

Supplementary Material

Table S1. Bacterial strains containing homologs of *R. etli* CE3 WreQ, WreU and WreV.

WreQ (YP_470339.1), WreU (YP_471772.1), WreV (YP_471773.1) were used individually as the query sequences in BLAST searches against the non-redundant protein sequence (nr) database using the blastp algorithm. In the first WreQ and WreU BLAST searches, Rhizobiaceae were excluded (to eliminate the very high number of *Rhizobium* and closely affiliated rhizobial strains) and the max target sequences were 1000 and 5000 respectively. All saved strains from that search had WreU homologs with E-values of less than $1e^{-30}$; the WreQ homologs of these strains had E-values less than $1e^{-89}$. In the WreV BLAST search, initially the strategy was the same as with WreQ, and all the resulting sequences had an E-value of 0.0. However, the majority of sequences belonged to Pseudomonadaceae. Thus, a separate blast was performed to exclude Pseudomonadaceae as well, and with 5000 max target sequences, resulting in E-values less than $2e^{-127}$. Finally a search of only “Alpha-Proteobacteriaceae” was conducted and species, rather than strains, with homologs to all three genes were saved. In this final table, strains containing the three gene homologs are listed, with the accession numbers of the protein homologs. The E-values are less than $1e^{-50}$, $1e^{-30}$, and $4e^{-70}$ for matches with WreQ, WreU, and WreV, respectively. Where a strain number is not provided, it can be found through the gene accession numbers. The Phylo column indicates the phylogenetic affiliation of the strain within the domain Bacteria: FCB refers to the super-phylum FCB within the Bacteria; Alpha, Beta, Gamma, Delta, and Zeta refer to the sub-phyla within the Proteobacteria.

Strain	WreQ accession	WreU accession	WreV accession	Phylo
<i>Chlorobium phaeobacteroides</i>	WP_015961134.1	WP_041467797.1	WP_015961150.1	FCB
<i>Pelodictyon phaeoclathratiforme</i>	WP_012507375.1	WP_012507376.1	WP_012507339.1	FCB
<i>Agrobacterium rhizogenes</i>	WP_034519680.1	WP_034519733.1	WP_034514206.1	Alpha
<i>Aureimonas altamirensis</i>	WP_060606375.1	WP_060601527.1	WP_039195620.1	Alpha
<i>Aureimonas frigidaquae</i>	WP_062227553.1	WP_062227554.1	WP_062227987.1	Alpha
<i>Azospirillum brasilense</i>	WP_035680550.1	WP_014198799.1	WP_014240519.1	Alpha
<i>Bradyrhizobium</i>	WP_027564699.1	WP_028141810.1	WP_027564879.1	Alpha
<i>Bradyrhizobium canariense</i>	WP_085348811.1	WP_085384688.1	WP_085394538.1	Alpha
<i>Bradyrhizobium erythrophlei</i>	WP_079604300.1	WP_074274213.1	WP_092115479.1	Alpha
<i>Candidatus Pelagibacter ubique</i>	WP_029454191.1	WP_075521062.1	WP_029454193.1	Alpha
<i>Mesorhizobium alhagi</i>	WP_085984070.1	WP_008835798.1	WP_008835795.1	Alpha
<i>Methylobacterium extorquens</i>	WP_076643959.1	WP_015822390.1	WP_076643956.1	Alpha
<i>Pseudoceanicola nitratireducens</i>	WP_093454891.1	WP_093454896.1	WP_093447298.1	Alpha
<i>Rhizobiales bacterium 63-7</i>	OJU66100.1	OJU71699.1	OJU71698.1	Alpha
<i>Rhizobium acidisoli</i>	WP_054182687.1	WP_054185004.1	WP_054185003.1	Alpha
<i>Rhizobium aegyptiacum</i>	WP_064694690.1	WP_064696812.1	WP_064696703.1	Alpha
<i>Rhizobium aethiopicum</i>	WP_092748744.1	SCB62257.1	SCB58533.1	Alpha
<i>Rhizobium alamii</i>	WP_037099615.1	WP_051942476.1	WP_051942478.1	Alpha
<i>Rhizobium bangladeshense</i>	WP_064705588.1	WP_064712006.1	WP_064710004.1	Alpha
<i>Rhizobium etli</i>	WP_011426089.1	WP_011427467.1	WP_011427468.1	Alpha
<i>Rhizobium favelukesii</i>	WP_024317389.1	WP_024314414.1	WP_024317388.1	Alpha

