSG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
 | | L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING | IAAGMF TG
IAAGMF TG
IAAGMF TG
IAAGMF TG
IAAGMF TG | 1023
1026
1025
1025
1016 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NIES 3756
Nostoc sp. PCC 7524
Nostoc sp. PCC 7107
Nostoc piecīnāle CENA 21 | 874 HLKLMRYFYV KWPFFKMV
877 HLKLMRYFYV KWPFFKMV
876 HLKLMRYFYV KWPFFKMV
877 HLKLLRYFYV KWPFFKMV
867 HLKLLRYFYM KWPFFKMV
868 HLKLLRYFYM KWPFFKMV

 | IS KVEMTLARVD MQMAG
IS KVEMTLARVD MQMAG
VS KVEMTLARVD MQMAG
IS KAEMTLARVD MQMAG
IS KAEMTLARVD MQMAG
IS KAEMTLARVD MQMAG | SHYVQE LSDPEDKSRF
SHYVQE LSDPEDKPRF
SHYVQE LSDPEDKPRF
RHYVQE LSNPEDKARF
RHYVQE LSNPEDKERF
RHYVQE LSNPEDKERF | EKVFEQIANE YY
EKVFEQIANE YY
DKVFEQIANE YY
EKVFEQIASE FY
DKVFEQIASE YY
 | YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDFVLK ITT
YLTRDFVLK ITT
YLTKDFVLK ITT
 | HSRLLDG DPVLQ
HGRLLDG DPVLQ
HSRLLDG DPVLQ
HHRLLDG DPVLQ
HNRLLDG DPVLQ
HTRLLDG DPVLQ
 | RSVQL RNGTIVF
RSVQL RNGTIVF
RSVQL RNGTIVF
RSVQL RNGTIVF
RSVQL RNGTIVF
RSVQL RNGTIVF | .GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR | QSKNNNATSG
QSKNNTATSG
QSKNNTATSG
QSKN-IATSG
QAKNTTATSG
QAKNTTATSG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
 | | L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING | IAAGMF TG
IAAGMF TG
IAAGMF TG
IAAGMF TG
IAAGMF TG
IAAGMF TG | 1023
1026
1025
1025
1016
1017 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NES 3756
Nostoc sp. PCC 7624
Nostoc sp. PCC 7107
Nostoc puscinale CENA 21
Nostoc pusciforme PCC 73102 | HLKLMRYFYV KUPFFKMV RYT HLKLMRYFYV KUPFFKMV RYT HLKLLRYFYV KUPFFKMV HLKLLRYFYW KUPFFKMV RS6 HLKLLRYFYM KUPFFKMV RS6 HLKLLRYFYK KUPFFKMV RHKLMRYFYV KUPFFKMV

 | IS KVEMTLARVD MQMAG
IS KVEMTLARVD MQMAG
VS KVEMTLARVD MQMAG
IS KAEMTLARVD MQMAG
IS KAEMTLARVD MQMAG
IS KAEMTLARVD MQMAG
IS KAEMTLARVD MQMAG | SHYVQE LSDPEDKSRF
SHYVQE LSDPEDKPRF
SHYVQE LSDPEDKPRF
RHYVQE LSNPEDKRFF
RHYVQE LSNPEDKERF
HHYVQE LSQSEDQLRF | EKVFEQIANE YY
EKVFEQIANE YY
DKVFEQIANE YY
EKVFEQIASE YY
DKVFEQIASE YY
AKVFDQIASE FY
 | YLTROLVLK ITT
YLTROLVLK ITT
YLTROLVLK ITT
YLTROLVLK ITT
YLTROFVLK ITT
YLTROFVLK ITT
YLTKOFVLK ITT
YLTROLVLK ITT
 | HSRLLDG DPULQ
HGRLLDG DPULQ
HSRLLDG DPULQ
HHRLLDG DPULQ
HTRLLDG DPULQ
HTRLLDG DPULQ
HTRLLDG DPULQ
 | RSVQL RNGTIVF
DRSVQL RNGTIVF
DRSVQL RNGTIVF
DRSVQL RNGTIVF
DRSVQL RNGTIVF
DRSVQL RNGTIVF
DRSVQL RNGTIVF | .GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR | QSKNNNATSG
QSKNNTATSG
QSKNTATSG
QSKN-IATSG
QAKNTTATSG
QSMNTNATSG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
 | | L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING | IAAGME TG
IAAGME TG
IAAGME TG
IAAGME TG
IAAGME TG
IAAGME TG
IAAGME TG | 1023
1026
1025
1025
1016
1017
1037 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NES 3756
Nostoc sp. PCC 7124
Nostoc ps. PCC 7107
Nostoc pischale CENA 21
Nostoc punctiforme PCC 73102
Anabaena sp. PCC 7108 | 874 HLKLMRYFYY KWPFFKMY
877 HLKLMRYFYY KWPFFKMY
876 HLKLMRYFYY KWPFFKMY
877 HLKLLYFYY KWPFFKMY
868 HLKLLRYFYM KWPFFKMY
888 HLKLLRYFYM KWPFFKMY
888 HLKLLRYFYM KWPFFKMY

 | IS KVEMTLAKVD MQMAA
IS KVEMTLAKVD MQMAA
VS KVEMTLAKVD MQMAA
IS KAEMTLAKVD MQMAI
IS KAEMTLAKVD MQMAI
IS KAEMTLAKVD IQMAI
IS KAEMTLAKVD IQMAI | SHYVQE LSDPEDKSRF
SHYVQE LSDPEDKPRF
SHYVQE LSDPEDKRFF
RHYVQE LSNPEDKRF
RHYVQE LSNPEDKRFF
RHYVQE LSSNEDKRFF
RHYVQE LSNPEDKSRF | EKVFEQIANE YY
EKVFEQIANE YY
DKVFEQIANE YY
DKVFEQIASE YY
DKVFEQIASE YY
AKVFDQIASE FY
DQVFEQIASE FY
 | YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDFVLK ITT
YLTRDFVLK ITT
YLTRDFVLK ITT
YLTRDLVLK ITT
 | HSRLLDG DP LQ
HGRLLDG DP LQ
HSRLLDG DP LQ
HNRLLDG DP LQ
HNRLLDG DP LQ
HTRLLDG DP LQ
HKRLLDG DP LQ
 | RSVQL RAGTIVF
RSVQL RAGTIVF
RSVQL RAGTIVF
RSVQL RAGTIVF
DRSVQL RAGTIVF
DRSVQL RAGTIVF
DRSVQL RAGTIVF | GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR | QSKNNNATSG
QSKNNTATSG
QSKN-TATSG
QAKNTTATSG
QAKNTTATSG
QSMNTNATSG
QYKN-TSTSG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
 | | L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING | IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG | 1023
1026
1025
1025
1016
1017
1037
1018 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. PEC 8756
Nostos sp. PCC 7624
Nostoc piscinale CENA 21
Nostoc punciforme PCC 7102
Anabaena sp. PCC 7108
Anabaena sp. PCC 7122 | 874 HLKLMRYFYV KUPFFKM
877 HLKLMRYFYV KUPFFKM
876 HLKLMRYFYV KUPFFKM
877 HLKLLRYFYM KUPFFKM
868 HLKLRYFYM KUPFFKM
888 HLKLRYFYM KUPFFKM
888 HLKLRYFYM KUPFFKM
806 HLKLLRYFYM KUPFFKM

 | IS KVEMTLARVD MQMAG
IS KVEMTLARVD MQMAG
IS KAEMTLARVD MQMAG
IS KAEMTLARVD MQMAI
IS KAEMTLARVD MQMAI
IS KAEMTLARVD IEMAI
IS KAEMTLARVD IEMAI
IS KAEMTLARVD IEMAI | SHYVQE LSDPEDKSRF
SHYVQE LSDPEDKPRF
RHYVQE LSDPEDKPRF
RHYVQE LSNPEDKRFF
RHYVQE LSNPEDKERF
HHYVQE LSQSEDQLRP
HHYVQE LSQSEDQLRP
RHYVDE LSSPEDKSRF
RHYVDE LSSPEDKSRF | EKVFEQIANE YY
EKVFEQIANE YY
DKVFEQIANE YY
EKVFEQIASE FY
DKVFEQIASE YY
EVVFEQIASE FY
DQVFEQIASE FY
DQVFEQIASE FY
 | YLTRDLVLK ITU
YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDFVLK ITT
YLTRDFVLK ITT
YLTRNLVL ITT
YLTRNLVLN ITT
YLTRNLVLN ITT
 | HSRLLDG DP'LQ
HGRLLDG DP'LQ
HSRLLDG DP'LQ
HHRLLDG DP'LQ
HTRLLDG DP'LQ
HTRLLDG DP'LQ
HKRLLDG DP'LQ
HKRLLDG DP'LQ
 | REVQL RNGTIVE
REVQL RNGTIVE
REVQL RNGTIVE
REVQL RNGTIVE
REVQL RNGTIVE
REVQL RNGTIVE
REVQL RNGTIVE
REVQL RNGTIVE
REVQL RNGTIVE | GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR | QSKNNNATSG
QSKNNTATSG
QSKNNTATSG
QAKNTATSG
QAKNTTATSG
QSKNTNATSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
IIHSRYSKG-
 | | L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING | IAAGMF YTG
IAAGMF YTG
IAAGMF YTG
IAAGMF YTG
IAAGMF YTG
IAAGMF YTG
IAAGMF YTG
IAAGMF YTG
IAAGMF YTG | 1023
1026
1025
1025
1016
1017
1037
1018
1008 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NES 3756
Nostoc sp. PCC 17624
Nostoc pischild CRA 21
Nostoc pinatilorae PCC 73102
Anabaena sp. PCC 7102
Anabaena cylindrica PCC 7122
Anabaena sp. 90 | 874 HLKLMRYFYV KUPFFKMV
877 HLKLMRYFYV KUPFFKMV
876 HLKLMRYFYV KUPFFKMV
866 HLKLRYFYM KUPFFKMV
868 HLKLRYFYM KUPFFKMV
858 HLKLRYFYM KUPFFKMV
860 HLKLLRYFYW KUPFFKMV
860 HLKLLRYFYW KUPFFKMV

 | IS KVEMTLARVD MQMAG
IS KVEMTLARVD MQMAG
IS KAEMTLARVD MQMAG
IS KAEMTLARVD MQMAG
IS KAEMTLARVD MQMAG
IS KAEMTLARVD IGMAG
IS KAEMTLARVD IEMAG
IS KAEMTLARVD IEMAG
IS KAEMTLARVD IEMAG
IS KAEMTLARVD IEMAG | CHYYQE LSDPEDKSRF
CHYYQE LSDPEDKPRF
RHYYQE LSNPEDKARF
RHYYQE LSNPEDKARF
RHYYQE LSNPEDKERF
HHYYQE LSQEDQLRF
RHYYDE LSNPEDKRFR
RHYYDE LSNPEDKPRF
RHYYDE LSNPEDKPRF | EKVFEQIANE YY
EKVFEQIANE YY
EKVFEQIASE FY
EKVFEQIASE YY
ETVFEQIASE YY
AKVFDQIASE FY
DQVFEQIASE FY
ETVFAQISSE FF
 | VLTRDLVLK ITT
VLTRDLVLK ITT
VLTRDLVLK ITT
VLTRDLVLK ITT
VLTRDVLK ITT
VLTRDVLK ITT
VLTRDVLK ITT
VLTRNLVLN ITT
FLTRDLVLK ITT
FLTRDLVLK ITT
 | HESRLLDG DP'LQ
HEGRLLDG DP'LQ
HEGRLLDG DP'LQ
HEGRLLDG DP'LQ
HENRLLDG DP'LQ
HENRLLDG DP'LQ
HENRLLDG DP'LQ
HENRLLDG DP'LQ
 | DREVQL RNGTIVE
DREVQL RNGTIVE
DREVQL RNGTIVE
DREVQL RNGTIVE
DREVQL RNGTIVE
DREVQL RNGTIVE
DREVQL RNGTIVE
DREVQL RNGTIVE | GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR
GF IQVSLLKRLR | QSKNNNATSG
QSKNNTATSG
QSKNNTATSG
QAKNTTATSG
QAKNTTATSG
QSMNTNATSG
QYKN-TSTSG
QYKN-TSTSG
QSKN-APTTG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
 | | L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING | IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG | 1023
1026
1025
1025
1016
1017
1037
1018
1008
1013 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NES 3756
Nostos sp. PCC 7524
Nostoc piscinale CENA 21
Nostoc punctiforme PCC 7102
Anabaena sp. PCC 7108
Anabaena sp. 90
Anabaena sp. 90
Anabaena sp. 90 | 874 HLKJMRYFYV KUPFFRM 877 HLKJMRYFYV KUPFFRM 876 HLKJMRYFYV KUPFFRM 877 HLKJRYFYV KUPFFRM 887 HLKJRYFYV KUPFFRM 888 HLKJRYFYV KUPFFRM 889 HLKJRYFYV KUPFFRM 880 HLKJRYFYV KUPFFRM 865 HLKJRYFYV KUPFFRM 865 HLKJRYFYV KUPFFRM

