

Supplementary Information

Table S1. Annotation of proteins that are involved in ER *N*-glycosylation pathways.

Abbreviation	Definition
DK	Dolichol kinase
ALG7	UDP- <i>N</i> -acetylglucosamine--dolichyl-phosphate <i>N</i> -acetylglucosaminephosphotransferase
ALG13	UDP-GlcNAc:dolichyl-pyrophosphoryl-GlcNAc GlcNAc transferase
ALG14	UDP-GlcNAc:dolichyl-pyrophosphoryl-GlcNAc GlcNAc transferase
ALG1	chitobiosyldiphosphodolichol beta-mannosyltransferase
ALG2	glycolipid 3-alpha-mannosyltransferase
ALG11	GDP-mannose:glycolipid 1,2-alpha-D-mannosyltransferase
ALG3	dolichol phosphomannose-oligosaccharide-lipid mannosyltransferase
ALG9	dolichol phosphomannose-oligosaccharide-lipid mannosyltransferase
ALG12	Alpha-1,6-mannosyltransferase
ALG6	Alpha-1,3-glucosyltransferase
ALG8	Alpha-1,3-glucosyltransferase
ALG10	Alpha-1,2 glucosyltransferase
ALG5	Dolichyl-phosphate beta-glucosyltransferase
DPM1	Dolichol-phosphate mannosyltransferase
STT3	
OST1	
OST2	
OST3/6	Dolichyldiphosphoryloligosaccharide-protein
OST4	
OST5	
WBP1	
SWP1	
RFT1	Flippase
GCS1	Mannosyl-oligosaccharide glucosidase I
GANAB	Alpha 1,3-glucosidase II
GANABb	Alpha 1,3-glucosidase II ,beta subunit
MAN1	Mannosyl-oligosaccharide alpha-1,2-mannosidase
UGGT	UDP-glucose:glycoprotein glucosyltransferase
CALNEX	Calnexin
CALRET	Calreticulin

Table S2. Predicted protein encoded-genes involved in the red microalga *Porphyridium* sp. ER N-glycosylation pathway.

