STORI: SELECTABLE TAXON ORTHOLOG RETRIEVAL ITERATIVELY

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STORI: SELECTABLE TAXON ORTHOLOG RETRIEVAL ITERATIVELY

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SUMMARY

Speciation and gene duplication are fundamental evolutionary processes that enable biological innovation. For over a decade, biologists have endeavored to distinguish orthology (homology caused by speciation) from paralogy (homology caused by duplication). Disentangling orthology and paralogy is useful to diverse fields such as phylogenetics, protein engineering, and genome content comparison.

A common step in ortholog detection is the computation of Bidirectional Best Hits (BBH). However, we found this computation impractical for more than 24 Eukaryotic proteomes. Attempting to retrieve orthologs in less time than previous methods require, we developed a novel algorithm and implemented it as a suite of Perl scripts. This software, Selectable Taxon Ortholog Retrieval Iteratively (STORI), retrieves orthologous protein sequences for a set of user-defined proteomes and query sequences. While the time complexity of the BBH method is O(#taxa^2), we found that the average CPU time used by STORI may increase linearly with the number of taxa.

To demonstrate one aspect of STORI's usefulness, we used this software to infer the orthologous sequences of 26 ribosomal proteins (rProteins) from the large ribosomal subunit (LSU), for a set of 115 Bacterial and 94 Archaeal proteomes. Next, we used established tree-search methods to seek the most probable evolutionary explanation of these data. The current implementation of STORI runs on Red Hat Enterprise Linux 6.0 with installations of Moab 5.3.7, Perl 5 and several Perl modules. STORI is available at: <http://github.com/jgstern/STORI>.

CHAPTER 1

INTRODUCTION

Evolutionary biology owes four decades of progress to shared protein and nucleic acid sequence data (Fuchs & Cameron 1991; Strasser, 2010; Mushegian, 2011). For example, comparisons of ribosomal RNA gene sequences shared by multiple laboratories studying diverse organisms led to the discovery of Archaea (Woese & Fox, 1977). Follow up work revealed evolutionary histories specific to the Archaeal, Eukaryal, and Bacterial spaces of life's tree (Battistuzzi & Hedges, 2009; Gribaldo & Brochier, 2009; Yoon et al., 2008). Phylogenetic study is useful for exploring the thermostability of Earth's earliest biomolecules (Gaucher et al., 2008); understanding the invention of novel receptor specificities (Bridgham et al., 2011); and providing context to antimicrobial drug resistance (Dridi et al., 2009).

Although initial phylogenies represented single gene families (typically, the gene for the ribosome's small subunit RNA), increasing availability of whole genomes allowed follow-up studies to use multiple protein families as phylogenetic markers (Pupko et al., 2002) yielding reconstructions with improved accuracy (Rokas et al., 2003). Increased taxonomic and genomic sampling (e.g., Wu et al., 2009; Lang et al., 2013) improves phylogenetic accuracy (Nabhan & Sarkar, 2011).

Another means of improving phylogenetic accuracy is to use orthologous (rather than paralogous) genes when generating a multiple alignment of the sequence data (Cao et al., 2000; Philippe et al., 2011). Orthologous genes share a common ancestor because of speciation, and are distinct from paralogous genes, which result from gene duplication (Kristensen et al., 2011).

Popular sources of phylogenetic data include the ribosomal protein (rProtein) genes, notwithstanding their low abundance relative to all prokaryotic gene families

(Dagan & Martin, 2006). The ribosome's essential role of translating information to function (Fox & Naik, 2004) deters gene loss (Makarova et al., 2001) or horizontal transfer (Sorek et al., 2007). Lecompte et al. (2002) exemplifies the standard method of rProtein retrieval: seed sequences from curated proteomes are selected, and used as queries in BLASTP (Altschul et al., 1997) similarity searches of additional proteome databases. Although tedious, this process is straightforward for Bacteria and Archaea. We found that Eukaryotic retrievals are complicated when ostensibly orthologous query sequences to the same target proteome produce different best hits (J. G. S. & E. A. G., unpublished data).

As an alternative to manual sequence retrieval, one can employ a variety of ortholog retrieval services (Zhou & Landweber, 2007; Chen et al., 2007; Kuzniar et al., 2008; Schmitt et al., 2011; Powell et al., 2011). These services usually depend on large databases of pre-computed information. For example, the Clusters of Orthologous Groups algorithm (Tatusov et al., 1997) requires computation of Bidirectional Best Hits (BBH), by storing the results of a BLAST search of every sequence of every proteome against a database of all other sequences.

On our Department's shared compute cluster (730 AMD Opteron CPUs; six cores/ CPU at 2400 MHz), we found it impractical to perform BBH computation for more than 24 Eukaryotic proteomes. In **Figure 1**, we show the effect of increased taxon sampling on the CPU time to find best hits of every protein sequence in the sample. The first part of the present study demonstrates a novel algorithm that may reduce the ortholog retrieval time for taxa sets containing >90 Bacteria, Archaea, or Eukaryotes (**Figure 2**). This algorithm is a new and potentially faster way to understand the data deluge created by DNA and protein sequencing technologies.

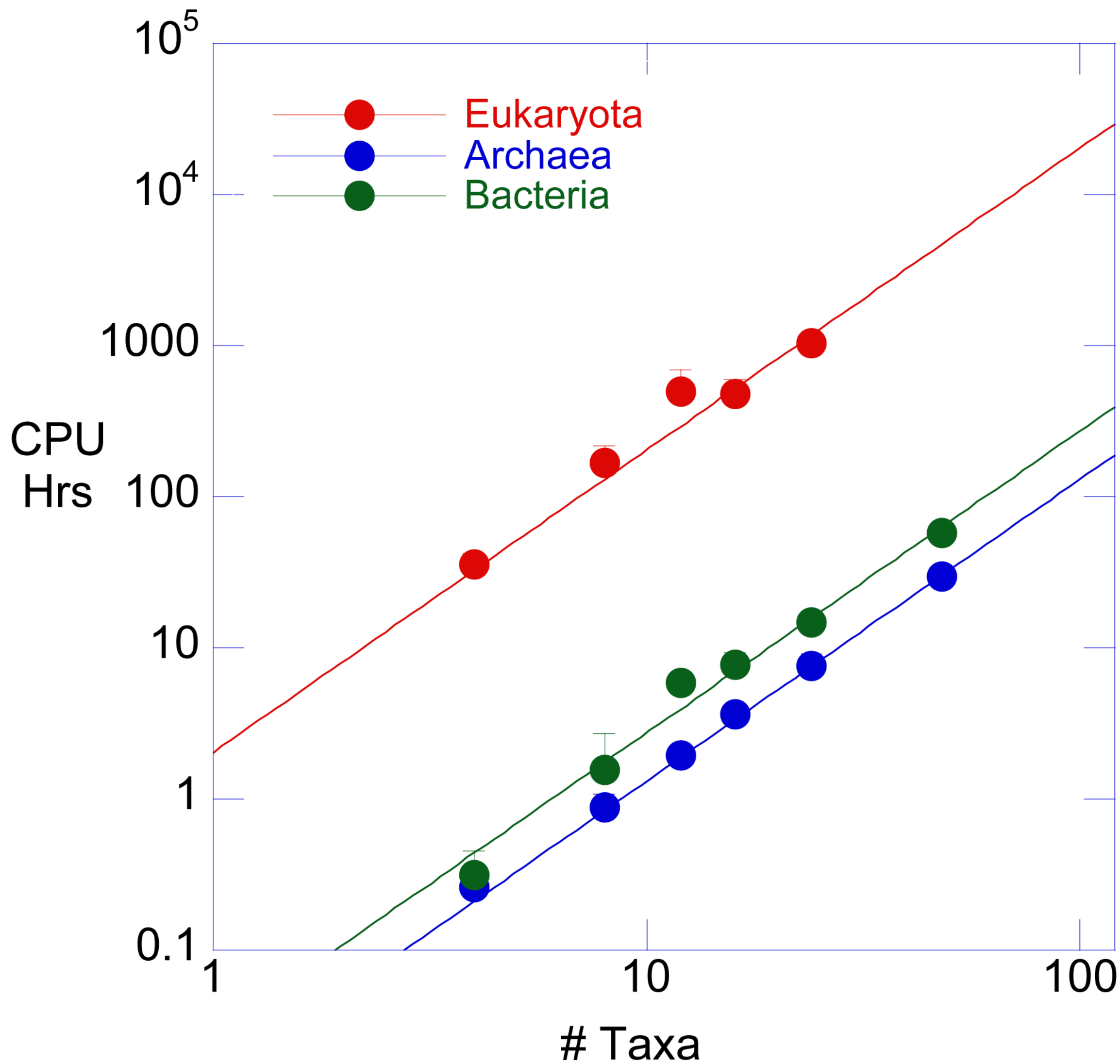


Figure 1. CPU time to Bidirectional Best Hits vs. size of taxa set
Points are the mean CPU time to generate a BLAST best-hit table (Kristensen et al., 2010) for every protein sequence in a sample of size 4, 8, 12, 16, 24, or 48 Bacterial, Archaeal, or Eukaryal taxa (except 48 Eukaryotes). Error bars show one standard deviation of the mean (n=3). For each size-point, we took three randomized subsamples from a proteome superset of 115 Bacterial, 94 Archaeal, or 51 Eukaryal taxa, whose genomes were in NCBI's RefSeq database. Using least-squares minimization in KaleidaGraph, we fit quadratic models to the data (Table 1).

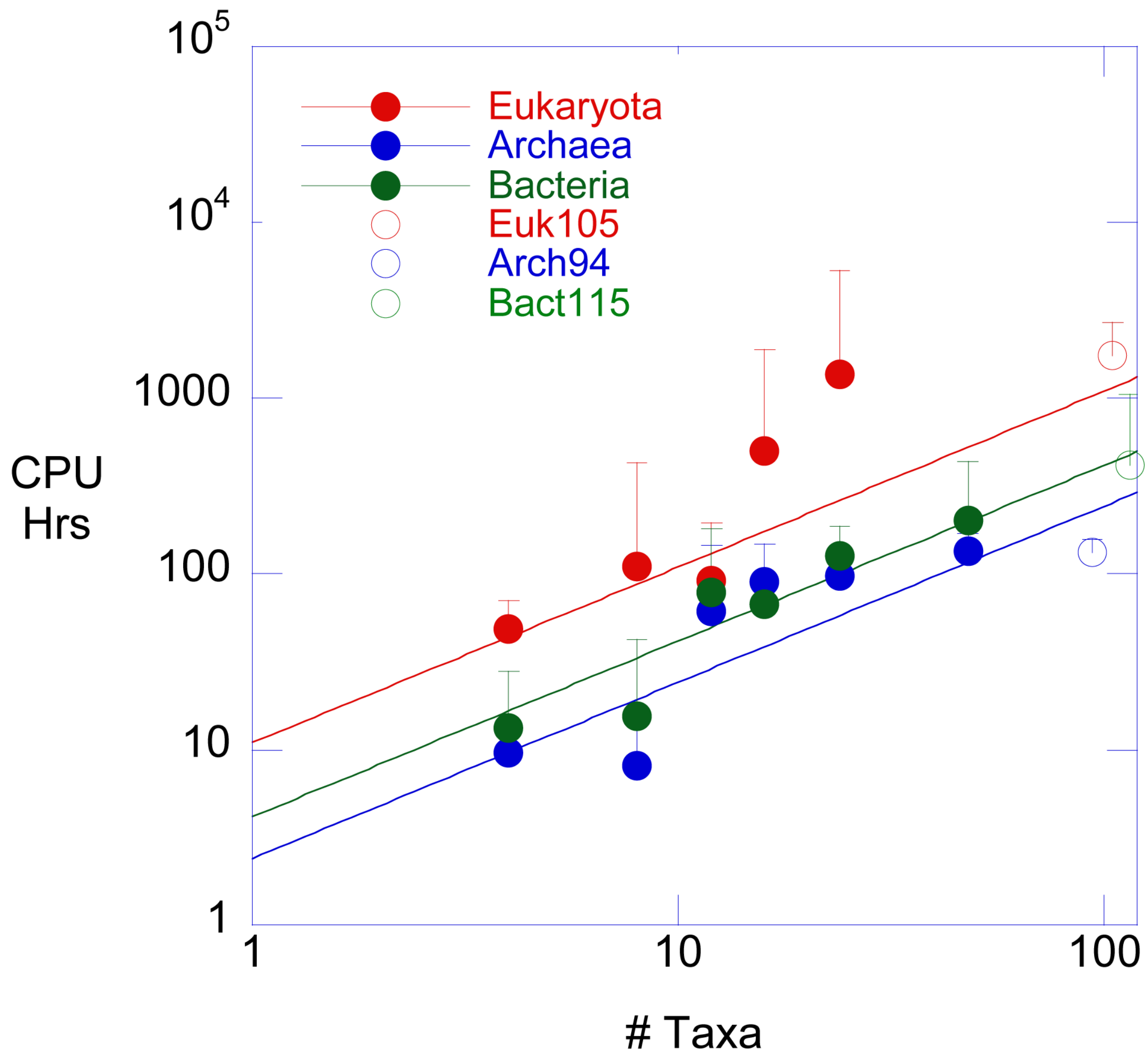


Figure 2: CPU time to STORI retrieval convergence vs. size of taxa set
Points are the mean CPU time until convergence of a STORI retrieval using different taxa sets, identical to those used in BBH benchmarking (Figure 1). Error bars as above. We also conducted triplicate retrievals using the taxa supersets of 115 Bacteria, 94 Archaea, or 105 Eukaryotes (hollow shapes). We fit linear models to the data (excluding the superset retrievals) (Table 2).

The microprocessor-fueled boom in molecular data has accompanied increasingly sophisticated methods of modeling evolutionary history. Felsenstein (2004) provides an illuminating account of phylogenetic development, from the first taxonomy inferred using numerical methods (Michener & Sokal, 1957) to contemporary Bayesian Inference and Maximum Likelihood algorithms (Yang & Rannala, 2012). We summarize the typical practice presently. Given a hypothesis, or model, of character replacement rates, bifurcating tree topology, and branch length, phylogenetic software evaluates the likelihood of the data (an alignment of molecular sequences from different species, or taxa). Typical algorithms maximize likelihood using the Markov Chain Monte Carlo method to iteratively sample the space of alternative models. Felsenstein (1981) explained how to calculate the likelihood of phylogenetic data given an evolutionary model.

An evolutionary narrative is sensitive not only to the tree-search parameters but also to rooting of the tree. Distances between taxa, inferred by quantifying sequence similarity, do not in and of themselves suggest a chronological speciation order. For example, consider taxa A, B, and C, and a star-shaped tree inferred using their sequence data. The evolutionary distance, or branch length, between A and B is 10, the distance from A to C is 20, and B to C is 20. Are A and B younger than C? The answer is only "yes" if the root of the tree lies on the branch leading to taxon C. For all we know, the root could present on the branch leading to B. The uniqueness of taxon C would only support the chronological priority of its speciation under a model with constant evolutionary rate (Felsenstein, 2004). The sequence of taxon C could alternatively be explained by a recent increase in its evolutionary rate. Polarizing (rooting) a topology requires deciding which taxon emerged first, ideally with guidance from radioisotope-dated fossils.

Fossils predating the Ediacaran period, ~635 million years ago, are challenging to preserve (Briggs, 2003), detect (Knoll, 2011), and interpret (Donoghue & Antcliffe, 2010). Questions persist regarding life's earliest speciation. For example, Foster et al. (2009) proposed that Eukaryotes originated from an Archaeal ancestor, *contra* the Three Domains model (see also: Hartman et al., 2006). In the latter part of the present study, we examine alternate models of speciation in the early Bacteria. We do not expect high confidence in any prediction of events that occurred over three billion years ago (Battistuzzi & Hedges, 2009). However, maximum likelihood is a statistically consistent method of inferring evolutionary models; with enough correctly aligned data, and with a sufficiently thorough search of tree-space, the most likely tree is the true tree (Chang, 1996).