 | IS KVEMILARVD NOMA
IS KVEMILARVD NOMA
IS KAEMILARVD NOMA
IS KAEMILARVD NOMA
IS KAEMILARVD IOMA
IS KAEMILARVD IOMA
IS KAEMILARVD IEMA
IS KAEMILARVD IEMA
IS KAEMILARVD IEMA
IS KAEMILARVD MEMA
IS KAEMILARVD MEMA | SHYVQE LSDPEDKSRF
SHYVQE LSDPEDKPRF
SHYVQE LSDPEDKPRF
RHYVQE LSNPEDKERF
RHYVQE LSNPEDKERF
RHYVQE LSQSEDQLRF
RHYVQE LSQSEDKSRF
RHYVDE LSSPEDKPRF
RHYVDE LSNPEDKPRF
RHYVDE LSNPEDKPRF | EXVFEQIANE YY
EXVFEQIANE YY
DXVFEQIANE YY
DXVFEQIASE FY
DXVFEQIASE YY
DXVFEQIASE FY
DXVFEQIASE FY
DXVFEQIASE FF
EXVFEQISSE FF
EXVFEQISSE FF
 | VLTRDLVLK ITU
VLTRDLVLK ITT
VLTRDLVLK ITT
VLTRDLVLK ITT
VLTRDLVLK ITT
VLTRDLVLK ITT
VLTRDLVLK ITT
VLTRDLVLK ITT
FLTRDLVLK ITT
FLTRDLVLK ITT
 | HSRLLDG DF'LQ
HGRLLDG DF'LQ
HSRLLDG DF'LQ
HHRLLDG DF'LQ
HHRLLDG DF'LQ
HKRLLDG DF'LQ
HKRLLDG DF'LQ
HKRLLDG DF'LQ
HKRLLDG DF'LQ
HKRLLDG DF'LQ
 | DREVQL RNGTIVF
DREVQL RNGTIVF
DREVQL RNGTIVF
DREVQL RNGTIVF
DREVQL RNGTIVF
DREVQL RNGTIVF
DREVQL RNGTIVF
DREVQL RNGTIVF
DREVQL RNGTIVF
DREVQL RNGTIVF | .GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR
.GF IQVSLLKRLR | QSKNNNATSG
QSKNNTATSG
QSKNNTATSG
QAKNTTATSG
QAKNTTATSG
QSMNTNATSG
QYKN-TSTSG
QSKN-APTTG
QSKN-APTTG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
 | | L LRGALLTING
L LRGALLTING | IAAGME TG
IAAGME TG | 1023
1026
1025
1016
1017
1018
1008
1018
1008
1013 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. PCC 7524
Nostoc sp. PCC 7524
Nostoc punctiforme PCC 73102
Anabaena sp. PCC 7108
Anabaena sp. PCC 7108
Anabaena sp. 90
Anabaena sp. 90
Anabaena sp. 90 | 874 HLXLMIYYY XUPFFXN
877 HLXLMIYYY XUPFFXN
876 HLXLNYYY XUPFFXN
867 HLXLNYYN XUPFFXN
888 HLXLNYYN XUPFFXN
888 HLXLNYYN XUPFFXN
888 HLXLNYYN XUPFFXN
800 HLXLNYYN XUPFFXN
800 HLXLNYYN XUPFFXN
805 HLXLNYYN XUPFFXN
855 HLX

 | IS KVEMTLARVD MQMAA
VS RVEMTLARVD MQMAA
VS RVEMTLARVD MQMA
IS KAEMTLARVD MQMAI
IS KAEMTLARVD MQMAI
IS KAEMTLARVD IEMAI
IS KAEMTLARVD IEMAI
IS KAEMTLARVD IEMAI
IS KAEMTLARVD MEMAI
IS KAEMTLARVD MEMAI
IS KAEMTLARVD MEMAI | SHYYQE LSDPEDKSRF
SHYYQE LSDPEDKPRF
SHYYQE LSDPEDKARF
RHYYQE LSNPEDKARF
RHYYQE LSNPEDKARF
RHYYQE LSSPEDKRFR
RHYYDE LSSPEDKRFR
RHYYDE LSSPEDKRFR
RHYYDE LSSPEDKRFR
RHYYDE LSNPEDKRFR
RHYYDE LSNPEDKRFR | EKVFEQIANE YY
EKVFEQIANE YY
DKVFEQIANE YY
DKVFEQIANE YY
DKVFEQIASE YY
AKVFDQIASE YY
DKVFEQIASE FY
DKVFEQIASE FY
DKVFEQIASE FY
AVILORIVE YH | YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDFVLK ITT
YLTRDFVLK ITT
YLTRDFVLK ITT
YLTRDLVLK ITT
FLTRDLVLK ITT
GUTRDLVLK ITT
GUTRDLVLK ITT
GUTRDLVLK ITT
GUTRDLVLK ITT

 | HSRLLDG DP'LQ
HGRLLDG DP'LQ
HSRLLDG DP'LQ
HHRLLDG DP'LQ
HHRLLDG DP'LQ
HHRLLDG DP'LQ
HHRLLDG DP'LQ
HGRLLDG DP'LQ
HGRLLDG DP'LQ
HGRLLDG DP'LQ
HGRLLDG DP'LQ | REVQL ROTIVE
REVQL ROTIVE
 | GF IQVSLLKRLR
GF IQVSLLKRLR | QSKNNNATSG
QSKNNTATSG
QSKNTATSG
QAKNTTATSG
QAKNTTATSG
QSMNTNATSG
QYKN-TSTSG
QSKN-APTTG
QSKN-APTTG
QSKN-APTTG
QSKN-APTTG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG- | | L LRGALLTING
L LRGALLTING
L IRGALLTING
L IRGALLTING
L IRGALLTING
L IRGALLTING
L IRGALLTING
L IRGALLTING
L IRGALLTING
L IRGALLTING
L IRGALLTING
 | IAAGME TG
IAAGME TG | 1023
1026
1025
1025
1016
1017
1018
1008
1013
1013
1013 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostco sp. NES 3756
Nostco sp. PCC 7524
Nostco piscinale CENA 21
Nostco piscinale CENA 21
Nostco punciforme PCC 7102
Anabaena sp. PCC 7108
Anabaena sp. PCC 7108
Anabaena sp. 90
Phornidium sp. 05CR | 874 HLXLMRYFY KUPFFKM
877 HLXLMRYFY KUPFFKM
877 HLXLMYFY KUPFFKM
876 HLXLMYFY KUPFFKM
868 HLXLMYFY KUPFFKM
868 HLXLMYFY KUPFFKM
869 HLXLRYFY KUPFFKM
865 HLXLKYFY KUPFFKM
855 HLXLKYFY KUPFFKM
855 HLXLKYFY KUPFFKM
855 HLXLKYFY KUPFFKM
855 HLXLKYFY KUPFFKM

 | IS KVEMTLARVD MOMAA
SIS KVEMTLARVD MOMA
VS KVEMTLARVD MOMA
SIS KAEMTLARVD MOMAI
SIS KAEMTLARVD MOMAI
SIS KAEMTLARVD IEMAI
SIS KAEMTLARVD IEMAI
SIS KAEMTLARVD MEMAI
SIS KAEMTLARVD MEMAI
SIS KAEMTLARVD MEMAI
SIS KVEMTLARVD LQIAI | SHYYQE LSDPEDKSRF
SHYYQE LSDPEDKPRF
SHYYQE LSDPEDKPRF
SHYYQE LSDPEDKPRF
SHYYQE LSNPEDKRF
SHYYQE LSNPEDKRF
SHYYQE LSNPEDKRF
SHYYQE LSNPEDKRF
SHYYQE LSNPEDKRF
SHYYQE LSNPEDKRF
SHYYQE LSNPEDKRF
SHYYQE LSNPEDKRF
SHYYQE LSNPEDKRF | EKVFEQIANE YY
EKVFEQIANE YY
DKVFEQIASE FY
EKVFEQIASE FY
EKVFEQIASE YY
AKVFDQIASE FY
DAVFEQIASE FY
ETVFAQISSE FF
EKVFEQISSE FF
EKVFEQISSE FF
EXVFLORIVBE YH
AVILDRIVDE YH
 | YLTROLVLS ITT
YLTROLVLS ITT
YLTROLVLS ITT
YLTROLVLS ITT
YLTROLVLS ITT
YLTROLVLS ITT
YLTROLVLS ITT
YLTROLVLS ITT
FLTROLVLS ITT
FLTROLVLS ITT
FLTROLVLS ITT
FLTROLVLS ITT
FQSROLVLS ITT
FQSROLVLS ITT
 | HSRLLDG DH'LQ
HGRLLDG DF'LQ
HIRRLLDG DF'LQ
HIRRLLDG DF'LQ
HIRRLLDG DF'LQ
HIRRLLDG DF'LQ
HKRLLDG DF'LQ
HKRLLDG DF'LQ
HKRLLDG DF'LQ
HKRLLDG DF'LR
 | REVQL ENGTIVE
REVQL ENGTIVE
REVQL ENGTIVE
REVQL ENGTIVE
REVQL ENGTIVE
REVQL ENGTIVE
REVQL ENGTIVE
REVQL ENGTIVE
REVQL ENGTIVE
REVQL ENSTIFE
REVQL ENSTIFE | GF IQVSLLKRLR
GF IQVSLLKRLR
GL LQVSLLKRLR
GL LQVSLLKRLR | QSKNNNATSG
QSKNNTATSG
QSKN-TATSG
QAKNTTATSG
QAKNTTATSG
QAKNTTATSG
QSKN-TSTSG
QSKN-APTTG
QSKN-APTTG
QSKN-APTG
QSKN-APTG
QHCK-SATPG
QHCK-SATPG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
IIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
 | | L LRGALLTING
L LRGALLTING | IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG
IAAGMENTG | 1023
1026
1025
1016
1017
1037
1018
1008
1013
1003
1003 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoce sp. NES 8756
Nostoce sp. PCC 7624
Nostoce piscinal e CBN 21
Nostoce piscinal e CBN 21
Anabaena sp. PCC 7105
Anabaena sp. PCC 7105
Anabaena sp. 90
Anabaena sp. 90
Anabaena sp. 90
Anabaena sp. 90
Schornidium sp. 605R
Phornidium sp. 605R | 874 HLXLBRYFY XDFFFMO
877 HLXLBRYFY XDFFFMO
866 HLXLBYFY XDFFFMO
867 HLXLBYFY XDFFFMO
868 HLXLBYFY XDFFFMO
868 HLXLBYFY XDFFFMO
868 HLXLBYFY XDFFFMO
866 HLXLBYFY XDFFFMO
865 HLXLBYFY XDFFFMO
865 HLXLBYFY XDFFFMO
865 HLXLBYFY XDFFFMO
866 HLXLBYFY XDFFFMO
866 HLXLBYFY XDFFFMO
866 HLXLBYFY XDFFFMO
866 HLXLBYFY XDFFFMO