Enzyme	<i>Porphyridium</i> sequence
DK	GGAAGAAAVLFLLEVRCASMPKVSPSLNVFMRALTDERDSGVLITTHMLLLVGCAGPLWVEDRISLHA QSFASRSRALSGVIAVGVLDLSTASFIGVHFGRTTPWSAGTPKSVEGSSAGFVGAVACFYAIHCFTSSSPFAPI PAPLSTRIPLMSSDIRSAAAVALASALAAVFEAHTTQIDNLVPLYLHAALSLLL
ALG7	MGAGWMYAGMLLVPAVGVLLRACIEAGDVYMGVVARALLLAVAGMVL TARMVPAAQALMEKAQ MFGYDINKKGTTPQGA VKVPEALGIVPATIFIVILCLLHSHALRAAHAPAWVHSFLPLDAGRSSLLPHDDSN LSSVVLYTSALASVTFMTLLGFADDVLDLRWRYKMVLPFGCMPLLANYSGSTSIVIPVPLRSLDFDKTLL DIGLLYFIYMALLSIFCTNAINIYAGINGLEAGQSFVIGCFILIHNAMQLNPHRHVEDLALLRSNNMFSVEI MLPFVMVTLGLLRHNWFPSRVFVGDTFCYFAGMTLAMGAILGHYAEILLFFIPQLINFVYSLPQLIGIVP CPRHRLPKYNVETKKLEPIKSHLNLVNL TLLCTGPLTEKRLCEVLMFLFQVACCSAGLAMRYLVIKYYLL
ALG13	MGASGERSVFTVVGSTEFDALIEAMTAPQMLRALRALGYTKLRVQYGRGKVFPRACGEDDGLFDEMVD CFRFKPSLTHDMQRAGLIISHAGAGSIFEALRMGKNLIVVINDRLMDNHQAEAEEMQALGHSYAATCSN LLDVIQSSVRSRCWRPFSVRSLSGSPDTRLALLMVSHNVDKS
ALG14	MSGQESDVGHVSAALAAAVFLSVLTSCLLASNNIRRRRKL VARTSSAEANMPPELSLDPLPHACGNG AGHKPTIMFVLGSGGHTAEMLHFVRDWFRCMPTFDENQRGIA YKFV FV VASTDNHSEQKVLELFKDA RGASHVEYEVAKIPRAREVRQSWVTSVFTTFIALLSSVIVYLKHRPDVLCNPGTCVPMACALFGRAV AVATTSVIYVESVARVRHLSLS GKLLYWL VDRFIVQWPHLQQTHPLSEYHGRLT
ALG1	MEWTITVFLWTCVALLCVHVAWGLDEIARLTWACLWASRVGGPKIQEDLTRDVHVAVLVNGDIGQSP RTLHHAEMLAKWSFRPSVSPSQFGAESDADLDEAGATVLSKGYEYEGGAISQQGAVPRSSSTRVTVFAYGD PPKSLVQTEPGMHPQFPTQGQTSPQVTFRKHARTRVRRDHGSAVYFITSVLATVSRALDLIEALWTCRP RLDALIMQNPPSIPSLLIALVF ARLRHGALVVVDWHNFGYTILRTTRAPSLLLVLAEWYESTLAPY ADAHL CVSTAMCEFLRDEWNVDAT VYYDMPHCVFRPVSVEEHD LFLRLEQEYSLPIATERGSYPVSCTLR TSCGERNQHTTRRSRDPFLCVSST SWTPDEDFELLFDALVELDKSLLQMSYSNTRTGETQVSNLERSLVSPQLLFVITGRGPLRAAFEARIARA DLRCILVVCAWLSKQDYAHL LGSADVG VCLHSSSSGLDLP MKA VDMLGAGLPVIAVDYGCITELIVPGK SGLLVRGADELASTILDMDGFPGKKGKRIGSEKGFGLSQVMREWIRAKYGLSDQRADSEWCRV VAPKLN TLLDLREDLPDPPSKFSL
ALG2	MVDEKEGRRVAIVHPDLGLGGAERLVVDAALGLQERGHKVIYTAHRDVQRCFPEVRPHLGGSVSCT LVNTYVPRSVLGRFHALCTVIQC VILALYVCVNASRVDVAFCDIVSAPALIFRMFGIPCIFYCHFPDQMLA DSIRVSHAKLAEVDSSFVAVIKRFGR LVYRAFVDRLERFAISRATCVAVNSQFTARMFSEVYPDLLRGHE RKEPIVYPAVNIRPSVGHDA SLTSRLWATFAEEMFPV KDPILLVSLNRF EK KKNVALAVRALHAIRSSD SLVPNKQLRDSIVLLIAGGDDDRLEENKQTLHNVRQLISELRLEAFVGVELNFDESKRISILRAARALYTP SSEHFGIVPLEAMAAGVPVIAVDSGGPRETVQDQATGFLCPAEPAAFAQAAARLVVDQKLA EELGKRGR ERAQSLFSVDALGTALEGLVHECCDAKLARTATKPSRKKQS
ALG11	MVLRYSYSSRVGQCRGRLDGTHEQECGDVFDVWVRPGGMEWTERVRAGVHVVLGLFVLYVSVLLGF GLLVLRAMRARQRDRDLRTRPSKDDASCAASGNAARDAKDAFVVSFLHPHALAGGGGERVLWLA IKALRGRFPDATDLKIRVFTKGAPRKADVLEKVFVQFGIDIFTTQFELRELWSESLLDGARYPFCTLLLQFL AGAIAGVECTLLHVATDLFIDTTGHAASLAVAKWLGCHVATYVHYPTISTDMHVVRSRSTSQFNNSSR IADSLFLSGAKLAYR LFSHMYGLAGGCADVMVNSSWTRSHISSLWSGSRRKISLVFPPIIDTKPLLAFG MDKRDPALIVSVAQFRPEKNHALQIEAFVKLLHKQSRDPRSDTLRPRVMIGGCRNADDAARVELLYEIEI QNTYHLRVPDQVELLVNVT RDQLHAYLAKASAAIHTMKDEHFGISVVEFQAAGVIAVAHNSGGVALDII QNGKYGFLAETADQFADCLSSALSLSNSSLAMIQTARDAASRYSD EGFATEVLKALQRVLPVD

Table S2. Cont.

