Figure legends:

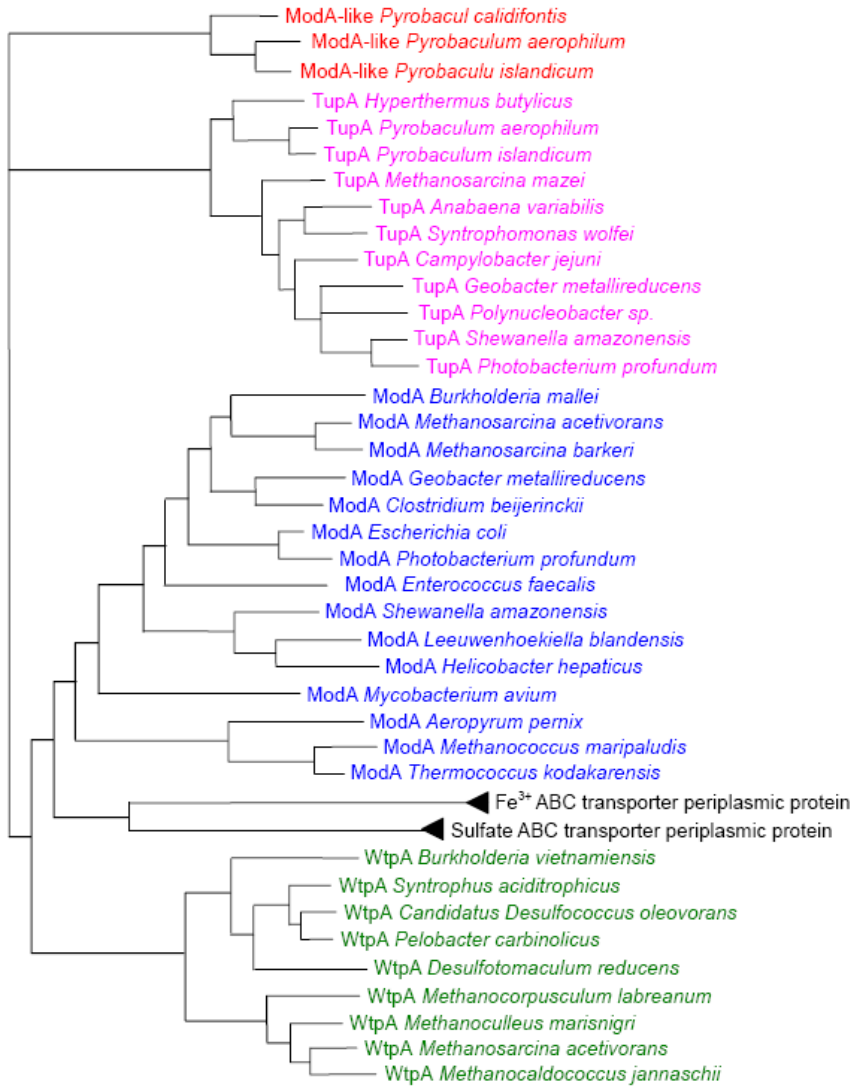
Fig. S1. Phylogenetic trees of periplasmic components of prokaryotic Mo/W transporters based on MrBayes and PHYML. ModA-like proteins are shown in red and bold, TupA in pink, WtpA in green and ModA in blue. The sulfate and Fe^{3+} ABC transporter branches were compressed and represented by family names. These trees were generated by corresponding programs and visualized via TreeView program. A. MrBayes analysis; B. PHYML analysis.

Fig. S2. CLUSTALW multiple alignment of ModA, WtpA and ModA-like. Residues involved in molybdate binding in ModA are shown in red background and residues involved in tungstate binding in WtpA in blue background. Overlapped residues between ModA and WtpA are shown in red background. Other residues shown in white on black or grey are conserved in homologues. The secondary structures of ModA and WtpA are based on the crystal structures identified in E. coli and Archaeoglobus fulgidus, respectively. Secondary structures of ModA-like proteins were predicted using GOR IV with default parameters (http://npsa-pbil.ibcp.fr/cgi-bin/npsa_automat.pl?page=npsa_gor4.html).

Fig. S3. MUSCLE multiple alignment of ModA, WtpA and ModA-like. See Fig. S2 legend for annotation of functional residues.

Fig. S1

A.


ModA-like Pyrobacul calidifontis
ModA-like Pyrobaculum aerophilum
ModA-like Pyrobaculu islandicum
TupA Hyperthermus butylicus
TupA Pyrobaculum aerophilum
TupA Pyrobaculum islandicum
TupA Methanosarcina mazei
TupA Anabaena variabilis
TupA Syntrophomonas wolfei
TupA Campylobacter jejuni
TupA Geobacter metallireducens
TupA Polynucleobacter sp.
TupA Shewanella amazonensis
TupA Photobacterium profundum
ModA Burkholderia mallei
ModA Methanosarcina acetivorans
ModA Methanosarcina barkeri
ModA Geobacter metallireducens
ModA Clostridium beijerinckii
ModA Escherichia coli
ModA Photobacterium profundum
ModA Enterococcus faecalis
ModA Shewanella amazonensis
ModA Leeuwenhoekiella blandensis
ModA Helicobacter hepaticus
ModA Mycobacterium avium
ModA Aeropyrum pernix
ModA Methanococcus maripaludis
ModA Thermococcus kodakarensis
Fe3+ ABC transporter periplasmic protein
Sulfate ABC transporter periplasmic protein
WtpA Burkholderia vietnamiensis
WtpA Syntrophus aciditrophicus
WtpA Candidatus Desulfococcus oleovorans
WtpA Pelobacter carbinolicus
WtpA Desulfotomaculum reducens
WtpA Methanocorpusculum labreanum
WtpA Methanoculleus marisnigri
WtpA Methanosarcina acetivorans
WtpA Methanocaldococcus jannaschii

B.

