An integrated phylogenomic approach toward pinpointing the origin of mitochondria

Zhang Wang and Martin Wu*

Figure S1. A rooted RAxML ML tree made with the mitochondrial marker dataset of 47 Alphaproteobacteria representatives. The tree was rooted using Beta and Gammaproteobacteria as the outgroup. Bootstrap values for internal nodes are shown beside them.

Figure S2. A rooted Bayesian tree made with the mitochondrial marker dataset of 47 Alphaproteobacteria representatives. The tree was rooted using Beta and Gammaproteobacteria as the outgroup. Posterior probability values for internal nodes are shown beside them.

Figure S3. A rooted RAxML ML tree made with the nuclear marker dataset of 47 Alphaproteobacteria representatives. The tree was rooted using Beta and Gammaproteobacteria as the outgroup. Bootstrap values for internal nodes are shown beside them.

Figure S4. A rooted Bayesian tree made with the nuclear marker dataset of 47 Alphaproteobacteria representatives. The tree was rooted using Beta and Gammaproteobacteria as the outgroup. Posterior probability values for internal nodes are shown beside them.

Figure S5. A rooted RAxML ML tree made with the phylum-level marker dataset of 47 Alphaproteobacteria representatives. The tree was rooted using Beta and Gammaproteobacteria as the outgroup. Bootstrap values for internal nodes are shown beside them.

Figure S6. A rooted Bayesian tree made with the phylum-level marker dataset of 47 Alphaproteobacteria representatives. The tree was rooted using Beta and Gammaproteobacteria as the outgroup. Posterior probability values for internal nodes are shown beside them.

Figure S7. A rooted RAxML ML tree made with the mitochondrial marker dataset of 72 Alphaproteobacteria and 6 mitochondria representatives. The tree was rooted using Beta and Gammaproteobacteria as the outgroup. Bootstrap values for internal nodes are shown beside them. Mitochondria representatives are highlighted in red.

Figure S8. A rooted Bayesian tree made with the mitochondrial marker dataset of 72 Alphaproteobacteria and 6 mitochondria representatives. The tree was rooted using Beta and Gammaproteobacteria as the outgroup. Posterior probability values for internal nodes are shown beside them. Mitochondria representatives are highlighted in red.

Figure S9. A rooted RAxML ML tree made with the nuclear marker dataset of 72 Alphaproteobacteria and 6 eukaryote representatives. The tree was rooted using Beta and Gammaproteobacteria as the outgroup. Bootstrap values for internal nodes are shown beside them. Eukaryote representatives are highlighted in red.

Figure S10. A rooted Bayesian tree made with the Dayhoff6 recoded mitochondria marker dataset of 72 Alphaproteobacteria and 6 mitochondria representatives. The tree was rooted using Beta and Gammaproteobacteria as the outgroup. Posterior probability values for internal nodes are shown beside them. Mitochondria representatives are highlighted in red.

Figure S11. A rooted Bayesian tree made with the Dayhoff6 recoded nuclear marker dataset of 72 Alphaproteobacteria and 6 eukaryote representatives. The tree was rooted using Beta and Gammaproteobacteria as the outgroup. Posterior probability values for internal nodes are shown beside them. Eukaryote representatives are highlighted in red.

Figure S12. A rooted RAxML ML tree made with the Dayhoff4 recoded mitochondria marker dataset of 72 Alphaproteobacteria and 6 mitochondria representatives. The tree was rooted using Beta and Gammaproteobacteria as the outgroup. Bootstrap values for internal nodes are shown beside them. Mitochondria representatives are highlighted in red.

Figure S13. A rooted RAxML ML tree made with the Dayhoff4 recoded nuclear marker dataset of 72 Alphaproteobacteria and 6 eukaryote representatives. The tree was rooted using Beta and Gammaproteobacteria as the outgroup. Bootstrap values for internal nodes are shown beside them. Eukaryote representatives are highlighted in red.

Figure S14. A rooted Bayesian consensus tree made with the nuclear dataset of 72 Alphaproteobacteria and 22 eukaryotes (highlighted in red). The tree was rooted using Beta and Gammaproteobacteria as the outgroup. The posterior probability support values of the internal nodes are shown beside them.

Supplementary Table 1. List of 50 top-ranked splits in the spectral analysis of the datasets with and without 18 genomes. Long-branch lineages that violate the well established phylogenetic relationships (e.g., the monophyly of mitochondria or Rickettsiales) are highlighted in bold.

Supplementary Table 2. List of nuclear and mitochondrial marker genes sorted by aminoGC, chi_square and substitution rate respectively.

Supplementary Table 3. Overview of 30 eukaryotic lineages selected for identifying the mitochondria-derived nuclear genes.

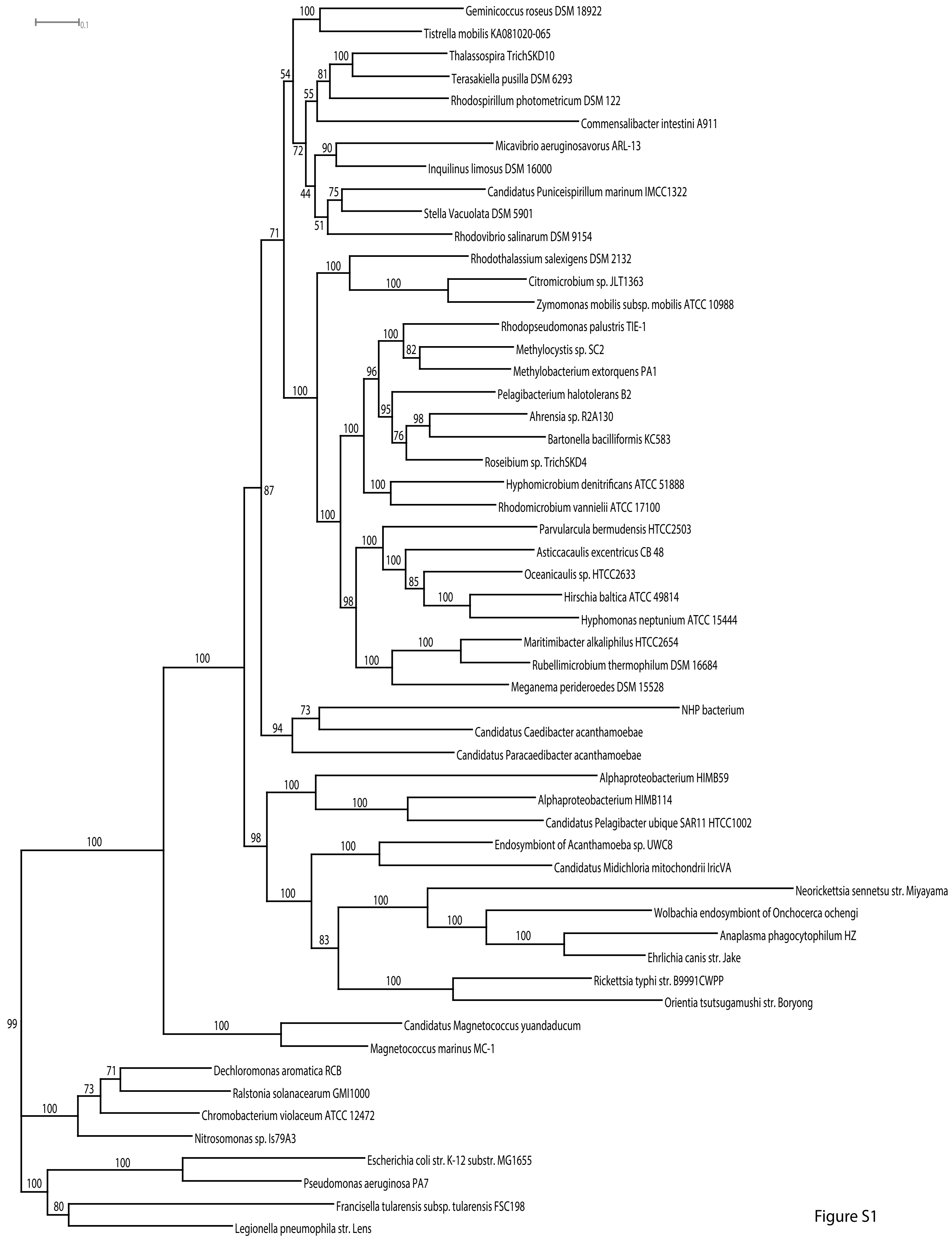
Supplementary Table 4. List of 200 Alphaproteobacterial genomes used in the phylogenomic analysis.