Rhizobium freirei	WP_004127129.1	WP_037155461.1	WP_004126244.1	Alpha
Rhizobium gallicum	WP_018446548.1	WP_026230627.1	WP_083636055.1	Alpha
Rhizobium hainanense	WP_075853437.1	SCB21882.1	WP_075856697.1	Alpha
Rhizobium laguerreae	WP_077978790.1	WP_077979743.1	WP_077979742.1	Alpha
Rhizobium leguminosarum	WP_037140272.1	WP_027687178.1	WP_027687179.1	Alpha
Rhizobium marinum	WP_029621142.1	WP_029618564.1	WP_081852123.1	Alpha
Rhizobium mesoamericanum	WP_040678303.1	WP_007537568.1	WP_028745825.1	Alpha
Rhizobium miluonense	WP_092851701.1	SCB34436.1	WP_092843462.1	Alpha
Rhizobium multihospitium	WP_092720446.1	WP_092720448.1	WP_092714704.1	Alpha
Rhizobium phaseoli	WP_064818631.1	WP_085744233.1	WP_064837511.1	Alpha
Rhizobium tibeticum	WP_072375736.1	WP_072373828.1	WP_072375735.1	Alpha
Rhizobium tropici	WP_015341683.1	WP_015341684.1	WP_015338445.1	Alpha
Rhizobium/Agrobacterium group	WP_007694703.1	WP_007694702.1	WP_047524929.1	Alpha
Rhodopseudomonas palustris	WP_041798076.1	WP_080506310.1	WP_080674905.1	Alpha
Sphingopyxis macrogoltabida	WP_054589353.1	WP_054590413.1	WP_082396031.1	Alpha
Acidovorax soli	SEA14343.1	SEA14367.1	SEA14422.1	Beta
Acidovorax wautersii	WP_092939072.1	WP_092939071.1	WP_092939238.1	Beta
Burkholderia sp. 9120	WP_035552665.1	WP_035552664.1	WP_035552662.1	Beta
Burkholderiales bacterium RIFCSPLOWO2_12_FULL_61_40	OGB28531.1	OGB28530.1	OGB28529.1	Beta
Candidatus Accumulibacter sp. 66-26	OJW49362.1	OJW49363.1	OJW49596.1	Beta
Candidatus Methylopumilus turicensis	WP_082048396.1	WP_045751174.1	WP_045751173.1	Beta
Comamonadaceae bacterium CG1_02_60_18	OIN91272.1	OIN91271.1	OIN91269.1	Beta
Comamonadaceae bacterium CG2_30_57_122	OIP13220.1	OIP13227.1	OIP13228.1	Beta
Cupriavidus sp. WS	WP_081651598.1	WP_029044350.1	WP_043367598.1	Beta
Deefgea rivuli	WP_027469006.1	WP_027469005.1	WP_027469004.1	Beta
Herbaspirillum aquaticum	WP_088756155.1	WP_088753704.1	WP_088756171.1	Beta
Herbaspirillum frisingense	WP_039875505.1	WP_079216977.1	WP_079216979.1	Beta
Herbaspirillum rubrisubalbicans	WP_058894123.1	WP_058894118.1	WP_082686138.1	Beta
Herbaspirillum seropedicae	WP_069375417.1	WP_069375029.1	WP_069375030.1	Beta
Herbaspirillum sp. B39	WP_034337931.1	WP_034330935.1	WP_034330937.1	Beta
Herbaspirillum sp. HZ10	WP_088752243.1	WP_088752242.1	WP_088752241.1	Beta
Herbaspirillum sp. RV1423	WP_034299669.1	WP_081768878.1	WP_081768877.1	Beta
Herbaspirillum sp. WT00C	WP_075259658.1	WP_075255625.1	WP_075255626.1	Beta
Herbaspirillum sp. YR522	WP_008117337.1	WP_008113559.1	WP_008117346.1	Beta
Herminiimonas arsenicoxydans	WP_011870663.1	WP_011870664.1	WP_011870665.1	Beta
Herminiimonas arsenitoxidans	WP_076593873.1	WP_076590916.1	WP_076590917.1	Beta

Hydrogenophaga palleronii	WP_066269231.1	WP_066269232.1	WP_066269233.1	Beta
Hydrogenophaga sp. IBVHS1	WP_086126805.1	WP_086126802.1	WP_086126799.1	Beta
Hydrogenophaga sp. PML113	WP_083293270.1	WP_070400211.1	WP_070400209.1	Beta
Hydrogenophaga sp. RAC07	WP_083240110.1	WP_069049138.1	WP_069048529.1	Beta
Hydrogenophaga sp. Root209	WP_082585539.1	WP_056267373.1	WP_056267049.1	Beta
Hydrogenophaga sp. SCN 70-13	ODT34034.1	ODT34033.1	ODT34031.1	Beta
Janthinobacterium	WP_086138461.1	WP_086138462.1	WP_086138463.1	Beta
Janthinobacterium agaricidamnosum	WP_038489190.1	WP_038498699.1	WP_038489192.1	Beta
Janthinobacterium lividum	WP_070254296.1	WP_070254295.1	WP_070254294.1	Beta
Janthinobacterium sp. Ant5-2-1	WP_058049808.1	WP_058049809.1	WP_058049810.1	Beta
Janthinobacterium sp. GW458P	WP_086143996.1	WP_086143912.1	WP_086143913.1	Beta
Janthinobacterium sp. KBS0711	WP_046686130.1	WP_046686131.1	WP_046686132.1	Beta
Janthinobacterium sp. Marseille	WP_012080109.1	ABR88537.1	WP_012080107.1	Beta
Janthinobacterium sp. S3-2	WP_065307061.1	WP_065307060.1	WP_065307077.1	Beta
Janthinobacterium sp. TND4EL3	WP_076565808.1	WP_076565810.1	WP_076565792.1	Beta
Laribacter hongkongensis	WP_027824056.1	WP_027824055.1	WP_027824054.1	Beta
Laribacter hongkongensis	WP_088861422.1	WP_088861421.1	WP_088861420.1	Beta
Limnohabitans planktonicus	WP_053170360.1	WP_053170358.1	WP_053171553.1	Beta
Methylothermobacter mobilis	WP_041928542.1	WP_015831982.1	WP_015831983.1	Beta
Methylothermobacter sp. G11	WP_081987064.1	WP_047549180.1	WP_047549183.1	Beta
Methylothermobacter sp. L2L1	WP_036303317.1	WP_036303315.1	WP_036303313.1	Beta
Methylothermobacter sp. RIFCSPLOWO2_02_FULL_45_14	OGV78172.1	OGV78179.1	OGV77391.1	Beta
Methylothermobacter versatilis	WP_013147951.1	WP_041359898.1	WP_013147953.1	Beta
Methylothermobacter sp. MP688	WP_013440922.1	WP_013440921.1	WP_013442499.1	Beta
Noviherbaspirillum autotrophicum	WP_040038466.1	WP_040038467.1	WP_040038468.1	Beta
Noviherbaspirillum massiliense	WP_019141885.1	WP_026075971.1	WP_019141883.1	Beta
Pandoraea pnomenus	WP_023598438.1	WP_023598439.1	WP_052167323.1	Beta
Pandoraea vervacti	WP_044458602.1	WP_044457406.1	WP_044458601.1	Beta
Paraburkholderia phenazinum	WP_090690488.1	WP_090690491.1	WP_090690498.1	Beta
Paraburkholderia sartisoli	WP_090532012.1	WP_090532010.1	WP_090532007.1	Beta
Paraburkholderia terrae	WP_086909626.1	WP_086909596.1	WP_086909597.1	Beta
Polaromonas glacialis	WP_029526176.1	WP_029526175.1	WP_029526173.1	Beta
Polaromonas jejuensis	WP_068831299.1	WP_068831300.1	WP_084389288.1	Beta
Polaromonas naphthalenivorans	WP_011802850.1	WP_011802849.1	WP_011802848.1	Beta
Polaromonas sp. A23	WP_077592725.1	WP_077592843.1	WP_077592727.1	Beta
Polaromonas sp. C04	WP_077563849.1	WP_077563851.1	WP_077563857.1	Beta
Polaromonas sp. CF318	WP_007862413.1	EJL78603.1	EJL78604.1	Beta
Polaromonas sp. CG9_12	WP_036808892.1	WP_036813202.1	WP_036808899.1	Beta