Enzyme	<i>Porphyridium</i> sequence
ALG3	MARGTDGSLACDGLTRRQAMGVTAEHVGARIMCSKENERGRTQGGGFACASWTRMIGEVLDRDLDRY TKRRDGMILSAFVLLFVAVSGSFVIVQVPYTEIDWVAYMQEVAGVLEGERDYIKLRGDTGPLVYPAGF VYIYSFLFYVTDAGVNVQLAQWIFLAVLLCTVAVVLGIYRVAITSQPGLMPPLVVMLLVASRRVMSLHV LRLFNDCEVALLAYASILLFAHNKWAFCVLYSLAVSVKMNALLYAPALLMLLLQANGVARTIGYLSIC AVVQIVLGLPFLISHPVQYLTKAFELSRVFEHRWSVNYAFLSIPTFTSKGLALVLLLGHLLATLAWFGSREV WGRKVHPVRSTGRAAADADYVLRVLFTCNLIGIAFARTLHYQFYAWYFHTLPYLLWRGRLPFALKLA VLLGIEMAYNIYPPRAWSSIVLHVCHAITIAALSATSSVSKSETNKHNH
ALG9	MRRRRSGPGRGGSSSGRERETRDGVVDRKPGGTAGSQRRMRTALSAIFSRHRAVPGWAPNVVTAFLF LLFLRLGSAMVSGIEDCDEFNYWEPLHYLVFGYGFQTWEYSPQFALRSYVFLLPYSVVAKIGSMVSLGS KGPAEIKYNAFLAVRFAQAFACAAAETLYDSVIWRFGKPAAXXLLLALLMAAPGLFRASVELLPSSFA MIGVCAATAAWLVGEFQLAVLGIAVAAVMGWPFAAVLGLPMSFHITYRKGILQFMQWMFSDGLVLAFT CFIVDTRFYGRFTLAPANLVIYNVLPAQGAGPTAFGVEDWKYYVFNMLNLNVSALLLVLYPLLWIWDG LVADAWPTRQDALTRLIFLSPAFIWL FVMFNQPHKEERFLAPVYPLVALVSAVSLDDVLRIVFGLSRNLSE SSRKYRVIVKNLFLCLAVVCVAFALGASRMLAVIKGYSAPMKIYTHLSTLELQYGEGRSKALPQDVYNIC VGKEWYRFPNSFFLPSSQFRLRFIKSEFSGLLPKEFAESGRGTQRTPPGMNMYNEEDPAQYFNDDLACHY FVELDLEESVSGTTPNPIPPEARAAIWEEDFLWSEKSRPFRAFYPVPGWEHQYWTLAKYRIYRNAHLLPF RRN
ALG12	MRLYRALPFCWILAYVALAPCYQKVEESFNTQAVHDLLYHAWWRRDKIQHFHDHVAFPGIVPRTFIIPC VIAALAFPFRLLL GATGKRLVHLVARLVVGAASAWSLDLIAGALEASHGVVIARAFVVVSCAQFHALYY ASRTL PNTFALILTNAALAMRIRRRFEASWILLAVVVALLRSEVLLLICCLVVDLWPLKNHSLESLVRIA LKL FSSALVTAFSSVAVDSYFWQRLSYPELEV