Supplementary File 1. The distribution of the 29 mitochondria-derived nuclear genes among individual genomes in the concatenated sequence alignment. The presence of gene in each genome is denoted as ‘1’ and highlighted in green. The absence of gene is denoted as ‘0’ and highlighted in red. The alpha-proteobacteria, nuclear, and beta/gamma-proteobacteria genomes are highlighted in red, blue and black, and taxonomy showing at order, phylum and class levels respectively.

Supplementary File 2. The presence of paralogs of the 29 mitochondria-derived nuclear genes and 26 mitochondria-encoded genes among individual genomes. The single copy gene in each genome is denoted as ‘1’ and highlighted in green. The absence of a gene in each genome is denoted as ‘0’ and highlighted in red. The gene with species-specific duplications in each genome is denoted as “copy number+S” and highlighted in gold. The gene with non-species-specific duplications in each genome is denoted as “copy number+NS” and highlighted in pink. The alpha-proteobacteria, nuclear, and beta/gamma-proteobacteria genomes are highlighted in red, blue and black, and taxonomy showing at order, phylum and class levels respectively.

Supplementary File 3. Individual protein sequences of 26 mitochondria-encoded genes and 29 mitochondria-derived nuclear genes.

Supplementary File 4. Individual sequence alignments of 26 mitochondria-encoded genes and 29 mitochondria-derived nuclear genes.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Commensalibacter intestini A911
Micavibrio aeruginosavorus ARL-13
Inquilinus limosus DSM 16000
Candidatus Puniceispirillum marinum IMCC1322
Stella Vacuolata DSM 5901
Rhodovibrio salinarum DSM 9154
Rhodothalassium salexigens DSM 2132
Citromicrobium sp. JLT1363
Zymomonas mobilis subsp. mobilis ATCC 10988
Rhodopseudomonas palustris TIE-1
Methylocystis sp. SC2
Methylobacterium extorquens PA1
Pelagibacterium halotolerans B2
Ahrensia sp. R2A130
Bartonella bacilliformis KC583
Roseibium sp. TrichSKD4
Hyphomicrobium denitrificans ATCC 51888
Rhodomicrobium vannielii ATCC 17100
Parvularcula bermudensis HTCC2503
Asticcacaulis excentricus CB 48
Oceanicaulis sp. HTCC2633
Hirschia baltica ATCC 49814
Hyphomonas neptunium ATCC 15444
Maritimibacter alkaliphilus HTCC2654
Rubellimicrobium thermophilum DSM 16684
Meganema perideroedes DSM 15528
NHP bacterium
Candidatus Caedibacter acanthamoebae
Candidatus Paracaedibacter acanthamoebae
Alphaproteobacterium HIMB59
Alphaproteobacterium HIMB114
Candidatus Pelagibacter ubique SAR11 HTCC1002
Endosymbiont of Acanthamoeba sp. UWC8
Candidatus Midichloria mitochondrii IricVA
Neorickettsia sennetsu str. Miyayama
Wolbachia endosymbiont of Onchocerca ochengi
Anaplasma phagocytophilum HZ
Ehrlichia canis str. Jake
Rickettsia typhi str. B9991CWPP
Orientia tsutsugamushi str. Boryong
Candidatus Magnetococcus yuandaducum
Magnetococcus marinus MC-1
Dechloromonas aromatica RCB
Ralstonia solanacearum GMI1000
Chromobacterium violaceum ATCC 12472
Nitrosomonas sp. Is79A3
Escherichia coli str. K-12 substr. MG1655
Pseudomonas aeruginosa PA7
Francisella tularensis subsp. tularensis FSC198
Legionella pneumophila str. Lens

Figure S1


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Citromicrobium sp. JLT1363
Rhodothalassium salexigens DSM 2132
Meganema perideroedes DSM 15528
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Maritimibacter alkaliphilus HTCC2654
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Asticcacaulis excentricus CB 48
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Hirschia baltica ATCC 49814
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Ahrensia sp. R2A130
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Alphaproteobacterium HIMB114
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Rhodovibrio salinarum DSM 9154
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Stella Vacuolata DSM 5901
Candidatus Paracaedibacter acanthamoebae
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NHP bacterium
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Candidatus Caedibacter acanthamoebae
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Thalassospira TrichSKD10
1
Terasakiella pusilla DSM 6293
1
Geminicoccus roseus DSM 18922
Tistrella mobilis KA081020-065
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Candidatus Midichloria mitochondrii IricVA
Endosymbiont of Acanthamoeba sp. UWC8
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Neorickettsia sennetsu str. Miyayama
1
1
1
Ehrlichia canis str. Jake
1
Anaplasma phagocytophilum HZ
1
Wolbachia endosymbiont of Onchocerca ochengi
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Orientia tsutsugamushi str. Boryong
Rickettsia typhi str. B9991CWPP
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Magnetococcus marinus MC-1
1
Ralstonia solanacearum GMI1000
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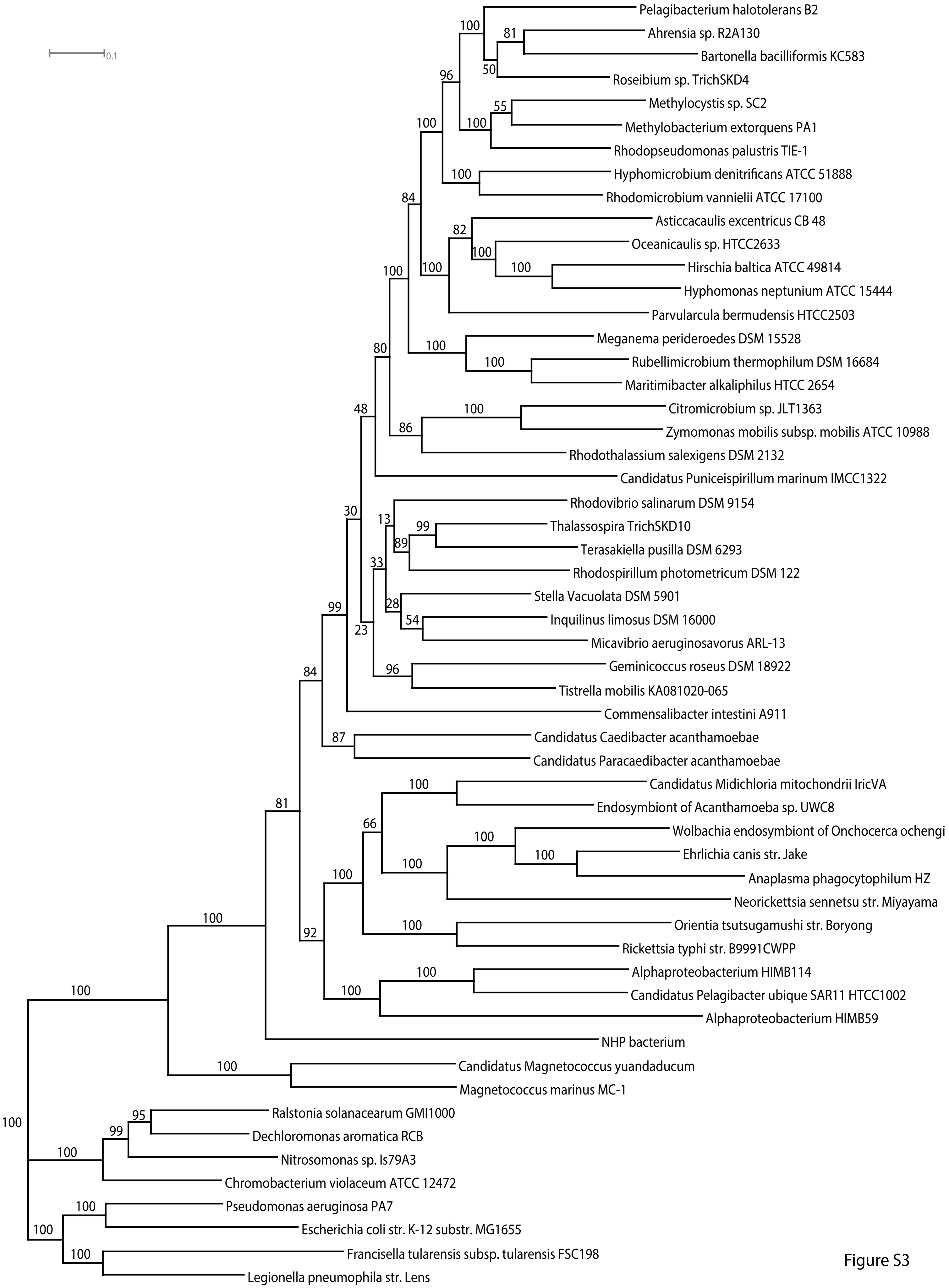
Pseudomonas aeruginosa PA7