Evolutionary narratives help us understand the present and prepare for the future. Yet the road from data to insight can be long. To improve the availability and organization of protein sequence data, we describe a novel ortholog retrieval algorithm and demonstrate its role in a phylogenetic pipeline. We name this algorithm Selectable Taxon Ortholog Retrieval Iteratively (STORI).

CHAPTER 2

MATERIAL AND METHODS

STORI algorithm

STORI is an example of how a simple implementation of the Monte Carlo method can be used to sample "protein family space". We consider a family of orthologous proteins, and its potentially paralogous families, as a Markov chain whose future state (future groupings of sequence accessions) depends only on the present state (present groupings of sequence accessions) (Gilks et al., 1996). The STORI algorithm repeatedly uses BLASTP search results to group protein sequences into hypothetical families of orthologs, which determine subsequent BLASTP queries, until family groupings stabilize to meet a convergence criterion (**Figure 3**). After repeated iteration, the family membership can converge to a steady state. An essential feature of STORI is that all BLASTP searches occur on-demand rather than prior to retrieval. To our knowledge, STORI is the first algorithm that uses randomized BLASTP searches to sample the space of potential orthologies.

We introduce the STORI algorithm by describing the data structure at its conceptual core. This data structure is a nested hash table in STORI.pl named %taxon_gi_assigned (**Figure 3**). STORI defines protein family space in terms of three levels: the protein families reside on the first level; the different taxa, or species, reside on the second level; and the third level accommodates best-hit disagreement over which protein sequence from a particular taxon belongs in a particular family.

Seed sequences loaded into %taxon_gi_assigned. At beginning of taxon list, call GetSeqs()

taxID	name	alpha	mu	zeta	alpha	mu	zeta
9646	Ailuropoda.melanoleuca	110831901 (32)	281341543 (33)	281341541 (33)	-1	-1	-1
9913	Bos.taurus	-1	-1	-1	-1	-1	-1
9615	Canis.lupus.familiaris	-1	-1	-1	-1	-1	-1
7955	Danio.rerio	-1	-1	-1	-1	-1	-1
9796	Equus.caballus	-1	-1	-1	-1	-1	-1
9031	Gallus.gallus	-1	-1	-1	-1	-1	-1
9606	Homo.sapiens	-1	-1	-1	-1	-1	-1
6085	Hydra.magnipapillata	-1	-1	-1	-1	-1	-1
9103	Meleagris.gallopavo	-1	-1	-1	326929282 (35)	2829708 (34)	326929267 (35)
13616	Monodelphis.domestica	-1	-1	-1	-1	-1	-1
10090	Mus.musculus	-1	-1	-1	-1	-1	-1
9986	Oryctolagus.cuniculus	-1	-1	-1	-1	-1	-1
10116	Rattus.norvegicus	-1	-1	-1	-1	-1	-1
9823	Sus.scrofa	-1	-1	-1	-1	-1	-1
59729	Taeniopygia.guttata	-1	-1	-1	-1	-1	-1
7070	Tribolium.castaneum	-1	-1	-1	-1	-1	-1
8364	Xenopus.Silurana.tropicalis	-1	-1	-1	-1	-1	-1

Figure 3: Schematic of the STORI algorithm, found in STORI.pl
Shown are the core steps of STORI.pl, retrieving paralogous hemoglobin-type families of Eumetazoa.

Figure 3A. Seed sequences from the user-guided beginSTORI.pl are loaded into memory (the hash %taxon_gi_assigned), with artificially high scores (parenthesis) to ensure their persistence over many iterations. The red box and arrow indicates the position of the sequence window and its trajectory after GetSeqs() completes (Fig. 3B).

GetSeqs() completes BLAST searches; call PruneAndReassignIntermediate(); Advance sliding window.

taxID	name	alpha	mu	zeta	alpha	mu	zeta
9646	Ailuropoda.melanoleuca	110831901 (33)	281341543 (34)	281341541 (34)	-1	-1	-1
9913	Bos.taurus	359061887 (2)	-1	297470342 (4)	-1	-1	-1
9615	Canis.lupus.familiaris	359319827 (1)	359319827 (3)	359319829 (4)	-1	-1	-1
7955	Danio.rerio	-1	130508612 (3)	47271417 (4)	-1	-1	-1
9796	Equus.caballus	-1	-1	-1	-1	-1	-1
9031	Gallus.gallus	-1	-1	-1	-1	-1	-1
9606	Homo.sapiens	-1	-1	-1	-1	-1	-1
6085	Hydra.magnipapillata	-1	-1	-1	-1	-1	-1
9103	Meleagris.gallopavo	-1	-1	-1	326929282 (35)	2829708 (34)	326929267 (35)
13616	Monodelphis.domestica	-1	-1	-1	-1	-1	-1
10090	Mus.musculus	-1	-1	-1	-1	-1	-1
9986	Oryctolagus.cuniculus	-1	-1	-1	-1	-1	-1
10116	Rattus.norvegicus	-1	-1	-1	-1	-1	-1
9823	Sus.scrofa	-1	-1	-1	-1	-1	-1
59729	Taeniopygia.guttata	-1	-1	-1	-1	-1	-1
7070	Tribolium.castaneum	-1	-1	-1	-1	-1	-1
8364	Xenopus.Silurana.tropicalis	-1	-1	-1	-1	-1	-1

Figure 3B. For each window of taxa, GetSeqs() loads seed or best-hit GIs into memory (best-hit GIs are results of BLASTP searches using each available sequence within the window). PruneAndReassignIntermediate() uses the score of each GI to move non-orthologous homologs to their preferred family. In this example, GI 359319827 is assigned to both the alpha and the mu families after the second call to GetSeqs(). At this point, the score in alpha is 1 and the score in mu is 3. Once called, PruneAndReassignIntermediate() clears 359319827 from alpha because 1 < 3. The series of dashed red boxes denotes the order of BLAST searches completed in the first call to GetSeqs(); the second call would appear the same except the boxes would be shifted one cell lower.

Window sliding complete; PruneAndReassign()

taxID	name	alpha	mu	zeta	alpha	mu	zeta
9646	Ailuropoda.melanoleuca	110831901 (33)	281341543 (34)	281341541 (34)	-1	-1	-1
9913	Bos.taurus	359061887 (2)	-1	297470342 (4)	-1	-1	-1
9615	Canis.lupus.familiaris	-1	359319827 (5)	359319829 (7)	-1	-1	-1
7955	Danio.rerio	-1	130508612 (7)	47271417 (10)	-1	-1	-1
9796	Equus.caballus	-1	-1	167621441 (12)	-1	-1	-1
9031	Gallus.gallus	-1	122315 (8)	73915350 (12)	229380 (1)	-1	-1
9606	Homo.sapiens	-1	51510893 (7)	4885397 (11)	4504347 (3)	-1	-1
6085	Hydra.magnipapillata	-1	-1	221122853 (9)	-1	-1	-1
9103	Meleagris.gallopavo	-1	-1	-1	326929282 (43)	2829708 (38)	326929267 (42)
13616	Monodelphis.domestica	-1	-1	-1	334333444 (9)	-1	334333440 (8)
10090	Mus.musculus	-1	-1	-1	145301578 (9)	-1	6754162 (9)
9986	Oryctolagus.cuniculus	-1	-1	-1	-1	-1	-1
10116	Rattus.norvegicus	-1	-1	-1	62078447 (9)	-1	290563160 (9)
9823	Sus.scrofa	-1	-1	-1	350581854 (9)	-1	350581838 (10)
59729	Taeniopygia.guttata	-1	-1	-1	323668297 (7)	-1	323669545 (8)
7070	Tribolium.castaneum	-1	-1	-1	-1	-1	91089691 (6)
8364	Xenopus.Silurana.tropicalis	-1	-1	-1	122509 (2)	-1	~~55742013 (1)~~

Figure 3C. Once the window has traversed the taxa list, PruneAndReassign() moves homologous sequences with a score of 1 to new “orphan” families. ResetAllScores sets the score of each sequence to 2, except for seeds, whose scores are reduced by the maximum non-seed score.

Merge (if $seedDecay < 1.4)

taxID	name	alpha	mu	zeta	alpha	mu	zeta	cytoglobin
9646	Ailuropoda.melanoleuca	110831901	281341543	281341541	-1	-1	-1	-1
9913	Bos.taurus	359061887	-1	297470342	-1	-1	-1	-1
9615	Canis.lupus.familiaris	-1	359319827	359319829	-1	-1	-1	-1
7955	Danio.rerio	-1	130508612	47271417	-1	-1	-1	-1
9796	Equus.caballus	-1	-1	167621441	-1	-1	-1	-1
9031	Gallus.gallus	-1	122315	73915350	-1	-1	-1	-1
9606	Homo.sapiens	-1	51510893	4885397	-1	-1	-1	-1
6085	Hydra.magnipapillata	-1	-1	221122853	-1	-1	-1	-1
9103	Meleagris.gallopavo	-1	-1	-1	326929282	2829708	326929267	-1
13616	Monodelphis.domestica	-1	-1	-1	334333444	-1	334333440	-1
10090	Mus.musculus	-1	-1	-1	145301578	-1	6754162	-1
9986	Oryctolagus.cuniculus	-1	-1	-1	-1	-1	-1	-1
10116	Rattus.norvegicus	-1	-1	-1	62078447	-1	290563160	-1
9823	Sus.scrofa	-1	-1	-1	350581854	350581840	350581838	-1
59729	Taeniopygia.guttata	-1	-1	-1	323668297	-1	323669545	-1
7070	Tribolium.castaneum	-1	-1	-1	-1	-1	91089691	-1
8364	Xenopus.Silurana.tropicalis	-1	-1	-1	122509	122303	-1	55742013

Figure 3D. If the run is sufficiently mature (seed/non-seed score ratio < 1.4), Merge evaluates families for uniqueness and merges redundant families. This Merge routine consists of two steps; first a triage step (light blue) determines families that are obviously different based on GI inequality; second a series of BLASTP searches test the best-hit reciprocity of select families of interest (dark blue), and if >80% of the sampled taxa possess this reciprocity, the families are merged.

Result

taxID	name	alpha	mu	zeta	cytoglobin
9646	Ailuropoda.melanoleuca	110831901	281341543	281341541	-1
9913	Bos.taurus	359061887	-1	297470342	-1
9615	Canis.lupus.familiaris	-1	359319827	359319829	-1
7955	Danio.rerio	-1	130508612	47271417	-1
9796	Equus.caballus	-1	-1	167621441	-1
9031	Gallus.gallus	-1	122315	73915350	-1
9606	Homo.sapiens	-1	51510893	4885397	-1
6085	Hydra.magnipapillata	-1	-1	221122853	-1
9103	Meleagris.gallopavo	326929282	2829708	326929267	-1
13616	Monodelphis.domestica	334333444	-1	334333440	-1
10090	Mus.musculus	145301578	-1	6754162	-1
9986	Oryctolagus.cuniculus	-1	-1	-1	-1
10116	Rattus.norvegicus	62078447	-1	290563160	-1
9823	Sus.scrofa	350581854	350581840	350581838	-1
59729	Taeniopygia.guttata	323668297	-1	323669545	-1
7070	Tribolium.castaneum	-1	-1	91089691	-1
8364	Xenopus.Silurana.tropicalis	122509	122303	-1	55742013

Figure 3E. Sequence organization that would result from steps A-D.

The keys of %taxon_gi_assigned are protein family names (e.g., “50S ribosomal subunit protein L4” or “hemoglobin”). Each key pairs with a value, and in our case, the value is a memory reference (pointer) to an anonymous hash. The keys of this “second-level” hash are NCBI Taxonomy ID numbers (e.g., “9606” for *Homo sapiens*, “562” for *Escherichia coli,* etcetera). Each taxon ID key pairs with a value, as before, a pointer to an anonymous hash. The keys of this “third-level” hash are NCBI GI protein sequence accession numbers (e.g. “209757056” for the sequence of 50S ribosomal subunit protein L4 from *Escherichia coli*, submitted on June 8, 2009 by Leopold et al. (2009). Each GI accession key pairs with a value, which is an integer equal to the number of times the key GI was the top hit of a BLASTP search executed by STORI.pl.

The Perl script beginSTORI.pl selects seed sequences from results of user-initiated keyword searches of randomly chosen local databases (**Figure 4**). Beginning with each of these seeds assigned to a unique family, STORI.pl retrieves best BLASTP hits for a few taxa at a time, sliding a “taxon window” (usually 4 taxa) down a randomized master taxon list, and progressively populating %taxon_gi_assigned{family name}{taxon ID} with top-hit GI accessions from BLASTP search results (**Figure 3**). The taxa in any window determine both the query sequences (seeds or results) and the subject proteomes. With each increment of the sliding window, the subroutine PruneAndReassignIntermediate adjusts the family designation of retrieved sequences: if a sequence is a best hit in multiple families, it is cleared from all families except for the family in which it was most *frequently* a best hit. Once the sliding window reaches the end of the master taxa list, this list shuffles and the window restarts at its beginning. The STORI.pl BLASTP searches repeat until sequence reassignment has become negligible or an arbitrary time limit is reached. To expedite sequence retrieval, the ShuffleTaxaArr subroutine juxtaposes assignment-poor taxa against assignment-rich taxa.

STORI.pl executes in parallel, as two serial Portable Batch System jobs submitted by STORIcontrol.pl to a Moab/Torque queue (Staples, 2006) (**Figure 4**). Executing on a head node, STORIcontrol.pl compares the results of the two STORI.pl jobs, measures the agreement, and passes the set of intersecting sequences to the next instantiations of STORI.pl. Iteration continues until 1) the accession grouping agreement is greater than 90% for three consecutive job sets, 2) these sets lack an increasing trend, and 3) consecutive job agreement scores differ less than 4%.

STORI runs on Red Hat Enterprise Linux 6.0 with installations of Moab 5.3.7, Perl 5 and several Perl modules. Users should expect about one week of setup time. The user guide is found in **APPENDIX A**.