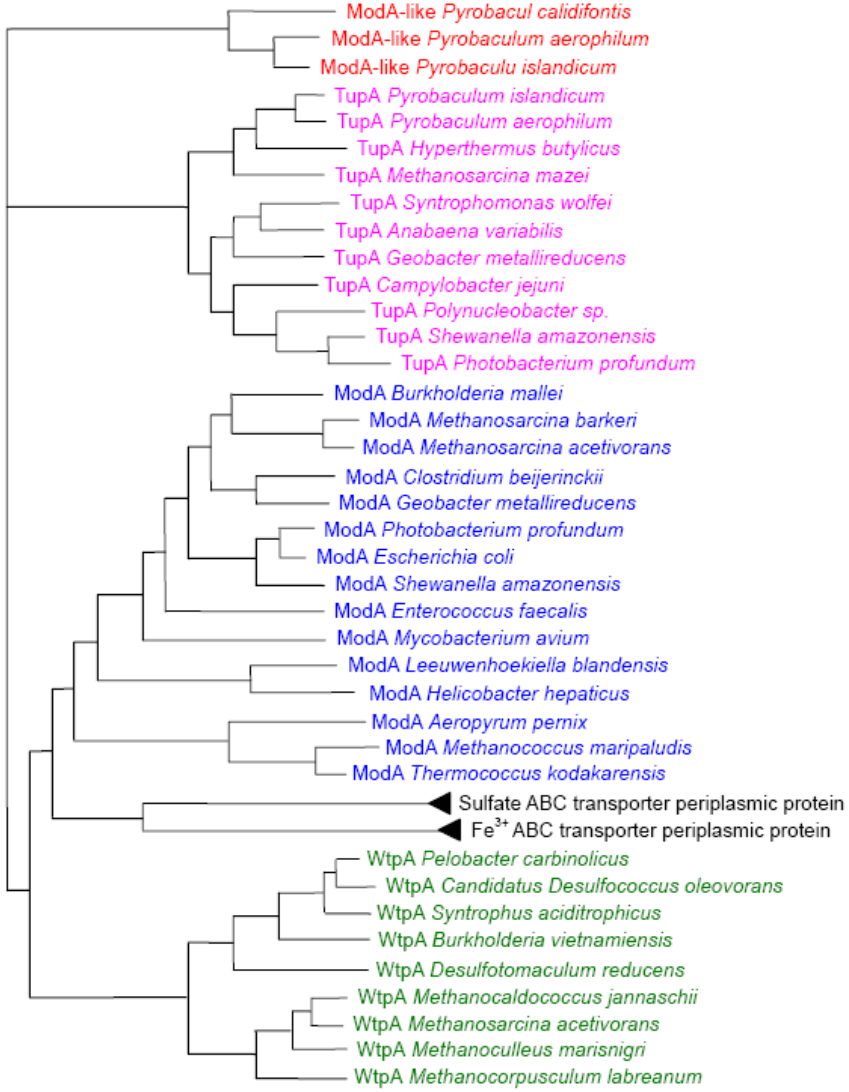
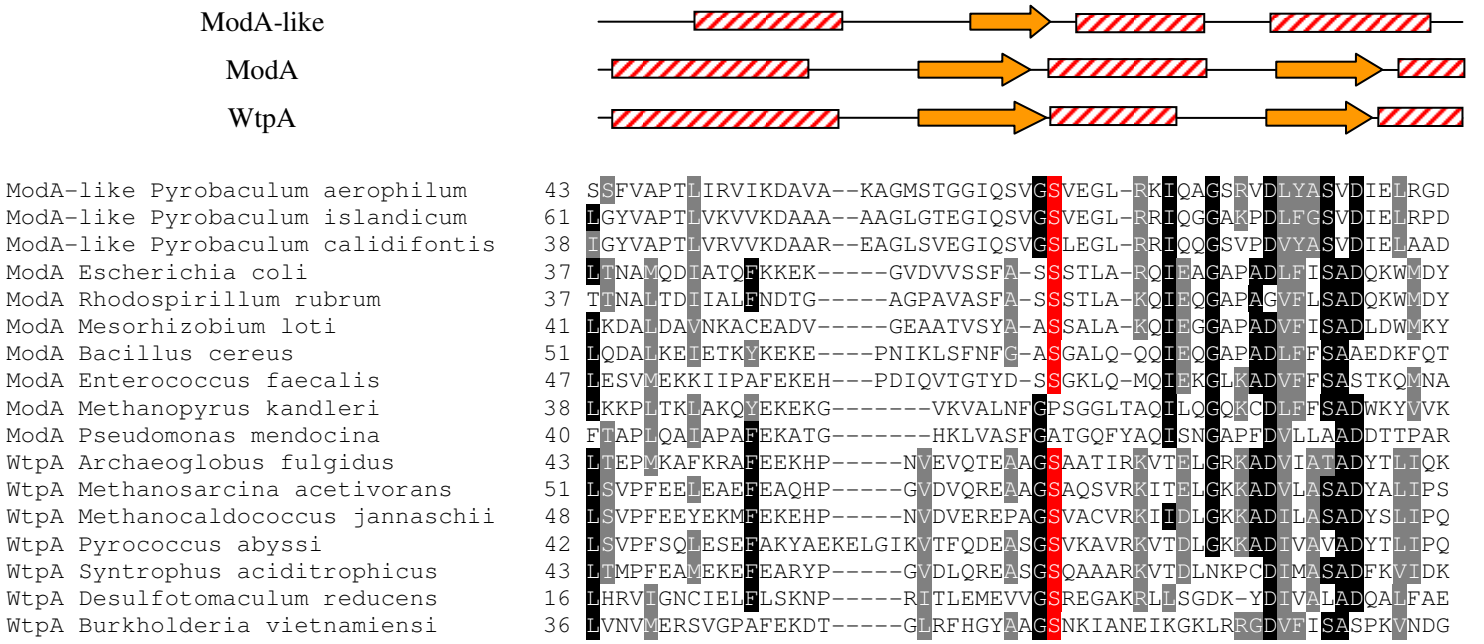
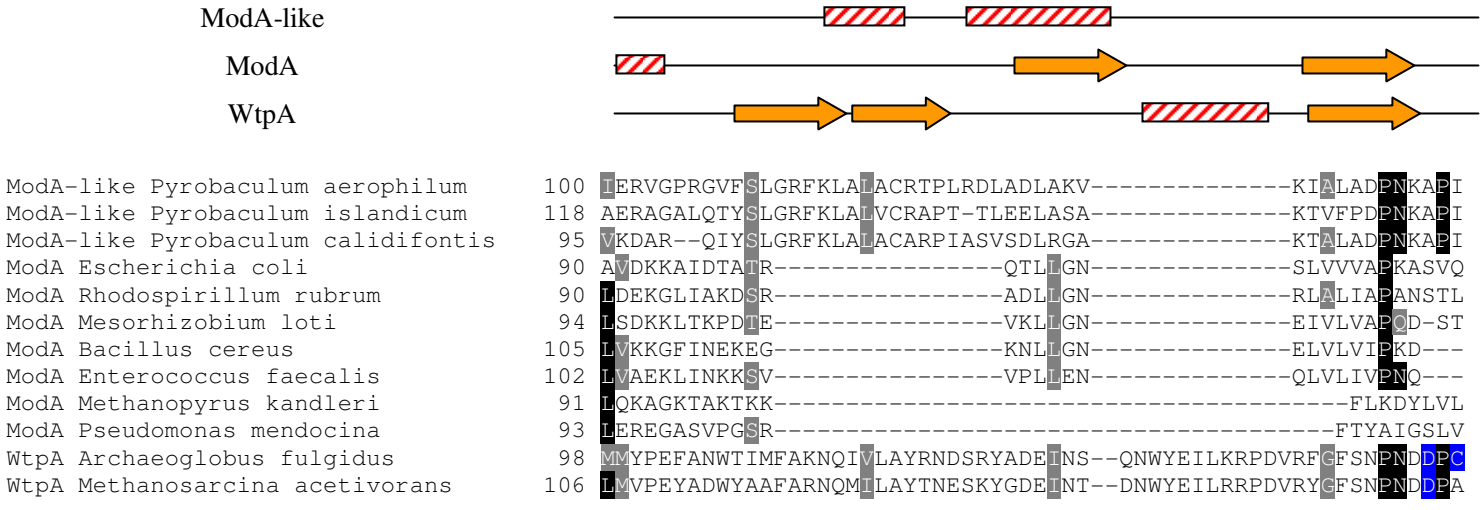