Figure S2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Thalassospira TrichSKD10
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Terasakiella pusilla DSM 6293
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Rhodospirillum photometricum DSM 122
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Stella Vacuolata DSM 5901
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Inquilinus limosus DSM 16000
23
Micavibrio aeruginosavorus ARL-13
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Geminicoccus roseus DSM 18922
Tistrella mobilis KA081020-065
Commensalibacter intestini A911
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Candidatus Paracaedibacter acanthamoebae
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Candidatus Midichloria mitochondrii IricVA
81
Endosymbiont of Acanthamoeba sp. UWC8
66
100
Wolbachia endosymbiont of Onchocerca ochengi
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Ehrlichia canis str. Jake
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100
Anaplasma phagocytophilum HZ
Neorickettsia sennetsu str. Miyayama
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Orientia tsutsugamushi str. Boryong
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Rickettsia typhi str. B9991CWPP
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Alphaproteobacterium HIMB114
100
100
Candidatus Pelagibacter ubique SAR11 HTCC1002
Alphaproteobacterium HIMB59
NHP bacterium
100
Candidatus Magnetococcus yuandaducum
Magnetococcus marinus MC-1
95
Ralstonia solanacearum GMI1000
99
100
Dechloromonas aromatica RCB
100
Nitrosomonas sp. Is79A3
Chromobacterium violaceum ATCC 12472
100
Pseudomonas aeruginosa PA7
100
Escherichia coli str. K-12 substr. MG1655
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Francisella tularensis subsp. tularensis FSC198
Legionella pneumophila str. Lens

Figure S3


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Rhodothalassium salexigens DSM 2132
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Alphaproteobacterium HIMB114
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1
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1
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1
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1
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Alphaproteobacterium HIMB59
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NHP bacterium
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Candidatus Caedibacter acanthamoebae
1
Candidatus Magnetococcus yuandaducum
Magnetococcus marinus MC-1
1
Nitrosomonas sp. Is79A3
1
1
Ralstonia solanacearum GMI1000
1
Dechloromonas aromatica RCB
Chromobacterium violaceum ATCC 12472
1
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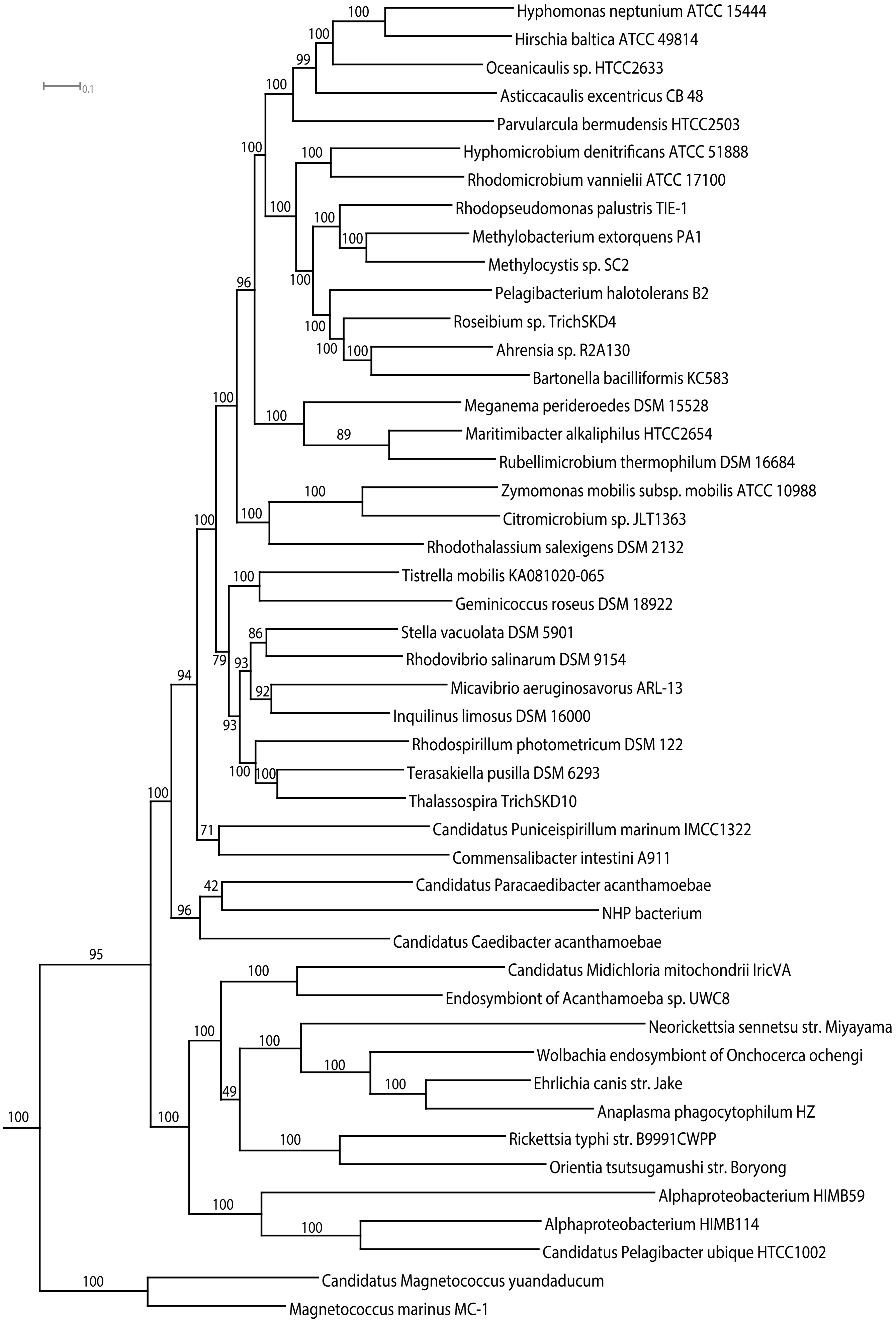
Pseudomonas aeruginosa PA7