 | IS KVENTLAFVD NOMAN
SKVENTLAFVD NOMAN
SKVENTLAFVD NOMAN
IS KABITLAFVD NOMAN
IS KABITLAFVD NOMAN
IS KABITLAFVD NOMAN
IS KABITLAFVD IEMAN
IS KABITLAFVD IEMAN
IS KABITLAFVD IEMAN
IS KABITLAFVD IEMAN
IS KVENTLAFVD LEMAN
IS KVENTLAFVD LEMAN | SHYVQE LSDPEDKSRF
SHYVQE LSDPEDKPRF
SHYVQE LSDPEDKPRF
SHYVQE LSNPEDKAFF
SHYVQE LSNPEDKAFF
SHYVQE LSNPEDKEFF
SHYVQE LSSPEDKPRF
SHYVQE LSSPEDKPRF
SHYVQE LSSPEDKPRF
SHYVQE LSNPEDKPRF
SHYVQE LSNPEDKPRF
SHYVQE LSNPEDKPRF
SHYVQE LSNPEDKPRF
SHYVQE LSNPEDKPRF
SHYVQE LSNPEDKPRF
SHYVQE LSNPEDKPRF
SHYVQE LSNPEDKPRF
SHYVQE LSNPEDKPRF | EKVFEQIANE YY
EKVFEQIANE YY
EKVFEQIANE YY
EKVFEQIANE YY
EKVFEQIANE YY
ETVFEQIANE YY
ETVFEQIANE YY
DKVFEQIANE FY
DKVFEQIANE FY
AVILDRIVDE YH
AVILDRIVDE YH
EALFTQIANE FY
 | YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDLVLK ITT
YLTRDFVLK ITG
YLTRDFVLK ITG
YLTRULVLK ITG
YLTRULVLK ITG
FLTRDLVLK ITG
FLTRDLVLK ITG
GQSRDLVLG ITG
YQSRDLVLG ITG
YQSRDLVLG ITG
YQSRDLVLG ITG
 | HSRLLDG DF LQ
HHGRLLDG DF LQ
HHGRLLDG DF LQ
HHRLLDG DF LQ
HHRLLDG DF LQ
HHRLLDG DF LQ
HKRLLDG DF LQ
 | REVQL REGTIVE
REVQL REGTIVE
REVQL REGTIVE
REVQL REGTIVE
REVQL REGTIVE
REVQL REGTIVE
REVQL REGTIVE
REVQL REGTIVE
REVQL REGTIVE
REVQL RESTIF
REVQL RESTIF | GF IQVSLLKRIR
GF IQVSLLKRIR
GL LQVSLLKRIR
GL LQVSLLKRIR
GL LQVSLLKRIR | QSKNNNATSG
QSKNNTATSG
QSKNTATSG
QAKNTTATSG
QAKNTTATSG
QAKNTATSG
QYKN-TSTSG
QYKN-TSTSG
QSKN-APTTG
QSKN-APTTG
QHGK-SATPG
QHGK-SATPG
EHQS-QSVTG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
 | | L LRGALLTING
L LRGALLTING
L RGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L LRGALLTING
L RGALLTING
L RGALLTING | IAAGME TG
IAAGME TG | 1023
1026
1025
1025
1017
1018
1003
1013
1003
1003
1003
1003 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostco sp. PCC 7524
Nostco sp. PCC 7524
Nostco piscinale CENA 21
Nostco piscinale CENA 21
Nostco punciforme PCC 73102
Anabaena sp. PCC 7108
Anabaena sp. PCC 7108
Anabaena sp. va 102
Phornidium sp. 05CR
Phornidium sp. 05CR
Distributoria acuaintat PCC 6304
deciliatoria acuaintat PCC 6304 | 874 HLXLBRYFY KUPFFKM
877 HLXLBRYFY KUPFFKM
877 HLXLBYFY KUPFFKM
876 HLXLBYFY KUPFFKM
868 HLXLBYFY KUPFFKM
868 HLXLBYFY KUPFFKM
860 HLXLBYFY KUPFFKM
865 HLXLBYFY KUPFFKM
855 HLXLBYFY KUPFFKM
855 HLXLBYFY KUPFFKM
856 HLXLBYFY KUPFFKM
856 HLXLBYFY KUPFFKM
856 HLXLBYFY KUPFFKM
856 HLXLBYFY KUPFFKM

 | IS KVENITLARVD MQMA'
IS KVENITLAVD MQMA'
SKVENITLAVD MQMA'
SKVENITLAVD MQMA'
IS KABITLAVD MQMA'
IS KABITLAVD MQMA'
IS KABITLAVD IEMA'
IS KABITLAVD IEMA'
IS KABITLAVD MEMA'
IS KABITLAVD MEMA'
IS KABITLAVD MEMA'
IS KVENITLSVD JUAJA
IS KVENITLSVD JUAJA
IS KVENITLSVD JUAJA | SHYVQE LSDPEDKSRF
SHYVQE LSDPEDKRF
SHYVQE LSDPEDKRF
SHYVQE LSNPEDKAF
SHYVQE LSNPEDKEF
SHYVQE LSNPEDKEF
SHYVQE LSNPEDKFF
SHYVQE LSNPEDKFF | EKVFEQIANE YY
EKVFEQIANE YY
EKVFEQIANE YY
EKVFEQIANE YY
EKVFEQIANE YY
ETVFEQIANE YY
DAVFEQIANE YY
DAVFEQIANE YY
DAVFEQIANE YY
EKVFEQIANE YN
AVILDRIVDE YH
AVILDRIVDE YH
AVILDRIVDE YH
AVILDRINDE YH
EALFEQIANE YN
EALFEQIANE YN
 | VLTROLVLS ITT
VLTROLVLS ITT
VLTROLVLS ITT
VLTROLVLS ITT
VLTROLVLS ITT
VLTROLVLS ITT
VLTROLVLS ITT
VLTROLVLS ITT
SLTROLVLS ITT
SLTROLVLS ITT
SLTROLVLS ITT
SQTROLVLS ITT
SQTROLVLS ITT
SQTROLVLS ITT
SQTROLVLS ITT
SQTROLVLS ITT
SQTROLVLS ITT
 | HSRLLDG DF'LQ
HGRLLDG DF'LQ
HHRLLDG DF'LQ
HHRLLDG DF'LQ
HHRLLDG DF'LQ
HKRLLDG DF'LQ
 | REVQL RNGTIVE
REVQL RNGTIVE | GF 10VSLLKRLR
GF 10VSLLKRLR
GF 10VSLLKRLR
GF 10VSLLKRLR
GF 10VSLLKRLR
GF 10VSLLKRLR
GF 10VSLLKRLR
GF 10VSLLKRLR
GF 10VSLLKRLR
GF 10VSLLKRLR
GL LQVSLLKRLR
GL LQVSLLKRLR
GL LQVSLLKRLR
GL LQVSLLKRLR
GL LQVSLLKRLR
GL LQVSLLKRLR
GL LQVSLLKRLR
GL LQVSLLKRLR | QSKNNNATSG
QSKNNTATSG
QSKNTATSG
QAKNTTATSG
QAKNTTATSG
QXKN-TATSG
QYKN-TSTSG
QYKN-TSTSG
QSKN-APTFG
QIGK-SATPG
QIGK-SATPG
QIGK-SATPG
QIGK-SATPG
QIGK-SATPG
QIGK-SATPG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
 | | L LRGALLTING
L RGALLTING | IAAGME YTG
IAACME YTG | 023
026
025
016
017
037
008
008
008
008
003
0008
003
003
003
00 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NES 3756
Nostoc sp. PCC 7624
Nostoc piscinale CEN 21
Nostoc piscinale CEN 21
Nostoc puscinose PCC 7102
Anabaena sp. va. 102
Phornidius sp. 06CR
Phornidius of 0.6CR
Phornidius sp. OCC 10902
Synechocccus elonguistus PCC 7942 | 874 HLXLBRYFY X KUPFFRAN
877 HLXLBRYFY X KUPFFRAN
877 HLXLBRYFY KUPFFRAN
868 HLXLRYFY KUPFFRAN
868 HLXLRYFY KUPFFRAN
868 HLXLRYFY KUPFFRAN
869 HLXLRYFY KUPFFRAN
865 HLXLRYFY KUPFFRAN
855 HLXLRYFY KUPFFRAN
855 HLXLRYFY KUPFFRAN
856 HLXLRYFY KUPFFRAN
856 HLXLRYFY KUPFFRAN
858 HLXLRYFY KUPFFRAN
858 HLXLRYFY KUPFFRAN
858 HLXLRYFY KUPFFRAN

 | IS KVENTLA VD MAMA
IS KVENTLA VD MAMA
VS KVENTLA VD MAMA
IS KARTLA VD MAMA
IS KARTLA VD MAMA
IS KARTLA VD MAMA
IS KARTLA VD IMAA
IS KVENTLA VD IMAA | CHYVQE LSDPEDASRE
CHYVQE LSDPEDASPE
CHYVQE LSDPEDASPE
CHYVQE LSNPEDASPE
CHYVQE LSNPEDASPE
CHYVQE LSNPEDASPE
HITVQE LSNPEDASPE
CHYVQE LSNPEDASPE | EKVFEQIANE YY
EKVFEQIANE YY
EKVFEQIANE YY
EKVFEQIANE YY
ETVFEQIANE YY
ETVFEQIANE YY
AKVFEQIANE YY
DKVFEQIANE FY
EKVFEQIANE FF
EKVFEQISNE FF
AVILDRIVDE YH
EALFTQIANE FY
ERVFSQIAAE FQ |
VLTROLVLE ITT
VLTROLVLE ITT
VLTROLVLE ITT
VLTROLVLE ITT
VLTROVLE ITT
VLTROVLE ITT
VLTROVLE ITT
VLTRUVLE ITT
SLTROLVLE ITT
SLTROLVLE ITT
SLTROLVLE ITT
SLTROLVLE ITT
SQRDLVL ITT
QSRDLVL ITT
QTROLVLE ITT
 | HISRLLDG DF LQ
HIGRLLDG DF LQ
HISRLLDG DF LQ
HIRRLLDG DF LQ
 | REVQL REGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NSTIF
REVQL NSTIF
REVQL NSTIF
REVQL NSTIF
REVQL NSTIF
REVQL NGTIVE
REVQL NGTIVE | GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GL IQVSLLKRIR
GL IQVSLLKRIR
GL IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR | QSKNNNATSG
QSKNNTATSG
QSKNT-TATSG
QAKNTTATSG
QAKNTTATSG
QKNTTATSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QKN-APTTG
QHKN-ATPTG
QHKN-ATPTG
QHKS-SATPG
QHGS-SATPG
QHGS-SATPG
QYRQQTETTG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
 | | L LRGALLTING
L LRGALLTING | IAAGME TG
IAAGME TG | 1023
1026
1025
1016
1017
1037
1018
1008
1013
1003
1003
1003
1003
1014
1031 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NES 3756
Nostos sp. PCC 7524
Nostos p. PCC 7524
Nostos piscinale CENA 21
Nostos punctiframe PCC 7102
Anabaena sp. PCC 7108
Anabaena sp. PCC 7108
Anabaena sp. va 102
Phornidium III-16 JDU 130791
docillatoria acuainata PCC 6304
Decillatoria se longatus PCC 742
Synechococcus elongatus PCC 6301 | 874 HLXLBRYFY KUPFFKM
877 HLXLBRYFY KUPFFKM
877 HLXLBYFY KUPFFKM
876 HLXLBYFY KUPFFKM
886 HLXLBYFY KUPFFKM
886 HLXLBYFY KUPFFKM
886 HLXLBYFY KUPFFKM
886 HLXLBYFY KUPFFKM
885 HLXLBYFY KUPFFKM
885 HLXLBYFY KUPFFKM
885 HLXLBYFY KUPFFKM
885 HLXLBYFY KUPFFKM
885 HLXLBYFY KUPFFKM
886 HLXLBYFY KUPFFKM
986 HLXLBYFY KUPFFKM
981 MLXLBYFY KUPFFKM
981 MLXLBYFY KUPFFKM
981 MLXLBYFY KUPFFKM
981 MLXLBYFY KUPFFKM

 | IS KVEHTLA VD NGM/
IS KVEHTLA VD NGM/
IS KVEHTLA VD NGM/
IS KABITLA VD NEM/
IS KABITLA VD NEM/
IS KABITLA VD NEM/
IS KABITLA VD NEM/
IS KVEHTLA VD NGM/
IS KVEHTLA VD NGM/
IS KVEHTLA VD NEM/
IS KVEHTLA VD NGM/
IS KVEHTLA VD NEM/
IS KVEHTLA VD | SHYVQE LSDPEDKSRF
SHYVQE LSDPEDKRF
SHYVQE LSNPEDKAF
SHYVQE LSNPEDKAF
SHYVQE LSNPEDKAF
SHYVQE LSNPEDKSF
SHYVQE LSNPEDKSF
SHYVQE LSNPEDKSF
SHYVQE LSNPEDKSF
SHYVQE LSNPEDKSF
SHYVQE LSNPEDKSF
SHYVQE LANPEDKSF
SHYVQE LANPEDKSF
SHYVQE LANPEDKSF
SHYVQE LANPEDKSF | EKVFEQIANE YY
EKVFEQIANE YY
EKVFEQIANE YY
EKVFEQIASE FY
EKVFEQIASE YY
ETVFEQIASE YY
DQVFEQIASE FY
ETVFAQISSE FF
EKVFEQIASE FY
EXVFEQIASE FY
EALFEQIASE NATLORIVE YH
AVILDRIVDE YH
AVILDRIVDE YH
AVILDRIVDE YH
EALFEQIASE FY
EALFEQIASE FY
ERVFEQIASE FY
ERVFEQIASE FY
ERVFEQIASE FY | KLTROLVLII ITT ILTROLVLII ITT ILTROLVLII ITT ILTROLVLII ITT ILTROLVLII ITT ILTROLVLII ITT ILTROLVLII ITT ILTROLVLIII ITT ILTROLVLIIII ITT ILTROLVLIIII ITT ILTROLVLIIII ITT ILTROLVLIII ITT ILTROLVLIIII ITT ILTROLVLIIIII ITT ILTROLVLIIII ITT