FYFNAVLNKSSDWGVSPFHWHYFTSALPRALAGAFPLAA FGLVQDPSCRRTCVPFVMFVALYSFLPHKELRFIFYAIPACNVCAATTVATVWTGRSSSKQSRLAWIMLL GILLVSAALLPLYASASYWNYPGGRALDGLIHGSAECEGNSTRGPLRVHIDAKSATTGINRFLERDDGKW LYSKEEDHSILTWVSDFELLVTERPTVDGFMIIHEEPFRRLRFPKALSWAELSAVVAVEPAIFVQCNTAL HATCENLQACFDVKTSGRASRTISGEAKEL
ALG6	MEDETSARTNTEAELARAVTRVALDGSASAMPVGP RR GALAVITLAAVLWRSVLAMYPYSGEGLPPMY GDFEAQRHWMELTVNLP RMWYVESELNDLKYWGLDYPLSAYMARLFASFAPPESVALVTSRGFESE VFRAWMRNSVIVADLLVWFPAVALFVSTYXXRTAAERDETALFAVLVAMPCLVLIDHAHFQYNAVGLG LFVLSVALLLRDSLVPDALGCFACLALNFKQMNLYALAVAFYLLGKASQRLRASGLAHAFTYLLILA GAVFVTFASVWWPWLGAWDDVRAVLLRVFPLHRGVYEDKVANAWCSLGLFYRPLRRVTPWAACLCAT LLASAPFCLSVLTKPGRRTFVLACAGVLSFFLFSYQVHEKHVLLPLTAVTMLCSDAPWLSVWMNAVAM LSVFPLLDREGSSLAYVGSQLLNVCVHLFFFGRIDDSMPPSKSTSSSSSSSAAAAGHRWRAVAVTCHIVA CHAAVELVRRPLCLIKRWPDLPTYVVTSSFLHLCAMYVLLRLLPRLPHAQHRYSSSAGTAEYSITEPQ PLKLG
ALG8	MDGARELLPLAAREEEEEYHESRTLVELAKGTTKPVYIMARVTLLDPTLASLLTLSVALRVLLHARYAS TDLNVHRDWMALTWNVHVRDWTAEISQWTLDYPLFAYLEYALAGVAHV LQVPGFELEDAGTQVN ASATVFLRSTVLVLEILFLFSGMYVLVGSLYHDRGADAATAPSVTQSSAATMALSGLWLSPGILMVDYM HFQYNSIALGLLLWTCVLLGNERKRLALDVGVALFVTALNTKHTLLYVAPCIGAAVLGVSNAGEDLKS AWSLLQRCLTLLRLGVVGTVCMLAIWSPFIYHGQIAHVLMRMFPFQRGLLHSYWAPNLWALYAGTDKL LAFVMGSEREKAWSTRGLVGMHPFAVLPSVGPRACALSLSLAAMIPAILLMLRLGNLRKSCFHGKTRLGI VLFSTAYCALCSFVFGYHVHEKAILLCVIPLAPLSTLAPEYMRIFRILACAGYYGLLPLLFTPAEQVPKCAF FVLHVSYLHRVSQKMQVNESAGEWLYMRGFVLELYCQFVHTWWFGHDRMHFLPLMLVSMYAACGV LVAWAMGLGRLFALHCELMAQNGPKSAKSE