Figure S4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Rhodomicrobium vannielii ATCC 17100
Rhodopseudomonas palustris TIE-1
Methylobacterium extorquens PA1
Methylocystis sp. SC2
Pelagibacterium halotolerans B2
Roseibium sp. TrichSKD4
Ahrensia sp. R2A130
Bartonella bacilliformis KC583
Meganema perideroedes DSM 15528
Maritimibacter alkaliphilus HTCC2654
Rubellimicrobium thermophilum DSM 16684
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Inquilinus limosus DSM 16000
Rhodospirillum photometricum DSM 122
Terasakiella pusilla DSM 6293
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Candidatus Puniceispirillum marinum IMCC1322
Commensalibacter intestini A911
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NHP bacterium
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Candidatus Midichloria mitochondrii IricVA
Endosymbiont of Acanthamoeba sp. UWC8
Neorickettsia sennetsu str. Miyayama
Wolbachia endosymbiont of Onchocerca ochengi
Ehrlichia canis str. Jake
Anaplasma phagocytophilum HZ
Rickettsia typhi str. B9991CWPP
Orientia tsutsugamushi str. Boryong
Alphaproteobacterium HIMB59
Alphaproteobacterium HIMB114
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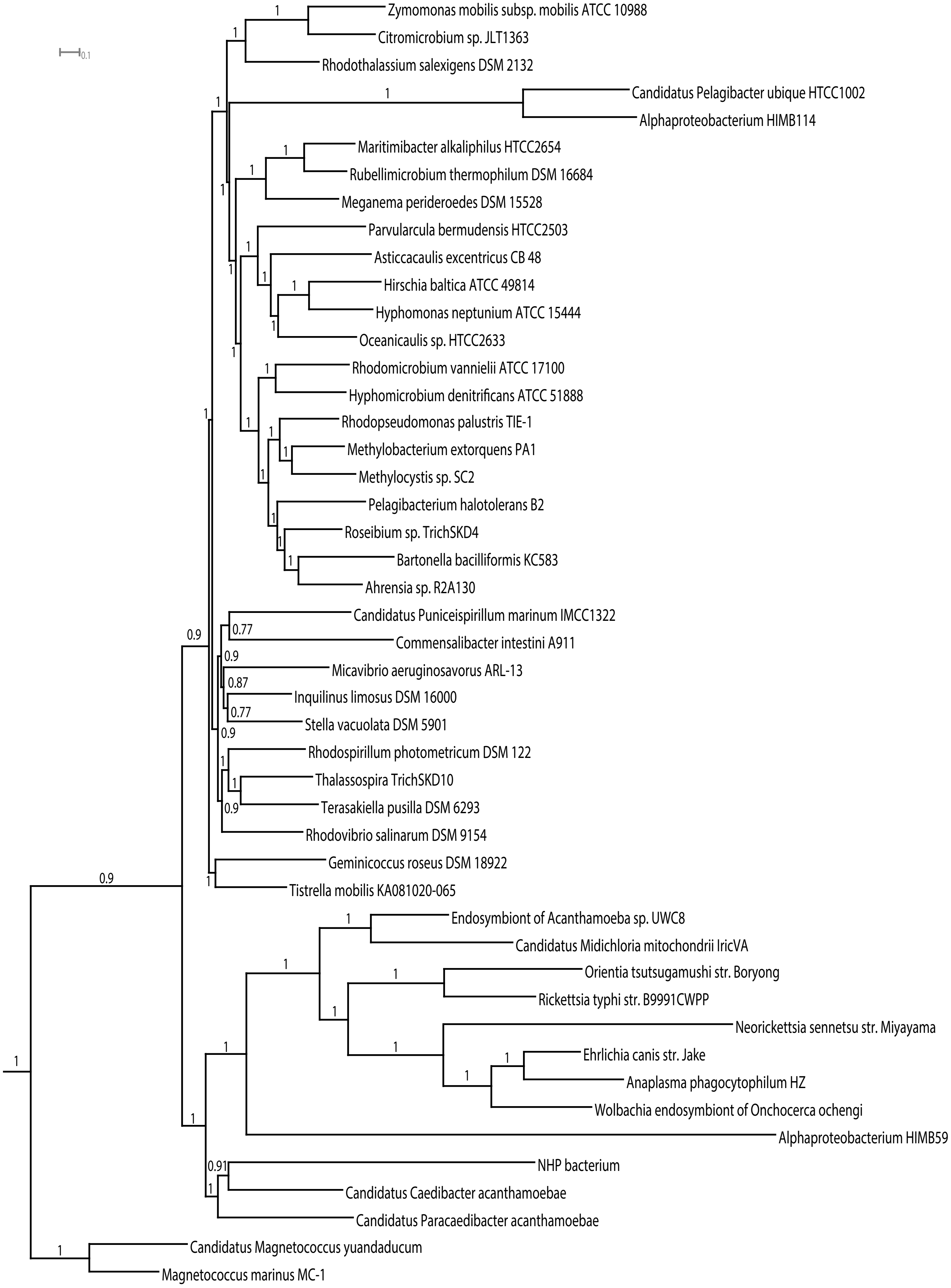
Figure S5



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Maritimibacter alkaliphilus HTCC2654
Rubellimicrobium thermophilum DSM 16684
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Parvularcula bermudensis HTCC2503
Asticcacaulis excentricus CB 48
Hirschia baltica ATCC 49814
Hyphomonas neptunium ATCC 15444
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Rhodopseudomonas palustris TIE-1
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Roseibium sp. TrichSKD4
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Commensalibacter intestini A911
Micavibrio aeruginosavorus ARL-13
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Rhodospirillum photometricum DSM 122
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Endosymbiont of Acanthamoeba sp. UWC8
Candidatus Midichloria mitochondrii IricVA
Orientia tsutsugamushi str. Boryong
Rickettsia typhi str. B9991CWPP
Neorickettsia sennetsu str. Miyayama
Ehrlichia canis str. Jake
Anaplasma phagocytophilum HZ
Wolbachia endosymbiont of Onchocerca ochengi
Alphaproteobacterium HIMB59
NHP bacterium
Candidatus Caedibacter acanthamoebae
Candidatus Paracaedibacter acanthamoebae
Candidatus Magnetococcus yuandaducum
Magnetococcus marinus MC-1
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0.9
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0.87
0.91

Figure S6


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Sagittula stellata E-37
Jannaschia sp. CCS1
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Octadecabacter antarcticus 307
100
Rubellimicrobium thermophilum DSM 16684
100
Paracoccus denitrificans PD1222
Meganema perideroedes DSM 15528
100
Parvularcula bermudensis HTCC2503
100
Phenylobacterium zucineum HLK1
100
99
Asticcacaulis excentricus CB 48
Brevundimonas subvibrioides ATCC 15264
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100
Maricaulis maris MCS10
96
Oceanicaulis sp. HTCC2633
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Hirschia baltica ATCC 49814
Hyphomonas neptunium ATCC 15444
100
100
Hyphomicrobium denitrificans ATCC 51888
Rhodomicrobium vannielii ATCC 17100
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Xanthobacter autotrophicus Py2
92
100
Rhodopseudomonas palustris DX-1
97
Methylocella silvestris BL2
Methylobacterium chloromethanicum CM4
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Ahrensia sp. R2A130
100
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Chelativorans sp. BNC1
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Bartonella quintana str. Toulouse
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Roseibium sp. TrichSKD4
Parvibaculum lavamentivorans DS-1
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Zymomonas mobilis subsp. mobilis ZM4
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Sphingomonas wittichii RW1
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Citromicrobium sp. JLT1363
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Rhodothalassium salexigens DSM 2132
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Stella Vacuolata DSM 5901
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NHP bacterium
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Mesostigma viride
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Marchantia polymorpha
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Phytophthora infestans
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Candidatus Midichloria mitochondrii IricVA
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Rickettsia typhi str. Wilmington
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Orientia tsutsugamushi str. Boryong
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Neorickettsia sennetsu str. Miyayama
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Ehrlichia canis str. Jake
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Anaplasma phagocytophilum HZ
Wolbachia endosymbiont of Culex quinquefasciatus Pel
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Magnetococcus marinus MC-1
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Pseudomonas aeruginosa PA7
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Legionella pneumophila str. Lens
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Nitrosomonas sp. Is79A3