ModA-like Pyrobacul calidifontis
ModA-like Pyrobaculum aerophilum
ModA-like Pyrobaculu islandicum
TupA Pyrobaculum islandicum
TupA Pyrobaculum aerophilum
TupA Hyperthermus butylicus
TupA Methanosarcina mazei
TupA Syntrophomonas wolfei
TupA Anabaena variabilis
TupA Geobacter metallireducens
TupA Campylobacter jejuni
TupA Polynucleobacter sp.
TupA Shewanella amazonensis
TupA Photobacterium profundum
ModA Burkholderia mallei
ModA Methanosarcina barkeri
ModA Methanosarcina acetivorans
ModA Clostridium beijerinckii
ModA Geobacter metallireducens
ModA Photobacterium profundum
ModA Escherichia coli
ModA Shewanella amazonensis
ModA Enterococcus faecalis
ModA Mycobacterium avium
ModA Leeuwenhoekiella blandensis
ModA Helicobacter hepaticus
ModA Aeropyrum pernix
ModA Methanococcus maripaludis
ModA Thermococcus kodakarensis
Sulfate ABC transporter periplasmic protein
Fe3+ ABC transporter periplasmic protein
WtpA Pelobacter carbinolicus
WtpA Candidatus Desulfococcus oleovorans
WtpA Syntrophus aciditrophicus
WtpA Burkholderia vietnamiensis
WtpA Desulfotomaculum reducens
WtpA Methanocaldococcus jannaschii
WtpA Methanosarcina acetivorans
WtpA Methanoculleus marisnigri
WtpA Methanocorpusculum labreanum

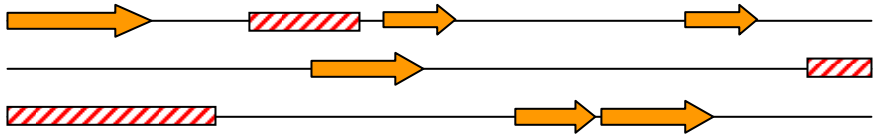
Fig. S2

ModA-like
ModA
WtpA
ModA-like Pyrobaculum aerophilum 1 ---MRMKTALLIVLISALLIVAAWIVAVTQKPASQPR----------AAACV-GD
ModA-like Pyrobaculum islandicum 1 MRRAVLIGALILVTIAFLLQIQQPPQKMQETAATTATPPLKSPEAAAPGATATKACS-GS
ModA-like Pyrobaculum calidifontis 1 -------MSPLAPPPSSATTPAPTSAAVSQTQSSAQA----------AACG-GS
ModA Escherichia coli 1 ----------MARKWLNLFAGAALSFAVAGNALADEG----------KITVFAAAS
ModA Rhodospirillum rubrum 1 ----------MHIGSLRGLLAAGSLALVLAAPAAQAE----------ELTVFAAAS
ModA Mesorhizobium loti 1 ------MTRKGFGLKAIAIGGLAAALMAAMPAAYAQD----------KVVVFAAAS
ModA Bacillus cereus 1 ----------MNKFTLRSIGTLIFSFLLIFSVACTNGDKKEKSTAKEGKTVELTISAAAS
ModA Enterococcus faecalis 1 ----------MSKQKKAVFLLSLFSLVALIAACTNQPQKETVSTKKE---EITLAAAAS
ModA Methanopyrus kandleri 1 ---------MRKVPIAIGILAVVVIAAAAGYYYTSSN----------QLTVFAAAS
ModA Pseudomonas mendocina 1 -------MHERGVFLIKAVQRSLLALLSFAGGVSAG----------EVKVAVAAN
WtpA Archaeoglobus fulgidus 1 ---------MHIGGGVVKIRILILLMLALFLLGCSSN---------VNTNVKLKVFHAGS
WtpA Methanosarcina acetivorans 1 ---------MNVDSRVFRFFLVFLILVVVASPGCVDNQPE-PGNTSAGEGEVLTVFHAGS
WtpA Methanocaldococcus jannaschii 1 ----------MIKRLIVISILLIVGTVLCGCMEQENVGQQNSEAQEKIVLKIFHAGS
WtpA Pyrococcus abyssi 1 ----------MRLGLKIASLAIVFLILGCLGGGET----ETGQKTAKLIIFHAGS
WtpA Syntrophus aciditrophicus 1 ----------MEKSFVKRVFAFFLILAAFAFLSLPQAFAEPKGTVVMFHAGS
WtpA Desulfotomaculum reducens 1 ----------MANNNCSLKIINAGA
WtpA Burkholderia vietnamiensis 1 ----------MGRKLLACCAMLAGVLIAKTSVAYEG----------TVDVLYAGS