Table S2. Cont.

Enzyme	<i>Porphyridium</i> sequence
ALG10	MPQPALVAAGAMLLVCLCLISALQPKPYMDELHVAQTQAYCRALASSSPSNMLDAIKSTPYDPAISTPP TPYLLVSVVRYIVLAPFPRLVPVLCVSPALRIASACIAFCALLQVHAILKNVLIKATATRQELLHHYL RIGM SQADWLSALALWLHPISSFFYMMFYTDNLAMLFLLLCMRQSHVFREPTLGKPV RVEYVAALMGV LASS VRQSYMIWHALVVACSVVALAEEMHPKIGRKT LQVERMWAHRATITWILWPHVLAGLLYAGFVAFNG GVAIGHREFHQPPHWMWFYFCAYRLIFYPDACRAEDVTVAGFSRAYLFSALEGTNARNRARMVVL ANLVLAGLVIVSIWLGTVHPFVLADNRHYSFALFRRVLTPSARFLFLPTYMLGFVWLVADLGPFCIATLP LLALGLVPVPLFEPRYFAPPFMISQFLTLLTQSRAARQKWYCGWFSSGIALSQIAAMLALFFFVPSRPPDA HLPQDASLGRWMP
ALG5	MLIGWVAAGKVSRLRISRESVRTAQYLCWRRLRTGQIRATPCLQVRRRCRYLGTSADRRPKLLGQAEGE GNMSSNIPMSEYTYIDPASM RPGRKEMFPSLFSSPAEVR LTVVVPAYNEEARLPAMMDEALAFLEKWGE EDNSFTYEIIVANDGSRDKTALVALEYTKRFS AQKVRVLSLAQNAGKGA AVKKGIMAARGAVILFC DAD GATRFADLSILYRQLELIARDQQADSL ENAHACVIGSR YHLKSSAERSLVREFVSRVFNLYVQYVGGV RG VRDTQC GFKLFRRSAQLIFPCMHLD RWA FDFVEALYIAQAHCVAISEVPVQWMEIPGSKLSVVKASLNM ARDMALMRWNYLTGVWSAGV PDLAHVGTQSNKFP
DPM1	DGLLVLS DTRMAGSDGPRGRDLYSVLLPTYNERENLPYIVWLLVRAFRSAGERCEILIVDDNSPDGTQEV ARRLQRYYNRHDADESDGLQDDVRIELLTRAGK LGLGSA YMHASKQARGNFV LILDADMSHHPK YIPR MIATQRTADYDIVTGC RYVPPHLLGGGVHGWDLRRKLVSRGANFLAQ LLLRPGVRDLTGSFRLYKRSAFE RIMQHMRSSGYVFQMEIIVRARRLNC SIAELPITFVDRLFGT SKLGSLEIVEYLQGLWMLLTS
RTF1	MGHDETGEGQDAALGLQGEHRHVAFVGAAMRGLSVIVLLQFVARVLSFLLKVV CARALGPARFAFGE VKLQLLVALALLPAREGFRKVALRARS DAHAAMLSW TAAAASCLIAVLA WRLFERFGLSHDL DAPDRY VHSLALMVA AWA AAIIEGVAEPSV VACARYQLYTAQAVSKSAALIAASCVT VVG VYRLPEVYLV LASAF GLLCYALLFLLFFAVWRHEQAQAATAPRFVFCSPFR TFSATPSGRDDGVII VQQLYQALVRFALGDGE NFVLLVTCSEQE QGAFKLASNIASLIARF LLEPLEELCFNVFSRLGNDLASFPQPTPGGSVTRV GSKTRDNS SAFHTLETTLRVALTVVVLTTGMVACIGPSFATL FVHLMYGSTWAEHTRAPMLLSMYFSYVMVMSVNG VVEALLNATATQKQORSYAAFTTLV SVGYLAAAWSSSHV LVGAAGLIMSNAVNMVLRIMFCARYAL HFVHMPLGWLGVIFPRARSGAGLALCGALTFSARRWLLPAVDTAKSGVALLLSPAVCAHFL LGVCSTAG GLGWIYTCERETISLGLGLYRGRGRGDETSKHL
STT3a	VDDGTYAFWNWFDASSWYPLGRIVGGTVYPGIMYTAALLH RAYRVIGIDLDIREVCVTLAPVFSGITALA TYMLTQQTWNEAAGLLAAAFVGVIPGYIARSAAGSYDNEAVAITALILTFALFVKAVNTGSIAWAALAS LSYLYMVSSWGGYIFVMNVIPIYVLTLLLMGRYTNRLYVSFCAFYVLGTLLSMQIRFVGFNAVQSSEHM GALGVFGILNLYCCAMWIQSFSSPQTFRAVLRLLL MGALSLAGIAAVYGIYSGYIGPWTGRFYTL LDPTY AKRKIPIIASVAEHQPTSWSAFFENHFLVMLMPVGIYHVL RNPNDTNVLLV VYGVFSTYFTGVMNRLML VYTPMCCVLA AIAISELLSVWMVPLKQKGVIPSVRSLFRSDVSSEEAASTSAAGSTSRKTAKRMSKR DAS SSTAVQQHGTAPVTDQVEVSLGLILV VFGMGIAFVHHCVWSSSEMHS SPVLSYKVRSGDRVFIDDFRE AYQWLNQNTASSTRVLSWWDYGYQLAGMSNVTTIVDNNTWNNTHIGTVGRCLNSDEVVAHRIARKLD VDYLVVFGGLIGYASDDLNKLIWPIRISGSVDPSVNERDYLTANGEYSIGDDASETLTNSLMFRLSYHRF ADV VAPSVEPIRDQNRGTVSKKARDIRLHSFEEVFTTGHWL VRIYRVKPPHARGFLLAPVAET