Figure S7


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Oceanicaulis sp. HTCC2633
Parvularcula bermudensis HTCC2503
Rhodomicrobium vannielii ATCC 17100
Hyphomicrobium denitrificans ATCC 51888
Xanthobacter autotrophicus Py2
Rhodopseudomonas palustris DX-1
Methylobacterium chloromethanicum CM4
Methylocella silvestris BL2
Roseibium sp. TrichSKD4
Pseudovibrio sp. JE062
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Rhizobium leguminosarum bv. trifolii WSM1325
Bartonella quintana str. Toulouse
Chelativorans sp. BNC1
Ahrensia sp. R2A130
Parvibaculum lavamentivorans DS-1
Candidatus Pelagibacter ubique SAR11 HTCC1002
Candidatus Pelagibacter IMCC9063
Alphaproteobacterium HIMB114
Kordiimonas gwangyangensis DSM 19435
Rhodothalassium salexigens DSM 2132
Zymomonas mobilis subsp. mobilis ZM4
Sphingomonas wittichii RW1
Citromicrobium sp. JLT1363
Roseomonas cervicalis ATCC 49957
Acidiphilium cryptum JF-5
Granulibacter bethesdensis CGDNIH1
Gluconobacter oxydans 621H
Gluconacetobacter diazotrophicus PAl 5
0.55
Commensalibacter intestini A911
Micavibrio aeruginosavorus ARL-13
Rhodospirillum centenum SW
Inquilinus limosus DSM 16000
Rhodovibrio salinarum DSM 9154
Candidatus Puniceispirillum marinum IMCC1322
Stella Vacuolata DSM 5901
Candidatus Paracaedibacter symbiosus
Candidatus Odyssella thessalonicensis L13
Candidatus Paracaedibacter acanthamoebae
0.87
NHP bacterium
Candidatus Caedibacter acanthamoebae
Alphaproteobacterium HIMB59
Thalassospira TrichSKD10
Terasakiella pusilla DSM 6293
Magnetospirillum magneticum AMB-1
Roseospirillum parvum DSM 12498
Rhodospirillum rubrum ATCC 11170
Roseospira marina DSM 15113
Geminicoccus roseus DSM 18922
Orientia tsutsugamushi str. Boryong
Rickettsia typhi str. Wilmington
Neorickettsia sennetsu str. Miyayama
Wolbachia endosymbiont of Culex quinquefasciatus Pel
Ehrlichia canis str. Jake
Anaplasma phagocytophilum HZ
Candidatus Midichloria mitochondrii IricVA
0.99
Endosymbiont of Acanthamoeba sp. UWC8
Reclinomonas americana
Phytophthora infestans
Rhodomonas salina
Hemiselmis andersenii
Mesostigma viride
Marchantia polymorpha
Candidatus Magnetococcus yuandaducum
Magnetococcus marinus MC-1
Chromobacterium violaceum ATCC 12472
Ralstonia solanacearum GMI1000
Dechloromonas aromatica RCB
Nitrosomonas sp. Is79A3
Francisella tularensis subsp. tularensis FSC198
Legionella pneumophila str. Lens
Escherichia coli str. K-12 substr. MG1655
Pseudomonas aeruginosa PA7

Figure S8


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Chelativorans sp. BNC1
Ahrensia sp. R2A130
Pseudovibrio sp. JE062
Roseibium sp. TrichSKD4
Methylocella silvestris BL2
Methylobacterium chloromethanicum CM4
Rhodopseudomonas palustris DX-1
Xanthobacter autotrophicus Py2
Hyphomicrobium denitrificans ATCC 51888
Rhodomicrobium vannielii ATCC 17100
Meganema perideroedes DSM 15528
Ketogulonicigenium vulgare Y25
Rubellimicrobium thermophilum DSM 16684
Paracoccus denitrificans PD1222
Jannaschia sp. CCS1
Octadecabacter antarcticus 307
Sagittula stellata E-37
Ruegeria sp. TM1040
Parvularcula bermudensis HTCC2503
Brevundimonas subvibrioides ATCC 15264
Asticcacaulis excentricus CB 48
Phenylobacterium zucineum HLK1
Oceanicaulis sp. HTCC2633
Maricaulis maris MCS10
Hirschia baltica ATCC 49814
Hyphomonas neptunium ATCC 15444
Parvibaculum lavamentivorans DS-1
Rhodothalassium salexigens DSM 2132
Kordiimonas gwangyangensis DSM 19435
Citromicrobium sp. JLT1363
Zymomonas mobilis subsp. mobilis ZM4
Sphingomonas wittichii RW1
Candidatus Puniceispirillum marinum IMCC1322
Magnetospirillum magneticum AMB-1
Roseospirillum parvum DSM 12498
Roseospira marina DSM 15113
Rhodospirillum rubrum ATCC 11170
Terasakiella pusilla DSM 6293
Thalassospira TrichSKD10
Stella Vacuolata DSM 5901
Micavibrio aeruginosavorus ARL-13
Inquilinus limosus DSM 16000
Rhodospirillum centenum SW
Rhodovibrio salinarum DSM 9154
Geminicoccus roseus DSM 18922
Commensalibacter intestini A911
Gluconobacter oxydans 621H
Gluconacetobacter diazotrophicus PAl 5
Acidiphilium cryptum JF-5
Granulibacter bethesdensis CGDNIH1
Roseomonas cervicalis ATCC 49957
Candidatus Paracaedibacter symbiosus
Candidatus Paracaedibacter acanthamoebae
Candidatus Odyssella thessalonicensis L13
Candidatus Caedibacter acanthamoebae
Orientia tsutsugamushi str. Boryong
Rickettsia typhi str. Wilmington
Endosymbiont of Acanthamoeba sp. UWC8
Candidatus Midichloria mitochondrii IricVA
Neorickettsia sennetsu str. Miyayama
Anaplasma phagocytophilum HZ
Ehrlichia canis str. Jake
Wolbachia endosymbiont of Culex quinquefasciatus Pel
Cryptococcus neoformans
Spizellomyces punctatus
Nematostella vectensis
Monosiga brevicollis
Arabidopsis thaliana
Phytophthora infestans
Alphaproteobacterium HIMB59
Candidatus Pelagibacter ubique SAR11 HTCC1002
Candidatus Pelagibacter IMCC9063
Alphaproteobacterium HIMB114
NHP bacterium
Magnetococcus marinus MC-1
Candidatus Magnetococcus yuandaducum
Legionella pneumophila str. Lens
Francisella tularensis subsp. tularensis FSC198
Escherichia coli str. K-12 substr. MG1655
Pseudomonas aeruginosa PA7
Nitrosomonas sp. Is79A3
Ralstonia solanacearum GMI1000
Dechloromonas aromatica RCB
Chromobacterium violaceum ATCC 12472