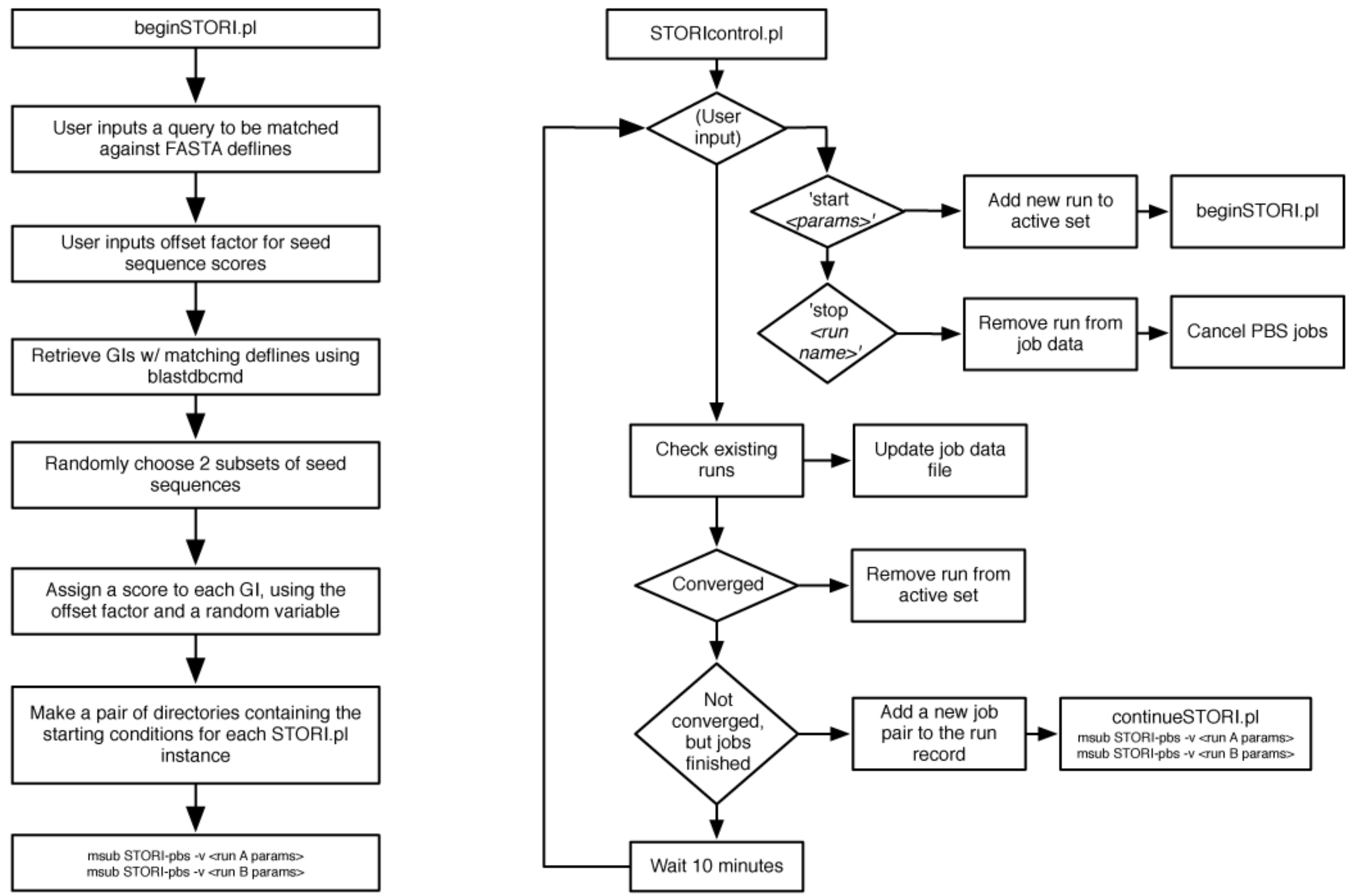


Figure 4. Algorithmic flow diagrams of the STORI “front and middle ends”

Retrieving Sequences

Although we used STORI to retrieve orthologous rProtein sequences from 115 Bacterial taxa, 94 Archaeal taxa, and 105 Eukaryal taxa, we limited the phylogenetic component of our study to the Bacterial and Archaeal domains.

Before detailing our sequence retrieval, let us define the term *taxon*. A taxon is a group of tips (leaves, or external nodes) on a phylogenetic tree. The group may be as exclusive as one leaf or as inclusive as all leaves on the tree. Furthermore, a taxonomic grouping must be consistent with the pattern of ancestry indicated by the rooted tree. In the present work, our use of *taxon* often refers to some external tree node corresponding to one sequence in a multiple sequence alignment. However, a taxon can have more than one member. Depending on the context, *taxon* may be synonymous with *clade* or *phylum*.

Querying the NCBI Genome database with "txid131567[organism]" on May 12, 2013 returned 6,708 hits; each hit corresponds to a genome project at any stage of completion. (Taxon ID 131567 is the "cellular life" taxon; its daughter taxa are txid2, Bacteria, txid2157, Archaea, and txid2759, Eukaryota.) Each one of these thousands of genomes at NCBI could be considered a leaf on the tree of life. Because the structure of such a rich tree would be computationally impractical to infer, we built a subset of the available data informed by existing standards of taxonomic sampling (Ciccarelli et al., 2006; Wu & Eisen, 2008; Battistuzzi & Hedges, 2009; Gribaldo & Brochier, 2009; Parfrey et al., 2010; Brochier-Armanet et al., 2011).

We used STORI to retrieve the 50S ribosomal protein sequences from a set of 115 Bacterial and 94 Archaeal proteomes. Of the 26 ribosomal protein families in our phylogenetic analysis, 17 are present in every Bacterial and Archaeal taxon ("Universal" families), and nine are present in every Bacterial taxon only ("Bacterial" families). The nine Bacterial families are: L9u, L12u, L17u, L19u, L20u, L21u, L27u, L31u, and L35u. The 17 Universal families are: L1pL10ae, L2, L3, L4, L5pL11e, L6pL9e, L10uP0ae, L11pL12e, L13, L14pL23e, L15pL27e, L16uL10ae, L18pL5e, L22pL17e, L23, L24pL26e, and L29pL35e. See **APPENDIX B** for the sequence accessions.

Separately, we used STORI to retrieve ribosomal protein sequences from systematically sampled subsets of 115 Bacterial, 94 Archaeal, and 105 Eukaryal proteomes. We used these retrievals to benchmark the compute time and accuracy of STORI. All of the prokaryotic data used in the present work are from finished genomes. 51 out of the 105 Eukaryotic taxa in this study have complete genomes, and it is from this set of 51 that we systematically sampled subsets (**APPENDIX C**).

To retrieve 23S rRNA sequences from corresponding genomes, we used the SILVA (Quast et al., 2013), and NCBI Nucleotide (Benson et al., 2013) databases. We retrieved a 23S sequence for every taxon of the 209 in our data set.

We generated a hand-corrected multiple sequence alignment for each family using CLUSTALW (Higgins & Sharp, 1988) and MacClade (Maddison & Maddison, 1989) (**APPENDIX C**).

Tree Inference

To search for the most probable history of the Bacterial Large Ribosomal Subunit, given the Multiple Sequence Alignment data, we used MrBayes 3.2.1 (Ronquist et al., 2012). We also used RAxML to search for the tree topology (history) under which the data are most likely (Stamatakis et al., 2005).

We ran MrBayes on three different datasets, and each of these three analyses asked a different phylogenetic question. The first phylogenetic question asked, what is the most probable topology for the 209 Bacteria and Archaea, given a concatenated alignment of the Universal protein families? The second question asked, what is the most probable topology for the 115 Bacteria, given a concatenated alignment of the Universal and Bacterial protein families? The third question asked, what is the most probable topology for the 209 Bacteria and Archaea, given the 23S rRNA alignment?

We conducted RAxML analyses (online at the CIPRES Science Gateway; Miller et al., 2010) on the same protein data sets as we used for the MrBayes analyses. All analyses of protein data assumed that amino acid substitution probabilities were those reported by Whelan & Goldman (2001); all analyses of 23S data assumed that nucleotide substitutions occurred under the model of Tamura & Nei (1993). Additional study would be necessary to develop a systematic justification for these model assumptions (Abascal et al., 2005; Keane et al., 2006).

Using the results of the above three MrBayes analyses, the RAxML analyses, and the literature, we constructed a Universal supertree topology by hand (Topology I; **Figure 5**). We combined an Archaeal topology from Gribaldo & Brochier (2009) with our Bacterial topology, by adding a branch between Thaumarchaeota on the published tree and Fusobacteria on our Bacterial tree. This "divide-and-conquer" approach incorporated the most accurate parts of different topologies in order to reconcile discrepancies between them, as we explain presently.

The MrBayes analysis of the Universal rProtein alignment modeled Deltaproteobacteria as paraphyletic, even though the (Bacterial + Universal) MrBayes analysis modeled this clade as monophyletic with 100% clade credibility. Our explanation of this discrepancy is that the (Bacterial + Universal) analysis used a longer alignment (3679 sites) than that used by the Universal alignment (2428 sites), and therefore the Bacterial topology was inferred from a more robust phylogenetic signal than present in the Universal alignment. Nonetheless, the rooted Universal tree provides an interesting prediction about early Bacterial speciation (see Results), which the Bacterial tree cannot do by itself.

We built Topology II **(Figure 5)** as we built Topology I, except that we used the RAxML predictions instead of the MrBayes predictions. No manual editing was necessary for Topology III, since its MrBayes run used a Universal 23S alignment. We assembled Topologies IV, V, and VI by hand as above, taking the inter-phylum relationships from the appropriate study and using our B+U MrBayes topology for intraphylum relationships. For Topology V, we used the Firmicutes topology as published, because our own analysis split this taxon into Bacilli and Clostridia. Topology V was unrooted as published, so we inferred that Deinococcus was the basal phylum from Wu et al., (2009). **APPENDIX D** provides Topologies I-VI in Newick format, with branch lengths optimized to the three datasets (described in **CHAPTER 3**).

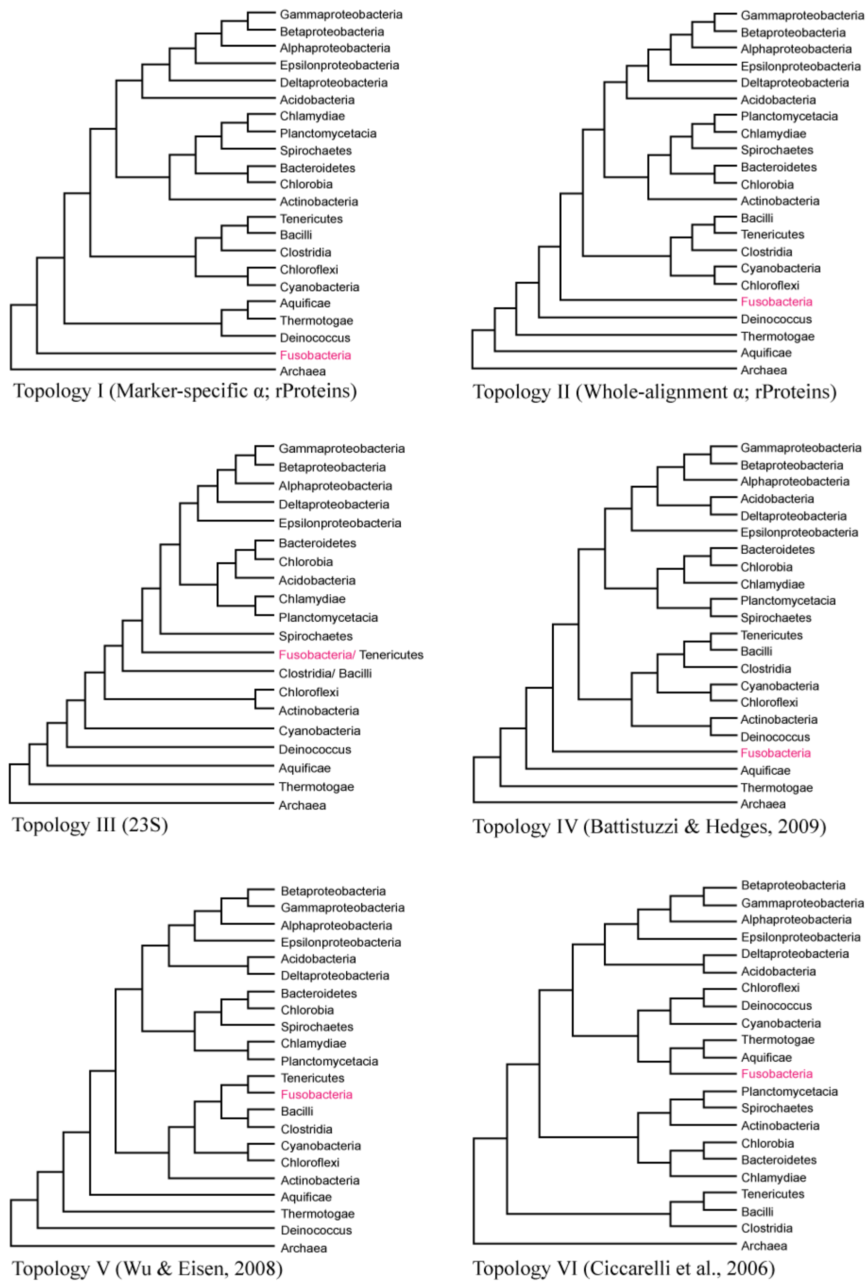


Figure 5. Alternative topological models of Bacterial phylogeny

We built six different models proposing six different sets of evolutionary relationships between Bacterial phyla. Each model assumes an identical history for the Archaeal phyla, as proposed by (Gribaldo & Brochier, 2009). Following are the sources for each topology's Bacterial domain. I, MrBayes analyses of 50S ribosomal protein data (this study); II, RAxML analyses of 50S ribosomal protein data (this study); III, MrBayes analysis of 23S ribosomal RNA data (this study); IV, Battistuzzi & Hedges (2009); V, Wu & Eisen (2008); VI, Ciccarelli et al., (2006). These trees are cladograms, which distort branch lengths for readability. We used Dendroscope (Huson & Scornavacca, 2012) to draw these trees.

CHAPTER 3

RESULTS

Benchmarking Compute Time

We measured the number of CPU-hours necessary for STORI to infer Eukaryotic, Archaeal, and Bacterial rProtein orthologs for different size proteome sets (also referred to as taxa sets). Each datum in **Figure 2** plots the average CPU-hours before retrieval convergence for three separate STORI retrievals; each retrieval is constrained to a set of x randomly selected taxa; $x = 4, 8, 12, 16, 24$, or 48.

Using the same taxa sets as above, we also measured the number of CPU-hours necessary for BBH computation (**Figure 1**). BBH computation is the first and most costly step in a typical orthology-inference workflow. The final step in this workflow can use the EdgeSearch algorithm to find "all maximal triangularly connected subgraphs" within the BBH graph (Kristensen et al., 2010) (wherein nodes are protein sequences and edges indicate the BBH/ ortholog relationship). Under the BBH paradigm, each triangularly connected subgraph corresponds to a gene family's orthologous protein sequences, plus any sequences due to lineage-specific duplications.

If it were possible to systematically constrain proteome size (e.g., choose 10^3 interesting protein sequences from the total pool of 10^4 protein sequences per Eukaryote), then BBH computation would be as practical for Eukaryotes as it is for Archaea and Bacteria. However, selecting sequences of interest requires prior knowledge of the sequence's biochemical function, and for non-annotated sequences, this knowledge is absent by definition. Producing a BBH table for n non-annotated sequences of similar length entails n BLAST searches of a size n database. Because each search requires time proportional to n (Altschul et al., 1997), we expect that the time required for BBH computation is proportional to n^2. Indeed, after we evaluated the likelihood (Barlow,

1989) of our BBH CPU-time data under a linear, quadratic, or power-law model, and corrected for different numbers of parameters using the Akaike and Schwarz Information Criteria (Burnham & Anderson, 2002; Felsenstein, 2004), we found that the quadratic model had the greatest posterior probability (**Table 1**).

In contrast to BBH-based approaches, STORI requires the user to place an upper limit f on the number of protein families allowed for a run, and specify a set of initial seed sequences. When the user initializes a STORI run, each family contains one seed sequence assigned to its parent taxon, and all other taxa are "empty" (lacking a sequence assignment). A window of size w slides through the taxa list, and for each family, any sequences encountered serve as BLAST queries against the w proteomes captured by the window (see Material and Methods). Putting aside the sequence pruning and family merging steps necessary to resolve best-hit disagreements and duplicate families, let us consider a single STORI iteration when practically all taxa in all families have been assigned a protein sequence, *but* the retrieval has not yet converged because family membership remains volatile. In this scenario, $(x - w + 1)w^2f$ BLAST searches occur in one iteration of STORI (**APPENDIX F**). For the tests reported in **Figure 2**, $w = 4$, $f = 80$, and x varies.

STORI iterations repeat until two different convergence criteria are met. The first criterion applies at the level of a single STORI.pl instantiation, and the second applies at the level of STORIcontrol.pl (see Material and Methods). Generalizing convergence time complexity is beyond our scope, except for what we can infer from observations. Repeating for the STORI data the model selection procedure we used for the BBH data, we found that our linear model had the greatest posterior probability (**Table 2**).

Table 1. Model selection statistics for BBH CPU time data. lnL is the natural logarithm of the likelihood of the data under each model (Barlow, 1989). K is the number of free parameters. ΔBIC is the Bayesian/ Schwarz Information Criterion reported relative to the maximum value in each domain. ΔAIC_c is the Aikake Information Criterion corrected for a small sample size. PP denotes the posterior probability of the model given the data (Burnham & Anderson, 2002).