Table S2. Cont.

Enzyme	Porphyridium sequence
STT3b	MAREGLAIRQSEALVRLGTMALIYVMAFSARLFSVIRYESIIHEFDPPWFNYRSTKVFVEDGMYAFWNWF DHKSWYPLGRVVGTVYPGIMFTAGFIYHALHALGFPEIHVREVCVLTAPIFSGLTAAAYLLGTEAYSSG AGLFAAVITSIVPGYMSRSTAGSFDNEGVAITALVFVFGFMRAVRTGSILYSALSAIAYLYMVSTWGGYI FVINIPIYVMVMLVLGRFSNRLYVAYSTFYVLGTLTLLSMQIRFVGFQAIQSKEKLAALAVFGFLHLYVFR WLYSLMPRRKFLLFSGTVAVLVGTVAIALSWAFRTNFFGPWEGRFYITLDPTYAQRFIPIASVSEHQPT AWASYFMDLHVLNLFVGLYLLMKGVTDNLLLVYAVFAAYFSGVMSRLMLVLAPASALMSGVALS EMTNKAAASVFEMVKRAPHDGSSTSTATLHPDGGTASSTDTAAQSGKRGAACKAVATRKAASVQGS STASSSGKTGAAMSRPFKVTLEVSVALLLIASFVLFKYIQHCLYMANHYSSPSVVIQLNDGSYWDFFRE AYFWLSQNTDPDDTVLSWWDYGYQLSGMANRTTIVDNNTWNNSHIATVGRCLNSDEKKAHTIARKLD VDYVLIIFGGLVGYSSDDINKFLWPIRISGSVDPSVKEEDYLTARGEYSMGEDASETLKNSLMYRLSYR NEVRNHGNFAVDLVRVQAPEHDITLRYFEEAFTSEHWLVRIYRVKQPDALGFT
OST1	MWECISTFPARSVITNRLLPFFCAFLISLRDLFCIFLFLARFGHFQKLDKMVLTMMVQCTVQNQFPDQSI AAYRVAIHPSDAEALHFLQACEHTDCFTDADGQRRLLSKTVEEGRDHGAQLYSFALTEPLMPGEERTLII KYGFGQALKPVESNVQTSKQVLKFDVSSEFFSPYVTLQDALELKTASGWTIDAVRSDSNDVKKISTGIVS RNVLAGVQPYTYTPVRVLVSGNSPLLKLDSEFRKIFTVSHWGNVNVREEYDLRNFGTALRGQNSRVDYDR GQHFNVPKLRFLRPPDASNYYRDWDGNVTSSTLHKPGVRTRIFDATTRFPLFGGWKNAFWISYDLPAS SLLSQSVGESTRFQLVGIVAPTIDASSILIDDLVAVSLPEGSHTHDAFVNGLDVETIDFGRNPATLAFKGR PVLELHMGTVLTGLSVAPSVVVEYRFSPLSLLGPFMIISFILLGFVAWILLGYMSDVLITPADAVRMTHP VYAKEKGQFAALCEGVMRVSAALHTLAAGISIPDQLQFFEEKSHALVLEL GALRS AVKSLEADV ASPVFF THVSNLVDL YNEWIPLKEQQRREPMAGDRLRELDGCLELELADLKFALGSI
OST2	MASSSVSSGSGSGPKSVWGLKSGYEAGVPLYL KVIDAYILAVFMTGIVQFAYCMVVGTFPFNAFLAGFISTVGTFLVTVSLRMQVNPQNLADPANSWQSLTL GRVVADWLFANLVLHMTVLNFIG
OST4	MITDEQLVSVATWGGYLVI GLVILYHFVVASASALPPSASASSASTKKDL
WBP1	MRLQNTWCGPMAGSFWYRLQPRGSTRVWLTMLGMIFMLLIVMGGAGVVAIGPDGRDRVVVIVPTLSD MQEKYKTIQEHLVETGYAVTVKALDAPDTAEILLMQDGEYVFDTAVSLVPRAQNLGPGWSAGAVLDFV DQGGSVFVAADYNYGAFTKQLAAGLGVQLDDKLNVIDHGSFDAGLDQDGSFSFIKAGGVTKAKPIVN AGSPSASSILFKGVGASLYTSNELVEPVLWGSPSAYCGRKFESATDIPLASGNEVVLGAVLQARNTGTGR GAYIGGVAMLQDQVMQLAGVKHRDFYLDLLSWTCGERGVLKAENVRHWLANNGEQRGTYKVQDDIG FALDVFEWAGALGHWIPTTPEDMQVEFTMLNPNYIRARLVPLVSESSGESASMHANLTIPDVIGIYKFEIAY VRTGYSHVALMENVNVRPFWHNEYERFIQAYPPYASAFVMMGSLIVFTAVVLYGKPTVDAERQHKAK DAR

Table S2. Cont.