Figure S9


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Sphingomonas wittichii RW1
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Citromicrobium sp. JLT1363
Kordiimonas gwangyangensis DSM 19435
1
Rhodothalassium salexigens DSM 2132
Meganema perideroedes DSM 15528
1
Rubellimicrobium thermophilum DSM 16684
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Ketogulonicigenium vulgare Y25
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Octadecabacter antarcticus 307
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Jannaschia sp. CCS1
1
Sagittula stellata E-37
1
Ruegeria sp. TM1040
Paracoccus denitrificans PD1222
1
Brevundimonas subvibrioides ATCC 15264
1
0.97
Asticcacaulis excentricus CB 48
0.62
Phenylobacterium zucineum HLK1
1
Hirschia baltica ATCC 49814
1
Hyphomonas neptunium ATCC 15444
1
1
Maricaulis maris MCS10
Oceanicaulis sp. HTCC2633
Parvularcula bermudensis HTCC2503
1
1
Rhodomicrobium vannielii ATCC 17100
Hyphomicrobium denitrificans ATCC 51888
0.94
Xanthobacter autotrophicus Py2
1
1
Rhodopseudomonas palustris DX-1
1
Methylobacterium chloromethanicum CM4
Methylocella silvestris BL2
1
Roseibium sp. TrichSKD4
1
Pseudovibrio sp. JE062
1
1
Rhizobium leguminosarum bv. trifolii WSM1325
1
1
Bartonella quintana str. Toulouse
1
1
Chelativorans sp. BNC1
Ahrensia sp. R2A130
0.98
Parvibaculum lavamentivorans DS-1
1
Candidatus Pelagibacter ubique SAR11 HTCC1002
1
Candidatus Pelagibacter IMCC9063
Alphaproteobacterium HIMB114
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Micavibrio aeruginosavorus ARL-13
Rhodospirillum centenum SW
0.95
Inquilinus limosus DSM 16000
1
Candidatus Paracaedibacter symbiosus
0.6
1
Candidatus Odyssella thessalonicensis L13
1
Candidatus Paracaedibacter acanthamoebae
1
NHP bacterium
Candidatus Caedibacter acanthamoebae
0.52
Candidatus Puniceispirillum marinum IMCC1322
0.66
Stella Vacuolata DSM 5901
0.52
Rhodovibrio salinarum DSM 9154
0.54
Alphaproteobacterium HIMB59
Roseomonas cervicalis ATCC 49957
1
Granulibacter bethesdensis CGDNIH1
1
1
Acidiphilium cryptum JF-5
1
Gluconobacter oxydans 621H
0.66
Gluconacetobacter diazotrophicus PAl 5
Commensalibacter intestini A911
1
Thalassospira TrichSKD10
1
Terasakiella pusilla DSM 6293
Magnetospirillum magneticum AMB-1
0.89
1
1
Roseospirillum parvum DSM 12498
1
Rhodospirillum rubrum ATCC 11170
Roseospira marina DSM 15113
Geminicoccus roseus DSM 18922
1
Orientia tsutsugamushi str. Boryong
0.7
Rickettsia typhi str. Wilmington
1
Neorickettsia sennetsu str. Miyayama
0.99
Wolbachia endosymbiont of Culex quinquefasciatus Pel
1
1
Ehrlichia canis str. Jake
Anaplasma phagocytophilum HZ
1
Candidatus Midichloria mitochondrii IricVA
0.66
Endosymbiont of Acanthamoeba sp. UWC8
Reclinomonas americana
1
1
Phytophthora infestans
1
Rhodomonas salina
1
Hemiselmis andersenii
1
Mesostigma viride
Marchantia polymorpha
1
1
Candidatus Magnetococcus yuandaducum
Magnetococcus marinus MC-1
1
Ralstonia solanacearum GMI1000
1
1
Nitrosomonas sp. Is79A3
Dechloromonas aromatica RCB
Chromobacterium violaceum ATCC 12472
0.97
Francisella tularensis subsp. tularensis FSC198
Legionella pneumophila str. Lens
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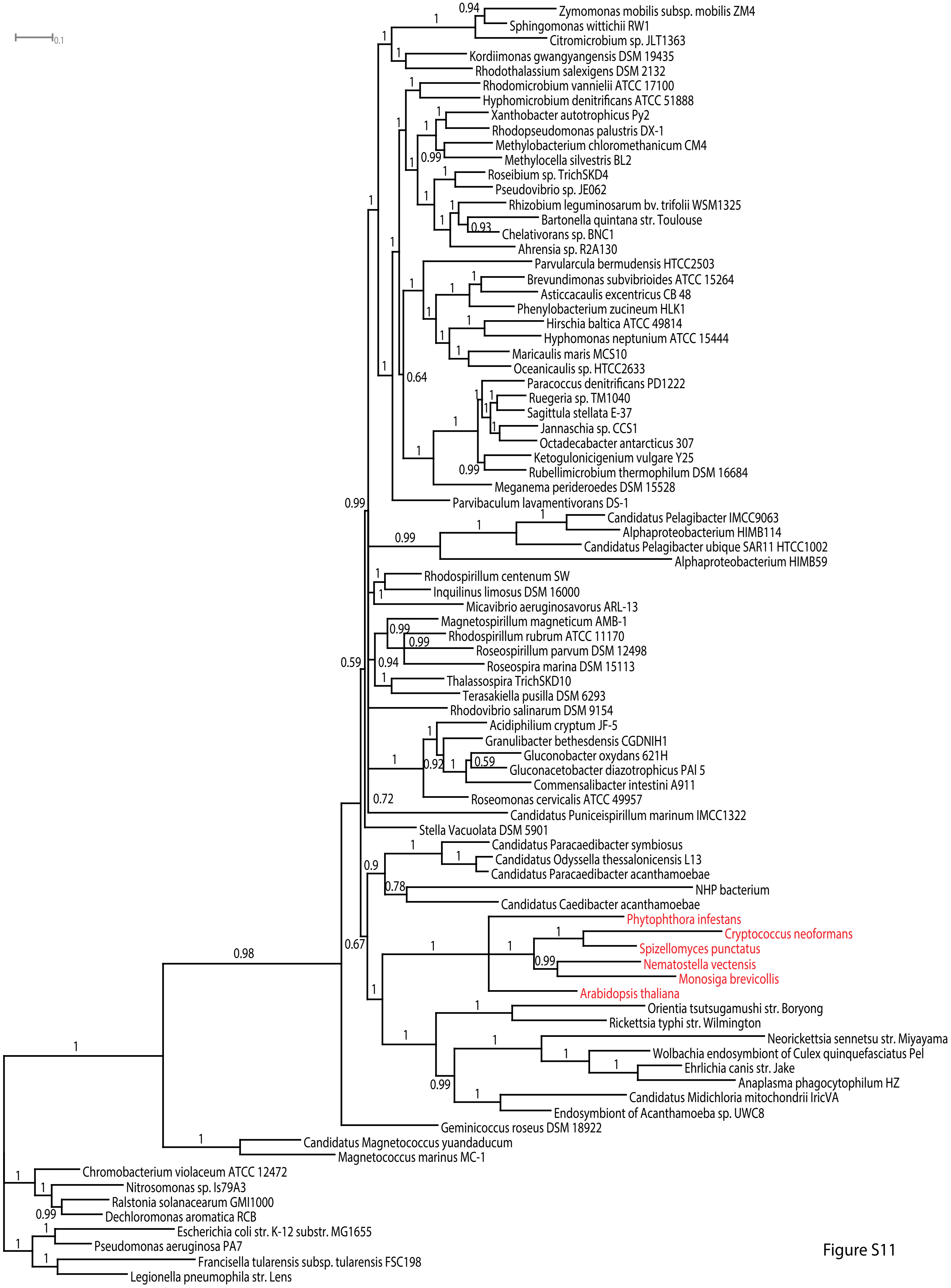
Escherichia coli str. K-12 substr. MG1655
Pseudomonas aeruginosa PA7

Figure S10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Rhodothalassium salexigens DSM 2132
Rhodomicrobium vannielii ATCC 17100
Hyphomicrobium denitrificans ATCC 51888
Xanthobacter autotrophicus Py2
Rhodopseudomonas palustris DX-1
Methylobacterium chloromethanicum CM4
Methylocella silvestris BL2
Roseibium sp. TrichSKD4
Pseudovibrio sp. JE062
Rhizobium leguminosarum bv. trifolii WSM1325
Bartonella quintana str. Toulouse
Chelativorans sp. BNC1
Ahrensia sp. R2A130
Parvularcula bermudensis HTCC2503
Brevundimonas subvibrioides ATCC 15264
Asticcacaulis excentricus CB 48
Phenylobacterium zucineum HLK1
Hirschia baltica ATCC 49814
Hyphomonas neptunium ATCC 15444
Maricaulis maris MCS10
Oceanicaulis sp. HTCC2633
Paracoccus denitrificans PD1222
Ruegeria sp. TM1040
Sagittula stellata E-37
Jannaschia sp. CCS1
Octadecabacter antarcticus 307
Ketogulonicigenium vulgare Y25
Rubellimicrobium thermophilum DSM 16684
Meganema perideroedes DSM 15528
Parvibaculum lavamentivorans DS-1
Candidatus Pelagibacter IMCC9063
Alphaproteobacterium HIMB114
Candidatus Pelagibacter ubique SAR11 HTCC1002
Alphaproteobacterium HIMB59
Rhodospirillum centenum SW
Inquilinus limosus DSM 16000
Micavibrio aeruginosavorus ARL-13
Magnetospirillum magneticum AMB-1
Rhodospirillum rubrum ATCC 11170
Roseospirillum parvum DSM 12498
Roseospira marina DSM 15113
Thalassospira TrichSKD10
Terasakiella pusilla DSM 6293
Rhodovibrio salinarum DSM 9154
Acidiphilium cryptum JF-5
Granulibacter bethesdensis CGDNIH1
Gluconobacter oxydans 621H
Gluconacetobacter diazotrophicus PAl 5
Commensalibacter intestini A911
Roseomonas cervicalis ATCC 49957
Candidatus Puniceispirillum marinum IMCC1322
Stella Vacuolata DSM 5901
Candidatus Paracaedibacter symbiosus
Candidatus Odyssella thessalonicensis L13
Candidatus Paracaedibacter acanthamoebae
NHP bacterium
Candidatus Caedibacter acanthamoebae
Phytophthora infestans
Cryptococcus neoformans
Spizellomyces punctatus
Nematostella vectensis
Monosiga brevicollis
Arabidopsis thaliana
Orientia tsutsugamushi str. Boryong
Rickettsia typhi str. Wilmington
Neorickettsia sennetsu str. Miyayama
Wolbachia endosymbiont of Culex quinquefasciatus Pel
Ehrlichia canis str. Jake
Anaplasma phagocytophilum HZ
Candidatus Midichloria mitochondrii IricVA
Endosymbiont of Acanthamoeba sp. UWC8
Geminicoccus roseus DSM 18922
Candidatus Magnetococcus yuandaducum
Magnetococcus marinus MC-1
Chromobacterium violaceum ATCC 12472
Nitrosomonas sp. Is79A3
Ralstonia solanacearum GMI1000
Dechloromonas aromatica RCB
Escherichia coli str. K-12 substr. MG1655
Pseudomonas aeruginosa PA7
Francisella tularensis subsp. tularensis FSC198
Legionella pneumophila str. Lens