Polaromonas sp. EUR3 1.2.1	WP_026781163.1	WP_026781159.1	WP_026781158.1	Beta
Polaromonas sp. JS666	WP_011484870.1	WP_011484869.1	WP_011484867.1	Beta
Polaromonas sp. OV174	WP_091998443.1	WP_091998447.1	WP_091998450.1	Beta
Pseudorhodofera sp. Leaf265	WP_056672590.1	WP_056672588.1	WP_056672598.1	Beta
Rhodofera antarcticus	WP_075585179.1	WP_075585216.1	WP_075585168.1	Beta
Rhodofera fermentans	WP_078364450.1	WP_078366834.1	WP_078364448.1	Beta
Rhodofera ferrireducens	OQW88136.1	OQW86158.1	OQW88139.1	Beta
Rhodofera sp. DCY110	WP_076197995.1	WP_076197993.1	WP_076198007.1	Beta
Sulfuriferula sp. AH1	WP_087447710.1	WP_087447709.1	WP_087447732.1	Beta
Thauera humireducens	WP_048706753.1	WP_048706755.1	AMO37809.1	Beta
Thauera terpenica	WP_040831089.1	WP_021250246.1	WP_021250247.1	Beta
Variovorax paradoxus	WP_057595238.1	WP_013543050.1	WP_062361990.1	Beta
Variovorax sp. CF313	WP_042673666.1	WP_007835336.1	WP_007835345.1	Beta
Variovorax sp. JS1663	WP_086924577.1	WP_086924597.1	WP_086924576.1	Beta
delta proteobacterium MLMS-1	WP_007292162.1	WP_007294049.1	WP_007294051.1	Delta
Geobacter ferrihydriticus	WP_074669617.1	WP_040101187.1	WP_052446538.1	Delta
Geobacter bemidjensis	WP_012530059.1	WP_012530060.1	WP_012530067.1	Delta
Geobacter sp. DSM 9736	WP_088533764.1	WP_088536670.1	WP_088533767.1	Delta
Geobacter sp. M21	WP_015837859.1	WP_015837858.1	WP_015837853.1	Delta
Geobacteraceae bacterium GWB2_52_12	OGT95934.1	OGT95928.1	OGT95936.1	Delta
Alishewanella aestuarii	WP_008608033.1	WP_008608034.1	WP_008608039.1	Gamma
Alishewanella sp. HH-ZS	WP_065956080.1	WP_065956079.1	WP_065956072.1	Gamma
Arsukibacterium ikkense	WP_046556227.1	WP_046556226.1	WP_052748930.1	Gamma
Arsukibacterium sp. MJ3	WP_046555083.1	WP_046555081.1	WP_052750195.1	Gamma
Catenovulum maritimum	WP_048693212.1	WP_048693214.1	WP_048693216.1	Gamma
Chania multitudinisentens	WP_024911805.1	WP_024911804.1	WP_024911803.1	Gamma
Colwellia psychrerythraea	WP_033083676.1	WP_033093120.1	WP_033093119.1	Gamma
Colwellia sp. TT2012	WP_057830224.1	WP_057832342.1	WP_057830226.1	Gamma
Crenothrix polyspora	WP_087147254.1	WP_087147253.1	WP_087147252.1	Gamma
Cycloclasticus sp. DSM 27168	WP_073023169.1	WP_073023168.1	WP_073023165.1	Gamma
Endozoicomonas atrinae	WP_066015304.1	WP_066015305.1	WP_066015306.1	Gamma
Halomonas pantelleriensis	WP_089656468.1	WP_089656469.1	WP_089656471.1	Gamma
Halomonas salina	WP_040186301.1	WP_081945756.1	WP_040186321.1	Gamma
Lonsdalea quercina	WP_094107939.1	WP_094107961.1	WP_094107940.1	Gamma
Marinobacter hydrocarbonoclasticus	WP_011786059.1	WP_011786058.1	WP_011786057.1	Gamma
Marinobacter lipolyticus	WP_018405035.1	WP_018405034.1	WP_018405033.1	Gamma
Marinobacter salinus	WP_070965578.1	WP_070973522.1	WP_070965581.1	Gamma
Marinobacterium lutimaris	SEG57113.1	SEG57098.1	SEG57078.1	Gamma