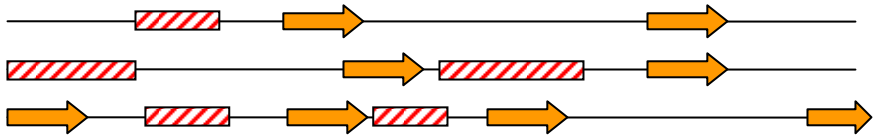

ModA-like
ModA
WtpA
ModA-like Pyrobaculum aerophilum 43 SSFVAPTLIRVIKDAVA--KAGMSTGGIQSVGSVEGL-RKIQAGSRVDLYASVDIELRGD
ModA-like Pyrobaculum islandicum 61 LGYVAPTLVKVVKDAAA--AAGLGTEGIQSVGSVEGL-RRIQGGAKPDLFGSVDIELRPD
ModA-like Pyrobaculum calidifontis 38 IGYVAPTLVRVVKDAAR--EAGLSVEGIQSVGSLEGL-RRIQQGSVPDVYASVDIELAAD
ModA Escherichia coli 37 LTNAMQDIATQFKKEK-----GVDVVSSFA-SSSTLA-RQIEAGAPADLFISADQKWMDY
ModA Rhodospirillum rubrum 37 TTNALTDIIALFNDTG-----AGPAVASFA-SSSTLA-KQIEQGAPAGVFLSADQKWMDY
ModA Mesorhizobium loti 41 LKDALDAVNKACEADV-----GEAATVSYA-ASSALA-KQIEGGAPADVFISADLDWMKY
ModA Bacillus cereus 51 LQDALKEIETKYKEKE----PNIKLSFNFG-ASGALQ-QQIEQGAPADLFFSAAEDKFQT
ModA Enterococcus faecalis 47 LESVMEKKIIPAFEKEH---PDIQVTGTYD-SSGKLQ-MQIEKGLKADVFFSASTKQMNA
ModA Methanopyrus kandleri 38 LKKPLTKLAKQYEKEKG-------VKVALNFGPSGGLTAQILQGQKCDLFFSADWKYVVK
ModA Pseudomonas mendocina 40 FIAPLQAIAPAFEKATG-------HKLVASFGATGQFYAQISNGAPFDVLLAADDTTPAR
WtpA Archaeoglobus fulgidus 43 LTEPMKAFKRAFEEKHP-----NVEVQTEAAGSAATIRKVTELGRKADVIATADYTLIQK
WtpA Methanosarcina acetivorans 51 LSVPFEELEAEFEAQHP-----GVDVQREAAGSAQSVRKITELGKKADVLASADYALIPS
WtpA Methanocaldococcus jannaschii 48 LSVPFEEYEKMFEKEHP-----NVDVEREPAGSVACVRKIIDLGKKADILASADYSLIPQ
WtpA Pyrococcus abyssi 42 LSVPFSQLESEFAKYAEKELGIKVTFQDEASGSVKAVRKVTDLGKKADIVAVADYTLIPQ
WtpA Syntrophus aciditrophicus 43 LTMPFEAMEKEFEARYP-----GVDLQREASGSQAAARKVTDLNKPCDIMASADFKVIDK
WtpA Desulfotomaculum reducens 16 LHRVIGNCIELFLSKNP-----RITLEMEVVGSREGAKRLLSGDK-YDIVALADQALFAE
WtpA Burkholderia vietnamiensi 36 LVNVMERSVGPAFEKDT-----GLRFHGYAAGSNKIANEIKGKLRRGDVFISASPKVNDG


ModA-like
ModA
WtpA
ModA-like Pyrobaculum aerophilum 100 IERVGPRGVFSLGRFKLALACRTPLRDLADLAKV----------KIALADPNKAPI
ModA-like Pyrobaculum islandicum 118 AERAGALQTYSLGRFKLALVCRAPT-TLEELASA----------KTVFPDPNKAPI
ModA-like Pyrobaculum calidifontis 95 VKDAR--QIYSLGRFKLALACARPIASVSDLRGA----------KTALADPNKAPI
ModA Escherichia coli 90 AVDKKAIDTATR----------QTLLGN----------SLVVVAPKASVQ
ModA Rhodospirillum rubrum 90 LDEKGLIAKDSR----------ADLLGN----------RLALIAPANSTL
ModA Mesorhizobium loti 94 LSDKKLTKPDTE----------VKLLGN----------EIVLVAPQD-ST
ModA Bacillus cereus 105 LVKKGFINEKEG----------KNLLGN----------ELVLVIPKD---
ModA Enterococcus faecalis 102 LVAEKLINKKSV----------VPLLEN----------QLVLIVPNQ---
ModA Methanopyrus kandleri 91 LQKAGKTAKTKK----------FLKDYLVL
ModA Pseudomonas mendocina 93 LEREGASVPGSR----------FTYAIGSLV
WtpA Archaeoglobus fulgidus 98 MMYPEFANWTIMFAKNQIVLAYRNDSRYADEINS--QNWYEILKRPDVRFGFSNPNDDPC
WtpA Methanosarcina acetivorans 106 LMVPEYADWYAAFARNQMILAYTNESKYGDEINT--DNWYEILRRPDVRYGFSNPNDDPA

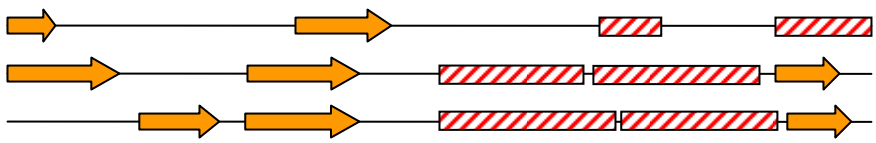
```
WtpA Methanocaldococcus jannaschii   103 MMMPKYADWYVMFARNEIVLAYTDKSKYKDEINS--TNWYKILQRPDVKIGFSNPNDDPC
WtpA Pyrococcus abyssi               102 LMVPNYTDFYVLFATNEIVIAFTEKSKYADEMLKNPDKWYEILAREDVSFGFSDPNQDPC
WtpA Syntrophus aciditrophicus        98 LLIPKHADWNIRFATNELVLCYTDKSKFAKEVNA--KNWYNILQRKGVVWGHSDPNLDPC
WtpA Desulfotomaculum reducens        70 LLVPEQVDNYFVFATDQIVIGYDRFSKGSKEIRP--ENWADILLQPEVRFARSDHNLDPC
WtpA Burkholderia vietnamiensi        91 LMGAANGDHVTWYVN-------------------------------------FAESPLLIGY
```




```
ModA-like Pyrobaculum aerophilum     146 GYRELAVSWWLQRDYGINLTARYKALGVGFYYNGT-L----------TITVPSALPNTNI
ModA-like Pyrobaculum islandicum     163 GYRELAAAWMLSRDLGVNLTAKYTALGVRFVYNGT-L----------YVYIPSSLPNTEA
ModA-like Pyrobaculum calidifontis   139 GYRELAVAYMLKKGGVADLTARYEALGIRFVDTAVGF----------NVTVPTALFSTAE
ModA Escherichia coli                120 KDFTIDSKTNWTSL----LNGGRLAVGD-----------------------PEHVPAGIY
ModA Rhodospirillum rubrum           120 KVAEVSSKTDFPAL----LGEGRLAVGD-----------------------PDHVPVGIY
ModA Mesorhizobium loti              123 VETKIEKGFDLAKL----VGDGKLAMGD-----------------------FKAVPAGKY
ModA Bacillus cereus                 132 ---SSLTKFQDLKD----EKIKKIALGT-----------------------PESVPAGKY
ModA Enterococcus faecalis           129 ---DQAKWHDFSDL----KKAQMIAIGD-----------------------PASVPAGQY
ModA Methanopyrus kandleri           111 VVSKTGEKKGIKSVKDITKPGVTVAVAD-----------------------PKAPVGEY
ModA Pseudomonas mendocina           114 LWSADAAYLDGTDAALQAGQFRHLAIAN-----------------------PKAAPYGLA
WtpA Archaeoglobus fulgidus          156 GYRSLMAIQLAELYYNDPTIFDELVAK---NSNLRFS-EDNGSYVLRMPSSERIEINKSK
WtpA Methanosarcina acetivorans      164 GYRSQMVTQLAESYYNDDMIYDDLMLA---NTGMTLTTEENGTALIHVPASEEISPNTSK
WtpA Methanocaldococcus jannaschii   161 GYRTQMVLQLAELYYKDPTIYDNLVLK---HSNIKVE-ENNGTYLILVP--KELDVDTNK
WtpA Pyrococcus abyssi               162 GYRSVMVMKLADLYYGKP-IFETLVEK---TTNIYAN-------GTHIYAPKEIIVKDKR
WtpA Syntrophus aciditrophicus       156 GYRALMVLQLAEKYYKKPGLYEKILANRPVENIR--------------------------
WtpA Desulfotomaculum reducens       128 GYRALMVWQLAEKFYNRPGLSNELEKACIPYTTY--------------------------
WtpA Burkholderia vietnamiensis      116 NSRSHFAGEFKSKRWDQVLREPGIRIGR----------------------TDPKLDPKGAF
```