Figure S11


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Zymomonas mobilis subsp. mobilis ZM4
Sphingomonas wittichii RW1
Citromicrobium sp. JLT1363
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Rhodothalassium salexigens DSM 2132
Kordiimonas gwangyangensis DSM 19435
Parvibaculum lavamentivorans DS-1
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Methylobacterium chloromethanicum CM4
Methylocella silvestris BL2
100
74
Xanthobacter autotrophicus Py2
Rhodopseudomonas palustris DX-1
70
100
100
Roseibium sp. TrichSKD4
Pseudovibrio sp. JE062
95
98
Chelativorans sp. BNC1
27
Rhizobium leguminosarum bv. trifolii WSM1325
90
100
Bartonella quintana str. Toulouse
Ahrensia sp. R2A130
100
Rhodomicrobium vannielii ATCC 17100
Hyphomicrobium denitrificans ATCC 51888
100
Meganema perideroedes DSM 15528
72
Jannaschia sp. CCS1
85
Octadecabacter antarcticus 307
85
Ketogulonicigenium vulgare Y25
96
Rubellimicrobium thermophilum DSM 16684
100
Ruegeria sp. TM1040
71
Sagittula stellata E-37
92
Paracoccus denitrificans PD1222
100
Phenylobacterium zucineum HLK1
93
Asticcacaulis excentricus CB 48
Brevundimonas subvibrioides ATCC 15264
100
100
Maricaulis maris MCS10
99
Oceanicaulis sp. HTCC2633
100
100
Hyphomonas neptunium ATCC 15444
Hirschia baltica ATCC 49814
Parvularcula bermudensis HTCC2503
71
24
Micavibrio aeruginosavorus ARL-13
Candidatus Puniceispirillum marinum IMCC1322
47
Gluconobacter oxydans 621H
100
Commensalibacter intestini A911
80
Gluconacetobacter diazotrophicus PAl 5
100
Granulibacter bethesdensis CGDNIH1
100
Acidiphilium cryptum JF-5
45
Roseomonas cervicalis ATCC 49957
18
67
Stella Vacuolata DSM 5901
100
Rhodospirillum centenum SW
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Inquilinus limosus DSM 16000
13
57
Rhodovibrio salinarum DSM 9154
Geminicoccus roseus DSM 18922
62
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Terasakiella pusilla DSM 6293
16
Thalassospira TrichSKD10
89
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Rhodospirillum rubrum ATCC 11170
97
Roseospira marina DSM 15113
50
Roseospirillum parvum DSM 12498
Magnetospirillum magneticum AMB-1
86
88
Candidatus Caedibacter acanthamoebae
100
Candidatus Paracaedibacter symbiosus
100
Candidatus Paracaedibacter acanthamoebae
Candidatus Odyssella thessalonicensis L13
NHP bacterium
95
Alphaproteobacterium HIMB59
100
Candidatus Pelagibacter IMCC9063
100
Alphaproteobacterium HIMB114
89
Candidatus Pelagibacter ubique SAR11 HTCC1002
99
100
Reclinomonas americana
100
Mesostigma viride
80
Marchantia polymorpha
74
Phytophthora infestans
100
Hemiselmis andersenii
Rhodomonas salina
100
100
Rickettsia typhi str. Wilmington
74
Orientia tsutsugamushi str. Boryong
100
Candidatus Midichloria mitochondrii IricVA
100
Endosymbiont of Acanthamoeba sp. UWC8
100
Neorickettsia sennetsu str. Miyayama
100
Wolbachia endosymbiont of Culex quinquefasciatus Pel
100
Ehrlichia canis str. Jake
Anaplasma phagocytophilum HZ
100
Candidatus Magnetococcus yuandaducum
Magnetococcus marinus MC-1
95
Ralstonia solanacearum GMI1000
44
Dechloromonas aromatica RCB
100
Chromobacterium violaceum ATCC 12472
Nitrosomonas sp. Is79A3
100
100
Pseudomonas aeruginosa PA7
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Escherichia coli str. K-12 substr. MG1655
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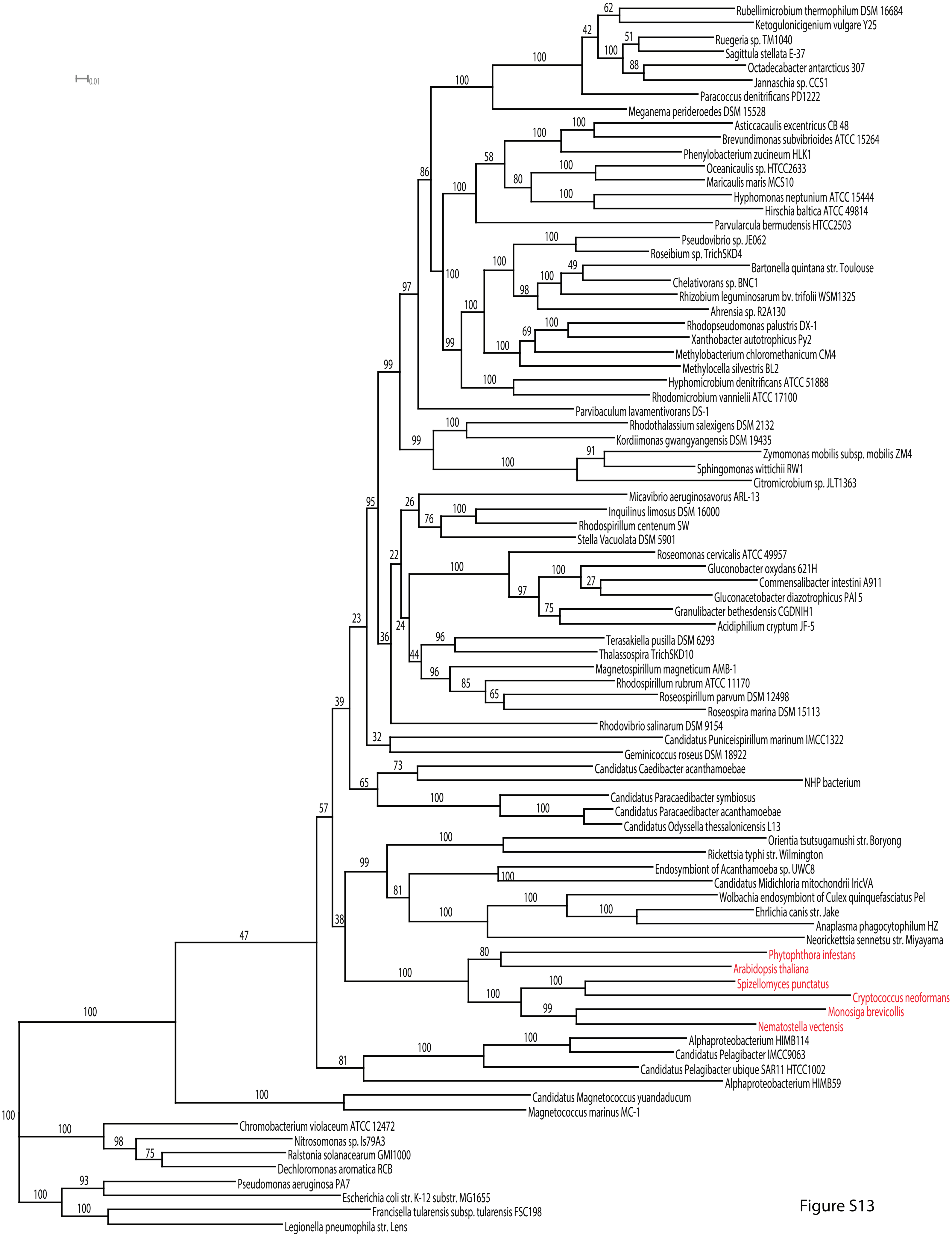
Legionella pneumophila str. Lens
Francisella tularensis subsp. tularensis FSC198