 | HISRILLOG DF LQ
HIGRILLOG DF LQ
HISRILLOG DF LQ
HIRRILLOG DF LQ | JREVQL RNGTIVE
NEVQL NGTIVE
NEVQL NSTIF
NEVQL NSTFF
NEVQL NSTFFF
NEVQL NSTFFF
NEVQL NSTFFF
NEVQL NSTFFF
NEVQL NSTFFF | GF 10VSLLKRIR
GF 10VSLLKRIR
GF 10VSLLKRIR
GF 10VSLLKRIR
GF 10VSLLKRIR
GF 10VSLLKRIR
GF 10VSLLKRIR
GF 10VSLLKRIR
GF 10VSLLKRIR
GF 10VSLLKRIR
GL L0VSLLKRIR
GL L0VSLLKRIR
GL L0VSLLKRIR
GL L0VSLLKRIR
GL L0VSLLKRIR
GF 10VSLLKRIR
GF 10VSLLKRIR
GF 10VSLLKRIR
GF 10VSLLKRIR
GF 10VSLLKRIR
 | QSKNNNATSG
QSKNNTATSG
QSKNTATSG
QSKNTATSG
QAKNTTATSG
QAKNTTATSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QSKN-APTTG
QIGK-SATPG
QIGK-SATPG
QIGK-SATPG
QIGK-SATPG
QIGQCESTR
QIGQUETTG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
UHSRYSKG-
UHSRYSKA-
LMRSRYSKG-
LMRSRYSKG- | | L LRGALLTING
L LRGALLTING
L LRGALLTING
L RGALLTING
L RGALLTING | IAAGME TG
IAAGME TG
 | 1023
1026
1025
1025
1016
1017
1037
1018
1018
1018
1018
1008
1013
1003
1003 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NES 3756
Nostoc sp. PCC 7624
Nostoc piscinale CENA 21
Nostoc piscinale CENA 21
Nostoc piscinale CENA 21
Anabaena sp. PCC 7108
Anabaena sp. Por 7108
Phornidium sp. OGS8
Phornidium sp. OGS8
Phornidium sp. OGS8
Phornidium p. OGS8
Phornidium sp. PCC 10802
Synechococcus e clongatus PCC 7942
Synechococcus e clongatus PCC 7942 | 874 HLXLBRYFY X KIPFFRAN
877 HLXLBRYFY X KIPFFRAN
877 HLXLBRYFY KIPFFRAN
876 HLXLBYFY KIPFFRAN
868 HLXLRYFY KIPFFRAN
868 HLXLRYFY KIPFFRAN
858 HLXLRYFY KIPFFRAN
856 HLXLBYFY KIPFFRAN
855 HLXLBYFY KIPFFRAN
855 HLXLBYFY KIPFFRAN
856 HLXLBYFY KIPFFRAN
858 HLXLBYFY KIPFFRAN

 | IS KVENTLAND MAMA
IS KVENTLAND MAMA
IS KVENTLAND MAMA
IS KARTLAND MAMA
IS KARTLAND MAMA
IS KARTLAND MAMA
IS KARTLAND MAMA
IS KARTLAND MAMA
IS KARTLAND HAMA
IS KARTLAND HAMA
IS KARTLAND HAMA
IS KARTLAND HAMA
IS KVENTLAND HAMA | SHYVQE LSDPEDASRE
SHYVQE LSDPEDASPE
SHYVQE LSDPEDASPE
SHYVQE LSNPDASF
SHYVQE LSNPDASE
SHYVQE SHYVQE LSNPDASE
SHYVQE SHYVQE SHYVQE SHYVQE SHYVQE
SHYVQE SHYVQE SHYVQE SHYVQE
SHYVQE SHYVQE SHYVQE SHYVQE SHYVQE
SHYVQE SHYVQE SHYVQE SHYVQE
SHYVQE SHYVQE SHYVQE SHYVQE SHYVQE
SHYVQE SHYVQE SHYVQE SHYVQE
SHYVQE SHYVQE SHYVQE SHYVQE
SHYVQE SHYVQE SHYVQE SHYVQE
SHYVQE SHYVQE SHYVQE SHYVQE SHYVQE
SHYVQE SHYVQE SHYVQE SHYVQE SHYVQE
SHYVQE SHYVQE SHYVQE SHYVQE SHYVQE SHYVQE SHYVQE SHYVQE SHYVQE SHYVQE
SHYVQE SHYVQE SHYVQE SHYVQE SHYVQE SHYVQE
SHYVQE SHYVQE SH | EXVFEQIANE YY
EXVFEQIANE YY
DXVFEQIANE YY
DXVFEQIASE YY
DXVFEQIASE YY
AXVFDQIASE YY
AXVFDQIASE YY
AXVFDQIASE YY
AXVFDQIASE YY
EXVFAQISSE FF
AVILDRIVDE YH
EALFYQIASE YY
ERVFSQIASE YQ
ERVFSQIASE YX
ERVFSQIASE YX
ER | XLTRDLVUB ITT
ILTRDLVUB ITT
ILTRDLVUB ITT
ILTRDLVUB ITT
ILTRDLVUB ITT
ILTRDLVUB ITT
ILTRDLVUB ITT
ILTRDLVUB ITT
ILTRULVUB ITT
ILTRULVUB ITT
INTRULVUB ITT

 | HISRLLDG DF LQ
HIGRLLDG DF LQ
HISRLLDG DF LQ
HISRLLDG DF LQ
HINRLLDG DF LQ
HIRRLLDG DF LQ
HIRRLLDG DF LQ
HIGRLLDG DF LQ
HIGRLLDG DF LQ | REVQL RNGTIVE
REVQL NOGTIVE
REVQL NOGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NSTIF
REVQL NGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NGTIVE
REVQL NGTIVE | GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GL LQVSLLKRIR
GL LQVSLLKRIR
GF LQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
GF IQVSLLKRIR
 | QSKNINNATSG
QSKNITATSG
QSKNITATSG
QSKNITATSG
QKKITTATSG
QMKITTATSG
QSMITNATSG
QSKIN-APTTG
QIKN-TSTSG
QIKN-APTTG
QIGK-SATPG
QIGK-SATPG
QIGK-SATPG
QIGCS-SATPG
QIROQUETTG
QIROSQTTSGA | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
IHSRYSKG-
IHSRYSKG-
ILRSRYSKG-
ILRSRYSKG-
ILRSRYSKG- | | L LRGALLTING
L LRGALLTING
L LRGALLTING
L REALLTING
L REALLTING
L REGALLTING
L REGALLTING
L REGALLTING
L REGALLTING
L REGALLTING
L REGALLTING
L REGALLTING
L REGALLTING
L REGALLTING |
IAAGMITTG
IAAGMITTG
IAAGMITTG
IAAGMITTG
IAAGMITTG
IAAGMITTG
IAAGMITTG
IAAGMITTG
IAAGMITTG
IAAGMITTG
IAAGMITTG
IAAGMITTG
IAAGMITTG
IAAGMITTG
IAAGMITTG
IAAGMITTG | 1023
1026
1025
1016
1017
1018
1013
1003
1003
1003
1003
1003
1003 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. PEC 7524
Nostos sp. PCC 7524
Nostos p. PCC 7524
Nostos piscinale CENA 21
Nostos punctiframe PCC 7102
Anabaena sp. PCC 7108
Anabaena sp. 90
Phornidium III-61 BUI 130791
decillatoria acumintal PCC 6504
decillatoria scip. PCC 1080
Synechococcus elongatus PCC 6501
Thermssynchococcus vulcanus
Mycosarcina pp. 611 | 874 HLXLMRYFY KUPFFKM 877 HLXLMRYFY KUPFFKM 876 HLXLMRYFY KUPFFKM 877 HLXLMRYFY KUPFFKM 868 HLXLRYFY KUPFFKM 868 HLXLRYFY KUPFFKM 868 HLXLRYFY KUPFFKM 869 HLXLRYFY KUPFFKM 860 HLXLRYFY KUPFFKM 865 HLXLRYFY KUPFFKM 865 HLXLRYFY KUPFFKM 866 HLXLRYFY KUPFFKM 866 HLXLRYFY KUPFFKM 868 HXLRYFY KUPFFKM 869 HXLRYFY KUPFFKM 861 HXLRYFY KUPFFKM 862 HXLRYFY KUPFFKM 863 HXLRYFY KUPFFKM 864 HXLRYFY KUPFFKM 865 HXLRYFY KUPFFKM 861 HXLRYFY KUPFFKM 862 HXLRYFY KUPFFKM 862 HXLRYFY KUPFFKM 862 HXLRYFY KUPFFKM

 | IS KVEHTLA'ND NGM/
IS KVEHTLA'ND NGM/
IS KVEHTLA'ND NGM/
IS KABITLA'ND NGM/
IS KVEHTLA'ND NG JALA
IS KVEHTLA'ND JALA | ATTYOE LSDPEDKSRF
ATTYOE LSDPEDKSRF
ATTYOE LSDPEDKSRF
ATTYOE LSDPEDKSRF
ATTYOE LSNPEDKERF
ATTYOE LSNPEDKERF
ATTYOE LSNPEDKSRF
ATTYOE LSNPEDKSRF | EKVFEQIANE YY
EKVFEQIANE YY
DKVFEDIANE YY
DKVFEQIASE YY
DKVFEQIASE YY
DKVFEQIASE YY
DKVFEQIASE YY
DKVFEQIASE Y
EKVFQIASE Y
EKVFQIASE Y
EKVFQIASE Y
EKVFQIASE Y
EKVFQIASE X
EALFQIASE X
EKVFQIASE X
EVVFQIASE X
EVV | XLTROLVIA ITT
NTROLVIA ITT
N

 | HISRLDG DFULO
HISRLDG DFULO
HIRLDG DFULO | REVGL BATIVE
REVGL NATIVE
REVGL NATIVE | GF 1QVSLLKRLR
GF 1QVALLKRLR
GF 1QVALLKRLR
GF 1QVALLKRLR
GF 1QVALLKRLR
GF 1QVALLKRLR
GF 1QVALLKRLR
GF 1QVALLKRLR
GF 1QVALLKRLR
 | QSKNNNATSG
QSKNNTATSG
QSKNTATSG
QSKNTATSG
QKNTTATSG
QKNTTATSG
QKNTTATSG
QKNTATSG
QKNTATSG
QKNTATSG
QKNTATTG
QKNTATSG
QKNTATTG
QKNTATSG
QKNTATTG
QHGS-SATPG
QHGS-SAVPG
QYRQUETTG
QYRQUETTG
QHRSQTSGA | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG- | | L LRGALLTING
I. RGALITING
L RGALLTING
L R | IAAGME TG
IAAGME TG | 1023
1026
1025
1016
1017
1037
1018
1003
1003
1003
1003
1003
1014
1031
1017
1053
1011
1030
 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NES 8756
Nostoc sp. PCC 7624
Nostoc piscinale CENA 21
Nostoc piscinale CENA 21
Anabaena sp. PCC 7108
Anabaena sp. PCC 7108
Anabaena sp. PCC 7108
Anabaena sp. PCC 7108
Phornidium sp. 9658
Phornidium sp. 9658
Phornidium p. 9658
Phornidium PCC 6304
Gocillatoria as p. PCC 10802
Synechococcus elongatus PCC 7912
Synechococcus elongatus PCC 7912
Synechococcus elongatus PCC 7912
Synechococcus elongatus PCC 7912 | 874 HLXLBRYFY XRPFFRAN
877 HLXLBRYFY XRPFFRAN
877 HLXLBRYFY XRPFFRAN
876 HLXLBYFY XRPFFRAN
868 HLXLRYFY XRPFFRAN
868 HLXLRYFY XRPFFRAN
858 HLXLRYFY XRPFFRAN
856 HLXLBYFY XRPFFRAN
855 HLXLBYFY XRPFFRAN
855 HLXLBYFY XRPFFRAN
856 HLXLBYFY XRPFFRAN
858 HLXLRYFY XRPFFRAN
858 HLXLBYFY XRPFFRAN
858 HLXLBYFY XRPFFRAN
858 HLXLBYFY XRPFFRAN
858 HLXLBYFY XRPFFRAN
858 HLXLBYFY XRPFFRAN
904 NALLBYFY XRPFFRAN
855 MLXLBYFY XRPFFRAN
855 MLXLBYFY XRPFFRAN

 | IS RVENTLAFVD NOMA
IS RVENTLAFVD NOMA
IS RUENTLAFVD LEIAN
IS RVENTLAFVD LEIAN | CHYVQE LSDPEDKSRF
CHYVQE LSDPEDKPRF
CHYVQE LSDPEDKPRF
CHYVQE LSDPEDKPRF
CHYVQE LSNPEDKRF
CHYVQE LSNPEDKRF | EKVFEQIANE YY
EKVFEQIANE YY
DKVFEQIANE YY
EKVFEQIASE EV
EVFEQIASE PY
DKVFEQIASE YY
DKVFEQIASE PY
DKVFEQIASE PY
DKVFEQIASE PY
DKVFEQIASE PY
DKVFEQIASE PY
DKVFEQIASE PY
DKVFEQIASE PY
DKVFEQIASE PY
DKVFEQIASE PY
DKVFEQIASE PY
CHURCHAR PY
DKVFEQIASE PY
CHURCHAR PY
DKVFEQIASE PY
CHURCHAR PY
DKVFEQIASE PY
DKVFEQIAS | X1.TRD.V.U. TT
V.T.TRD.V.U. TT
V.T.TRD.V.U. TT
V.T.TRD.V.U. TT
V.T.TRD.V.U. TT
V.T.TRD.V.U. TT
V.T.TRD.V.U. TT
V.T.TRD.V.U. TT
V.T.TRD.V.U. TT
V.T.TRD.V.U. TT
V.S.TRD.V.U. TT
V.S.TRD.V.U. TT
V.S.TRD.V.U. TT
V.S.TRD.V.U. TT
V.T.TRD.V.U. TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T.TT
V.T.TRD.V.T
V.T.TRD.V.T
V.T.TRD.V.T
V.T.TRD.V.T
V.T.TRD.V.T