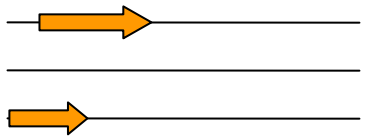



```
ModA-like Pyrobaculum aerophilum     195 TDIAPSLDGAWTKLEIGAVDCVYAYVPFLVNKHLSLKPHGEETGYWTAYIGEAPGGKAVY
ModA-like Pyrobaculum islandicum     212 VDVAPNLDGSWAKFEAGAGRCMFAYVPFLLGKGLQLRPAGGGTSYWEPYTAEAGG-RTYY
ModA-like Pyrobaculum calidifontis   189 VKVAPSLDGSWSMFETGQVDCVFAYLPFILGKGVELKPAGASAELWEVYVGDYGR-GQFY
ModA Escherichia coli                153 AKEALQKLGAWDTLSP-------KLAPAEDVRGALALVERNEAPLGIVYGSDAVASKGVK
ModA Rhodospirillum rubrum           153 TKEAFTKLGLWDGVAN-------KLAPANDVRGALTFVERGESPLGVVYSTDSAVSEKVK
ModA Mesorhizobium loti              156 GKAALESLGVWSSVEG-------KVAQAENVRAALKLVSTGEAALGIVYATDAHADKGVK
ModA Bacillus cereus                 162 AKASLTHENLWNDVQN-------KFVFTKDVRQVLTYVETGNVDAGIVYKTDALISEKVK
ModA Enterococcus faecalis           159 AEEGLKALGAWSYVEK-------HASFGTNVTEVLEWVANASAEAGLVYATDAATNSKVA
ModA Methanopyrus kandleri           147 TQRALEKLGIWDKIVKNGN----LKARPGTVNQVATMVKNDQIDAGFVYRS-VAVGFGLP
ModA Pseudomonas mendocina           151 AMQVLDKLGLSEAVKG-------KLVEGQNITQAHQFVSTGNAELGFVALSQVYQDGKLG
WtpA Archaeoglobus fulgidus          212 IMIRSMEMELIHLVESGELDYFFIYKSVAKQHGFNFVELPVEIDLSSPDYAELYSKVKVV
WtpA Methanosarcina acetivorans      221 IMLRSMEVELSSALETGEIDYLYIYRSVAEQHGFEYVALPPAIDLSSLEYADNYSKVQVE
WtpA Methanocaldococcus jannaschii   215 LFVRSKETDLLAPLEAGAFDYLFIYKSVANQHHLKYIELPKEINLGYYEYADTYKKVALK
WtpA Pyrococcus abyssi               211 VVIRPKETDLVGLVESGSLDYFFIYKSVAEQHNLKYITLPNEINLKDFSKADFYKKVSIT
WtpA Syntrophus aciditrophicus       190 ----PKSVELVSLLQTGNMDYAWEYRSVAVQHNLKYVSLPDKINLGNYKEDPYYSQAVVK
WtpA Desulfotomaculum reducens       162 ----PKSMDLAGALLEGKVDYAFLYSSEAKQLGFPYINLPSKINLSNPAHADYYDQASIS
WtpA Burkholderia vietnamiensis      155 TVDMMKKAADFYHQPDLVEKTLGAPENPEQVLPEETLVGRLQSGQLDAGFFYSTETSDLK
```




```
ModA-like Pyrobaculum aerophilum     255 VYVFKP---PYDFLNDPPMPVRVVLLDPSGKPAKIINVGHFEAFVASFTEKGDCVLEALK
ModA-like Pyrobaculum islandicum     271 VYVFKP---PYDFAEDPPIKAVAVLLGP---PVKTIRVGHFEAFVASYTELGNCVIESLK
ModA-like Pyrobaculum calidifontis   248 VYVFKP---PYDFFQDPPLAIYVNFVDPSGRVVRAVRVGRFEAFVASFTERGDCVVEALK
ModA Escherichia coli                206 VVATFP---EDS-HKKVEYPVAVVEGHNN-ATVKAFYDYLKGPQAAEIFKRYGFTIK---
ModA Rhodospirillum rubrum           206 TLALLP---ESS-HKPVTYPVATVKAKDT-KTARAFVDFLKGAKAKAVFERYGFQVKP--
ModA Mesorhizobium loti              209 VVGTFP---EDS-HPPIIYPVAQTADSKD-KDTTAFLKCLQSAKAGALFKEQGFTVLTPS
ModA Bacillus cereus                 215 IG-ETA---AATSHEPIHYPLGVIKESKHKKEATSFYEYLQSKDAQSIFKKYGFTVLS--
```

```
ModA Enterococcus faecalis          212 IVAAMP---EAVLKKPIIYPVGKVAASKKQKSADAFLNFLQSQQCRKYFENIGFKLTK--
ModA Methanopyrus kandleri          202 IVQMFP----HSLTGPIIWGAAVIKGGNE-QLAEDFLNYCLEHIDEFKKYGWSPA-----
ModA Pseudomonas mendocina          204 SGSAWIVP--EAMYEPIRQDAVILRQGAGNPAAAALVEYLQGAEAARVIESFGYKLP---
WtpA Archaeoglobus fulgidus         272 LANG-----KEVTGKPIVYGITIPKNAENRELAVEFVKLVISEEGQEILR-ELGQEPLVP
WtpA Methanosarcina acetivorans     281 MVNG-----EVVTGSPIVYGVTIPNNAENSELATEFVALLLGETGQQIFI-ENGQPPIVP
WtpA Methanocaldococcus jannaschii  275 IIAKN----KTINAKPIVYGMTVPTNAPHKKEAIEFVKFVLG--HPEVLE-NNGQPAIIP
WtpA Pyrococcus abyssi              271 LGSTG----KTIYAKPIVYGITVLKDAPNRELALEFLKFLLSEKGKEIFR-ENHQDFLTP
WtpA Syntrophus aciditrophicus      246 VTGKKPGEYMEMKGASTTYGITLIKNAPNQEAAVAFLEYMLNPKGGLKILKDQGQPPFIP
WtpA Desulfotomaculum reducens      218 VESKIPGKNIIIHGKPIEFAVGLVKTTQNPELAQAFIDLLAGPEG-HAILEECG---LIP
WtpA Burkholderia vietnamiensis     215 IPAVRP---APELQAKARYTLTILGDAPNPAGAARFVDFLLSAKGRALLKEHGVDVVKPT
```




```
ModA-like Pyrobaculum aerophilum    312 NMNLTAYGFVK-------------
ModA-like Pyrobaculum islandicum    325 KMDLSKYGFI--------------
ModA-like Pyrobaculum calidifontis  305 KMDLAKYGFVK-------------
ModA Escherichia coli                   ------------------------
ModA Rhodospirillum rubrum              ------------------------
ModA Mesorhizobium loti             264 N-----------------------
ModA Bacillus cereus                    ------------------------
ModA Enterococcus faecalis              ------------------------
ModA Methanopyrus kandleri              ------------------------
ModA Pseudomonas mendocina              ------------------------
WtpA Archaeoglobus fulgidus         326 PRADTAVPSLKAMVEVS-------
WtpA Methanosarcina acetivorans     335 AIAEGKDSMPEELQALVV------
WtpA Methanocaldococcus jannaschii  328 AVAYGNVPEELKDLVKIEK-----
WtpA Pyrococcus abyssi              326 PVAFGNVPEEIKGLVEIKE-----
WtpA Syntrophus aciditrophicus      306 CRVPTQKMKSTLPEKLQKLVEVKD
WtpA Desulfotomaculum reducens      274 C-----------------------
WtpA Burkholderia vietnamiensis     272 VAGNAQAVPPSLQAVIDAAQ----
```