Methyloglobulus morosus	WP_023495340.1	WP_023495341.1	WP_023495342.1	Gamma
Methylophaga sp. 41_12_T18	OUR72752.1	OUR72751.1	OUR72772.1	Gamma
Nitrincola nitratireducens	WP_036513279.1	EXJ09743.1	EXJ09744.1	Gamma
Oceanimonas sp. GK1	WP_041543213.1	WP_014293024.1	WP_014293023.1	Gamma
Oleiphilus	WP_068474530.1	WP_068553922.1	WP_068474520.1	Gamma
Photobacterium ganghwense	WP_047883801.1	WP_047883800.1	WP_047883802.1	Gamma
Photobacterium iliopiscarium	WP_045038329.1	WP_045038330.1	WP_045038331.1	Gamma
Photobacterium kishitanii	WP_065173147.1	WP_065173146.1	WP_065173145.1	Gamma
Photobacterium leiognathi	WP_023931563.1	WP_023931565.1	WP_045063689.1	Gamma
Photobacterium marinum	WP_007466443.1	WP_007466442.1	WP_036800127.1	Gamma
Photobacterium sp. SKA34	WP_006646475.1	WP_006646476.1	WP_039860628.1	Gamma
Photorhabdus asymbiotica	WP_065821825.1	WP_065821916.1	WP_065821915.1	Gamma
Photorhabdus asymbiotica	WP_036770100.1	WP_036770139.1	WP_036770093.1	Gamma
Pseudoalteromonas	WP_024589810.1	WP_024589809.1	WP_024589808.1	Gamma
Pseudoalteromonas lipolytica	WP_074989256.1	WP_074989257.1	WP_074989258.1	Gamma
Pseudoalteromonas luteoviolacea	WP_063378454.1	WP_063378455.1	WP_063378456.1	Gamma
Pseudoalteromonas luteoviolacea	WP_039608254.1	WP_039608255.1	WP_039608256.1	Gamma
Pseudoalteromonas rubra	WP_049864426.1	WP_046007017.1	WP_049864427.1	Gamma
Pseudoalteromonas sp. BMB	WP_069020842.1	WP_069020844.1	WP_069020848.1	Gamma
Pseudoalteromonas sp. BSi20429	WP_007584995.1	WP_007584994.1	WP_033026984.1	Gamma
Pseudomonas aeruginosa	WP_023130787.1	WP_023120375.1	WP_023130786.1	Gamma
Pseudomonas alcaliphila	WP_075747014.1	WP_064494598.1	WP_064494599.1	Gamma
Pseudomonas antarctica	WP_064451500.1	WP_064451502.1	WP_083359481.1	Gamma
Pseudomonas brassicacearum	ALQ02335.1	WP_025212585.1	WP_081352378.1	Gamma
Pseudomonas chengduensis	WP_090336757.1	WP_090336759.1	WP_090336760.1	Gamma
Pseudomonas chlororaphis	WP_053269669.1	WP_053280338.1	WP_053280337.1	Gamma
Pseudomonas composti	WP_074940188.1	WP_074940192.1	WP_074940422.1	Gamma
Pseudomonas fluorescens	WP_034155277.1	WP_034126702.1	WP_034126705.1	Gamma
Pseudomonas fluorescens	WP_003183858.1	WP_003189797.1	WP_003189805.1	Gamma
Pseudomonas frederiksbergensis	WP_076031558.1	WP_071554248.1	WP_071554254.1	Gamma
Pseudomonas oleovorans	WP_037054107.1	WP_037054105.1	WP_037054102.1	Gamma
Pseudomonas psychrotolerans	WP_058761729.1	WP_058760362.1	WP_058761296.1	Gamma
Pseudomonas putida	WP_069942133.1	WP_069942135.1	WP_069942131.1	Gamma
Pseudomonas sp. 1-7	KFJ93089.1	KFJ93088.1	KFJ93087.1	Gamma
Pseudomonas sp. C5pp	WP_039615100.1	WP_039615098.1	WP_039615101.1	Gamma
Pseudomonas sp. GM48	WP_007988308.1	WP_007985416.1	WP_007985421.1	Gamma
Pseudomonas sp. M30-35	WP_087516444.1	WP_087516445.1	WP_087516446.1	Gamma
Pseudomonas sp. MT-1	WP_045428458.1	WP_045428457.1	WP_045428456.1	Gamma