Figure S12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Jannaschia sp. CCS1
Paracoccus denitrificans PD1222
Meganema perideroedes DSM 15528
Asticcacaulis excentricus CB 48
Brevundimonas subvibrioides ATCC 15264
Phenylobacterium zucineum HLK1
Oceanicaulis sp. HTCC2633
Maricaulis maris MCS10
Hyphomonas neptunium ATCC 15444
Hirschia baltica ATCC 49814
Parvularcula bermudensis HTCC2503
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Roseibium sp. TrichSKD4
Bartonella quintana str. Toulouse
Chelativorans sp. BNC1
Rhizobium leguminosarum bv. trifolii WSM1325
Ahrensia sp. R2A130
Rhodopseudomonas palustris DX-1
Xanthobacter autotrophicus Py2
Methylobacterium chloromethanicum CM4
Methylocella silvestris BL2
Hyphomicrobium denitrificans ATCC 51888
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Parvibaculum lavamentivorans DS-1
Rhodothalassium salexigens DSM 2132
Kordiimonas gwangyangensis DSM 19435
Zymomonas mobilis subsp. mobilis ZM4
Sphingomonas wittichii RW1
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Inquilinus limosus DSM 16000
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Stella Vacuolata DSM 5901
Roseomonas cervicalis ATCC 49957
Gluconobacter oxydans 621H
Commensalibacter intestini A911
Gluconacetobacter diazotrophicus PAl 5
Granulibacter bethesdensis CGDNIH1
Acidiphilium cryptum JF-5
Terasakiella pusilla DSM 6293
Thalassospira TrichSKD10
Magnetospirillum magneticum AMB-1
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Geminicoccus roseus DSM 18922
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NHP bacterium
Candidatus Paracaedibacter symbiosus
Candidatus Paracaedibacter acanthamoebae
Candidatus Odyssella thessalonicensis L13
Orientia tsutsugamushi str. Boryong
Rickettsia typhi str. Wilmington
Endosymbiont of Acanthamoeba sp. UWC8
Candidatus Midichloria mitochondrii IricVA
Wolbachia endosymbiont of Culex quinquefasciatus Pel
Ehrlichia canis str. Jake
Anaplasma phagocytophilum HZ
Neorickettsia sennetsu str. Miyayama
Phytophthora infestans
Arabidopsis thaliana
Spizellomyces punctatus
Cryptococcus neoformans
Monosiga brevicollis
Nematostella vectensis
Alphaproteobacterium HIMB114
Candidatus Pelagibacter IMCC9063
Candidatus Pelagibacter ubique SAR11 HTCC1002
Alphaproteobacterium HIMB59
Candidatus Magnetococcus yuandaducum
Magnetococcus marinus MC-1
Chromobacterium violaceum ATCC 12472
Nitrosomonas sp. Is79A3
Ralstonia solanacearum GMI1000
Dechloromonas aromatica RCB
Pseudomonas aeruginosa PA7
Escherichia coli str. K-12 substr. MG1655
Francisella tularensis subsp. tularensis FSC198
Legionella pneumophila str. Lens

Figure S13


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Zymomonas mobilis subsp. mobilis ZM4
Sphingomonas wittichii RW1
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Citromicrobium sp. JLT1363
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Rhodothalassium salexigens DSM 2132
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Candidatus Pelagibacter IMCC9063
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Alphaproteobacterium HIMB114
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Candidatus Pelagibacter ubique SAR11 HTCC1002
Parvibaculum lavamentivorans DS-1
Parvularcula bermudensis HTCC2503
1
Brevundimonas subvibrioides ATCC 15264
1
Asticcacaulis excentricus CB 48
1
Phenylobacterium zucineum HLK1
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1
Hirschia baltica ATCC 49814
Hyphomonas neptunium ATCC 15444
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Maricaulis maris MCS10
Oceanicaulis sp. HTCC2633
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Rhodomicrobium vannielii ATCC 17100
0.99
Hyphomicrobium denitrificans ATCC 51888
1
Roseibium sp. TrichSKD4
Pseudovibrio sp. JE062
1
1
0.99
Rhizobium leguminosarum bv. trifolii WSM1325
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Bartonella quintana str. Toulouse
1
Chelativorans sp. BNC1
1
Ahrensia sp. R2A130
1
Xanthobacter autotrophicus Py2
Rhodopseudomonas palustris DX-1
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Methylobacterium chloromethanicum CM4
0.99
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Methylocella silvestris BL2
Blastochloris sulfoviridis
Paracoccus denitrificans PD1222
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Ketogulonicigenium vulgare Y25
RhodoHTCC2255
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0.99
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Sagittula stellata E-37
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Jannaschia sp. CCS1
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Octadecabacter antarcticus 307
Rubellimicrobium thermophilum DSM 16684
Meganema perideroedes DSM 15528
Candidatus Puniceispirillum marinum IMCC1322
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Acidiphilium cryptum JF-5
1
Granulibacter bethesdensis CGDNIH1
1
0.99
1
Gluconobacter oxydans 621H
Gluconacetobacter diazotrophicus PAl 5
0.99
Commensalibacter intestini A911
Roseomonas cervicalis ATCC 49957
Magnetospirillum magneticum AMB-1
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Roseospirillum parvum DSM 12498
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Rhodospirillum rubrum ATCC 11170
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Roseospira marina DSM 15113
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Thalassospira TrichSKD10
Terasakiella pusilla DSM 6293
Stella Vacuolata DSM 5901
0.61
Rhodovibrio salinarum DSM 9154
0.51
Micavibrio aeruginosavorus ARL-13
1
Rhodospirillum centenum SW
1
Inquilinus limosus DSM 16000
1
Thalassiosira pseudonana
Phytophthora infestans
0.99
Chlamydomonas reinhardtii
1
Micromonas pusilla
Arabidopsis thaliana
1
1
Dictyostelium discoideum
Tetrahymena thermophila
0.82
Naegleria gruberi
Monosiga brevicollis
0.99
1
Trichoplax adhaerens
0.99
1
Nematostella vectensis
0.57
Strongylocentrotus purpuratus
1
0.89
Drosophila melanogaster
1
Caenorhabditis elegans
1
Schistosoma mansoni
0.85
Homo sapiens
0.99
Cryptococcus neoformans
1
1
Saccharomyce cerevisiae
1
Nectria haematococca
1
Spizellomyces punctatus
1
Batrachochytrium dedrobatidis
Allomyce macrogynus
0.89
0.81
1
Orientia tsutsugamushi str. Boryong
Rickettsia typhi str. Wilmington
1
Neorickettsia sennetsu str. Miyayama
1
1
Wolbachia endosymbiont of Culex quinquefasciatus Pel
1
Ehrlichia canis str. Jake
Anaplasma phagocytophilum HZ
0.87
0.98
1
Candidatus Midichloria mitochondrii IricVA
Endosymbiont of Acanthamoeba sp. UWC8
1
Alphaproteobacterium HIMB59
1
Candidatus Paracaedibacter symbiosus
1
Candidatus Odyssella thessalonicensis L13
0.99
Candidatus Paracaedibacter acanthamoebae
NHP bacterium
0.74
Candidatus Caedibacter acanthamoebae
1
Geminicoccus roseus DSM 18922
1
Candidatus Magnetococcus yuandaducum
Magnetococcus marinus MC-1
1
Methylococcus capsulatus str. Bath
Escherichia coli str. K-12 substr. MG1655
1
Chromobacterium violaceum ATCC 12472
Thiobacillus denitrificans ATCC 25259

Figure S14