	Model	lnL	K	ΔBIC	ΔAIC_c	PP BIC	PP AIC_c
Euks	$y=12.1x$	-69.9	6	32.6	32.6	0.000	0.000
	$y=2.02x^2$	-53.6	6	0	0	0.569	0.943
	$y=2.78x^{1.87}$	-53.0	7	0.556	5.61	0.431	0.0570
Arch	$y=0.214x$	-178	7	385	385	0.000	0.000
	$y=0.0130x^2$	14.4	7	0	0	0.578	0.988
	$y=.00164x^{1.94}$	14.9	8	0.632	8.84	0.422	0.0119
Bact	$y=0.336x$	-65.9	7	119	119	0.000	0.000
	$y=0.0271x^2$	-6.25	7	0	0	0.513	0.985
	$y=0.0396x^{1.88}$	-5.41	8	0.106	8.31	0.487	0.0154

Table 2. Model selection statistics for STORI retrieval convergence time data. Column headings are as in Table 1.

	Model	lnL	K	ΔBIC	ΔAIC_c	PP BIC	PP AIC_c
Euks	$y=11.0x$	-73.0	6	0	0	0.544	0.716
	$y=1.18x^2$	-74.0	6	2.05	2.05	0.195	0.257
	$y=19.9x^{0.643}$	-72.9	7	1.47	6.52	0.261	0.0274
Arch	$y=2.42x$	-49.47	7	0	0	0.542	0.954
	$y=0.0730x^2$	-52.82	7	6.70	6.70	0.0190	0.0334
	$y=1.36x^{1.21}$	-48.79	8	0.425	8.63	0.439	0.0127
Bact	$y=4.15x$	-58.69	7	0	0	0.524	0.696
	$y=0.201x^2$	-59.53	7	1.69	1.69	0.225	0.299
	$y=1.99x^{1.27}$	-58.53	8	1.47	9.68	0.251	0.00550

Benchmarking Accuracy

We measured the accuracy of STORI by comparing GI groupings in each retrieval replicate (**Figure 2**) against manually verified Archaeal, Bacterial, or Eukaryal reference families (**APPENDIX G**). Shown in **Figure 6A** are the accuracies of sequence assignments for all non-empty taxa in every family of each retrieval replicate, versus the convergence score of that family. Shown in **Figure 6B** are the accuracies of phyletic patterns for every family of each retrieval replicate, versus the convergence score of that family. These accuracy comparisons ignored families present in retrieval replicates that were absent from the reference set.

The STORI algorithm relies upon a measurement of the convergence between two independent STORI.pl runs. We calculate this convergence metric in checkSTORI.pl (called from STORIcontrol.pl). The script checkSTORI.pl tests GI accession identity to match each family in run A with its counterpart family in run B, if present. The convergence score for a particular family is the number of taxa with identical GI accessions between family A and family B, divided by the total number of taxa.

We do not observe sequence accuracy to have dependence on convergence score (**Figure 6A)**, although average sequence accuracy is >99%. On the other hand, we find a positive correlation between the accuracy of a family's phyletic pattern and convergence score of this family (**Figure 6B)**.

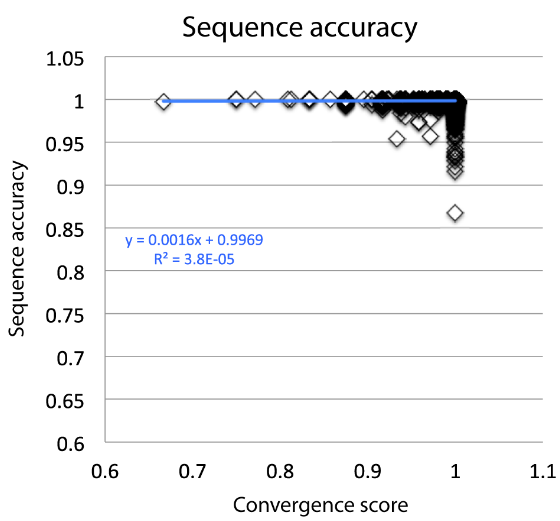


Figure 6A

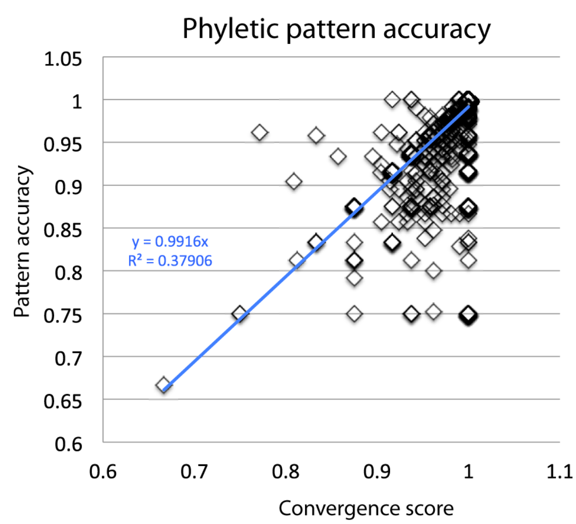


Figure 6B

Figure 6. Accuracy of families retrieved by each replicate run

The most probable history of the Bacterial 50S, given its sequences

Assuming that the root of the Universal tree lies along the branch between Bacteria and Archaea (Iwabe et al., 1989; Gogarten & Taiz, 1992; Fournier & Gogarten, 2010; Dagan et al., 2010; *contra* Cavalier-Smith, 2010), our Universal tree predicts that Bacterial diversification began with emergence of Fusobacteria (**Figure 5; Figure 7**).

We were curious about how well our MrBayes-inferred model of Bacterial 50S evolution explained our data compared to models previously published (Ciccarelli et al., 2006; Wu & Eisen, 2008; Battistuzzi & Hedges, 2009); and compared to our RAxML and 23S models. To compare the fit of alternative topological models to the data, we compared the Site-Specific Likelihood (Yang, 1997; Jow et al., 2002) of the data under each model, using the Approximately Unbiased (AU) test (Shimodaira & Hasegawa, 2001). This statistic estimates the frequency that the alignment data under a particular model would be more likely than under all other considered models, after repeated data sampling and likelihood optimization. The AU p-value accounts for a model's sensitivity to data sampling error (Shimodaira, 2002).

We show the AU results in **Table 3**. These tests selected Topology I as the model under which our protein alignment data are the most likely. Topology II is slightly less preferable, and III – VI give explanations of the protein data that are significantly less likely than those of I and II. This selection is unsurprising since models I and II were generated using our protein data, and III – VI were not.

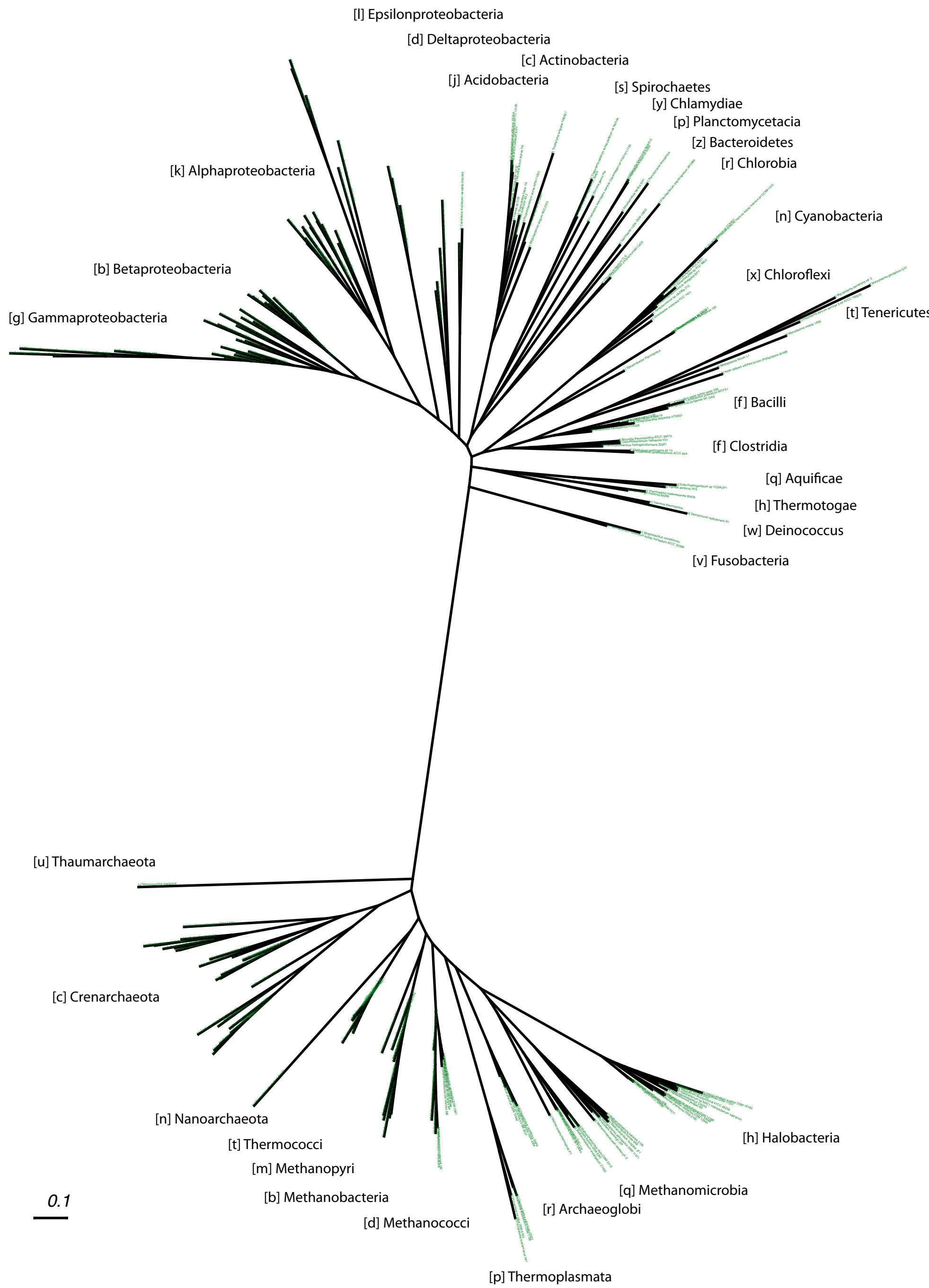


Figure 7. Likelihood-optimized phylogeny of Bacteria and Archaea

This phylogeny uses Topology I (Figure 5). We used PAML (Yang, 2007) to infer the branch lengths under which the data are most likely. Bacterial branch lengths inferred from B+U alignment; Archaeal branches and inter-domain branch inferred using the U alignment. The distance between Fusobacteria and its sister clade is from the B+U inference, but the ratio of the Fusobacteria branch length to the sister branch length is from the U inference. Scale bar indicates 0.1 substitutions/site.

Table 3: Approximately Unbiased p-values for phylogenetic model selection. We optimized the branch lengths of six different topological models (I – VI) to maximize the likelihood of three different alignment datasets (Universal Protein, Bacterial + Universal Protein, and Universal 23S). We explain the meaning of these p-values in the main text.

	U Prot	(B + U) Prot	23S
I	7.7×10^{-1}	4.9×10^{-1}	4.1×10^{-1}
II	3.6×10^{-1}	5.3×10^{-1}	4.1×10^{-1}
III	1.0×10^{-11}	3.0×10^{-104}	6.6×10^{-1}
IV	5.9×10^{-2}	3.0×10^{-3}	4.2×10^{-1}
V	1.0×10^{-3}	2.0×10^{-5}	4.4×10^{-1}
VI	1.0×10^{-4}	6.0×10^{-54}	3.6×10^{-1}

Also unsurprising is that Topology III, the model generated using our 23S alignment, is the preferred explanation of our 23S alignment. Less expected was that Topology III does not explain the 23S alignment dramatically better than any of the other topologies. These AU tests suggest that ribosomal protein sequence alignments contain more phylogenetic information than ribosomal RNA nucleotide alignments. Additional studies will be necessary to situate this particular finding within a general understanding of the phylogenetic informativeness of nucleotide versus protein data (White et al., 2007; Townsend et al., 2008).

Let us compare our "best guess" of 50S Bacterial topology (Topology I; **Figures 5 and 7**) with earlier proposals from the Hedges, Eisen, and Bork laboratories (respectively, Topologies IV, V, and VI; **Figure 5**). Fusobacteria may reside within a Terrabacteria-like clade in V, or within a thermophilic clade in VI, or at a basal position in I and IV. Topologies IV and V both contain the Terrabacteria clade (save Deinococci), and if the Actinobacteria are omitted, so does Topology I. Topologies IV and V group Bacteroidetes, Chlorobia, Chlamydiae, Planctomycetacea, and Spirochaetes; whereas, Actinobacteria are present in this clade for Topologies I and VI. Chloroflexi and Cyanobacteria group closely in all topologies, although Deinococci may be nearby, as in IV and VI, or near the base of Bacteria, as in I and V. In topologies I and VI, Aquificae and Thermotogae form a basal (I) or derived (VI) clade. These two phyla occupy non-claded basal positions in IV and V. All four topologies clade Tenericutes, Bacilli, and Clostridia, and these phyla group within Terrabacteria for I, IV, and V. All four topologies group Acidobacteria with Proteobacteria.

Topology I's universal data likelihood score is higher than that of Topology II, although we used identical data to infer both models. It seems clear that our MrBayes run sampled tree-space more successfully than our RAxML run. However, future study will be necessary to determine whether this difference is a feature unique to MrBayes' tree-sampling algorithm. Our decision to allow MrBayes to independently optimize the shape parameter (α) for separate gene partitions in the concatenated alignment may have enabled this software to propose the model under which the data are most likely. The latter explanation would be consistent with an analysis of multigene amino acid data sets by Pupko et al. (2002). These authors found that among-site variation in evolutionary rate is best modeled by a separate Gamma distribution for each gene.

APPENDIX E provides our most likely model of Bacterial and Archaeal history, as shown in **Figure 7**.

CHAPTER 4

DISCUSSION

Given the assumptions of our analysis, we found that the earliest speciation within the Bacterial domain produced ancestral Fusobacteria. Extant members of this phylum are commensal inhabitants of the human mouth (*Fusobacterium nucleatum*; Kapatral et al., 2002), although some are human pathogens (*Streptobacilus moniliformis*; Nolan et al., 2009), and others live in anoxic marine sediments (*Ilyobacter polytropus*; Sikorski et al., 2010). The sizes of finished Fusobacterial genomes in GenBank are 1.5 – 4.4 million base pairs, and these genome sizes are larger than those of many known symbiotic bacteria (McCutcheon & Moran, 2011).

Previous studies expressed low confidence in the phylogenetic placement of Fusobacteria, due to a genome composition best explained by an unusually high number of lateral gene transfers (Mira et al., 2004; Battistuzzi & Hedges, 2009). Additional studies using a larger set of phylogenetic markers will be necessary to clarify the history of Bacteria. Future studies should incorporate novel Fusobacteria, Deinococci, Aquificae, Thermotogae, and other phyla with an unstable phylogenetic position. In light of this study's success using a heterogeneous α parameter, we encourage further development and testing of heterogeneous evolutionary models (e.g. Lopez et al., 1999; Foster, 2004; Kolaczkowski & Thornton, 2008).

We have demonstrated a Markov Chain Monte Carlo algorithm that predicts sequence orthology for 100-taxa data sets from Bacteria, Archaea, and Eukaryota. STORI offers a new way to retrieve constrained sets of orthologous families in time roughly linear to the number of taxa. In contrast with other methods, STORI constrains the number of families retrievable in a single run.

The requirement of a user-specified family limit may increase the accessibility of ortholog retrieval to fields beyond phylogenomics. For example, a protein engineer may not be interested in alignments of orthologous sequences from 80 different families. However, she may be interested in maximizing alignment quality for one protein family – and gaining a residue-level understanding of enzymatic function. In this scenario, STORI is ideal, because it will retrieve the orthologs of interest while minimizing costly BLAST searches of unrelated families.