<i>Pseudomonas</i> sp. NFACC19-2	WP_072424717.1	WP_072424718.1	WP_072424719.1	Gamma
<i>Pseudomonas stutzeri</i>	WP_063540504.1	WP_063540515.1	WP_063540503.1	Gamma
<i>Pseudomonas synxantha</i>	WP_057022239.1	WP_057022149.1	WP_057022240.1	Gamma
<i>Pseudomonas toyotomiensis</i>	WP_074914515.1	WP_059391714.1	WP_059391715.1	Gamma
<i>Pseudomonas veronii</i>	WP_046483495.1	WP_046384274.1	WP_046384261.1	Gamma
<i>Psychromonas aquimarina</i>	WP_028862360.1	WP_028862361.1	WP_028862362.1	Gamma
<i>Psychromonas ossibalaenae</i>	WP_019615916.1	WP_019615917.1	WP_019615919.1	Gamma
<i>Rheinheimera perlucida</i>	WP_019674728.1	WP_019674726.1	WP_019674701.1	Gamma
<i>Sedimenticola thiotaurini</i>	WP_046859767.1	WP_046859766.1	WP_046859765.1	Gamma
<i>Shewanella algae</i>	WP_071237806.1	WP_071477444.1	WP_071237804.1	Gamma
<i>Thioalkalivibrio</i> sp. AKL10	WP_026340938.1	WP_081624528.1	WP_026340942.1	Gamma
<i>Thioalkalivibrio</i> sp. AKL12	WP_018951797.1	WP_018951790.1	WP_026289538.1	Gamma
<i>Thioalkalivibrio</i> sp. AKL6	WP_018145916.1	WP_026182128.1	WP_018145952.1	Gamma
<i>Thioalkalivibrio</i> sp. AKL7	WP_081624430.1	WP_019611620.1	WP_019612086.1	Gamma
<i>Thioalkalivibrio</i> sp. AKL8	WP_026304840.1	WP_081623074.1	WP_026304844.1	Gamma
<i>Thioalkalivibrio</i> sp. ALJ16	WP_018873978.1	WP_026280011.1	WP_018872892.1	Gamma
<i>Thioalkalivibrio</i> sp. ALM2T	WP_026333161.1	WP_026333164.1	WP_026333157.1	Gamma
<i>Thioalkalivibrio</i> sp. ALMg13-2	WP_019568703.1	WP_081620896.1	WP_026331226.1	Gamma
<i>Thioalkalivibrio</i> sp. ALMg2	WP_019563934.1	WP_081621424.1	WP_026330565.1	Gamma
<i>Thioalkalivibrio</i> sp. ALMg9	WP_018169554.1	WP_081620143.1	WP_026305952.1	Gamma
<i>Thioalkalivibrio</i> sp. K90mix	WP_012982927.1	WP_012982924.1	WP_012982951.1	Gamma
<i>Thioalkalivibrio versutus</i>	WP_047250985.1	WP_047250991.1	WP_047251909.1	Gamma
<i>Thiothrix lacustris</i>	OQX06987.1	OQX08772.1	OQX02620.1	Gamma
<i>Vibrio alginolyticus</i>	WP_086050204.1	WP_065646566.1	WP_065646570.1	Gamma
<i>Vibrio anguillarum</i>	AQP34955.1	WP_019282752.1	AQP34953.1	Gamma
<i>Vibrio cholerae</i>	WP_000433077.1	ADF80985.1	WP_076025069.1	Gamma
<i>Vibrio crassostreae</i>	WP_048661363.1	WP_048663200.1	WP_048663203.1	Gamma
<i>Vibrio cyclitrophicus</i>	WP_016791019.1	WP_016797283.1	WP_016797280.1	Gamma
<i>Vibrio genomosp. F10</i>	WP_017040691.1	WP_065576635.1	WP_065576634.1	Gamma
<i>Vibrio harveyi</i> CAIM1075	WP_050914487.1	WP_050937014.1	WP_050914489.1	Gamma
<i>Vibrio metoecus</i>	WP_055052054.1	WP_055044314.1	WP_055052055.1	Gamma
<i>Vibrio mimicus</i>	WP_000433076.1	WP_070382450.1	WP_000494954.1	Gamma
<i>Vibrio nigripulchritudo</i>	WP_022552005.1	WP_022552020.1	WP_022552006.1	Gamma
<i>Vibrio parahaemolyticus</i>	WP_020904316.1	WP_020904315.1	WP_020904314.1	Gamma
<i>Vibrio splendidus</i>	WP_017087969.1	WP_017085935.1	WP_017085937.1	Gamma
<i>Vibrio tasmaniensis</i>	WP_065106141.1	WP_041472952.1	WP_065113257.1	Gamma
<i>Vibrio vulnificus</i>	WP_013572513.1	WP_013572512.1	WP_013572511.1	Gamma
<i>Mariprofundus ferrooxydans</i>	WP_018294067.1	WP_026195384.1	WP_018294071.1	Zeta

Zetaproteobacteria bacterium CG2_30_46_52	OIP99107.1	OIP99141.1	OIQ00419.1	Zeta
Zetaproteobacteria bacterium TAG-1	WP_038246546.1	WP_038246540.1	WP_038249350.1	Zeta

Table S2. Bacterial strains containing homologs of *R. etli* CE3 WreQ, WreV and *P. aeruginosa* O6 WbpL.

WreQ (YP_470339.1), WbpL (AAF23990.1) and WreV (YP_471773.1) were used individually as query sequences in BLAST searches against the non-redundant protein sequence (nr) database using the blastp algorithm. WreQ and WreV searches were performed following the same strategy as in Table S1. The WbpL BLAST search was performed by excluding Pseudomonadaceae and the maximum target sequences were set at 1000. The resulting matches to WbpL all have E-values less than $7e-32$. Strains containing homologs to the three genes are listed below, along with the accession numbers of the protein homologs and the phylogenetic affiliations of the strains. Where strain numbers are absent, they can be found by investigating the gene accessions.

Strain	WreQ accession	WbpL accession	WreV accession	Phylo
Alphaproteobacteria bacterium	OFW83437.1	OFW83436.1	OFW84297.1	Alpha
Azospirillum humicireducens	WP_063635086.1	WP_063635083.1	WP_063635087.1	Alpha
Azospirillum lipoferum	WP_014248476.1	WP_012974782.1	WP_085556015.1	Alpha
Azospirillum oryzae	WP_085089998.1	WP_085089995.1	WP_085089999.1	Alpha
Azospirillum sp. B506	WP_042696170.1	WP_042696173.1	WP_042696169.1	Alpha
Azospirillum thiophilum	WP_045580795.1	WP_045580792.1	WP_045580796.1	Alpha
Devosia chinhatensis	WP_046103598.1	WP_046103597.1	WP_046103596.1	Alpha
Devosia chinhatensis	WP_046103598.1	WP_046103597.1	WP_046103596.1	Alpha
Devosia sp. 67-54	OJX19969.1	OJX19967.1	OJX19968.1	Alpha
Devosia sp. Root105	WP_082528546.1	WP_055884710.1	WP_055872943.1	Alpha
Haematospirillum jordaniae	WP_066132823.1	AMW34221.1	WP_066133023.1	Alpha
Magnetospirillum gryphiswaldense	WP_041634754.1	WP_041634753.1	WP_052589129.1	Alpha
Magnetospirillum gryphiswaldense	CDL00675.1	CDL00674.1	CDL00757.1	Alpha
Magnetospirillum sp. XM-1	WP_068430147.1	CUW37957.1	WP_068430462.1	Alpha
Mesorhizobium sp. YR577	WP_091914561.1	WP_091914110.1	WP_091914112.1	Alpha
Mesorhizobium sp. YR577	WP_091914561.1	WP_091914110.1	WP_091914112.1	Alpha
Rhizobium sp. Root149	WP_062557229.1	WP_062557228.1	WP_062557230.1	Alpha
Rhodocista sp. MIMtkB3	WP_075773469.1	WP_075772476.1	WP_075769167.1	Alpha
Rhodospirillaceae bacterium	OUX31398.1	OUX31399.1	OUX31397.1	Alpha
Rhodospirillales bacterium	OHC75555.1	OHC75553.1	OHC75556.1	Alpha
Terasakiella sp. PR1	WP_069186887.1	WP_069186886.1	WP_069186888.1	Alpha
Thalassospira alkalitolerans	WP_085616563.1	WP_085615659.1	WP_085614765.1	Alpha
Thalassospira mesophila	WP_085582449.1	WP_085578919.1	WP_085578921.1	Alpha
Thalassospira profundimaris	WP_064788430.1	WP_008888595.1	WP_008888594.1	Alpha
Thalassospira sp. MCCC	WP_085588244.1	WP_085590024.1	WP_085590155.1	Alpha
Thalassospira sp. Nap_22	KXJ56428.1	KXJ54524.1	KXJ54525.1	Alpha
Thalassospira sp. TSL5-1	WP_073955943.1	WP_073956208.1	WP_073955272.1	Alpha
Thalassospira xiamenensis	WP_062958433.1	WP_062960508.1	WP_062960509.1	Alpha