Fig. S3

```
ModA-like Pyrobaculum calidifontis    1 MSPLAPPPSSATTPAPTSAAVSQTQSSAQ----------------------------AA
ModA-like Pyrobaculum aerophilum      1 -MRMKTALLIVLISALLIVAAWIVAVTQKPA-----------------------SQPRAA
ModA-like Pyrobaculum islandicum      1 ------MRRAVLIGALILVTIAFLLQIQQPPQKMQETAATTATPPLKSPEAAAPGATATK
ModA Methanopyrus kandleri            1 -----MRKVPIAIGILAVVVIAAAAGY-------------------------------YY
ModA Mesorhizobium loti               1 MTRKGFGLKAIAIGGLAAALMAAMP---------------------------------AA
ModA Escherichia coli                 1 --MARKWLNLFAGAALSFAV-----------------------------------AGNAL
ModA Rhodospirillum rubrum            1 -MHIGSLRGLLAAGSLALVL-----------------------------------AAPA
ModA Bacillus cereus                  1 --MNKFTLRSIGTLIFSFLL-IFSVACTNGD--------------------KKEKSTAKE
ModA Enterococcus faecalis            1 ---MSKQKKAVFLLSLFSLV-ALIAACTNQP-----------------------QKETVS
ModA Pseudomonas mendocina            1 MHERGVFLIKAVQRSLLALALSFA----------------------------------GG
WtpA Burkholderia vietnamiensis       1 MGRKLLACCAMLAGVLIAKT--------------------------------------SV
WtpA Desulfotomaculum reducens        1 ------------------------------------------------------------MA
WtpA Syntrophus aciditrophicus        1 --MEKSFVKRVFAFFLILAAFAFLSLPQA----------------------------FA
WtpA Archaeoglobus fulgidus           1 -MHIGGGVVKIRILILLMLA-LFLLGCSS----------------------------NV
WtpA Methanosarcina acetivorans       1 -MNVDSRVFRFFLVFLILVV-VASPGCVDNQ--------------------PEPGNTSAG
WtpA Pyrococcus abyssi                1 ------MRLGLKIASLAIVF--LILGCLG-----------------------GGETETG
WtpA Methanocaldococcus jannaschii    1 ------MIKRLIVISILLIVGTVLCGCMEQE--------------------NVGQQNSEA

ModA-like Pyrobaculum calidifontis   32 ACGGSVIGYVAPTLVRVV-KDAAREA----------GLSVEGIQSVGSLEGLRRIQQ-GS
ModA-like Pyrobaculum aerophilum     37 ACVGDVSSFVAPTLIRVIKDAVAKA----------GMSTGGIQSVGSVEGLRKIQA-GS
ModA-like Pyrobaculum islandicum     55 ACSGSPLGYVAPTLVKVV-KDAAAAA----------GLGTEGIQSVGSVEGLRRIQG-GA
ModA Methanopyrus kandleri           25 TSSNQLTVFAAASLKKPL-TKLAKQYEKEK------GVKVAL-NFGPSGGLTAQILQ-GQ
ModA Mesorhizobium loti              28 YAQDKVVVFAAASLKDAL-DAVNKACEADV------GEAATV-SYAASSALAKQIEG-GA
ModA Escherichia coli                24 ADEGKITVFAAASLTNAM-QDIATQFKKEK------GVDVVS-SFASSSTLARQIEA-GA
ModA Rhodospirillum rubrum           24 AQAEELTVFAAASTTNAL-TDIIALFNDT-------GAGPAVASFASSSTLAKQIEQ-GA
ModA Bacillus cereus                 38 GKTVELTISAAASLQDAL-KEIETKYKEKEP-----NIKLSF-NFGASGALQQQIEQ-GA
ModA Enterococcus faecalis           34 TKKEEITLAAAASLESVMEKKIIPAFEKEHP-----DIQVTG-TYDSSGKLQMQIEK-GL
ModA Pseudomonas mendocina           27 VSAGEVKVAVAANFTAPL-QAIAPAFEKAT------GHKLVA-SFGATGQFYAQISN-GA
WtpA Burkholderia vietnamiensis      23 AYEGTVDVLYAGSLVNVMERSVGPAFEKDT------GLRFHG-YAAGSNKIANEIKGKLR
WtpA Desulfotomaculum reducens        3 NNNCSLKIINAGALHRVI-GNCIELFLSKNP-----RITLEM-EVVGSREGAKRLLS-GD
WtpA Syntrophus aciditrophicus       30 EPKGTVVMFHAGSLTMPF-EAMEKEFEARYP-----GVDLQR-EASGSQAAARKVTDLNK
WtpA Archaeoglobus fulgidus          30 NTNVKLKVFHAGSLTEPM-KAFKRAFEEKHP-----NVEVQT-EAAGSAATIRKVTELGR
WtpA Methanosarcina acetivorans      39 -EGEVLTVFHAGSLSVPF-EELEAEFEAQHP-----GVDVQR-EAAGSAQSVRKITELGK
WtpA Pyrococcus abyssi               29 QKTAKLIIFHAGSLSVPF-SQLESEFAKYAEKELGIKVTFQD-EASGSVKAVRKVTDLGK
WtpA Methanocaldococcus jannaschii   35 QEKIVLKIFHAGSLSVPF-EEYEKMFEKEHP-----NVDVER-EPAGSVACVRKIIDLGK

ModA-like Pyrobaculum calidifontis   80 VPDVYASVDIELAADVK--------DARQIYSLGRFKLALACARPIA-----------SV
ModA-like Pyrobaculum aerophilum     85 RVDLYASVDIELRGDI------ERVGPRGVFSLGRFKLALACRTPLRDLA--------DL
ModA-like Pyrobaculum islandicum    103 KPDLFGSVDIELRPDA------ERAGALQTYSLGRFKLALVCRAP------------TTL
ModA Methanopyrus kandleri           76 KCDLFFSADWKYVVKLQ-KA--GKTAKTKKFLKDYLVLVVSKTGEKKGIK-----SVKDI
ModA Mesorhizobium loti              79 PADVFISADLDWMKYLS-DKKLTKPDTEVKLLGNEIVLVAPQDSTVETKI----EKGFDL
ModA Escherichia coli                75 PADLFISADQKWMDYAV-DKKAIDTATRQTLLGNSLVVVAPKASVQKDFTIDSKTNWTSL