 | HISRILDG DFILO
HHRILDG DFILO
HISRILDG DFILO
HISRILDG DFILO
HIRRILDG DFILO
HIRRIDG DFILO
HIRRIDG DFILO
HIRRIDG DFILO | URINGL BAGTINE
RENGL MATTINE
RENGL | GF IQVSLLKRLR
GF IQVSLLKRL
GF IQVSLLKRL
GF IQVSLLKRL
GF IQVSLLKRL
GF IQVSLLKRL
GF IQVSLLKRL
GF IQVSLLKRL
GF IQVSLLKRL
GF IQVSLLKRL
GL IQVSLLKRL
GL IQVSLLKRL
GL IQVSLLKRL
GF IQVSLLKR
GF IQVSLLKR
GF IQVSLLKR
GF IQVSLLKR
GF IQVSLLKR
GF IQVSL
GF IQVSLK
GF IQVSLK
GF IQVSLK
GF IQVSL
GF IQVSLK
GF I | QSKNINNATSG
QSKNITATSG
QSKNITATSG
QSKNITATSG
QSKNITATSG
QKKITTATSG
QKKITATSG
QYKN-TSTSG
QYKN-TSTSG
QSKI-APTTG
QHGK-SATPG
QHGK-SATPG
QHGK-SATPG
QHGK-SATPG
QHGK-SATPG
QHGK-SATPG
QHGK-SATPG
QHGK-SATPG
QHGK-SATPG
QHGRATSG
DNSQUPENG |
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
ILRSRYSKG-
ILRSRYKGC-
ULRSRYSKG-
ULRSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG- | | L LRGALLTING
L RGALLTING
L RGALLTING | IAAGME TG
IAAGME TG |
1023
1026
1025
1016
1017
1018
1003
1013
1003
1013
1003
1013
1013
1013
1013
1013
1013
1014
1031
1017
1053
1017
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055
1055 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NES 8756
Nostos sp. PCC 7624
Nostos piscinale CENA 21
Nostos piscinale CENA 21
Nostos punctiforme PCC 7102
Anabaena sp. PCC 7108
Anabaena sp. 90
Monidium sp. PCC 7108
Anabaena sp. 90
Phornidium IIIel BUU 130791
Øscillatoria acuminata PCC 6304
Øscillatoria scinga PCC 70802
Synechococcus elongatus PCC 6301
Thermsynchococcus vulcanus
Mycosarcina pp. 611
Syncehocystis sp. 611
Syncehocystis sp. 612 | 874 HLXLBRYFY KUPFFKM 877 HLXLBRYFY KUPFFKM 877 HLXLBYFY KUPFFKM 876 HLXLBYFY KUPFFKM 877 HLXLBYFY KUPFFKM 888 HLXLBYFY KUPFFKM 888 HLXLBYFY KUPFFKM 888 HLXLBYFY KUPFFKM 850 HLXLBYFY KUPFFKM 856 HLXLBYFY KUPFFKM 851 HLXLBYFY KUPFFKM 851 HLXLBYFY KUPFFKM 851 HLXLBYFY KUPFFKM 852 HLXLBYFY KUPFFKM 853 MLXLBYFY KUPFFKM 854 KULLBYFY KUPFFKM 855 MLXLBYFY KUPFFKM 850 KULLBYFY KUPFFKM 851 KU

 | IS KVEHTLA'ND NGMA
IS KVEHTLA'ND NGMA
IS KUEHTLA'ND NGMA
IS KABHTLA'ND NGMA
IS KVEHTLA'ND NGMA
IS KVEHTLA'ND NGLA
IS KVEHTLA'ND NGLA | ATTYOE LSDPEDKSRF
ATTYOE LSDPEDKSRF
ATTYOE LSDPEDKSRF
ATTYOE LSDPEDKSRF
ATTYOE LSNPEDKSRF
ATTYOE LSNPEDKSRF | EXVFEQIANE YY
EXVFEQIANE YY
DAVFEDIANE YY
DAVFEDIANE YY
DAVFEDIANE YY
DAVFEDIANE YY
DAVFEDIANE YY
DAVFEDIANE Y
DAVFEDIANE Y
EXVFEDIANE Y
DAVFEDIANE Y
EXVFEDIANE Y
AULDR'UNC W
HALPOLINE Y
EXVFEDIANE Y
CRIYDDIANE Y
DALFODIANE Y | XLTRDLVLB ITT
ILTRDLVLB ITT
ILTRDLVL ITT
ILTRDLVL ITT
ILTRDVLD ITT
ILTRDVLD ITT
ILTRDVLD ITT
ILTRULVL ITT
ILTRLVLD ITT

 | NISRILDG DF LO
MISRILDG DF LO
NISRILDG DF LO
NISRILGG DF LO
NISRIL | REVOL BATTLY
REVOL BATTLY
REVOL NATTLY
REVOL NATTLY
RE | GF IQVSLLKRLR
GF IQVSLLKRL
GF IQVSLLKRL
GL IQVSLLKRL
GL IQVSLLKRL
GL IQVSLLKRL
GF IQVSLK
GF IQVSL | QSKNINNATSG
QSKNITATSG
QSKNITATSG
QSKNITATSG
QAKNITATSG
QAKNITATSG
QAKNITATSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG
QYKN-TSTSG | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG-
HIRSRYSKG- | SKPADELIH. NPTSEYAP | L LRGALLTING
L REGALITING
L REGALITING
L REGALTING
L REGALTING
 | IAAGME TG
IAAGME TG | 1023
1026
1025
1025
1026
1016
1017
1018
1018
1008
1013
1003
1013
1013
1013
1014
1053
1011
1030
1053
1011
1030
1053
1011
1034
1066
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077
1077 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NES 3756
Nostos sp. PCC 7624
Nostos puscins (C Total
Nostos puscins) (C Total
Anabaena sp. PCC 7108
Anabaena sp. PCC 7108
Anabaena sp. PCC 7108
Manhaena sp. PCC 7108
Manhaena sp. PCC 7108
Phornidium sp. PCC 10802
Synechococcus elongatus PCC 7942
Synechococcus elongatus PCC 7942
Synechococcus elongatus PCC 7942
Synechococcus sp. PCC 10802
Synechococcus sp. PCC 10803
Plaveria primela infanta | 874 HLXLBRYFY X KPFFFKM 877 HLXLBRYFY X KPFFFKM 877 HLXLBRYFY X KPFFFKM 876 HLXLBYFY X KPFFFKM 877 HLXLBYFY X KPFFFKM 868 HLXLBYFY X KPFFFKM 868 HLXLBYFY X KPFFFKM 868 HLXLBYFY X KPFFFKM 869 HLXLBYFY X KPFFFKM 865 HLXLBYFY X KPFFFKM 866 HLXLBYFY X KPFFFKM 867 HLXLBYFY X KPFFFKM 868 NLXLBYFY K KPFFFKM 861 HLXLBYFY X KPFFFKM 862 HLXLBYFY K KPFFFKM 863 HLXLBYFY K KPFFFKM 864 HLXLBYFY K KPFFFKM 864 HLXLBYFY K KPFFFKM 865 HLXLBYFY K KPFFFKM 865 HLXLBYFY K KPFFFKM 865 HLXLBYFY K KPFFFKM 865 MLXLBYFY K KPFFFKM 865 MLXLBYFY K KPFFFKM

 | IS RVENTLAPID NOMA
IS RVENTLAPID NOMA
IS RUENTLAPID NO LEAN
IS RVENTLAPID NO LEAN | CHYVQE LSDPEDKSRF
CHYVQE LSDPEDKPRF
CHYVQE LSDPEDKPRF
CHYVQE LSDPEDKPRF
CHYVQE LSDPEDKRF
CHYVQE LSQFEDKF
CHYVQE LSQFE
CHYVQE LSQFEDKF
CHYVQE LSQFE
CHYVQE LSQFE
CH | EXVERSIANE YY
EXVENDIAE Y
EXVENDIAE Y
EXVENTIAE Y
EXVE | X1_TRDLVUB ITT YU_TRDLVUB ITT YU_TRDUB ITT YU_TRDUB ITT YU_TRDUB YU_TRDUB YU_TRUB YU_TRDUB<

 | HERLIG OF DA | USYOL BOTINE
BYOL BOTINE
BYOL NOTIVE
BYOL | GF 10YSLIKEL
GF 10YSLIKER
GF | QSKNINNATSG
QSKNITATSG
QSKNITATSG
QSKNITATSG
QAKNITATSG
QAKNITATSG
QMINTATSG
QMINTATSG
QYKNITSTSG
QYKNITSTSG
QYKNITSTSG
QIGKIS-SATPG
QIGKIS-SATPG
QIGKIS-SATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QIGKIS-GATPG
QI |
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
HARSRYSKG-
HARSRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG- | SRPADELIH. NTSEYAP | L LRGALLTING
LRGALLTING
LRGALLTN
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALLTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTNG
LRGALTN | IAAGME TG
IAAGME TG | 1023
1026
1025
1025
1026
1017
1037
1038
1013
1003
1003
1003
1003
1003
1003
 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NES 8756
Nostoc sp. PCC 7128
Nostoc punctiforme PCC 7102
Anabaena sp. PCC 7108
Anabaena sp. PCC 7108
Anabaena sp. PCC 7108
Anabaena sp. PCC 7108
Anabaena sp. 90
Anabaena sp. 90
Anabaena sp. 90
Shornidium srillei E001 10070
Monisticum sp. 90
Strachococcus elongatus PCC 7422
Synechococcus elongatus PCC 6304
Mycosarcina pc. 611
Synechococcus elongatus PCC 640
Flavorai sp. 611
Synechococcus elongatus PCC 640
Flavorai pringlei
Zon myra | 874 HLXLBRYFY KUPFFKM 877 HLXLBRYFY KUPFFKM 877 HLXLBYFY KUPFFKM 876 HLXLBYFY KUPFFKM 877 HLXLBYFY KUPFFKM 868 HLXLBYFY KUPFFKM 858 HLXLBYFY KUPFFKM 858 HLXLBYFY KUPFFKM 858 HLXLBYFY KUPFFKM 856 HLXLBYFY KUPFFKM 857 HLXLBYFY KUPFFKM 858 HLXLBYFY KUPFFKM 850 HXLBYFY KUPFFKM 851 HXLBYFY KUPFFKM 852 HXLBYFY KUPFFKM 852 HXLBYFY KUPFFKM 853 HXLBYFY KUPFFKM 854 HXLBYFY KUPFFKM 855 HXLBYFY KUPFFKM 856 HXLBYFY K | IS KVEHTLAND NOMM
IS KVEHTLAND NOMM
SKENTLAND NOMM
IS KABITLAND NO | ATTYOE LSDPEDKSRF
ATTYOE LSDPEDKSRF
ATTYOE LSDPEDKSRF
ATTYOE LSDPEDKSRF
ATTYOE LSDPEDKSRF
ATTYOE LSNPEDKSRF
ATTYOE LSNPEDKSRF | EKYFEQIANE YY
EKYFEQIANE YY
DNYFEQIANE YY
DNYFEQIANE YY
DNYFEQIASE YY
DNYFEQIASE YY
DNYFQIASE YY
DNYFQIASE YY
DNYFQIASE YY
DNYFQIASE Y
DNYFQIASE Y
EKYFQIASE Y
EKYFQIASE Y
EKYFQIASE Y
EKYFQIASE Y
EKYFQIASE Y
EKYFQIASE Y
EKYFQIASE Y
EKYFQIASE Y
EKYFQIASE Y
CONTROLOG Y
EKYFQIASE Y
CONTROLOG Y
CON | KLTROLVIA ITT NLTROLVIA ITT NLTROLVIA <th>HISRILDG DF LO
MISRILDG DF LO
MISRILDG DF LO
MISRILDG DF LO
MISRILDG DF LO
MIRILDG DF</th> <th>REVGL NOTIVE
REVGL NOTIVE
REVGL</th> <th>GP IOVSLIKRE
GF IOVSLIKRE
MINISTER
GF IOVSLIKRE
GF IOVSLI</th> <th>QSKNNNATSG
QSKNTATSG
QSKNTATSG
QSKNTATSG
QAKNTATSG
QAKNTATSG
QAKNTATSG
QAKNTATSG
QAKNTATSG
QAKNTATSG
QSKN-APTTG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKSATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGK</th> <th>VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-</th> <th>SKPADELIH, NTSEYAP
SKPADELIH, NTSEYAP
HEP UP DOD</th> <th>L LRGALLTING
LRGALLTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTI</th> <th>IAAGMR TG
IAAGMR TG</th> <th>023
026
025
0025
0016
0017
0037
0018
0008
0013
0003
0003
0014
0014
0017
0017
0053
0014
0053
0014
0053
0014
0053
0014
0053
0014
0055
0016
0016
0016
0017
0017
0017
0017
0017</th> | HISRILDG DF LO
MISRILDG DF LO
MISRILDG DF LO
MISRILDG DF LO
MISRILDG DF LO
MIRILDG DF | REVGL NOTIVE
REVGL | GP IOVSLIKRE
GF IOVSLIKRE
MINISTER
GF IOVSLIKRE
GF IOVSLI | QSKNNNATSG
QSKNTATSG
QSKNTATSG
QSKNTATSG
QAKNTATSG
QAKNTATSG
QAKNTATSG
QAKNTATSG
QAKNTATSG
QAKNTATSG
QSKN-APTTG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKSATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGKS-SATPG
QIGK | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG- | SKPADELIH, NTSEYAP
SKPADELIH, NTSEYAP
HEP UP DOD | L LRGALLTING
LRGALLTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTING
LRGALTI | IAAGMR TG
IAAGMR TG | 023
026
025
0025
0016
0017
0037
0018
0008
0013
0003
0003
0014
0014
0017
0017
0053
0014
0053
0014
0053
0014
0053
0014
0053
0014
0055
0016
0016
0016
0017
0017
0017
0017
0017 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NES 3756
Nostos sp. PCC 7624
Nostos p. PCC 7624
Nostos purchar and the spectra
Anabaena of Informe PCC 7102
Anabaena sp. PCC 7108
Anabaena of Informe PCC 7122
Anabaena sp. PCC 7108
Montalians sp. 90
Phornidians p. 90
Phornidians p. 9050
Phornidians PCC 6904
Gocillatoria acuminata PCC 6904
Gocillatoria acuminata PCC 6904
Gocillatoria sp. PCC 10802
Synechococcus elongatus PCC 6914
Gynechococcus elongatus PCC 6914
Synechococcus sulcanus
Mycosarcina sp. 611
Synechococus sulcanus
Flaveria trinervia
Flaveria trinervia
Flaveria trinelia
Zoa mays
Escherichia coli | 874 HLXLBRYFY X KPFFFKM 877 HLXLBRYFY X KPFFFKM 877 HLXLBRYFY X KPFFFKM 876 HLXLBYFY X KPFFFKM 877 HLXLBYFY X KPFFFKM 868 HLXLBYFY X KPFFFKM 868 HLXLBYFY X KPFFFKM 868 HLXLBYFY X KPFFFKM 869 HLXLBYFY X KPFFFKM 856 HLXLBYFY X KPFFFKM 858 HLXLBYFY X KPFFFKM 858 HLXLBYFY X KPFFFKM 858 HLXLBYFY X KPFFFKM 858 HLXLBYFY K KPFFKM