We have several ideas for the improvement of STORI. We would like to enable STORI to run on a single multi-core node in addition to a cluster environment. Many researchers do not have access to the particular compute cluster resources that we benefited from while developing STORI. Adding capability to run on a single machine, real or virtual, would make the STORI method accessible to more researchers.

Another improvement to STORI would be algorithmic. Although the current version is faster than previous methods, additional speed improvements should be possible with a negligible impact on accuracy. In a typical retrieval, roughly half of the families have a convergence score of 1.0 after only two or three job-sets (< 200 CPU-hours). However, the present version of STORI executes BLASTP searches on *all* families, no matter their convergence score, until the *average* convergence score of all families is larger then 0.90 three times in a row with a nonincreasing trend. It should be possible to adjust the iteration to discriminate between families with a score of 1.0 and all others, such that only families with a convergence score < 1.0 are subject to additional BLASTP queries. This change would redirect the "attention" of STORI to those families with the greatest need, and could reduce the time to retrieval convergence.

In the longer term, we would be interested to see alternative similarity search algorithms implemented in STORI. For example, the reciprocal smallest distance algorithm determines orthologous sequence pairs by using maximum likelihood to estimate the evolutionary distance between candidate pairs (Wall et al., 2003). This method could be adopted in STORI to choose best hits not by the top BLAST result but rather by the hit with the shortest branch length to the query, in a maximum-likelihood phylogeny containing the query and the top 10 best BLAST hits.

Finally, STORI will only realize its full potential if it is widely used and the results that it helps generate are widely understood. It may be possible and worthwhile to develop a new type of database in which orthologs are determined not by one research group with a large amount of computing power but rather by a large number of research groups, each with a modest amount of computing power. With an appropriate environment for sharing, the combined insight of many researchers would be greater than the sum of its parts.

Ortholog retrieval has applications beyond phylogenetic inference and protein engineering. This technique may contribute to predicting molecular phenotypes such as protein-protein interaction (De Bodt et al., 2009), and understanding evolutionary processes such as amino acid substitution (Conant et al., 2007) or gene duplication (Jordan et al., 2004). Although ortholog identification and genome assembly are independently useful, these techniques can synergize (ÓhÉigeartaigh et al., 2011; Ruttink et al., 2013). We provide a new method of accessing protein databases with potential use in diverse fields.

Our Perl implementation of STORI returns predictions as lists of NCBI GI accessions, which is a format convenient for retrieval using the Constraint-based Multiple Protein Alignment Tool (Papadopoulos & Agarwala, 2007).

APPENDIX A

SELECTABLE TAXON ORTHOLOG RETRIEVAL ITERATIVELY

(STORI) USER'S GUIDE

Welcome to the STORI! This algorithm is a new way to retrieve protein families. The unique aspect of our method is an iterative search of "family space". We consider a protein family and its potentially paralogous families as a Markov chain whose future state (future grouping of sequence accessions) depends only on the present state (present grouping of sequence accessions). After repeated iteration, the family membership can converge to a steady state. We assess convergence by measuring the agreement between two parallel chains, whose initial states were randomized. Because family optimization occurs iteratively, this algorithm bypasses precomputation of reciprocal best hits.

The first step is to make sure that Perl is configured properly[1]. The run environment for these scripts needs Perl to have access to several modules from CPAN: Statistics::Descriptive, Data::Dumper, List::MoreUtils, Time::Elapse, LWP::Simple, Bio::SeqIO, and Getopt::Long. If you do not have root access, and these modules are not already functional, then do a non-root Perl module installation to some location in your home directory. We've included a separate text file with the commands that worked on our system (nonroot-cpan.txt).

Look over the scripts in the STORI directory and change the file paths as appropriate for your system[2]. Here is a list of the different paths that STORI needs to run, as we configured them for our system. These directories are found at the beginning of at least one of each script:

```
/tmp/jstern7
/nv/hp10/jstern7/perl5reinstall/lib
nv/hp10/jstern7/perl5reinstall/lib/perl5
/nv/hp10/jstern7/STORI
/nv/hp10/jstern7/STORI/getParentTaxa.pl
/nv/hp10/jstern7/STORI/STORIcontrol_job_statistics.txt
/nv/hp10/jstern7/STORI/job_data_STORI.txt
/nv/hp10/jstern7/STORI/checkSTORI.pl
/nv/hp10/jstern7/STORI/checkSTORI-noseqs.pl
/nv/hp10/jstern7/STORI/continueSTORIfast_t.pl
/nv/hp10/jstern7/STORI/continueSTORI_48hr.pl
/nv/hp10/jstern7/STORI/beginSTORI.pl
```

---

[1] When executing Perl scripts, it might be necessary to "module load perl" at the beginning of your terminal session depending on your computing environment. Note that 'module' in the context of this command is different from a Perl module that one would download from http://www.cpan.org/.
[2] We wrote this algorithm intending it for use on a cluster with the Torque/Moab job scheduler, although we see no reason why it could not be adopted for use with a different scheduler.

```
/nv/hp10/jstern7/STORI/GetMissingSeqs.pl
/nv/hp10/jstern7/STORI/STORI-pbs_t
/nv/hp10/jstern7/STORI/taxids_GIs.txt
/nv/hp10/jstern7/STORI/makeblastdb
/nv/hp10/jstern7/STORI/blastp
/nv/hp10/jstern7/STORI/blastdbcmd
/nv/hp10/jstern7/STORI/bp_nrdb_SHA.pl
/nv/hp10/jstern7/STORI/STORI.pl
/nv/hp10/jstern7/scratch/universal120312
/nv/hp10/jstern7/scratch/universal120312/blast
/nv/hp10/jstern7/scratch/universal120312/hits
/nv/hp10/jstern7/clustalw21/clustalw2
/nv/hp10/jstern7/clustalo/clustalo
```

Also, make sure that every path refers to a file or folder that actually exists. If you run into difficulty with the setup, it is probably due to an incorrect path.

The next step to setting up STORI is building its database. Use getFastas.pl, getFastas.pbs, and taxids_GIs.txt. Be sure to make changes as applicable to your system (i.e. the file paths)[3]. Also, set up a project directory on a file system with fast read/write access[4], and create empty subdirectories called "blast", "fasta", and "hits". E.g., our project directory "scratch/universal120312" contains these three subdirectories.

Downloading the sequences for the default taxa list takes about 24 hours[5]. Once this script completes, the end of the file retrieval_log.txt will have a table showing the fraction of each taxon successfully downloaded. Some taxa may not have downloaded fully[6]. Protein sequences from these taxa can be downloaded manually from NCBI Protein. Go to www.ncbi.nlm.nih.gov/protein and paste the query part of the url (txidXX[orgn]) from the log file into the search field. Hit "Search." Click Send To>File>FASTA>Create File[7].

---

[3] These scripts depend on blastdbcmd, blastp, and makeblastdb, which are executables from NCBI's excellent BLAST suite, version 2.2.25+. They should work as is, but if you run into problems, see the documentation at: ftp://ftp.ncbi.nih.gov/blast/

[4] Actually, STORI is set up to copy the databases to a node's local /tmp volume, which should be faster than scratch. But this will only work if such a volume exists.

[5] Once getFastas.pl finishes downloading the default taxa set, the size of the fastas/ dir will be about 2 GB. To reiterate, please set $projectDir to a location in scratch space, because scratch disks are faster than normal storage, and STORI will make many random reads from $projectDir.

[6] You should also check the size of the files in the fasta directory using "ls –lht". If you know that some taxon has 15168 protein sequences at NCBI, but its FASTA file is only 142 KB, something went wrong. The automated retrieval of protein sequence data remains challenging (Stein, 2002; Dessimoz et al., 2012). An alternative to retrieval from NCBI is the Reference Proteomes from the Quest for Orthologs website.

[7] To upload these FASTA files from a local machine (Mac or PC) to a cluster, we use the SFTP client Cyberduck.

Cull the redundancy from the downloaded FASTA files, and turn them into BLAST databases using makeNr.pl[8,9]. After finishing[10] makeNr.pl, archive the project directory[11], and move the archive to a backup volume.

STORIcontrol is for starting, stopping, or pausing runs. STORIstats is for checking progress and viewing results[12]. STORIcontrol and STORIstats are meant to run occasionally on a head node[13].

In a typical use of STORIcontrol, we launch it from the shell with

```
>perl ~/STORI/STORIcontrol.pl
```

Next, we start a retrieval:

```
STORI>start <run-name> <scratch/dir> <taxa file> <windowSize>
<finalMaxFams>
```

For example, we can retrieve the Bacterial ribosomal proteins with the command:

```
STORI>start all_rProt_115bact_a /nv/hp10/jstern7/scratch/STORI_runfiles
bacteria 4 80
```

The name of the run is "all_rProt_115bact_a". Its data files will be stored in /nv/hp10/jstern7/scratch/STORI_runfiles[14]. For this run, STORI will use the Taxon IDs specified in the text file taxa-master[bacteria].txt[15]. The size of the search window is 4 taxa. The maximum number of allowable families is 80.

STORI makes a request of us:

```
Please enter an expression to match with protein names:
```

We enter:

---

[8] Make sure that the hits/ directory contains a file for every taxon – else the downstream script getParentTaxa.pl will fail. As long as the getFastas.pl result was satisfactory, this will be fine.

[9] This script is mostly a wrapper for BioPerl's bp_nrdb.pl by Dr. Jason Stajich.

[10] Run time is an hour or so. makeNr.pl may fail to create the BLAST database for a taxon if this taxon's FASTA file deviates from the FASTA format. We encountered a problem with txid9 (*Buchnera aphidicola*) because an entry for GI # 15616631 contained two carriage returns. We deleted this entry by hand and re-ran the script.

[11] E.g., tar -czf universal120312.tar.gz universal120312

[12] We added some "pre-alpha" functions to STORIstats for comparing family distance, which require Clustalw, Clustalo, Belvu, and ssearch36. (STORIstats will still report retrieval results if these programs are not installed.)

[13] If doing more extensive distance comparisons, run STORIstats on a compute node in an interactive session.

[14] Note that this path was absent from the earlier list and that in this example we had previously created the run directory, i.e. `mkdir ~/scratch/STORI_runfiles`.

[15] The taxa files need to be in the same directory as the STORI scripts, and should be named according to the format: "taxa-master[<user specified clade name>].txt". Note that STORI will have problems if an ID in this taxa file does not have a corresponding BLAST database or hitDir file.

```
 [rR]ibosomal\s[pP]rotein\s[lLsS]\d+(\s|\/|[a-z]|[A-Z])
```

STORI uses Perl regular expressions; in this case, matches will be protein names with any capitalization, and following the protein number, either a space or any letter (e.g. L24 or L24e)[16].

Next, STORI asks:

```
what offset factor? (usually 3)
```

and we enter:

```
what offset factor? (usually 3)
1
```

(We'll explain offset factor below.) STORI next uses blastdbcmd to search the FASTA deflines for our input string. From the matching entries, STORI picks two randomized samples, each containing `<finalMaxFams>` sequences[17], and will use the protein sequences of each sample as the initial state of two independent chains.

```
satisfied?
yes
```

(We could have typed "no" to repeat the search.)

```
3 2 1>blastoff
```

STORI begins two parallel, independent runs. Each chain is a serial PBS job submitted using msub.

Now let's try retrieving Eumetazoan hemoglobin.

```
STORI>start hemoglobin_eumetazoa_1x_STORI
/nv/hp10/jstern7/scratch/STORM3_runfiles eumetazoa 4 20
[...]
Please enter an expression to match with protein names: [hH]emoglobin
```

Hemoglobin presents in nearly every Eumetazoan, but what is its evolutionary provenance? Is it possible that hemoglobin resulted from a gene duplication prior/during Eumetazoa radiation, and that the evidence of this duplication remains in the form of a lower-eukaryote paralog? Let us attempt to find out[18]...

---

[16] We developed STORI for research purposes. To use STORI in a production environment, one would need to improve the front end and probably also port to a type safe language. User inputs to a Perl script can be exploited to compromise network security.
[17] Taxa are randomly picked without replacement until the # of sequences is ≥ the maximum number of families (a value specified by the user).
[18] We also would do well to consult the literature; for example: Roesner, A., et al. A Globin Gene of Ancient Evolutionary Origin in Lower Vertebrates: Evidence for Two Distinct Globin Families in Animals

```
start hemoglobin_euk_8x_STORI /nv/hp10/jstern7/scratch/STORM3_runfiles
eukaryota 4 20
```

Previously, our offset factor was 1, but here it will be 8. This change makes the initial state of the chains more influential to the rest of the run. We have found that adding influence to these initial seed sequences can prevent families from disappearing during iteration[19]. Such disappearance is common when a protein is absent from a large portion of the subject taxa. For Eumetazoa, the seeds do not need a "handicap", because there won't be much opportunity for more conserved families to push them out. However, when the subject taxa are a diverse selection of Eukaryotes, the conserved families may push out hemoglobin[20].

To stop a run, we could type[21]:

```
stop hemoglobin_euk_8x_STORI
```

STORIcontrol should be run about once a day, depending on the parameters of the retrieval runs. STORIcontrol is responsible for judging convergence, and it can run in background (using GNU screen). If not running in background, it is fine to just run periodically[22].

Now we will run STORIstats.pl to check on the progress of our runs. Before doing so it is usually good to run STORIcontrol.pl once, so that the file job_data_STORI.txt is updated[23].

```
>perl ~/STORI/STORIstats.pl
```

The most important commands are `show`, `summarize`, `annotate`, and `rename`. These commands are best explained by example:

```
STORI> show runs
```

Mol Biol Evol (2005) 22(1): 12-20; Gribaldo, S., et al. Functional Divergence Prediction from Evolutionary Analysis: A Case Study of Vertebrate Hemoglobin Mol Biol Evol (2003) 20(11): 1754-1759; Hardison, R. C. A brief history of hemoglobins: plant, animal, protist, and bacteria. Proc Natl Acad Sci U S A. 1996 June 11; 93(12): 5675–5679.

[19] Because STORI creates new protein families whenever it encounters "orphan" best-hits (see Material and Methods), it is possible for a family to be "squeezed out", and there are no guarantees that orthology predictions will correspond with user-supplied seeds. In our tests using ribosomal protein seed sequences, the squeeze-out impediment was minor.

[21] This feature has not been tested thoroughly and should be used with care.

[22] For users familiar with MrBayes, the "chain swapping" step of STORI is facilitated by STORIcontrol; therefore, this script must either run in background on the head node, or be manually run by the user about once daily. STORIcontrol must run repeatedly in order for the runs to run.

[23] However, if STORIcontrol submits any new PBS jobs, then it may take a few hours for data from their corresponding runs to be accessible to STORIstats.

```
showing the runs
1: hemoglobin_eumetazoa_1x_STORI 0.85
2: all_rProt_115bact_a 0.77
3: hemoglobin_euk_8x_STORI 0.51
(0 converged runs)
(0 paused runs)
STORI> summarize hemoglobin_eumetazoa_1x_STORI
12 families added to clipboard.
STORI> Name 6
[...]
STORI> show clipboard
0: hemoglobin_subunit_zeta
3: myoglobin_Danio_rerio
4: hemoglobin_eumetazoa_1x_STORI_orphph53_0
6: hemoglobin_eumetazoa_1x_STORI_orphh162_3
7: hemoglobin_subunit_alpha
9: PREDICTED_hemoglobin_subunit
11: cullinassociated_NEDD8dissociated_protein
STORI> annotate 3
[...]
STORI> rename 3 myoglobin
STORI> annotate 4
[...]
STORI> rename 4 cytoglobin
STORI> annotate 6
[...]
STORI> rename 6 neuroglobin
STORI> annotate 9
[...]
STORI> rename 9 hemoglobin_epsilon
STORI> annotate 11
[...]
STORI> show clipboard
0: hemoglobin_subunit_zeta
3: myoglobin
4: cytoglobin
6: neuroglobin
7: hemoglobin_subunit_alpha
9: hemoglobin_epsilon
11: cullinassociated_NEDD8dissociated_protein
STORI> show clipboard -all eumetazoa.txt
showing entire clipboard using org file eumetazoa.txt
[...]
```

What we did is take STORI's latest forecast of family organization and save it to a clipboard. We had STORIstats attempt to name each family automatically, and we corrected its mistakes by looking at the deflines ourselves and using our brains. Then we outputted the clipboard with a formatting amenable to copying and pasting in Excel or OpenOffice. To download an alignment, we could head over to http://www.ncbi.nlm.nih.gov/tools/cobalt/ and submit the accessions from one of the families. Note that the clipboard will disappear when we close STORIstats.