ModA Rhodospirillum rubrum           75 PAGVFLSADQKWMDYLD-EKGLIAKDSRADLLGNRLALIAPANSTLKVAEVSSKTDFPAL
ModA Bacillus cereus                 90 PADLFFSAAEDKFQTLV-KKGFINEKEGKNLLGNELVLVIPKDSSLTKFQ--------DL
ModA Enterococcus faecalis           87 KADVFFSASTKQMNALV-AEKLINKKSVVPLLENQLVLIVPNQ---------DQAKWHDF
ModA Pseudomonas mendocina           78 PFDVLLAADDTTPARLE-REGASVPGSRFTYAIGSLVLWSADAAYLDGTD--------AA
WtpA Burkholderia vietnamiensis      76 RGDVFISASPKVNDGLMGAANGDHVTWYVNFAESPLLIGYNSRSHFAGEF--KSKRWDQV
WtpA Desulfotomaculum reducens       55 KYDIVALADQALFAELL-VP--EQVDNYFVFATDQIVIGYDRFSKGSKEI--RPENWADI
WtpA Syntrophus aciditrophicus       83 PCDIMASADFKVIDKLL-IP--KHADWNIRFATNELVLCYTDKSKFAKEV--NAKNWYNI
WtpA Archaeoglobus fulgidus          83 KADVIATADYTLIQKMM-YP--EFANWTIMFAKNQIVLAYRNDSRYADEI--NSQNWYEI
WtpA Methanosarcina acetivorans      91 KADVLASADYALIPSLM-VP--EYADWYAAFARNQMILAYTNESKYGDEI--NTDNWYEI
WtpA Pyrococcus abyssi               87 KADIVAVADYTLIPQLM-VP--NYTDFYVLFATNEIVIAFTEKSKYADEMLKNPDKWYEI
WtpA Methanocaldococcus jannaschii   88 KADILASADYSLIPQMM-MP--KYADWYVMFARNEIVLAYTDKSKYKDEI--NSTNWYKI

ModA-like Pyrobaculum calidifontis  121 SD-LRGAKTALADPNKAPIGYR-----ELAVAYMLKKGGVADLTARYEALGIRFVDTAVG
ModA-like Pyrobaculum aerophilum    131 AK----VKIALADPNKAPIGYR-----ELAVSWWLQRDYGINLTARYKALGVGFYYNGTL
ModA-like Pyrobaculum islandicum    145 EE-LASAKTVFPDPNKAPIGYR-----ELAAAWMLSRDLGVNLTAKYTALGVRFVYNGTL
ModA Methanopyrus kandleri          128 TK--PGVTVAVADPKA-PVGEYTQRALEKLGIW---------------------------
ModA Mesorhizobium loti             134 AKLVGDGKLAMGDFKAVPAGKYGKAALESLGVW---------------------------
ModA Escherichia coli               134 LN---GGRLAVGDPEHVPAGIYAKEALQKLGAW---------------------------
ModA Rhodospirillum rubrum          134 LG---EGRLAVGDPDHVPVGIYTKEAFTKLGLW---------------------------
ModA Bacillus cereus                141 KD-EKIKKIALGTPESVPAGKYAKASLTHENLW---------------------------
ModA Enterococcus faecalis          137 SDLKKAQMIAIGDPASVPAGQYAEEGLKALGAW---------------------------
ModA Pseudomonas mendocina          129 LQAGQFRHLAIANPKAAPYGLAAMQVLDKLGLS---------------------------
WtpA Burkholderia vietnamiensis     134 LR-EPGIRIGRTDPKLDPKGAFTVDMMKKAADFYHQPDLVE-------------------
WtpA Desulfotomaculum reducens      110 LL-QPEVRFARSDHNLDPCGYRALMVWQLAEKFYNRPGLS--------------------
```

```
WtpA Syntrophus aciditrophicus        138 LQ-RKGVVWGHSDPNLDPCGYRALMVLQLAEKYYKKPGLY--------------------
WtpA Archaeoglobus fulgidus           138 LK-RPDVRFGFSNPNDDPCGYRSLMAIQLAELYYNDPTIFDELVAKNSNLRF-SEDNGSY
WtpA Methanosarcina acetivorans       146 LR-RPDVRYGFSNPNDDPAGYRSQMVTQLAESYYNDDMIYDDLMLANTGMTLTTEENGTA
WtpA Pyrococcus abyssi                144 LA-REDVSFGFSDPNQDPCGYRSVMVMKLADLYYGKP-IFETLVEKTTNIYA----NGTH
WtpA Methanocaldococcus jannaschii    143 LQ-RPDVKIGFSNPNDDPCGYRTQMVLQLAELYYKDPTIYDNLVLKHSNIKV-EENNGTY

ModA-like Pyrobaculum calidifontis    175 FNVTV--PTALFSTAEVKVAPSLDGSWSMFEIGQVDCVFAYLP-FILGKGVELKP--AGA
ModA-like Pyrobaculum aerophilum      182 TITV---PSALPNTNITDIAPSLDGAWTKLEIGAVDCVYAYVP-FLVNKHLSLKP--HGE
ModA-like Pyrobaculum islandicum      199 YVYI---PSSLPNTEAVDVAPNLDGSWAKFEAGAGRCMFAYVP-FLLGKGLQLRP--AGG
ModA Methanopyrus kandleri            158 -------DKIVKNGNLKARPGTVNQVATMVKNDQIDAGFVYRS-VAVGFGLPIVQ--MFP
ModA Mesorhizobium loti               167 -------SSVEGK---VAQAENVRAALKLVSIGEAALGIVYATDAHADKGVKVVG--TFP
ModA Escherichia coli                 164 -------DTLSPK---LAPAEDVRGALALVERNEAPLGIVYGSDAVASKGVKVVA--TFP
ModA Rhodospirillum rubrum            164 -------DGVANK---LAPANDVRGALTFVERGESPLGVVYSTDSAVSEKVKTLA--LLP
ModA Bacillus cereus                  173 -------NDVQNK---FVFTKDVRQVLTYVEIGNVDAGIVYKTDALISEKVKIGE--TAA
ModA Enterococcus faecalis            170 -------SYVEKH---ASFGTNVTEVLEWVANASAEAGLVYATDAATNSKVAIVA--AMP
ModA Pseudomonas mendocina            162 -------EAVKGK---LVEGQNITQAHQFVSIGNAELGFVALSQVYQDGKLGSGSAWIVP
WtpA Burkholderia vietnamiensis       174 -------KTLGAPENPEQVLPEET-LVGRLQSGQLDAGFFYST-ETSDLKIPAVR--PAP