 | IS KVENTLAFVD NOMM
IS KVENTLAFVD NOMM
IS KVENTLAFVD NOMM
IS KAENTLAFVD NOMM
IS KAENTLAFVD NOMM
IS KAENTLAFVD NOMM
IS KAENTLAFVD NOMM
IS KAENTLAFVD NOMM
IS KAENTLAFVD NOMM
IS KVENTLAFVD NOMM
IS KVENTLAFVD NOMM
IS KVENTLAFVD LEMA
IS KVENTLAFVD KING
IS KVENTLAFVD LEMA
IS KVENTLAFVD KING
IS KVENTLAFVD | CHYVQE LSDPEDKSRF
CHYVQE LSDPEDKPRF
CHYVQE LSDPEDKPRF
CHYVQE LSDPEDKPRF
CHYVQE LSDPEDKRF
CHYVQE LSDPEDKRF
CHYVQE LSQFEDKRF
CHYVQE LSQFE
CHYVQE LSQFEDKRF
CHYVQE LSQFE
CHYVQE LSQFE
CHYVQ | EXTEDIANE YY
EXTERNA (1990)
EXTERNA | KLTROLVLA ITT
KLTROLVLA ITT
KLTROL
 | HERLLG DF 0.
HERLLG DF 0.
HERLLG FF 0.
HE | NEWOL INSTITUTE
NEW COLLECTION
NEW COLLECTIO | GF 10YSLIKER
GF |
QSKNNNATSG
QSKNNTATSG
QSKNTATSG
QSKNTATSG
QSKNTATSG
QKANTTATSG
QKANTTATSG
QKANTTATSG
QYKN-TSTSG
QSKN-APTTG
QKS-APTTG
QKG-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS-SATPG
QHGS- | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG-
NIHSRYSKG- | SKPADELIH. NPTSEYAP
HEP
SKPADELIH. NPTSEYAP
HEP
NPSEYAP | L LRGALLTING
L RGALLTING
L RGALLTN
L RGALLTNG
L RGALTNG
L RGALTNG
L RGALLTNG
L RGALTNG
L RGALLTNG
L RGALTNG
L RGALLTNG
L RGALLTNG
L RGALLTNG
L RGALLTNG
L RGALLTNG
L RGALLTNG
L | IAAGMETTG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG
IAAGMETG | 023
026
025
025
0016
0017
0037
0018
0018
0018
0013
0013
0013
0013
0031
0031
 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoce sp. NES 5756
Nostoce sp. PCC 71524
Nostoce sp. PCC 71524
Nostoce principal and the state of the state
Nostoce principal and the state of the state
Nostoce principal and the state of the state
Nostoce principal and the state of the state
Anabaena sp. PCC 7108
Anabaena sp. PCC 7108
Constraint state
Phornidium sp. PCC 7108
Constraint sp. PCC 7108
Sprechoccous elongatus PCC501
Thermosymchococus vulcanus
Mycoarcina pringlei
Zoa mays
Escherichia coli | 874 HLXLBRYFY KUPFFRAN
877 HLXLBRYFY KUPFFRAN
877 HLXLRYFY KUPFFRAN
868 HLXLRYFY KUPFFRAN
868 HLXLRYFY KUPFFRAN
868 HLXLRYFY KUPFFRAN
860 HLXLRYFY KUPFFRAN
865 HLXLRYFY KUPFFRAN
865 HLXLRYFY KUPFFRAN
865 HLXLRYFY KUPFFRAN
866 HLXLRYFY KUPFFRAN
868 HLXLRYFY KUPFFRAN
868 HLXLRYFY KUPFFRAN
868 HLXLRYFY KUPFFRAN
868 HLXLRYFY KUPFFRAN
868 HLXLRYFY KUPFFRAN
869 HLXLRYFY KUPFFRAN
869 HLXLRYFY KUPFFRAN
869 HLXLRYFY KUPFFRAN
869 HLXLRYFY KUPFFRAN
869 HLXLRYFY KUPFFRAN
860 HLXLRYFY KUPFFRAN

 | IS RVENTLARVD NOMA
IS RVENTLAVD NOMA
IS RUENTLAVD LAND
IS RUENTLAV | SHYVQE LSDPEDKRSRF
SHYVGE LSDPEDKRRF
SHYVGE LSDPEDKRRF
SHYVGE LSDPEDKRRF
SHYVGE LSNPEDKARF
SHYVGE LSNPEDKRFF
SHYVGE SHYFF
SHYVGE SHYFF
SHYVGE SHYFF
SHYVF
SHYVF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SHYFF
SH | ERVFEQ1ANE YY
ERVFEQ1ANE YY
DRVFEQ1ANE YY
DRVFEQ1ANE YY
DRVFEQ1ASE FY
DRVFEQ1ASE YY
DRVFEQ1ASE YY
DRVFEQ1ASE YY
DRVFEQ1ASE YY
DRVFEQ1ASE Y
ERVFEQ1SE F
ERVFEQ1SE F
ERVFEQ1ASE Y
DRVFEQ1ASE |

 | | 089VGL BINGTIVE
98VGL NGTVE
98VGL NGTVE
9 | GP IOVSLIKRE
GF IOVSLIKRE
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINISTER
MINIST | QSKNNNATSG
QSKNTATSG
QSKNTATSG
QSKNTATSG
QKNTTATSG
QMATTATSG
QMATTATSG
QMATTATSG
QMATTATSG
QMATTATSG
QSKN-APTTG
QKN-APTTG
QKN-APTTG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG
QMGC-SATPG |
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
HISRYSKG-
PISKE-
SKG-
SKG-
SKG-
SKG-
SKG-
SKG-
SKG-
SKG | SRPADELIH, NPTSEVAP
DPNRPAG-LIKL, NPTSEVAP
NRPAG-LIKL, NPASEVPP | L LRGALLTING
L RGALLTING
L RGALTING
L RGALLTING
L RGALTING
L | ІААСИК ТС
ІААСИК ТС
ІААСИС ТС
ІАСИС ТС
ІААСИС ТС
ІААСИС ТС
ІАСИС ТС
ІАСИС ТС
ІААСИС ТС
ІАСИС ТС
ІАСИС
ІАСИС ТС
ІАСИС ТС
ІАСИС ТС
ІАСИС ТС
ІАСИС ТС
ІАСИС
ІАСИС ТС
ІАСИС ТС
ІАСИС
ІАСИС
ІАСИС ТС
ІАСИС ТС
ІАСИС ТС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІАСИС
ІА | 023
026
025
025
016
017
037
0018
0018
0018
0013
0013
0013
0013
0013
0014
0017
0030
0014
0017
0031
0017
0030
0014
0017
0030
0016
0016
0016
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0013
0013
0014
0017
0017
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0014
0017
0017
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0018
0017
0018
0018
0018
0017
0018
0017
0018
0018
0017
0018
0018
0017
0030
0018
0018
0018
0017
0030
003
004
005
005
005
005
005
005
005 |
| Anabaena variabilis ATCC 29413
Anabaena sp. PCC 7120
Nostoc sp. NES 3756
Nostos sp. PCC 7624
Nostos p. PCC 7162
Nostos purchar and the sp. 2018
Anabaena ejinofrae PCC 7162
Anabaena ejindrica PCC 7122
Anabaena sp. PCC 7168
Montalian sp. 90
Phornidian sp. 90
Phornidian sp. 90
Phornidian sp. 9050
Phornidian sp. PCC 10802
Synecheoccus elongatus PCC 5912
Synecheoccus elongatus PCC 5912
Synecheoccus sulcanus PCC 5912
Synecheoccus sulcanus PCC 5912
Synecheoccus sulcanus PCC 5912
Synecheoccus sulcanus PCC 5912
Flaveria trinervia
Flaveria trinervia
Flaveria trinervia
Escherichia coli | 874 HLXLMRYFY KUPFFRM 877 HLXLMRYFY KUPFFRM 877 HLXLMRYFY KUPFFRM 876 HLXLMRYFY KUPFFRM 877 HUXLMRYFY KUPFFRM 868 HLXLRYFY KUPFFRM 868 HLXLRYFY KUPFFRM 869 HLXLRYFY KUPFFRM 860 HLXLRYFY KUPFFRM 861 HLXLRYFY KUPFFRM 865 HLXLRYFY KUPFFRM 865 <td< th=""><th>IS RUBHILAFUD NOMM
IS RUBHILAFUD NOMM
IS RUBHILAFUD NOMM
IS RABHILAFUD NOMM
IS RABHILAFUD NOMM
IS RABHILAFUD NOMM
IS RABHILAFUD NOMM
IS RABHILAFUD NOMM
IS RUBHILAFUD LEIAI
IS LEIMFRAGE PEIA
IS LEIMFRAGE PEIA</th><th>ATTYOE LSDPEDKSRF
ATTYOE LSDPEDKPRF
ATTYOE LSDPEDKPRF
NTYOE LSDPEDKPRF
NTYOE LSNPEDKARF
NTYOE LSNPEDKARF
NTYOE LSNPEDKRF
NTYOE LSNPEDKRF
ATTYOE LSNPEDKRF
ATTYOE LSNPEDKRF
HITYEL LSNPEDKRF</th><th>EXVFEQIANE YY
EXVFEQIANE YN
EXVFEQIANE YN
EXVFE
FALLENN FE
E
FALLENN FE
E
FALLENN FE
E
FALLENN FE
E
FALLENN FE
E
FALLENN FE
E
FALLENN FE
E
FALLENN FE
E
FALLENN FE
FALLENN FE
FAL</th><th></th><th>HSRLLDG DFULO
HORILDG DFULO
HERILDG DFULO
HE</th><th>ABYOL INSTITUTE
WYUN INSTITUT</th><th>GF IQVSLLKRER,
GF IQVSLLKRER,
GL IQVSLLKRER,
GL IQVSLLKRER,
GL IQVSLLKRER,
GL IQVSLLKRER,
GL IQVSLLKRER,
GF IQVALLKRER,
GF IQVALLKRER,
GF IQVALLKRER,
GF IQVALLKRER,
GF IQVALLKRER,
MV CANTTARER
INV CANTTARER
INV CANTTARER
INV CANTTARER
INV CANTTARER
INV CANTTARER
INV CANTTARER</th><th>QSKNNNATSG
QSKNNTATSG
QSKNTATSG
QSKNTATSG
QSKNTATSG
QKARTTATSG
QKARTTATSG
QKARTTATSG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKN</th><th>VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-</th><th>SKPADELIH. NPTSEYAP
PP
BEP
DP
NPAG-LVKL NPASEYPP</th><th>L LEGALITING
L REALITING
L REA</th><th>ІААСИЯТСЯ :
IAACUN TG
IAACUN T</th><th>023
026
025
025
0016
0017
0037
0018
0008
0013
0013
0013
0013
0014
0031
0011
0053
0011
0053
0011
0053
0011
0034
066
9700
883
mding</th></td<> | IS RUBHILAFUD NOMM
IS RUBHILAFUD NOMM
IS RUBHILAFUD NOMM
IS RABHILAFUD NOMM
IS RABHILAFUD NOMM
IS RABHILAFUD NOMM
IS RABHILAFUD NOMM
IS RABHILAFUD NOMM
IS RUBHILAFUD LEIAI
IS LEIMFRAGE PEIA
IS LEIMFRAGE PEIA | ATTYOE LSDPEDKSRF
ATTYOE LSDPEDKPRF
ATTYOE LSDPEDKPRF
NTYOE LSDPEDKPRF
NTYOE LSNPEDKARF
NTYOE LSNPEDKARF
NTYOE LSNPEDKRF
NTYOE LSNPEDKRF
ATTYOE LSNPEDKRF
ATTYOE LSNPEDKRF
HITYEL LSNPEDKRF | EXVFEQIANE YY
EXVFEQIANE YN
EXVFEQIANE YN
EXVFE
FALLENN FE
E
FALLENN FE
E
FALLENN FE
E
FALLENN FE
E
FALLENN FE
E
FALLENN FE
E
FALLENN FE
E
FALLENN FE
E
FALLENN FE
FALLENN FE
FAL | | HSRLLDG DFULO
HORILDG DFULO
HERILDG DFULO
HE | ABYOL INSTITUTE
WYUN INSTITUT | GF IQVSLLKRER,
GF IQVSLLKRER,
GL IQVSLLKRER,
GL IQVSLLKRER,
GL IQVSLLKRER,
GL IQVSLLKRER,
GL IQVSLLKRER,
GF IQVALLKRER,
GF IQVALLKRER,
GF IQVALLKRER,
GF IQVALLKRER,
GF IQVALLKRER,
MV CANTTARER
INV CANTTARER
INV CANTTARER
INV CANTTARER
INV CANTTARER
INV CANTTARER
INV CANTTARER | QSKNNNATSG
QSKNNTATSG
QSKNTATSG
QSKNTATSG
QSKNTATSG
QKARTTATSG
QKARTTATSG
QKARTTATSG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKN-APTTG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKNTATSG
QKKN | VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
VIHSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG-
NIKSRYSKG- | SKPADELIH. NPTSEYAP
PP
BEP
DP
NPAG-LVKL NPASEYPP | L LEGALITING
L REALITING
L REA | ІААСИЯТСЯ :
IAACUN TG
IAACUN T | 023
026
025
025
0016
0017
0037
0018
0008
0013
0013
0013
0013
0014
0031
0011
0053
0011
0053
0011
0053
0011
0034
066
9700
883
mding |