Eventually[24], these runs will converge, at which point they will no longer be displayed as an active run. They will be accessible with the command "`show converged`".

[24] For the runs in this example, probably 10 days. Other runs could take longer or shorter. If you want something fast, make a new taxa list of 20 archaea and retrieve 4 highly conserved families. This run should finish in less than 2 days, and it would be best to keep STORIcontrol running the whole time.

APPENDIX B

SEQUENCE ACCESSIONS

Bacterial rProteins:

	short name	full_name	phylum	L20u	L21u	L19u	L27u	L17u
234267	bjsoliusit	Solibacter.usitatus.Ellin6076	acidobacteria	122255365	116622264	116621684	116622265	116624173
204669	bjkorivers	Candidatus.Koribacter.versatilis.Ellin345	acidobacteria	94967746	94967049	94969903	94967050	94968284
770	bkanapmarg	Anaplasma.marginale.str.St.Maries	alphaproteobacteria	254800294	222419284	255004739	255004253	254995155
212042	bkanapphag	Anaplasma.phagocytophilum.HZ	alphaproteobacteria	109893095	88598016	88598438	88598139	88597755
283165	bkbartquin	Bartonella.quintana.str.Toulouse	alphaproteobacteria	49473759	49473806	49474758	49473807	49474379
29459	bkbrucmeli	Brucella.melitensis.16M	alphaproteobacteria	54041828	119365937	54041824	225853290	81852027
314261	bkpelaubiq	Candidatus.Pelagibacter.ubique.HTCC1062	alphaproteobacteria	91762422	91762651	91762617	91762650	91763184
269484	bkehrlcani	Ehrlichia.canis.str.Jake	alphaproteobacteria	109893113	122064978	92090555	123614894	123614833
314225	bkerytlito	Erythrobacter.litoralis.HTCC2594	alphaproteobacteria	122543232	84786472	122544285	122545038	122544189
290633	bkglucoxyd	Gluconobacter.oxydans.621H	alphaproteobacteria	58001152	58001038	58001090	58001039	58001244
290400	bkjannccs1	Jannaschia.sp.CCS1	alphaproteobacteria	89052942	89054771	89053233	89054772	89053109
266835	bkmesoloti	Mesorhizobium.loti.MAFF303099	alphaproteobacteria	13474219	13473425	13473622	13473424	13470576
323098	bknitrwino	Nitrobacter.winogradskyi.Nb255	alphaproteobacteria	109893129	74419507	90109941	74419508	74420451
279238	bknovoarom	Novosphingobium.aromaticivorans.DSM.12444	alphaproteobacteria	87198710	87198951	87199429	87198952	87200539
1063	bkrhodspha	Rhodobacter.sphaeroides.2.4.1	alphaproteobacteria	254800336	146279803	146276241	146279804	332560165
1076	bkrhodpalu	Rhodopseudomonas.palustris.CGA009	alphaproteobacteria	60390470	39933235	56749612	39933236	39936288
269796	bkrhodrubr	Rhodospirillum.rubrum.ATCC.11170	alphaproteobacteria	109893146	83592578	116256031	83592577	83593995
257363	bkricktyph	Rickettsia.typhi.str.Wilmington	alphaproteobacteria	51460099	51460230	51459549	51460231	51460126
542	bkzymomobi	Zymomonas.mobilis.subsp.Mobilis.ZM4	alphaproteobacteria	338708560	338707940	56551975	67461301	56551438
62928	bbazoaebn1	Azoarcus.sp.EbN1	betaproteobacteria	166219605	166984918	166199517	166223746	166216136
269483	bbburk383	Burkholderia.sp.383	betaproteobacteria	109893101	119365939	90109935	123569380	119361756
243365	bbchroviol	Chromobacterium.violaceum.ATCC.12472	betaproteobacteria	34496806	34496303	34499127	34496304	34499614
159087	bbdecharom	Dechloromonas.aromatica.RCB	betaproteobacteria	109893109	119365950	92090552	123626583	119365865
485	bbneisgono	Neisseria.gonorrhoeae.FA.1090	betaproteobacteria	226730427	317165055	226724802	317165056	240113940
323848	bbnitrmult	Nitrosospira.multiformis.ATCC.25196	betaproteobacteria	82701624	82702938	82701706	82702939	82701926
264198	bbralseutr	Ralstonia.eutropha.JMP134	betaproteobacteria	72118385	72120055	72119635	72120054	72120250
292415	bbthiodeni	Thiobacillus.denitrificans.ATCC.25259	betaproteobacteria	109893167	74316882	90109946	74316883	74316449
267748	btmycomobi	Mycoplasma.mobile.163K	tenericutes	47459462	47459139	47459263	47459140	47459097
243273	btmycogeni	Mycoplasma.genitalium.G37	tenericutes	12045050	12045087	12045303	12045089	12045031
134821	btureaparv	Ureaplasma.parvum.serovar.3.str.ATCC.700970	tenericutes	14195151	81789066	14285733	20139831	81789061
272633	btmycopene	Mycoplasma.penetrans.HF.2	tenericutes	26554367	26553894	26553556	26553896	26554439
265311	btmesoflor	Mesoplasma.florum.L1	tenericutes	50365006	50365259	50365356	50365257	50364966
322098	btasteyell	Aster.yellows.witches.broom.phytoplasma.AYWB	tenericutes	123518019	162139694	116255991	123518044	123518127
246194	bfcarbhydr	Carboxydothermus.hydrogenoformans.Z2901	firmicutes	109893103	119365942	90109936	123576981	123575545
49338	bfdesuhafn	Desulfitobacterium.hafniense.Y51	firmicutes	219666286	219670344	219669772	219670342	219666519
264732	bfmoorther	Moorella.thermoacetica.ATCC.39073	firmicutes	109893121	119365963	116256015	83572337	123523770
1488	bfclosacet	Clostridium.acetobutylicum.ATCC.824	firmicutes	20978632	81775522	20978634	20139609	81775430
1502	bfclosperf	Clostridium.perfringens.str.13	firmicutes	20978574	81766684	182625832	20139452	81766498
1314	bfstrepyog	Streptococcus.pyogenes.M1.GAS	firmicutes	50913984	50913997	116256045	15674862	209558654
66692	bfbaciclau	Bacillus.clausii.KSMK16	firmicutes	60390297	81678836	61214761	67461331	81679081
272558	bfbacihalo	Bacillus.halodurans.C125	firmicutes	15615700	15615573	15615041	15615571	15612726
235909	bfgeobkaus	Geobacillus.kaustophilus.HTA426	firmicutes	56421251	56421145	56419737	56421143	56418669
1590	bflactplan	Lactobacillus.plantarum.WCFS1	firmicutes	31563099	81733707	38258521	38258525	81733728
314315	bflactsake	Lactobacillus.sakei.subsp.sakei.23K	firmicutes	109893119	119365960	90109940	81428287	123563682
221109	bfoceaihey	Oceanobacillus.iheyensis.HTE831	firmicutes	31563139	81746085	39931976	39932409	81747263
851	bvfusonucl	Fusobacterium.nucleatum.subsp.nucleatum.ATCC.25586	fusobacteria	339890467	19714716	19703772	339891186	19714917
34105	bvstremoni	Streptobacillus.moniliformis	fusobacteria	269123272	269123277	269123679	269123279	269123126
62977	bgacinadp1	Acinetobacter.sp.ADP1	gammaproteobacteria	60390407	50085966	56749494	50085965	50086189
9	bgbuchaphi	Buchnera.aphidicola.str.APS	gammaproteobacteria	15616748	311087282	15617001	311087283	15617092
203907	bgblocflor	Candidatus.Blochmannia.floridanus	gammaproteobacteria	39931817	81713103	39931813	39931816	81713093
291272	bgblocpenn	Candidatus.Blochmannia.pennsylvanicus.str.BPEN	gammaproteobacteria	109893097	119365934	92090547	123641160	123641088
167879	bgcolwpsyc	Colwellia.psychrerythraea.34H	gammaproteobacteria	109893107	71143584	92090550	71147790	71144729
263	bgfrantula	Francisella.tularensis.subsp.holarctica	gammaproteobacteria	89256697	156502906	56707323	156502905	224456567
233412	bghaemducr	Haemophilus.ducreyi.35000HP	gammaproteobacteria	33149032	33147673	33149149	33147674	33149153
349521	bghahechej	Hahella.chejuensis.KCTC.2396	gammaproteobacteria	109893117	119365957	116256006	123530795	119365874
283942	bgidioloih	Idiomarina.loihiensis.L2TR	gammaproteobacteria	56179514	56178596	56179834	56178597	56180000
446	bglegipneu	Legionella.pneumophila.str.Lens	gammaproteobacteria	166219657	52842857	166199554	52842856	54296391
243233	bgmethcaps	Methylococcus.capsulatus.str.Bath	gammaproteobacteria	53805114	53803715	53802417	53803714	53803449
1229	bgnitrocea	Nitrosococcus.oceani.ATCC.19707	gammaproteobacteria	109893128	76884793	92090560	76884794	76884076
74109	bgphotprof	Photobacterium.profundum.SS9	gammaproteobacteria	60390457	81697527	90414892	67461421	81697529
228	bgpseuhalo	Pseudoalteromonas.haloplanktis.TAC125	gammaproteobacteria	332534268	332531716	332535258	332531715	332533188
317	bgpseusyri	Pseudomonas.syringae.pv.phaseolicola.1448A	gammaproteobacteria	66045405	63254673	63255240	63254674	330966885
259536	bgpsycarct	Psychrobacter.arcticus.2734	gammaproteobacteria	71039536	71039113	71039555	71039112	71038070
623	bgshigflex	Shigella.flexneri.2a.str.2457T	gammaproteobacteria	335575680	84027994	67472004	67472013	84027991
317025	bgthiocrun	Thiomicrospira.crunogena.XCL2	gammaproteobacteria	109893166	119366002	116256053	123555994	119365919
36870	bgwigglos	Wigglesworthia.glossinidia.endosymbiont.of.Glossina.brevipalpis	gammaproteobacteria	31340356	81741625	31340354	31340350	81741589
562	bgeschcoli	Escherichia.coli	gammaproteobacteria	15802128	331674717	209762576	209758196	15803821
265606	bprhodbalt	Rhodopirellula.baltica.SH1	planctomycetacia	39931770	81712368	39931766	67461499	81712399
521674	bpplanlimn	Planctomyces.limnophilus	planctomycetacia	296122750	296120628	296120451	296120511	296120770
290434	bsborrgari	Borrelia.garinii.Pbi	spirochaetes	51598449	51599029	51598953	51599031	51598758

173	bsleptinte	Leptospira.interrogans.serovar.Copenhageni.str.Fiocruz.L1130	spirochaetes	31563145	81748287	56749630	39931982	5163232
158	bstrepdent	Treponema.denticola.ATCC.35405	spirochaetes	60390508	81700158	56749636	67461472	81700210
160	bstreppall	Treponema.pallidum.subsp.pallidum.str.Nichols	spirochaetes	6094027	6094031	6094025	6094044	6094020
243274	bhthermari	Thermotoga.maritima.MSB8	thermotogae	15644340	15644207	15644319	15644205	15644220
391009	bhthermela	Thermosipho.melanesiensis.BI429	thermotogae	150020817	150020928	150021666	150020926	150020874
216816	bcbifilong	Bifidobacterium.longum.NCC2705	actinobacteria	23465929	81753804	338755135	67461533	338753795
257309	bccorydiph	Corynebacterium.diphtheriae.NCTC.13129	actinobacteria	38233752	38234352	38234104	38234351	38233159
196164	bccoryeffi	Corynebacterium.efficiens.YS314	actinobacteria	259505619	259507889	25028488	259507888	259506740
38289	bccoryjeik	Corynebacterium.jeikeium.K411	actinobacteria	109893108	122064974	92090551	123651364	260579205
106370	bcfrancci3	Frankia.sp.CcI3	actinobacteria	109893115	122064981	116256004	123737662	123765283
281090	bcleifxyli	Leifsonia.xyli.subsp.xyli.str.CTCB07	actinobacteria	50955432	161760709	50955108	50954530	50955539
1769	bcmycolepr	Mycobacterium.leprae.TN	actinobacteria	13633838	13633836	3122695	13633837	7674210
247156	bcnocafarc	Nocardia.farcinica.IFM.10152	actinobacteria	54023884	54023320	54026118	54023321	54022805
1747	bcpropacne	Propionibacterium.acnes.KPA171202	actinobacteria	314972096	282854194	313836665	327330689	50843282
100226	bcstrecoel	Streptomyces.coelicolor.A3.2	actinobacteria	21220095	21221055	21223950	21221054	21223109
269800	bctherfusc	Thermobifida.fusca.YX	actinobacteria	109893165	161723105	92090574	72162580	72163016
2039	bctropwhip	Tropheryma.whipplei.TW0827	actinobacteria	39931909	81722666	39931913	28493439	81722671
813	bychlatrac	Chlamydia.trachomatis.AHAR13	chlamydiae	237803267	297749429	6831619	15605144	290463286
83555	bychlaabor	Chlamydophila.abortus.S263	chlamydiae	333410489	81312987	81312604	81312986	81313061
340177	brchlochlo	Chlorobium.chlorochromatii.CaD3	chlorobia	109893104	78188834	90109937	78188833	78189779
194439	brchlotepi	Chlorobium.tepidum.TLS	chlorobia	21674938	21674325	21673989	21674326	21674970
243164	bxdehaethe	Dehalococcoides.ethenogenes.195	chloroflexi	109893110	122064975	92090553	123618366	123618893
255470	bxdehacbdb	Dehalococcoides.sp.CBDB1	chloroflexi	109893111	122064976	92090554	123619959	119365866
216389	bxdehabav1	Dehalococcoides.sp.BAV1	chloroflexi	189041860	146270723	189041769	189042388	189041503
479434	bxsphather	Sphaerobacter.thermophilus	chloroflexi	269837200	269837832	269836503	269837833	269837095
251221	bngloeviol	Gloeobacter.violaceus.PCC.7421	cyanobacteria	35213353	35211387	35211390	35211386	35214142
1219	bnprocmari	Prochlorococcus.marinus.subsp.marinus.str.CCMP1375	cyanobacteria	33241271	33240874	33239924	33240875	33241137
32046	bnsyneelon	Synechococcus.elongatus.PCC.6301	cyanobacteria	81300086	56750340	56751578	81300029	81301017
316279	bnsynecc99	Synechococcus.sp.CC9902	cyanobacteria	109893163	119365999	78169577	123581981	123581059
321332	bnsyneja23	Synechococcus.sp.JA23Ba.213	cyanobacteria	109893161	86608226	116256049	86608225	86609046
1148	bnsynepcc	Synechocystis.sp.PCC.6803	cyanobacteria	16331323	16330952	16330014	16330953	16329916
197221	bntherelon	Thermosynechococcus.elongatus.BP1	cyanobacteria	31563124	81743955	39931951	39932395	81744000
243230	bwdeinradi	Deinococcus.radiodurans.R1	deinococcus	15807000	56966573	15805781	15805126	15807123
274	bwtherther	Thermus.thermophilus	deinococcus	46198493	325533869	218766866	46199725	325533865
264462	bdbdelbact	Bdellovibrio.bacteriovorus.HD100	deltaproteobacteria	42523128	42525172	42523585	42525171	42524351
876	bddesudesu	Desulfovibrio desulfuricans	deltaproteobacteria	220903765	220905511	220905053	376296247	220903961
338963	bdpelocarb	Pelobacter.carbinolicus.DSM.2380	deltaproteobacteria	109893131	77546259	90109942	77546258	77544426
351604	bdgeoburan	Geobacter uraniireducens	deltaproteobacteria	148264669	148262387	148265778	148262388	148263166
197	blcampjeju	Campylobacter.jejuni.RM1221	epsilonproteobacteria	166219627	283955421	205355556	283955420	119361759
235279	blhelihepa	Helicobacter.hepaticus.ATCC.51449	epsilonproteobacteria	32265944	32265509	32266434	32265508	32266903
210	blhelipylo	Helicobacter.pylori.26695	epsilonproteobacteria	208434084	2500293	317011343	332673142	15612277
224324	bqaquiaeol	Aquifex.aeolicus.VF5	aquificae	15606270	15606746	15606954	15606836	15605667
436114	bqsulfurih	Sulfurihydrogenibium.sp.YO3AOP1	aquificae	188997586	188996699	188996138	188996700	188996210
146919	bzsalirube	Salinibacter.ruber.DSM.13855	bacteroidetes	294508835	122069611	294507641	294507426	294507077
402612	bzflavpsyc	Flavobacterium.psychrophilum.JIP0286	bacteroidetes	150024982	150026248	150025916	150026247	150025380