Enzyme	Porphyridium sequence
GCS1	<p>MDTDTAVYTRSTAVCINASSRRASRHTASPTASLLTTYAIISRECSACSSCASGAPPRAPSASILLPLLFPFR KLVDQQRSSRQALGRDVSTRLLRACRMGMARRACA VRVIALLA VLVGARSCVLADTPPNHRRWGLWR PRLIAGVRSNVRDSAMFGIGWQGE GAVRSALRMCADDGSNGVQFGYVRHDGRAYAQQVIVDAQLQVK MNMDWILVEHKTRDHLPAFAWVLRITGEHIETE QDSRSASGASYVSLFLTAASGADEDDIEGQEEEPHV SEIECTGHSSDVCIQGQSGRSVSALTPYKLMYKQPTYGTPATLSFAARPPKLAYPEHIVSTWDASISALLV AKDASKHSGPRRDLSQPVTVLGAWAREQQFASEQHVLRYMKDDGSGVRTLHADDPEAVDSCADART CSVAVVQRVLERDFRVEIVFSEFAFDELLE VSLCGAALDERIERARRAFDDRHALFRGIAQNYKAGSTET RMATYALSNNLGGFGFFHGSSWVERENTEIATSTDAGIEPKNKLETREVAQVLGQDGKLAALTPQNLFTA TPRS VVFPGRFLWDEGFHQLVVLQWDTQLALESLMSWLG VIRSSGWIPREQVLGFEEARAAFPKHISHLMI QNPSVANPPTMLMPWQVLARRCHNMHQGTKENSLDRVHPEQDATCSAATWEHVANALGLHLRWLDT NQRTRDASAYQWKGRNERHRPQNGRNPFTWASGLDDYPRARVPSAQEKHLDLHTWMVWAHAAMVTI TSLAGHSESSVDALKRRADELKSMMETQFGGSDRHGLLFDLDRDGAQIEHVGYVSLFPLMLGLVPHDS PRVGAALAAMQDPEQLWSVAGIRSLSKSDDYLLKGDQYWTGPVWIPINYL LLAGLHNKYAAYPGPYRE RARALYDDLRRITVTN MARNFEQQSTLFENYNDRTGDGQKGRFLTGWSSLIVLIMAEYEYGLIV</p>
GANAB	<p>MRNAARGRALAARALLWVAGVLALAILAFNPLRECEGATWNKLTCAQSGFCSRHRGLPPRPHNQVTY AVRPESVHV GSSPNDDGAVSGLVSISTVDSGSEAESMSVDLAFQIRAYDNGVMRWTLDEQPGNGRFERY RPTDGVLVDSLRAVRITEDTDLDRSSPLRLRVCSACKAGLTDPPVLVIDYNPLRVTLDESARGAPLVILNG HELLRFERQDEDIIEPPESQQHEEAPTHQANSEHSPEVGGDHEGASHVADGTDHSDEY MAGYYDDVAGN ENDFGLDAYTAPYEDYNHGLDDMHA VPYGEDA VPDDIALREFEAPVAPHGSETAHACRGC FQETFDGH TDVKARGPESIGVDIEFPRA SHVFGIPERTSSFALQDTKRDGLAQSGESLSDPYRMYNLDVFEYELNSPFG LYGSVPLLTAVTDGGHWSGVFWLNPSETYVDVTGANGTASGGHNGSNTSITTHWFSESGVMDVFLGG GDMPCIVYNQYVSLTGPAAVPNTFALGFHQSRWKADFEADTRA VDRSFDTHDVPYDVLWLDIEHTDGK RYFTWDLNKYPNPVQLQHDIDARGRKMVTIIDPHVKRDGN YALHRFAEENGLYVKEADGTTDYVGFVCW PGSSSYDFVNP AVRAAWASRFSPEFYKELTPSLYTWVDMNEPSVFN GPEQTMPKGLKHFGGWEHRDV HNLYGLFVQRATFEGLLQARNSTDRPFVLSRAFFAGSQRFGA VWTGDNAASWGHLQASIPMLLSLQISGI VFSGADIGGFFGNPTRPLAVRWYQAAAFQPFRAHKHIDADPREPWLLGNDNMQHIRKAISERYTFLPY WYTLFAVASTVLDASDARAASKDGMHHPMPRIWWHFP SERALLGGKEQEHSWMVGDALLVAPVLSE NTEAHRVRLPGGGGGDVSKNAPKSANSNSGATASRWF DLYGDYAE LSGGETHIYNEVSLDRMFV FQRG GTIVPRKMRRRRSTVAMNLDPLTLVVALDSFETAHG TLYVDDGKSFA YEEGNFVRSFEFSSNRLTARTV AGSEEWLDDQRTERSRILCEKILVLGLAVEPSTILAE TIHRNADGSYVPKTVELERDINFNFYAQSRKLVV RRLPFRAYSGDWTLHLM</p>
GANABb	<p>MARELLGLRSACHDSRVLLAAAKDMRALQLSLSAVVA VVLAHALSRVHGDPGVRVRGAGAQR LQQY PHGQPFSCVPLDAPPGRTRAVQLPYALVNDDHDCADGSD EPGTSACSGAGGYFVCDADVGAPSIHASFV DDGVCDCDGSDEYAGRTHCQNVCD AQWERAIQESERKVGAFQRALAKRKRMEKDGWTL LAKDRDEI NASAALDTEGSLKKVGEYDAHIEELGRLVKRWEDGLARNPTS DINLTVSESAGQSTSAEADSELTTESDT VQGAETMDVLSKWPPSRCAD FISA WPSEKEEKLGRGLPHQLVDSFVSATERLCKIMPFTSCVHQDAERES FHALSIDARLLAAKSCVD AIQKERKLLLDK VQDRQSQA AERIRTL DANHARFP GVRVLRDNCYRSP LGA YEYEICPLVKVLQYEHGRQIAKLGDFKSLMSI ESSVRMDFRLGDYCWGRSRRSITVDLACDESEAIVEVSE PSQCKYHMFVSTAAVCE DGM LDV ASRQLD TLRSTRHGSQVPASDPRDEL</p>

Table S2. Cont.