Figure 5. Multiple protein sequence alignment of phosphoenolpyruvate carboxylase. Only the alignment of region 5 (carboxyl terminal region involved in allosteric regulation of PEPCs) is shown in this figure. The multiple sequence alignment was performed using CLC Sequence Viewer.

Because the PEPCs in the order *Nostocales* contained lysine at position 954 and valine at position 967, we substituted the glutamate residue at position 954 in *Sy*PEPC with lysine (the protein was named *Sy*PEPC_E954K) and the serine residue at position 967 with valine (*Sy*PEPC_S967V). Biochemical analysis revealed that *Sy*PEPC_S967V had no enzymatic activity, but purified *Sy*PEPC_E954K (Fig. 6A) had enzymatic activity. *Sy*PEPC_E954K activity was reduced to 60% in the presence of 1 mM aspartate or malate (Fig. 6B), although neither 1 mM aspartate nor malate markedly decreased *Sy*PEPC_addition of 5 mM aspartate or malate showed similar results to 1 mM on *Sy*PEPC and *Sy*PEPC_E954K (Fig. 6B). The *V*_{max} value of *Sy*PEPC_E954K was increased to 2.2 units/mg. The K_m value of *Sy*PEPC_E954K for PEP (0.82 mM) was more than double that of *Sy*PEPC, but the K_m value for HCO₃⁻ (0.76 mM) was not altered. The inhibitory effect of fumarate was also enhanced in *Sy*PEPC_E954K compared with *Sy*PEPC (Fig. 6C).

A conserved lysine residue in Anabaena 7120 PEPC is important for allosteric regulation. The importance of the amino acid residue at position 954 in SyPEPC was then examined in another cyanobacterium, Anabaena 7120. The lysine residue at position 946 in AnPEPC is equivalent to the glutamate residue at position 954 in SyPEPC. We substituted lysine 946 of AnPEPC with glutamate, and named the protein AnPEPC_K946E. Both GST-tagged AnPEPC and AnPEPC_K946E were similarly purified by affinity chromatography (Fig. 7A). The optimum pH and temperature of AnPEPC were 8.0 and 35 °C (Fig. 7B). The activity of AnPEPC in the absence or presence of either malate or aspartate was determined at various PEP concentrations (Fig. S2). A biochemical assay demonstrated that AnPEPC_K946E was less inhibited by malate (the activity decreased to 80% in the presence of 1 mM malate) than AnPEPC, the activity of which decreased to less than 30% in the same conditions (Fig. 7C). Additionally, 5 mM malate had a similar effect to 1 mM malate on both AnPEPC and AnPEPC_K946E (Fig. 7D). The inhibitory effect of aspartate on AnPEPC was not altered by this amino acid substitution (Fig. 7D). The V_{max} values of AnPEPC and AnPEPC_K946E for PEP were 1.1 and 0.8 mM, respectively. The K_m values of AnPEPC_K946E for HCO₃⁻ were 0.24 and 0.25 mM, respectively.

Discussion

In this study, we demonstrated the biochemical properties of *Sy*PEPC, which are unique among cyanobacterial PEPCs. Other groups showed that the optimum pH and temperature of the PEPCs in *Thermosynechococcus vulcanus* and *Coccochloris peniocystis* are pH 9.0 and 42 °C, and pH 8.0 and 40 °C, respectively^{14,15}. The optimum pH of cyanobacterial PEPCs is thus 7.0–9.0; *Sy*PEPC is relatively active at acidic pH and low temperature (Fig. 1B and C). The optimum pH of C4-type PEPCs from *Sorghum*, *Digitaria sanguinalis*, and *Zea mays* is 7.0–8.0^{15,19,20}, and therefore the optimum pH of *Sy*PEPC is similar to C4-type plants (Fig. 1B). *In silico* analysis provided the





aliphatic index (Ai), which was calculated from the ratio of alanine, valine, isoleucine, and leucine in the primary amino acid sequence²¹. High Ai values suggest proteins are highly stable over a large range of temperatures. The Ai values of the PEPCs in *Nostocales* are higher than in *Chroococcales*²¹, and the *in silico* prediction is consistent with our results; *An*PEPC is more active at high temperature than *Sy*PEPC (Figs 1B and 7B). The combination of *in silico* and biochemical analyses thus drives the development of PEPC studies in cyanobacteria, as also shown in the multiple alignment and phylogenetic tree (Figs 4 and 5).

The K_m value of SyPEPC for PEP was 0.34 mM (Fig. 2), which is close to the K_m value of PEPCs of *Thermosynechococcus vulcanus* (0.58 mM)¹⁵. The K_m value of AnPEPC for PEP (1.1 mM) was higher than those of unicellular cyanobacteria, demonstrating the apparent distinction of PEPC kinetics between the orders *Chroococcales* and *Nostocales*. The K_m values for PEP of the PEPCs in *Oryza sativa* and *Flaveria pringlei* (C3-plants) are 0.03–0.56 mM and those of PEPCs in *Flaveria trinervia* and *Zea mays* (C4-plants) are 0.28–1.5 mM^{22–24}. The K_m value for PEP of SyPEPC is thus in between C3- and C4-plants. In the case of PEPCs of *Flaveria* species, the increased PEP saturation kinetics depends on a serine residue at position 774²². Our data revealed that the amino acid at positions 954 in SyPEPC and 946 in AnPEPC affect the K_m values for PEP, but not for bicarbonate. These results indicate the residue important for the binding of PEP to PEPC is different from that in higher plants. The K_m value for bicarbonate of SyPEPC (0.8 mM) was higher than those of PEPCs in both C3- and C4-plants (between 0.06 and 0.33 mM)²³. These results may indicate the necessity for a carbon concentration mechanism in cyanobacteria to support carbon fixation by encapsulation of Rubis CO₂. Phylogenetic analyses revealed that the kinetic changes of *Flaveria* PEPCs occurred during the last steps of the evolutionary process⁷, and the variation among cyanobacterial PEPCs may also have appeared during recent evolution.

We found that *Sy*PEPC was less inhibited by metabolic effectors, and that a single amino acid substitution at position 954 affected the allosteric regulation by malate or aspartate (Fig. 6B). The inhibitory effect of the metabolites on *Sy*PEPC was higher at pH 9.0 than at pH 7.3 (Fig. 3), while the optimal enzymatic activity was at pH 7.3 (Fig. 1C). In *Coccochloris peniocystis*, PEPC activity is higher at pH 8.0 than at pH 7.0, while the inhibitory effect of aspartate or malate is greater at pH 7.0 than at pH 8.0¹⁴. Thus, the optimal pHs for enzymatic activities and inhibitory effects by metabolites are not correlated in cyanobacteria. The importance of the amino acid substitution between glutamate and lysine was conserved in another cyanobacterium, *Anabaena* 7120 (Fig. 7C). Among *Flaveria* species, *F. pringlei* performs C3-type photosynthesis and *F. trinervia* performs C4-type photosynthesis^{9,25,26}. The C3-type PEPCs in *Flaveria* containing an arginine residue at position 884 are inhibited by malate, while the C4-type PEPCs containing a glycine residue at position 954 in *Sy*PEPC is not equivalent to the residue at position 884 in *Flaveria* PEPCs (Fig. 5). The lysine residue at position 946 in *Anabaena* is highly conserved among nitrogen-fixing cyanobacteria (Fig. 5), and the positive charge of lysine may play critical role in malate binding. The inhibitory effect of aspartate was not affected by substitution of the lysine residue at position 946 in *An*PEPC (Fig. 7D). At least five amino acid residues play roles in the binding of aspartate to PEPC



Figure 7. Biochemical analysis of *Anabaena* **7120 PEPCs** (*An***PEPC**). (A) Purification of GST-tagged *An***PEPC** and *An***PEPC_K946E** (the lysine residue was substituted with glutamate). Proteins were electrophoresed on an 8% SDS-PAGE gel, and stained with Instant Blue reagent. Arrowheads indicate the molecular weight. (**B**) Effect of temperature and pH on *An***PEPC** activity. Data represent relative values of means \pm SD from three independent experiments. Sixteen pmol (0.6µg) of *Sy***PEPC** was used for the enzyme assay. One unit of PEPC activity was defined as the consumption of 1µmol NADPH per minute. (**C**) Effect of malate on *An***PEPC_K946E** activity. Data represent means \pm SD of relative activity from three independent experiments. *An***PEPC** activity in the absence of malate was set at 100%. (**D**) Effect of aspartate on *An***PEPC_K946E** activity. The data represent means \pm SD of relative activity from three independent experiments. The *An***PEPC** activity in the absence of aspartate was set at 100%.

.....

proteins¹⁵ (Fig. 5); therefore, other amino acids compensate for the absence of the lysine residue at position 946 in *An*PEPC during aspartate binding. Thus, we discovered changes in allosteric regulation by a single amino acid substitution are conserved in both cyanobacteria and higher plants, although the key residues differ. In this study, we focused on region 5 of cyanobacterial PEPCs and showed the importance of this region in allosteric regulation. The structure of cyanobacterial PEPCs remains to be determined and future biochemical studies will elucidate the detailed mechanism of allosteric inhibition in cyanobacterial PEPCs.