WtpA Desulfotomaculum reducens        149 -------NELEKACIPYTTYPKSMDLAGALLEGKVDYAFLYSS-EAKQLGFPYIN--LPS
WtpA Syntrophus aciditrophicus        177 -------EKILANRPVENIRPKSVELVSLLQIGNMDYAWEYRS-VAVQHNLKYVS--LPD
WtpA Archaeoglobus fulgidus           196 VLRMPSSERIEINKSKIMIRSMEMELIHLVESGELDYFFIYKS-VAKQHGFNFVE--LPV
WtpA Methanosarcina acetivorans       205 LIHVPASEEISPNTSKIMLRSMEVELSSALEIGEIDYLYIYRS-VAEQHGFEYVA--LPP
WtpA Pyrococcus abyssi                198 -IYAP--KEIIVKDKRVVIRPKETDLVGLVESGSLDYFFIYKS-VAEQHNLKYIT--LPN
WtpA Methanocaldococcus jannaschii    201 LILVP--KELDVDTNKLFVRSKETDLLAPLEAGAFDYLFIYKS-VANQHHLKYIE--LPK

ModA-like Pyrobaculum calidifontis    230 SAELWEVYVGDY-GRGQFYVYVFKPPYDFFQDPPLAIYVNFVDPSGRVVRAVRVGRFEAF
ModA-like Pyrobaculum aerophilum      236 ETGYWTAYIGEAPGGKAVYVYVFKPPYDFLNDPPMPVRVVLLDPSGKPAKIINVGHFEAF
ModA-like Pyrobaculum islandicum      253 GTSYWEPYTAEA-GGRTYYVYVFKPPYDFAEDPPIKAVAVLLGP---PVKTIRVGHFEAF
ModA Methanopyrus kandleri            208 H---------------------------------------SLTGPIIWGAAVIK-GGNEQL
ModA Mesorhizobium loti               215 E---------------------------------------DSHPPIIYPVAQTADSKDKD-
ModA Escherichia coli                 212 E---------------------------------------DSHKKVEYPVAVVE-GHNNAT
ModA Rhodospirillum rubrum            212 E---------------------------------------SSHKPVTYPVATVK-AKDTKT
ModA Bacillus cereus                  221 A---------------------------------------TSHEPIHYPLGVIKESKHKKE
ModA Enterococcus faecalis            218 E-------------------------------------AVLKKPIIYPVGKVAASKKQKS
ModA Pseudomonas mendocina            212 E-------------------------------------AMYEPIRQDAVILRQGAGNPA
WtpA Burkholderia vietnamiensis       223 E-----------------------------------------LQAKARYTLTILGDAPNPAG
WtpA Desulfotomaculum reducens        199 KINL---------SNPAHADYYDQASISVESKIPGKNIIIHGKPIEFAVGLVKTTQNPEL
WtpA Syntrophus aciditrophicus        227 KINL---------GNYKEDPYYSQAVVKVTGKKPGEYMEMKGASTTYGITLIKNAPNQEA
WtpA Archaeoglobus fulgidus           253 EIDL---------SSPDYAELYSKVKVVLANGK-----EVTGKPIVYGITIPKNAENREL
WtpA Methanosarcina acetivorans       262 AIDL---------SSLEYADNYSKVQVEMVNGE-----VVTGSPIVYGVTIPNNAENSEL
WtpA Pyrococcus abyssi                252 EINL---------KDFSKADFYKKVSITLGSTGK----TIYAKPIVYGITVLKDAPNREL
WtpA Methanocaldococcus jannaschii    256 EINL---------GYYEYADTYKKVALKIIAKNK----TINAKPIVYGMTVPTNAPHKKE

ModA-like Pyrobaculum calidifontis    289 VASFTERGDCVVEALKK-MDLAKYGFVK---------------------------
ModA-like Pyrobaculum aerophilum      296 VASFTEKGDCVLEALKN-MNLTAYGFVK---------------------------
ModA-like Pyrobaculum islandicum      309 VASYTELGNCVIESLKK-MDLSKYGFI----------------------------
ModA Methanopyrus kandleri            229 AEDFL---NYCLEHIDE---FKKYGWSPA---------------------------
ModA Mesorhizobium loti               236 TTAFL---KCLQSAKAG-ALFKEQGFTVLTPSN-----------------------
ModA Escherichia coli                 233 VKAFY---DYLKGPQAA-EIFKRYGFTIK---------------------------
ModA Rhodospirillum rubrum            233 ARAFV---DFLKGAKAK-AVFERYGFQVKP--------------------------
ModA Bacillus cereus                  243 ATSFY---EYLQSKDAQ-SIFKKYGFTVLS---------------------------
ModA Enterococcus faecalis            241 ADAFL---NFLQSQQCR-KYFENIGFKLTK--------------------------
ModA Pseudomonas mendocina            234 AAALV---EYLQGAEAA-RVIESFGYKLP---------------------------
WtpA Burkholderia vietnamiensis       244 AARFV---DFLLSAKGR-ALLKEHGVDVVKP---TVAGNAQAVPPSLQAVIDAAQ
WtpA Desulfotomaculum reducens        250 AQAFI---DLLAGPEGH-AILEECGLIPC----------------------------
WtpA Syntrophus aciditrophicus        278 AVAFL---EYMLNPKGGLKILKDQGQPPFIPCRVPTQKMKSTLPEKLQKLVEVKD
WtpA Archaeoglobus fulgidus           299 AVEFV---KLVISEEGQ-EILRELGQEPLVP---PRA---DTAVPSLKAMVEVS-
WtpA Methanosarcina acetivorans       308 ATEFV---ALLLGETGQ-QIFIENGQPPIVP---AIAEGKDSMPEELQALVV---
WtpA Pyrococcus abyssi                299 ALEFL---KFLLSEKGK-EIFRENHQDFLTP---PVA--FGNVPEEIKGLVEIKE
WtpA Methanocaldococcus jannaschii    303 AIEFV---KFVLGH--P-EVLENNGQPAIIP---AVA--YGNVPEELKDLVKIEK
```