<i>Azoarcus toluclasticus</i>	WP_040394211.1	WP_051092234.1	WP_018988035.1	Beta
<i>Lautropia</i> sp. SCN 70-15	ODT33269.1	ODT33266.1	ODT33268.1	Beta
<i>Methylibium</i> sp. NZG	KNZ31778.1	KNZ31777.1	KNZ31776.1	Beta
<i>Aeromonas veronii</i>	WP_005350303.1	WP_005338066.1	WP_005338065.1	Gamma
<i>Aquisalimonas asiatica</i>	SEO80355.1	SEO80337.1	SEO80272.1	Gamma
<i>C. Tenderia electrophaga</i>	ALP53219.1	ALP54791.1	ALP53220.1	Gamma
<i>C. Thiodiazotropha endoloripes</i>	WP_068994608.1	WP_068994607.1	WP_068994639.1	Gamma
<i>Cellvibrio</i> sp. PSBB006	WP_087465803.1	WP_087465802.1	WP_087465797.1	Gamma
<i>Crenothrix</i> sp. D3	OTE95239.1	OTE95238.1	OTE95237.1	Gamma
<i>Ectothiorhodospira marina</i>	WP_090255654.1	WP_090255652.1	WP_090250421.1	Gamma
<i>gamma proteobacterium IMCC2047</i>	EGG98104.1	EGG99498.1	EGH00084.1	Gamma
<i>Halomonas utahensis</i>	WP_077530405.1	WP_077530383.1	WP_077530382.1	Gamma
<i>Immundisolibacter cernigliae</i>	WP_068803522.1	WP_068803523.1	WP_083214804.1	Gamma
<i>Legionella geestiana</i>	WP_028385720.1	WP_051550994.1	WP_051550925.1	Gamma
<i>Legionella israelensis</i>	WP_058500563.1	WP_058500543.1	WP_058500737.1	Gamma
<i>Marinobacter mobilis</i>	WP_091817059.1	WP_091817062.1	WP_091817065.1	Gamma
<i>Methylobacter tundripaludum</i>	WP_006890946.1	WP_006890945.1	WP_006890944.1	Gamma
<i>Methylomicrobium</i>	WP_005371725.1	WP_005371723.1	WP_005371722.1	Gamma
<i>Methylomicrobium alcaliphilum</i>	WP_014146586.1	WP_046061293.1	WP_046060910.1	Gamma
<i>Methylomicrobium buryatense</i>	WP_017841410.1	WP_040575735.1	WP_017841407.1	Gamma
<i>Methylosarcina fibrata</i>	WP_020562151.1	WP_020562152.1	WP_020562153.1	Gamma
<i>Methylosarcina lacus</i>	WP_029646324.1	WP_024296937.1	WP_024296936.1	Gamma
<i>Methylovulum miyakonense</i>	WP_019868468.1	WP_019868467.1	WP_019868466.1	Gamma
<i>Methylovulum psychrotolerans</i>	WP_088618707.1	WP_088618706.1	WP_088618705.1	Gamma
<i>Microbulbifer variabilis</i>	WP_020411331.1	WP_026304876.1	WP_020411328.1	Gamma
<i>Motiliproteus</i> sp. MSK22-1	WP_076720080.1	WP_076720081.1	WP_076720083.1	Gamma
<i>Rheinheimera</i> sp. SA_1	WP_082971652.1	WP_068063778.1	WP_082971650.1	Gamma
<i>Stenotrophomonas rhizophila</i>	WP_061203702.1	KWW13329.1	WP_061203704.1	Gamma
<i>Thioalkalivibrio</i> sp. AKL11	WP_083916429.1	WP_026288304.1	WP_018941009.1	Gamma
<i>Thioalkalivibrio</i> sp. AKL17	WP_026289054.1	WP_018947748.1	WP_018945921.1	Gamma
<i>Thioalkalivibrio</i> sp. ALJ15	WP_083925125.1	WP_020146293.1	WP_020146532.1	Gamma
<i>Thioalkalivibrio</i> sp. ALJ2	WP_081616998.1	WP_018994651.1	WP_018994650.1	Gamma
<i>Thioalkalivibrio</i> sp. ALR17-21	WP_024329946.1	WP_024329948.1	WP_024328922.1	Gamma
<i>Thiohalomonas denitrificans</i>	WP_092998985.1	WP_092999077.1	WP_092992255.1	Gamma
<i>Deltaproteobacteria bacterium</i>	OGQ52421.1	OGQ54831.1	OGQ57681.1	Delta