Methods

Construction of cloning vectors for recombinant protein expression. The region of the *Synechocystis* 6803 genome containing the *ppc* (sll0920, encoding *SyPEPC*) ORF was amplified by PCR using KOD plus neo polymerase and the primers 5'-GAAGGTCGTGGGATCATGAACTTGGCAGTTCCTG-3' and 5'-GATGCGGCCGCTCGAGTCAACCAGTATTACGCATTC-3'. The amplified DNA fragments were cloned into the *Bam*HI-*Xho*I site of pGEX5X-1 (GE Healthcare Japan, Tokyo, Japan) using an In-Fusion HD cloning kit (Takara Bio, Shiga, Japan). Site-directed mutagenesis was commercially performed by Takara Bio. For *SyPEPC_*E954K and *SyPEPC_*S967V, +2860–2862 and +2899–2901 from the start codon were changed from GAA to AAA and from TCT to GTG, respectively.

The region of the *Anabaena* 7120 genome containing the *ppc* (all4861, encoding *An*PEPC) ORF was artificially synthesized and cloned into the *Bam*HI-*Xho*I site of pGEX5X-1 by Takara Bio.

Affinity purification of recombinant proteins. The expression vectors were transformed into *E. coli* BL21(DE3) (Takara Bio). Several liters of *E. coli* containing the vectors were cultivated at 30 °C by shaking (150 rpm), and protein expression was induced overnight by adding 0.01 mM isopropyl β -D-1-thiogalactopyranoside (Wako Chemicals, Osaka, Japan).

Affinity chromatography for protein purification was performed as described previously²⁷. Briefly, *E. coli* cells from 2 L culture were disrupted by sonication VC-750 (EYELA, Tokyo, Japan) for 5 min with 30% intensity, and

centrifuged at $5,800 \times g$ for 2 min at 4 °C. The supernatant was transferred to a new 50-mL plastic tube, and $560 \,\mu\text{L}$ of glutathione-Sepharose 4B resin (GE Healthcare Japan, Tokyo, Japan) was added. After rotating for 30 min, the resin was washed with $500 \,\mu\text{L}$ of PBS-T (1.37 M NaCl, 27 mM KCl, 81 mM Na₂HPO₄·12H₂O, 14.7 mM KH₂PO₄, 0.05% Tween-20) with 1 mM ATP, and eluted three times with $500 \,\mu\text{L}$ of GST elution buffer (50 mM Tris-HCl, pH 8.0, 10 mM reduced glutathione). The protein concentration was measured with a PIERCE BCA Protein Assay Kit (Thermo Scientific, Rockford, IL). Protein purification was confirmed by SDS-PAGE with staining with InstantBlue (Expedion Protein Solutions, San Diego, CA).

Enzyme assay. For the assay of the purified proteins, 4 pmol of *Sy*PEPCs or 16 pmol of *An*PEPCs were mixed in a 1 mL assay solution (100 mM MOPS-Tris, 10 mM MgCl₂, 1 mM EDTA, 50 mM NaHCO₃, 0.2 mM nicotina-mide adenine dinucleotide hydride (NADH), 2.5 mM PEP, 10 U of malate dehydrogenase (Oriental Yeast, Tokyo, Japan)). For the cell extract assay, 150 µg of total proteins was added to 1 mL assay solution. The absorbance at A_{340} was measured using a Hitachi U-3310 spectrophotometer (Hitachi High-Tech., Tokyo, Japan). One unit of PEPC activity was defined as the consumption of 1 µmol NADPH per minute. V_{max} and K_m values were determined by a Lineweaver-Burk double reciprocal plot. The results were plotted as a graph of the rate of reaction against the concentration of substrate. The Y and X intercepts were $1/V_{max}$ and $-1/K_m$, respectively.

Bacterial strains. The glucose-tolerant (GT) strain of *Synechocystis* sp. PCC 6803, isolated by Williams²⁸, and *Nostoc* sp. PCC 3756 from the National Institute of Environmental Science (Tsukuba, Japan) were grown in modified BG-11 medium, consisting of BG-11₀ liquid medium²⁰ supplemented with 5 mM NH₄Cl (buffered with 20 mM HEPES-KOH, pH 7.8). The liquid cultures were bubbled with air containing 1% (v/v) CO₂ (flow rate was 20–50 mL/min) and incubated at 30 °C under continuous white light (~50–70 µmol photons m⁻² s⁻¹). For enzymatic assay, the cells were suspended in 1 mL of assay solution with one-tenth of a tablet of Complete mini protease inhibitor (Roche, Basel, Switzerland), followed by disruption with a VC-750 sonicator (EYELA) for 3 min with 30% intensity. The cell extracts were centrifuged at 5,800 × g for 2 min at 4 °C, and the supernatant was used for PEPC activity assay.

Statistical analysis. *P*-values were determined using paired two-tailed Student's *t*-tests with Microsoft Excel for Mac 2011 (Redmond, WA, USA). All results were obtained using biologically independent replicates.

References

- 1. Andersson, I. & Backlund, A. Structure and function of RuBisCO. Plant Physiol. Biochem. 46, 275-291 (2008).
- Rae, B. D., Long, B. M., Badger, M. R. & Price, G. D. Functions, compositions, and evolution of the two types of carboxysomes: polyhedral microcompartments that facilitate CO₂ fixation in cyanobacteria and some proteobacteria. *Microbiol. Mol. Biol. Rev.* 77, 357–379 (2013).
- 3. Yang, C., Hua, Q. & Shimizu, K. Metabolic flux analysis in *Synechocystis* using isotope distribution from ¹³C-labeled glucose. *Metab. Eng.* **4**, 202–216 (2002).
- O'Leary, B., Park, J. & Plaxton, W. C. The remarkable diversity of plant PEPC (phosphoenolpyruvate carboxylase): recent insights into the physiological functions and post-translational controls of non-photosynthetic PEPC. *Biochem. J.* 436, 15–34 (2011).
- Izui, K., Matsumura, H., Furumoto, T. & Kai, Y. Phosphoenolpyruvate carboxylase: a new era of structural biology. Ann. Rev. Plant Biol. 55, 69–84 (2004).
- Chollet, R., Vidal, J. & O'Leary, M. H. PHOSPHOENOLPYRUVATE CARBOXYLASE: A ubiquitous, highly regulated enzyme in plants. Annu Rev Plant Physiol. Plant Mol. Biol. 47, 273–298 (1996).
- Svensson, P., Bläsing, O. E. & Westhoff, P. Evolution of C4 phosphoenolpyruvate carboxylase. Arch. Biochem. Biophys. 414, 180–188 (2003).
- Ting, I. P. & Osmond, C. B. Multiple forms of plant phosphoenolpyruvate carboxylase associated with different metabolic pathways. Plant Physiol. 51, 448–453 (1973).
- Monson, R. K., Moore, B. D., Ku, M. S. & Edwards, G. E. Co-function of C3-and C4-photosynthetic pathways in C3, C4 and C3-C4 intermediate *Flaveria* species. *Planta* 168, 493–502 (1986).
- Takahashi-Terada, A. *et al.* Maize phosphoenolpyruvate carboxylase. Mutations at the putative binding site for glucose 6-phosphate caused desensitization and abolished responsiveness to regulatory phosphorylation. *J. Biol. Chem.* 280, 11798–806 (2005).
- 11. Kai, Y. *et al.* Three-dimensional structure of phosphoenolpyruvate carboxylase: a proposed mechanism for allosteric inhibition. *Proc. Natl. Acad. Sci. USA* **96**, 823–828 (1999).
- Shylajanaciyar, M. *et al.* Analysis and elucidation of phosphoenolpyruvate carboxylase in cyanobacteria. *Protein J.* 34, 73–81 (2015).
 Luinenburg, I. & Coleman, J. R. Identification, characterization and sequence analysis of the gene encoding phosphoenolpyruvate carboxylase in *Anabaena* sp. PCC 7120. *J. Gen. Microbiol.* 138, 685–691 (1992).
- 14. Owttrim, G. W. & Colman, B. Purification and characterization of phosphoenolpyruvate carboxylase from a cyanobacterium. J. Bacteriol. 168, 207-212 (1986).
- Chen, L. M., Omiya, T., Hata, S. & Izui, K. Molecular characterization of a phosphoenolpyruvate carboxylase from a thermophilic cyanobacterium, *Synechococcus vulcanus* with unusual allosteric properties. *Plant Cell Physiol.* 43, 159–169 (2002).
- 16. Benziman, M. Role of phosphoenolpyruvate carboxylation in Acetobacter xylinum. J. Bacteriol. 98, 1005–1010 (1969).
- Matsumura, H. et al. Crystal structures of C4 form maize and quaternary complex of E. coli phosphoenolpyruvate carboxylases. Structure 10, 1721–1730 (2002).
- Paulus, J. K., Schlieper, D. & Groth, G. Greater efficiency of photosynthetic carbon fixation due to single amino-acid substitution. Nat. Commun. 4, 1518 (2013).
- 19. Echevarria, C. *et al.* The effect of pH on the covalent and metabolic control of C4 phosphoenolpyruvate carboxylase from *Sorghum* leaf. *Arch. Biochem. Biophys.* **315**, 425–430 (1994).
- 20. Rippka, R. Isolation and purification of cyanobacteria. Methods Enzymol. 167, 3-27 (1988).
- Smith, A. A. & Plazas, M. C. In silico characterization and homology modeling of cyanobacterial phosphoenolpyruvate carboxylase enzymes with computational tools and bioinformatics servers. Am. J. Biochem. Mol. Biol. 1, 319–336 (2011).
- Bläsing, O. E., Westhoff, P. & Svensson, P. Evolution of C4 phosphoenolpyruvate carboxylase in *Flaveria*, a conserved serine residue in the carboxyl-terminal part of the enzyme is a major determinant for C4-specific characteristics. *J. Biol. Chem.* 275, 27917–27923 (2000).
- Muramatsu, M., Suzuki, R., Yamazaki, T. & Miyao, M. Comparison of plant-type phosphoenolpyruvate carboxylases from rice: Identification of two plant-specific regulatory regions of the allosteric enzyme. *Plant Cell Physiol.* 56, 468–480 (2014).

- 24. Dong, L. Y., Masuda, T., Kawamura, T., Hata, S. & Izui, K. Cloning, expression, and characterization of a root-form phosphoenolpyruvate carboxylase from *Zea mays*: Comparison with the C4-form enzyme. *Plant Cell Physiol.* **39**, 865–873 (1998).
- Engelmann, S., Bläsing, O. E., Gowik, U., Svensson, P. & Westhoff, P. Molecular evolution of C4 phosphoenolpyruvate carboxylase in the genus *Flaveria*-a gradual increase from C3 to C4 characteristics. *Planta* 217, 717–725 (2003).
 Insection of C4 phosphoenolpyruvate carboxylase in *Flaveria*-a gradual increase from C3 to C4 characteristics. *Planta* 217, 717–725 (2003).
- Jacobs, B., Engelmann, S., Westhoff, P. & Gowik, U. Evolution of C₄ phosphoenolpyruvate carboxylase in *Flaveria*: determinants for high tolerance towards the inhibitor L-malate. *Plant Cell Environ.* **31**, 793–803 (2008).
- Osanai, T. et al. ChlH, the H subunit of the Mg-chelatase, is an anti-sigma factor for SigE in Synechocystis sp. PCC 6803. Proc. Natl. Acad. Sci. USA 106, 6860–6865 (2009).
- Williams, J. G. K. Construction of specific mutations in photosystem II photosynthetic reaction center by genetic engineering methods in Synechocystis 6803. Methods Enzymol. 167, 766–778 (1988).

Acknowledgements

This work was supported by the Ministry of Education, Culture, Sports, Science, and Technology, Japan, by a grant to T.O. from ALCA (Project name "Production of cyanobacterial succinate by the genetic engineering of transcriptional regulators and circadian clocks") from the Japan Science and Technology Agency and by JSPS KAKENHI Grant-in-Aid for Scientific Research on Innovative Areas Grant Number 16H06559.

Author Contributions

M.T. designed research, performed experiments, analysed data, and wrote the manuscript. M.Y.H. designed research. T.O. analysed data and wrote the manuscript.

Additional Information

Supplementary information accompanies this paper at http://www.nature.com/srep

Competing financial interests: The authors declare no competing financial interests.

How to cite this article: Takeya, M. *et al.* Allosteric Inhibition of Phosphoenolpyruvate Carboxylases is Determined by a Single Amino Acid Residue in Cyanobacteria. *Sci. Rep.* **7**, 41080; doi: 10.1038/srep41080 (2017).

Publisher's note: Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This work is licensed under a Creative Commons Attribution 4.0 International License. The images or other third party material in this article are included in the article's Creative Commons license, unless indicated otherwise in the credit line; if the material is not included under the Creative Commons license, users will need to obtain permission from the license holder to reproduce the material. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/

© The Author(s) 2017