Enzyme	<i>Porphyridium</i> sequence
MAN1a	MQDASLEHQQCVAIDFVYSMLSEEAKARFAIERFGLDPFRRVGSYAAYKQQLRNARGCSSTLVSPSSS MHASACAGVPTKAPAPYVFEHDDIQAKADAIRNATRGAFLAYTFYAFGSDELAPLSRGGVNNFGGMG VTIIDLSTLYMMDLMEEYALARAWVENQLSFERVGEVVVFETIIRVVGGLASTFQLTGDELFLRKADEL GKLLGFAFHSPSGVPPFLCHLGRRCYAKTSHNEMIPAEAGSIQLEFRALSAMSSDPFIQIRFSADDFRL VDSYFEAGEVVRVDGNVSMGSLPSPKINFRTGRFKSSMHMLGAPSDSYEYLFKLWVQSGYTERHLFEKF RNVVRDTIRYLLRRSPALGLYYVFELSGGQPITKMDHFSCFFPATLASACSLPFAPLSNAERAEMELAE MLAETCHEMYSRSPSGLAPEHVLFDTGKRDWVMFGSYEQRPEAIEAFLFLWRTRNPKYRDWAWSIFER IQQHSRTAEGAYATLSKARSRRPPKADRMHSFLISETFKYL YLMFQPDHVLPMHLFVLNTEAHPLLLQPH GLLPQAQDASKDGGTSAGSLP
* UGGT	VSDAPRTWLVSASAAHVLDLNVVLAPQVDKDVKKRRTILAEYVLDVAVIISGSAWENAYAPGQDEQEG KGAVAQSVQGLQLALKRFGGQLVSDTVVMQNVGYYQLRATQPSRLR VEMIGAGRDFVFEATGEPYV GVMLDSXX XXXXXXXXXXXXXXXXXSAGRAWQRHVPVHFLTAKSKEPIHVFSVASGHL YERFLRIMMLSASRQSSRPIK FWLLGNYSMPFKAALPAFAAEHGFDYELVAYQWPPWLRQSQRVWLWAYKILFLDVLFPDLDVSHVIF IDSDQVVRGDLAELLSYQPLPHGAPYAFVPCDSRVDVEGFRFWKHGYWRGVLGERPYHISALFLVDLR RFRRIAAGDALRVQYQLLSRDPASLSNLDQDLPSMNKPGGLPIASLPLDWLWCETWCAEDTKWRARTI DLCNNPMTKEPKLVSAKRIIPEWQLDKEATKSMARILAVNASVSCNVGEKNSAEPP
CALNEX	MDDEELARLMEAYGGGGFGGMGENYEDEDPYGGLGAGGFGDMPPPGLLEDDLVIDSGVDSEAYSPDPA PASALFLETQRNAFDEDRWVYSSKAQYNGRFVLGGGRAPGIHGDKGAMLSEKARFYGAVAMLPEPVV VAHGDKLVFQYEVKFDSTCSGAYMKLPKSPFATPDVFDNSVQYSIMFGPKCGDTAKVHVIIQSEHPT TGKLTEHHLTNPPAPFIFGSETHLYTLVLDVAAQTYEVRVDGDVKKAGSLAHDFFPPFPSTIPDAKDTK PADWEDEPRIPDPSATKPADWEDAPLFIPEDESATKPDDWLEDEEPQIPDPSAVKPDEWEDSEDGAWQAP LIENPKCVDNCGPWVAPQIANPDYKKGWTPMIDNPKYVGPWAPREIENPDYKVEQVTLPIAALAF EIWAMDYGIIFDNVYLGTSVEDAEAFANATTVVKRAAETKKEHTAKK DASDGN SKIKNQVLDAADAV ANALEVVLSPIDALLRKHGLDVYVDAALDFVGSHP LIPSVGIPLV LVVFFLV LTAHRKKQTRSSRTTAVPD VXICEEDGRAASGRCCGACTVSGAIRDHTRAEAGSGGXRRRKA EH
CALRET	MSRARVWQCVLRIAAVASACGFCAAGRWDLSKKPENGAVPFYTMPVVEPPAHAYLWEDFQYKTSFF QVKPGDTEATSWMYARGRGADGAPEIGSIDPLWYRVDKGIGFRKRQRQHYKVARKLDIDTIPDGFTIQF DVRCKAFWTCGLFWKLLAAPLNSVQDFKDTSPSSIVFGPDRCNEKSRVLVIITTKNPVSGEYEEHVLQN APEPHNHVYKATNL YRLSLFFERGEAVVAVNDKEYVYSLDNDFFPPFPQRKMVDDPADSKPSDWVDER EVVDLDDRQPDDWDETQEPWIPDTSVQKPDDWLEENAFMKDPNVRKPDFWDDEEDGPWQESWITNP LCLTGKCGTWHQPQIPNPNFRGKWKPR TIPNPDFKGEWQPRKIPNPTYEIDSVSQSIMLPVAGVALDVLV SDYNIWFDNLVYGRSDSEAKYLAEEETSKKKQFYETYFEAYPPTVDSEGIPLKEKPWQEMRTHDSQKGAA ETA AKDEL

* Due to missing information in our genomic data, we have only partial data for the UGGT; the line of X's represent this missing information.