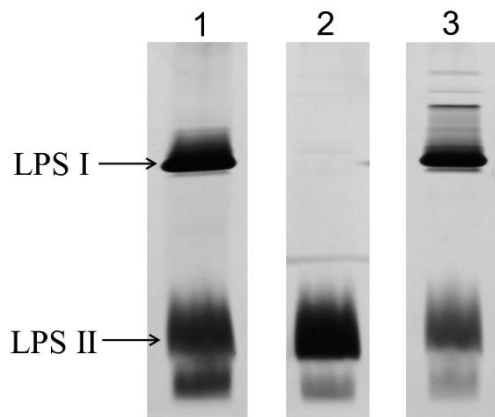


Fig. S1. Complementation of the *R. etli wreU::Km* mutant strain CE566 with *His₆-wreU*. Silver-stained SDS-PAGE (18% gel) of LPS samples from whole-cell lysates. Lanes: lane 1, CE3 (wild-type); lane 2, CE566 (*wreU::Km*); lane 3, CE566/pLS22 (*wreU::Km/His₆-wreU*). LPS I carries O antigen, whereas LPS II does not [1, 2].

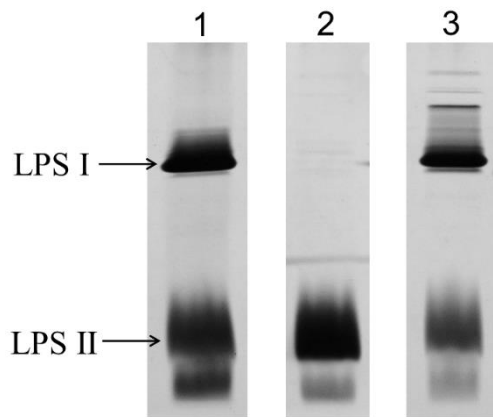
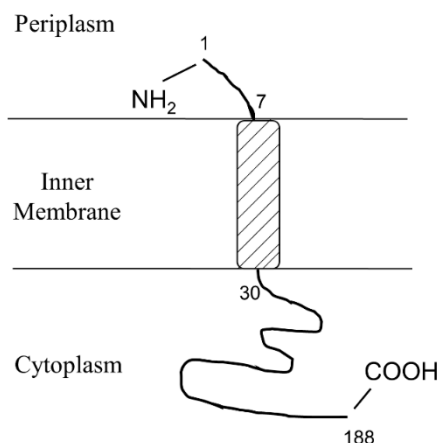


Fig. S2. Complementation of the *R. etli wreG::Tn5* mutant strain CE358 with *wreG-His₆*. Silver-stained SDS-PAGE (18% gel) of LPS samples from whole-cell lysates. Lanes: lane 1, CE3 (wild-type); lane 2, CE358 (*wreG::Tn5*); lane 3, CE358/pTL63 (*wreG::Tn5/wreG-His₆*).

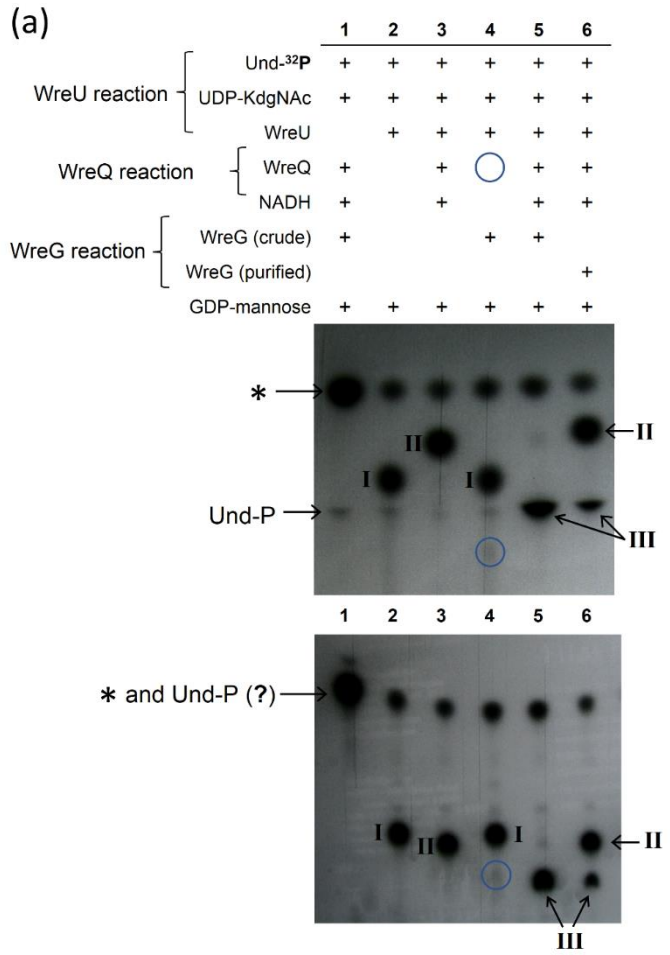
(a) WreU (188 aa)



(b)