	short name	full_name	phylum	L35u	L9u	L12u	L31u
234267	bjsoliusit	Solibacter.usitatus.Ellin6076	acidobacteria	122255366	116626133	116624534	116620150
204669	bjkorivers	Candidatus.Koribacter.versatilis.Ellin345	acidobacteria	94967745	94971561	94971703	94967059
770	bkanapmarg	Anaplasma.marginale.str.St.Maries	alphaproteobacteria	254802426	254994707	255004017	222418943
212042	bkanapphag	Anaplasma.phagocytophilum.HZ	alphaproteobacteria	148887061	88597969	88598668	88598224
283165	bkbartquin	Bartonella.quintana.str.Toulouse	alphaproteobacteria	49473758	49474085	49474308	49474686
29459	bkbrucmeli	Brucella.melitensis.16M	alphaproteobacteria	54041898	20178071	336455286	54041863
314261	bkpelaubiq	Candidatus.Pelagibacter.ubique.HTCC1062	alphaproteobacteria	91762423	91762171	91763153	91762285
269484	bkehrlcani	Ehrlichia.canis.str.Jake	alphaproteobacteria	148887072	119370948	123759467	161702944
314225	bkerytlito	Erythrobacter.litoralis.HTCC2594	alphaproteobacteria	162007983	84787384	123004981	84786676
290633	bkglucoxyd	Gluconobacter.oxydans.621H	alphaproteobacteria	58001153	58001193	58001276	300567829
290400	bkjannccs1	Jannaschia.sp.CCS1	alphaproteobacteria	89052941	89054111	89053058	89053232
266835	bkmesoloti	Mesorhizobium.loti.MAFF303099	alphaproteobacteria	13474220	13476508	13470541	13473364
323098	bknitrwino	Nitrobacter.winogradskyi.Nb255	alphaproteobacteria	148887087	74420756	74420411	74421801
279238	bknovoarom	Novosphingobium.aromaticivorans.DSM.12444	alphaproteobacteria	87198709	87199435	87198056	87199401
1063	bkrhodspha	Rhodobacter.sphaeroides.2.4.1	alphaproteobacteria	221638164	146277393	146278577	146276242
1076	bkrhodpalu	Rhodopseudomonas.palustris.CGA009	alphaproteobacteria	39933119	39936143	39936332	39933995
269796	bkrhodrubr	Rhodospirillum.rubrum.ATCC.11170	alphaproteobacteria	148887104	83591751	83594028	83592408
257363	bkricktyph	Rickettsia.typhi.str.Wilmington	alphaproteobacteria	51460098	51459612	51459650	51459561
542	bkzymomobi	Zymomonas.mobilis.subsp.Mobilis.ZM4	alphaproteobacteria	56552412	56552123	338707502	338707145
62928	bbazoaebn1	Azoarcus.sp.EbN1	betaproteobacteria	166231154	166223770	166222133	226705228
269483	bbburk383	Burkholderia.sp.383	betaproteobacteria	148887067	115305517	109893752	148878572
243365	bbchroviol	Chromobacterium.violaceum.ATCC.12472	betaproteobacteria	34496805	34499092	34499649	34497202
159087	bbdecharom	Dechloromonas.aromatica.RCB	betaproteobacteria	148840419	115305523	109893759	148878593
485	bbneisgono	Neisseria.gonorrhoeae.FA.1090	betaproteobacteria	194098022	317164468	317165364	59802424
323848	bbnitrmult	Nitrosospira.multiformis.ATCC.25196	betaproteobacteria	82701623	82703069	82701891	82703206
264198	bbralseutr	Ralstonia.eutropha.JMP134	betaproteobacteria	72118384	72119104	72120287	72119221
292415	bbthiodeni	Thiobacillus.denitrificans.ATCC.25259	betaproteobacteria	148887125	74318120	74316415	74316057
267748	btmycomobi	Mycoplasma.mobile.163K	tenericutes	47459463	47459007	47459369	300567887
243273	btmycogeni	Mycoplasma.genitalium.G37	tenericutes	12045049	12044945	12045222	255660256
134821	btureaparv	Ureaplasma.parvum.serovar.3.str.ATCC.700970	tenericutes	20139830	17865534	14195181	13124472
272633	btmycopene	Mycoplasma.penetrans.HF.2	tenericutes	26553970	26554037	26554025	300567837
265311	btmesoflor	Mesoplasma.florum.L1	tenericutes	50365005	50364898	50365418	50365453
322098	btasteyell	Aster.yellows.witches.broom.phytoplasma.AYWB	tenericutes	148887062	118574297	84789847	158564268

246194	bfcarbhydr	Carboxydothermus.hydrogenoformans.Z2901	firmicutes	148840412	115305519	109893754	158564305
49338	bfdesuhafn	Desulfitobacterium.hafniense.Y51	firmicutes	219666285	219670926	219666477	219670831
264732	bfmoorther	Moorella.thermoacetica.ATCC.39073	firmicutes	148887082	115305532	109893773	148878600
1488	bfclosacet	Clostridium.acetobutylicum.ATCC.824	firmicutes	20139605	17865517	20978568	300568063
1502	bfclosperf	Clostridium.perfringens.str.13	firmicutes	20139453	20178068	77170826	258676980
1314	bfstrepyog	Streptococcus.pyogenes.M1.GAS	firmicutes	50913983	139474606	94545873	50913912
66692	bfbaciclau	Bacillus.clausii.KSMK16	firmicutes	81678827	81600616	81601108	300567939
272558	bfbacihalo	Bacillus.halodurans.C125	firmicutes	15615701	15616592	15612685	15616342
235909	bfgeobkaus	Geobacillus.kaustophilus.HTA426	firmicutes	56421252	56422012	56418631	56421916
1590	bflactplan	Lactobacillus.plantarum.WCFS1	firmicutes	38258529	38258345	28377498	31076915
314315	bflactsake	Lactobacillus.sakei.subsp.sakei.23K	firmicutes	148887080	115305530	109893771	123563771
221109	bfoceaihey	Oceanobacillus.iheyensis.HTE831	firmicutes	54036312	81744966	81747271	31076968
851	bvfusonucl	Fusobacterium.nucleatum.subsp.nucleatum.ATCC.25586	fusobacteria	339890466	19705133	339891974	254304076
34105	bvstremoni	Streptobacillus.moniliformis	fusobacteria	269123271	269123512	269123260	269123306
62977	bgacinadp1	Acinetobacter.sp.ADP1	gammaproteobacteria	54036255	50085517	50083578	300567893
9	bgbuchaphi	Buchnera.aphidicola.str.APS	gammaproteobacteria	15616747	15617153	15616664	15617167
203907	bgblocflor	Candidatus.Blochmannia.floridanus	gammaproteobacteria	54036294	81666694	81666884	300567857
291272	bgblocpenn	Candidatus.Blochmannia.pennsylvanicus.str.BPEN	gammaproteobacteria	148887063	115305514	109893747	158562844
167879	bgcolwpsyc	Colwellia.psychrerythraea.34H	gammaproteobacteria	118573004	71145719	71145628	71146547
263	bgfrantula	Francisella.tularensis.subsp.holarctica	gammaproteobacteria	254369557	151568872	123169675	151568288
233412	bghaemducr	Haemophilus.ducreyi.35000HP	gammaproteobacteria	33149033	33148402	33149093	33148963
349521	bghahechej	Hahella.chejuensis.KCTC.2396	gammaproteobacteria	148887076	115305529	109893766	83648617
283942	bgidioloih	Idiomarina.loihiensis.L2TR	gammaproteobacteria	56179515	56180047	56178465	300567929
446	bglegipneu	Legionella.pneumophila.str.Lens	gammaproteobacteria	166231193	307610289	52840566	52840887
243233	bgmethcaps	Methylococcus.capsulatus.str.Bath	gammaproteobacteria	53805115	53803661	53804625	300567919
1229	bgnitrocea	Nitrosococcus.oceani.ATCC.19707	gammaproteobacteria	148887086	76882071	76884109	76882092
74109	bgphotprof	Photobacterium.profundum.SS9	gammaproteobacteria	90410625	90414461	90413409	90413620
228	bgpseuhalo	Pseudoalteromonas.haloplanktis.TAC125	gammaproteobacteria	77360341	332535622	109893785	332532295
317	bgpseusyri	Pseudomonas.syringae.pv.phaseolicola.1448A	gammaproteobacteria	63256111	330971573	330976632	63254373
259536	bgpsycarct	Psychrobacter.arcticus.2734	gammaproteobacteria	71039537	71038881	71039428	71039456
623	bgshigflex	Shigella.flexneri.2a.str.2457T	gammaproteobacteria	332767220	67472260	67472254	73621822
317025	bgthiocrun	Thiomicrospira.crunogena.XCL2	gammaproteobacteria	148887124	124106340	109893814	148878588
36870	bgwiggglos	Wigglesworthia.glossinidia.endosymbiont.of.Glossina.brevipalpis	gammaproteobacteria	31340357	31340332	31340331	31076943
562	bgeschcoli	Escherichia.coli	gammaproteobacteria	215486936	168988769	218429831	168988787
265606	bprhodbalt	Rhodopirellula.baltica.SH1	planctomycetacia	32474649	327542670	32477743	73621818
521674	bpplanlimn	Planctomyces.limnophilus	planctomycetacia	296122749	296122870	296120713	296121188
290434	bsborrgari	Borrelia.garinii.Pbi	spirochaetes	51598450	51598375	51598647	300567909
173	bsleptinte	Leptospira.interrogans.serovar.Copenhageni.str.Fiocruz.L1130	spirochaetes	54036313	73917548	67461208	31076974
158	bstrepdent	Treponema.denticola.ATCC.35405	spirochaetes	54036274	42527182	81570127	73621829
160	bstreppall	Treponema.pallidum.subsp.pallidum.str.Nichols	spirochaetes	6094064	6094101	6094098	300568099
243274	bhthermari	Thermotoga.maritima.MSB8	thermotogae	15644339	15643626	15643223	15644432
391009	bhthermela	Thermosipho.melanesiensis.BI429	thermotogae	150020816	150021300	150020401	150021051
216816	bcbifilong	Bifidobacterium.longum.NCC2705	actinobacteria	54036315	81754429	81753606	31076978
257309	bccorydiph	Corynebacterium.diphtheriae.NCTC.13129	actinobacteria	38233751	38234824	38233051	38233449
196164	bccoryeffi	Corynebacterium.efficiens.YS314	actinobacteria	259505618	259508444	259508467	259507090
38289	bccoryjeik	Corynebacterium.jeikeium.K411	actinobacteria	148840418	109895424	109893758	148878575
106370	bcfrancci3	Frankia.sp.CcI3	actinobacteria	124078994	108862057	109893763	124056500
281090	bcleifxyli	Leifsonia.xyli.subsp.xyli.str.CTCB07	actinobacteria	50955433	50955939	50954152	300567903
1769	bcmycolepr	Mycobacterium.leprae.TN	actinobacteria	13633839	1173068	13432204	1173026
247156	bcnocafarc	Nocardia.farcinica.IFM.10152	actinobacteria	54023883	54027549	54027085	300567921
1747	bcpropacne	Propionibacterium.acnes.KPA171202	actinobacteria	327333952	50843662	340773037	313827398
100226	bcstrecoel	Streptomyces.coelicolor.A3.2	actinobacteria	21220096	21222316	21223035	21223719
269800	bctherfusc	Thermobifida.fusca.YX	actinobacteria	134039203	72163491	72163054	72162819
2039	bctropwhip	Tropheryma.whipplei.TW0827	actinobacteria	161486579	28493072	81629754	28493281
813	bychlatrac	Chlamydia.trachomatis.AHAR13	chlamydiae	15605569	255507421	296436757	339625667
83555	bychlaabor	Chlamydophila.abortus.S263	chlamydiae	81312498	333410532	81312569	73621754
340177	brchlochlo	Chlorobium.chlorochromatii.CaD3	chlorobia	148840413	78188080	78188334	78188305
194439	brchlotepi	Chlorobium.tepidum.TLS	chlorobia	21674937	21674941	21672995	21674394
243164	bxdehaethe	Dehalococcoides.ethenogenes.195	chloroflexi	148840420	115305524	109893760	300567941
255470	bxdehacbdb	Dehalococcoides.sp.CBDB1	chloroflexi	148840421	115305525	109893761	148878594
216389	bxdehabav1	Dehalococcoides.sp.BAV1	chloroflexi	189042766	189043248	189042992	146270725
479434	bxsphather	Sphaerobacter.thermophilus	chloroflexi	269837201	269837623	269837632	269837834
251221	bngloeviol	Gloeobacter.violaceus.PCC.7421	cyanobacteria	35213354	35213201	35212167	35214995
1219	bnprocmari	Prochlorococcus.marinus.subsp.marinus.str.CCMP1375	cyanobacteria	33241270	33241283	33239679	33241133
32046	bnsyneelon	Synechococcus.elongatus.PCC.6301	cyanobacteria	81300087	61233371	81299442	81301013
316279	bnsynecc99	Synechococcus.sp.CC9902	cyanobacteria	148887122	124106337	109893811	148880089
321332	bnsyneja23	Synechococcus.sp.JA23Ba.213	cyanobacteria	148887120	86608558	86608700	86609050
1148	bnsynepcc	Synechocystis.sp.PCC.6803	cyanobacteria	16331324	161344758	16330008	16329912
197221	bntherelon	Thermosynechococcus.elongatus.BP1	cyanobacteria	34222857	61233368	81743859	31076955
243230	bwdeinradi	Deinococcus.radiodurans.R1	deinococcus	15807001	15805142	15807037	15805851
274	bwtherther	Thermus.thermophilus	deinococcus	62297685	333965814	46200078	325533845
264462	bdbdelbact	Bdellovibrio.bacteriovorus.HD100	deltaproteobacteria	42523127	42521682	42524384	300567879
876	bddesudesu	Desulfovibrio desulfuricans	deltaproteobacteria	220903766	376295696	220904900	220905562
338963	bdpelocarb	Pelobacter.carbinolicus.DSM.2380	deltaproteobacteria	148887080	77545675	77544390	77546368
351604	bdgeoburan	Geobacter uraniireducens	deltaproteobacteria	148264670	148265695	148263133	148266075
197	blcampjeju	Campylobacter.jejuni.RM1221	epsilonproteobacteria	166231172	283953973	283954232	283955602
235279	blhelihepa	Helicobacter.hepaticus.ATCC.51449	epsilonproteobacteria	161546632	32265810	32265861	32263296
210	blhelipylo	Helicobacter.pylori.26695	epsilonproteobacteria	217034630	254779464	317177943	254779456
224324	bqaquiaeol	Aquifex.aeolicus.VF5	aquificae	15606166	15607017	15606948	15607141
436114	bqsulfurih	Sulfurihydrogenibium.sp.YO3AOP1	aquificae	188997587	188997593	188996247	188996903
146919	bzsalirube	Salinibacter.ruber.DSM.13855	bacteroidetes	294508834	294507377	294507787	294507158