WreU	---MGLKRAVDFLLALIASVILLVPIILVVALSVRLTSPGPILYWSKRIGR	47
WbaP	RSSRFLKRTFDIVCSIMILIIASPLMIYLWYKV-TRDGGPAIYGHQRVGR	322
PglC	MYEKVEKRI FDFILALVLLVLFSPVILITALLIKI-TQGSVIFTQNR PGL	49
WecP	PIYAFIKRGM DILAAVIAIPLFSPMLLATAVLIKLESPGPVMFLQNRV GK	278
WreU	FNQIFLMPKFRSMRVDTPTVATHLL-----ENPERFETPI	82
WbaP	HGKLFPCYKFRSMVMNSQEV LKELLANDPIARAWEKDFKLKNDPRITAV	372
PglC	DEKIFK IYKFKTMSDERDEKG-----ELLS--DELRLKAF	82
WecP	GNRDFRIYKFRSMCQNSEQHG-----AQFAQDGD MRVTRV	313
WreU	GSFLRKSSLDEL PQLWCILAGKMSFV GPRPALYNQYDLIELRTVY--GVD	130
WbaP	GRFIRKTSLDEL PQLFNVLKGDMSLVGPRPIVSDELERYCDDVDY YL---	419
PglC	GKIVRSLSLDEL LQLFNVLKGDMSFV GPRPLLVEYLP LYNKEQ---KLRH	129
WecP	GKVI RKLRIDEL PQLFFNVLKGDMSLIGPRPEQRTFVDQFDREIPF YMYRH	363
WreU	KLLPGLTGWAQINGRDE---LPIPEKVKVFDVEYLER RSLGFDMRILFLTA	177
WbaP	MAKPGMTGLWQVSGRND---VDYDTRVYFDSWYVKNWTLWNDIAILFKTA	466
PglC	KVRPGITGWAQVNGRNA---ISWQKKFELDVYYVKNISFLLDLKIMFLTA	176
WecP	IVRPGISGWAQVVHGYAADADDTRI KIEHDFYIKNFSLWLDVLI VERTI	413
WreU	EKV VRRKGIKH-----	188
WbaP	KVVLRRDGAY-----	476
PglC	LKVLKRS GVSKEGHVTTEKFNGKN	200
WecP	RTILTGF GAR-----	423

Fig. S3. (a) Topological model for *R. etli* CE3 WreU. The shaded rectangle boxes represent transmembrane (TM) segments. The numbers indicate the amino acid positions of the boundary of each TM domain. (b) Multiple sequence alignment of the *R. etli* CE3 WreU (YP_471772) with *C. jejuni* PglC (YP_002344517), the C-terminal domain (274-476 aa) of *S. enterica* WbaP (NP_461027) and the C-terminal domain (229-423) of *A. hydrophila* WecP (EU274663), by use of the Clustal Omega program [3] (available on the World Wide Web at www.ebi.ac.uk/Tools/msa/clustalo/). Identical amino acids are highlighted in black and similar amino acids are highlighted in grey.



[³²P] WreU-WreQ-WreG coupled enzyme assay

○ Und-PP-KdgNAc-Man?

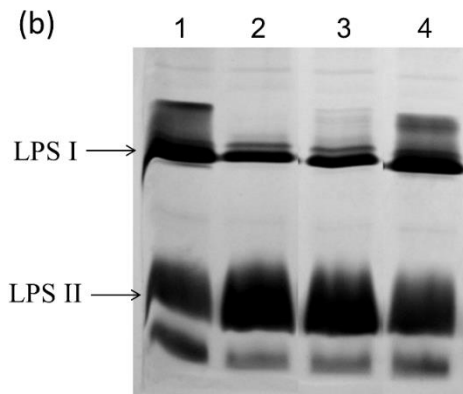
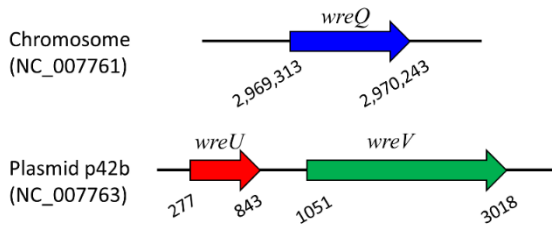


Fig. S4. (a) Highlight of the possible Und-PP-KdgNAc-Man product present in Fig. 5. (b) Suppression of *R. etli wreQ::Tn5* mutant strain CE166 by introducing multiple copies of *wreU* or *wreG* gene. Lanes: lane 1, CE3 (*R. etli* wild-type strain); lane 2, CE166 (*wreQ::Tn5*); lane 3, CE166/pLS22, strain CE166 harboring pLS22 plasmids expressing His₆-WreU; lane 4, CE166/pTL63, strain CE166 harboring pTL63 plasmids expressing WreG-His₆. Note that extra copies of *wreG* suppressed the deficiency in O-antigen amount (lane 4), whereas extra copies of *wreU* did not (lane 3). Hypothesis 1 of Fig. 1(c) would have predicted suppression by multiple copies of *wreU*. A probable explanation of the suppression is that higher concentrations of WreG compensate for its weaker catalysis when KdgNAc is the acceptor residue in the reaction instead of the preferred QuiNAc residue.

Rhizobium etli CE3



Colwellia psychrerythraea 34H

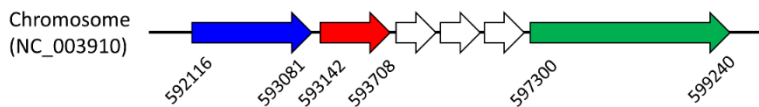


Fig. S5. The genomic locations of *Rhizobium etli* strain CE3 *wreV*, *wreU*, *wreQ* genes and their orthologs in *Colwellia psychrerythraea* strain 34H. *wreV*, *wreU*, *wreQ* and their orthologs are shown in green, red, blue respectively. Protein accession numbers: *R. etli* CE3 WreV (YP_471773), WreU (YP_471772), WreQ (YP_470339); *C. psychrerythraea* 34H WreV ortholog (WP_011041444), WreU ortholog (WP_011041440), WreQ ortholog (WP_011041439).

REFERENCES

1. **Carlson RW, Kalembasa S, Turowski D, Pachori P, Noel KD.** Characterization of the lipopolysaccharide from a *Rhizobium phaseoli* mutant that is defective in infection thread development. *J Bacteriol* 1987;169(11):4923-4928.
2. **Noel KD, Forsberg LS, Carlson RW.** Varying the abundance of O antigen in *Rhizobium etli* and its effect on symbiosis with *Phaseolus vulgaris*. *J Bacteriol* 2000;182(19):5317-5324.
3. **Sievers F, Wilm A, Dineen D, Gibson TJ, Karplus K et al.** Fast, scalable generation of high-quality protein multiple sequence alignments using Clustal Omega. *Mol Syst Biol* 2011;7:539.