402612	bzflavpsyc	Flavobacterium.psychrophilum.JIP0286	bacteroidetes	150024983	150025892	150025249	150025207

Universal rProteins:

txid	short name	full_name	phylum	L1pL10ae	L11pL12e	L10uP0ae	L15pL27e	L3
234267	bjsoliusit	Solibacter.usitatus.Ellin6076	acidobacteria	122252854	116625381	116624535	122253101	116624202
204669	bjkorivers	Candidatus.Koribacter.versatilis.Ellin345	acidobacteria	94971705	94971706	94971704	94968273	94968254
770	bkanapmarg	Anaplasma.marginale.str.St.Maries	alphaproteobacteria	161544992	300659824	255004016	56416985	255004478
212042	bkanapphag	Anaplasma.phagocytophilum.HZ	alphaproteobacteria	123494573	88598050	88597775	88597993	88598512
283165	bkbartquin	Bartonella.quintana.str.Toulouse	alphaproteobacteria	49474310	49474311	49474309	49474385	49474404
29459	bkbrucmeli	Brucella.melitensis.16M	alphaproteobacteria	33301460	38605402	20978587	265995128	42559669
314261	bkpelaubiq	Candidatus.Pelagibacter.ubique.HTCC1062	alphaproteobacteria	91763151	91763150	91763152	91763178	91763160
269484	bkehrlcani	Ehrlichia.canis.str.Jake	alphaproteobacteria	123615102	72393939	123615101	115502657	109893428
314225	bkerytlito	Erythrobacter.litoralis.HTCC2594	alphaproteobacteria	122545487	123293821	122543133	122544184	123293706
290633	bkglucoxyd	Gluconobacter.oxydans.621H	alphaproteobacteria	58001278	58001279	58001277	58001250	58001269
290400	bkjannccs1	Jannaschia.sp.CCS1	alphaproteobacteria	122499581	89053054	89053057	89053102	89053074
266835	bkmesoloti	Mesorhizobium.loti.MAFF303099	alphaproteobacteria	13470539	13470538	13470540	13470570	13470551
323098	bknitrwino	Nitrobacter.winogradskyi.Nb255	alphaproteobacteria	91207364	74420408	97181798	115502680	74420426
279238	bknovoarom	Novosphingobium.aromaticivorans.DSM.12444	alphaproteobacteria	123490350	87198855	87198055	161760695	87199270
1063	bkrhodspha	Rhodobacter.sphaeroides.2.4.1	alphaproteobacteria	77462248	146278580	97181908	146278549	221638113
1076	bkrhodpalu	Rhodopseudomonas.palustris.CGA009	alphaproteobacteria	39936335	118597284	315601224	39936294	39936313
269796	bkrhodrubr	Rhodospirillum.rubrum.ATCC.11170	alphaproteobacteria	91207375	83594031	97181901	115502696	83594020
257363	bkricktyph	Rickettsia.typhi.str.Wilmington	alphaproteobacteria	51459648	51459647	51459649	51460132	51460151
542	bkzymomobi	Zymomonas.mobilis.subsp.Mobilis.ZM4	alphaproteobacteria	56551622	56551621	56551623	56551432	260752974
62928	bbazoaebn1	Azoarcus.sp.EbN1	betaproteobacteria	160166287	166230101	166229704	166234433	166233115
269483	bbburk383	Burkholderia.sp.383	betaproteobacteria	91207344	118597141	97181513	115502644	109893416
243365	bbchroviol	Chromobacterium.violaceum.ATCC.12472	betaproteobacteria	34499651	34499652	34499650	34499622	34499641
159087	bbdecharom	Dechloromonas.aromatica.RCB	betaproteobacteria	91207350	300659856	97181615	83288442	109893424
485	bbneisgono	Neisseria.gonorrhoeae.FA.1090	betaproteobacteria	226724946	226702724	240113978	75507304	81311149
323848	bbnitrmult	Nitrosospira.multiformis.ATCC.25196	betaproteobacteria	91207362	82701888	82701890	82701919	82701900
264198	bbralseutr	Ralstonia.eutropha.JMP134	betaproteobacteria	91207374	72120290	72120288	72120257	72120276
292415	bbthiodeni	Thiobacillus.denitrificans.ATCC.25259	betaproteobacteria	91207385	74316412	97182096	115502723	74316423
267748	btmycomobi	Mycoplasma.mobile.163K	tenericutes	47458974	47458303	47459368	47459088	47459070
243273	btmycogeni	Mycoplasma.genitalium.G37	tenericutes	12044934	12044933	12045221	12045022	12045004
134821	btureaparv	Ureaplasma.parvum.serovar.3.str.ATCC.700970	tenericutes	33301591	168308002	13959498	81624427	168282378
272633	btmycopene	Mycoplasma.penetrans.HF.2	tenericutes	26553478	26553477	26554026	26554447	26454475
265311	btmesoflor	Mesoplasma.florum.L1	tenericutes	50365424	50365425	50365419	50364956	50364938
322098	btasteyell	Aster.yellows.witches.broom.phytoplasma.AYWB	tenericutes	162139696	118597134	84789848	115502638	109893411
246194	bfcarbhydr	Carboxydothermus.hydrogenoformans.Z2901	firmicutes	91207345	118597144	97181562	115502647	109893418
49338	bfdesuhafn	Desulfitobacterium.hafniense.Y51	firmicutes	219666475	219666474	219666476	219666509	219666490
264732	bfmoorther	Moorella.thermoacetica.ATCC.39073	firmicutes	123523759	118597260	97181725	115502675	109893524
1488	bfclosacet	Clostridium.acetobutylicum.ATCC.824	firmicutes	33301464	300660000	20978631	81775428	325510539
1502	bfclosperf	Clostridium.perfringens.str.13	firmicutes	33301458	300660002	110802684	81766495	42559666
1314	bfstrepyog	Streptococcus.pyogenes.M1.GAS	firmicutes	226730318	161761321	57014103	50913458	15674287
66692	bfbaciclau	Bacillus.clausii.KSMK16	firmicutes	61214583	300659838	61214765	81679083	81822272
272558	bfbacihalo	Bacillus.halodurans.C125	firmicutes	15612683	15612682	15612684	15612716	15612697
235909	bfgeobkaus	Geobacillus.kaustophilus.HTA426	firmicutes	56418629	300659822	56418630	56418660	56418641
1590	bflactplan	Lactobacillus.plantarum.WCFS1	firmicutes	33301440	38605252	28377497	81733730	28377832
314315	bflactsake	Lactobacillus.sakei.subsp.sakei.23K	firmicutes	91207355	118597252	97181709	115502668	109893434
221109	bfoceaihey	Oceanobacillus.iheyensis.HTE831	firmicutes	33301446	38605316	29336685	81747265	42559644
851	bvfusonucl	Fusobacterium.nucleatum.subsp.nucleatum.ATCC.25586	fusobacteria	254302294	300660020	34762881	34764208	254303420
34105	bvstremoni	Streptobacillus.moniliformis	fusobacteria	269123302	269123301	269123259	269124019	269122979
62977	bgacinadp1	Acinetobacter.sp.ADP1	gammaproteobacteria	61214615	50083575	61214999	81695752	50086215
9	bgbuchaphi	Buchnera.aphidicola.str.APS	gammaproteobacteria	15616666	15616667	254798365	15617099	11134328
203907	bgblocflor	Candidatus.Blochmannia.floridanus	gammaproteobacteria	61214656	300659986	61215254	81713095	42559603
291272	bgblocpenn	Candidatus.Blochmannia.pennsylvanicus.str.BPEN	gammaproteobacteria	91207341	118597137	123640820	83288439	109893412
167879	bgcolwpsyc	Colwellia.psychrerythraea.34H	gammaproteobacteria	91207348	71146537	97181600	83288440	71144335
263	bgfrantula	Francisella.tularensis.subsp.holarctica	gammaproteobacteria	122324636	300659834	166229726	254368640	156501620
233412	bghaemducr	Haemophilus.ducreyi.35000HP	gammaproteobacteria	33149095	33149096	33149094	33149160	33149183
349521	bghahechej	Hahella.chejuensis.KCTC.2396	gammaproteobacteria	123530597	118597246	97181692	115502662	109893432
283942	bgidioloih	Idiomarina.loihiensis.L2TR	gammaproteobacteria	56178463	300659826	56178464	56180007	56180034
446	bglegipneu	Legionella.pneumophila.str.Lens	gammaproteobacteria	160166207	52840563	166229739	81822646	52840574
243233	bgmethcaps	Methylococcus.capsulatus.str.Bath	gammaproteobacteria	53804627	300659814	53804626	53803436	53803548
1229	bgnitrocea	Nitrosococcus.oceani.ATCC.19707	gammaproteobacteria	91207363	76884112	162139857	115502679	76884101
74109	bgphotprof	Photobacterium.profundum.SS9	gammaproteobacteria	61215565	300660076	90413410	90414975	90415162
228	bgpseuhalo	Pseudoalteromonas.haloplanktis.TAC125	gammaproteobacteria	77359190	332532793	332532795	332533195	109893540
317	bgpseusyri	Pseudomonas.syringae.pv.phaseolicola.1448A	gammaproteobacteria	330953208	300660090	63258491	63258463	330966911
259536	bgpsycarct	Psychrobacter.arcticus.2734	gammaproteobacteria	91207373	71039431	71039429	71038063	71038044
623	bgshigflex	Shigella.flexneri.2a.str.2457T	gammaproteobacteria	33301551	333014337	67471995	54039116	42560221
317025	bgthiocrun	Thiomicrospira.crunogena.XCL2	gammaproteobacteria	91207384	118597355	97182087	115502722	109893569
36870	bgwigglos	Wigglesworthia.glossinidia.endosymbiont.of.Glossina.brevipalpis	gammaproteobacteria	33301561	54039099	31340349	81741591	42559632
562	bgeschcoli	Escherichia.coli	gammaproteobacteria	301019396	15804573	209751836	209757236	387609026
265606	bprhodbalt	Rhodopirellula.baltica.SH1	planctomycetacia	61215692	300660098	32477742	81712446	42559597
521674	bpplanlimn	Planctomyces.limnophilus	planctomycetacia	296120711	296120710	296120712	296120765	296120747
290434	bsborrgari	Borrelia.garinii.Pbi	spirochaetes	51598649	51598650	51598648	51598752	51598732
173	bsleptinte	Leptospira.interrogans.serovar.Copenhageni.str.Fiocruz.L1130	spirochaetes	33301448	300660034	29336691	7674186	24213439
158	bstrepdent	Treponema.denticola.ATCC.35405	spirochaetes	61215633	300660122	325474851	325473242	81831476
160	bstreppall	Treponema.pallidum.subsp.pallidum.str.Nichols	spirochaetes	6094026	6093999	6093996	6094017	6094076
243274	bhthermari	Thermotoga.maritima.MSB8	thermotogae	15643221	15643220	15643222	15644229	15644248
391009	bhthermela	Thermosipho.melanesiensis.BI429	thermotogae	150020538	150020537	150020402	150020864	150020845
216816	bcbifilong	Bifidobacterium.longum.NCC2705	actinobacteria	33301451	254798418	29336743	338753788	42559648

257309	bccorydiph	Corynebacterium.diphtheriae.NCTC.13129	actinobacteria	38233047	38233046	38233050	38233138	38233085
196164	bccoryeffi	Corynebacterium.efficiens.YS314	actinobacteria	259508473	300659776	259508468	259506760	259506793
38289	bccoryjeik	Corynebacterium.jeikeium.K411	actinobacteria	91207349	118597152	97181608	83288441	260579267
106370	bcfrancci3	Frankia.sp.CcI3	actinobacteria	86566145	118597162	123737803	86566176	109893429
281090	bcleifxyli	Leifsonia.xyli.subsp.xyli.str.CTCB07	actinobacteria	50954137	50954136	50954151	50955548	50955566
1769	bcmycolepr	Mycobacterium.leprae.TN	actinobacteria	13633707	13633834	13633835	3122694	2344833
247156	bcnocafarc	Nocardia.farcinica.IFM.10152	actinobacteria	54027088	300659818	54027086	54022760	54022700
1747	bcpropacne	Propionibacterium.acnes.KPA171202	actinobacteria	314970505	50843342	327327974	340773002	327326712
100226	bcstrecoel	Streptomyces.coelicolor.A3.2	actinobacteria	21223031	21223030	21223034	21223101	21223082
269800	bctherfusc	Thermobifida.fusca.YX	actinobacteria	91207383	72163057	97182082	83305653	72163045
2039	bctropwhip	Tropheryma.whipplei.TW0827	actinobacteria	54041606	300660124	61215276	81722672	28493521
813	bychlatrac	Chlamydia.trachomatis.AHAR13	chlamydiae	226724888	339625983	255348677	237804862	339626212
83555	bychlaabor	Chlamydophila.abortus.S263	chlamydiae	62185277	81312566	81312568	81313066	81313080
340177	brchlochlo	Chlorobium.chlorochromatii.CaD3	chlorobia	91207346	78188331	97181579	115502648	78189807
194439	brchlotepi	Chlorobium.tepidum.TLS	chlorobia	21672993	21672992	161485732	21674979	21674998
243164	bxdehaethe	Dehalococcoides.ethenogenes.195	chloroflexi	91207351	300659842	97181626	83288443	109893425
255470	bxdehacbdb	Dehalococcoides.sp.CBDB1	chloroflexi	91207352	118597156	97181641	83288444	109893426
216389	bxdehabav1	Dehalococcoides.sp.BAV1	chloroflexi	189041813	189040956	189040913	189041415	189042842
479434	bxsphather	Sphaerobacter.thermophilus	chloroflexi	269837634	269837635	269837633	269837085	269837066
251221	bngloeviol	Gloeobacter.violaceus.PCC.7421	cyanobacteria	35212165	35212164	35212166	35214482	35210645
1219	bnprocmari	Prochlorococcus.marinus.subsp.marinus.str.CCMP1375	cyanobacteria	33239681	33239682	33239680	33241144	33241161
32046	bnsyneelon	Synechococcus.elongatus.PCC.6301	cyanobacteria	61215370	300660108	81299443	81301024	81301041
316279	bnsynecc99	Synechococcus.sp.CC9902	cyanobacteria	123580617	118597311	97182069	115502720	109893566
321332	bnsyneja23	Synechococcus.sp.JA23Ba.213	cyanobacteria	123502652	86608697	97182060	115502719	86610028
1148	bnsynepcc	Synechocystis.sp.PCC.6803	cyanobacteria	16330010	16330011	16330009	16329924	16329941
197221	bntherelon	Thermosynechococcus.elongatus.BP1	cyanobacteria	33301564	38605298	161485774	81744002	42559634
243230	bwdeinradi	Deinococcus.radiodurans.R1	deinococcus	15807039	15807040	15807038	15807109	15805340
274	bwtherther	Thermus.thermophilus	deinococcus	730540	224510788	294979563	333967321	46199630
264462	bdbdelbact	Bdellovibrio.bacteriovorus.HD100	deltaproteobacteria	42524386	300659782	42524385	42524358	42524375
876	bddesudesu	Desulfovibrio desulfuricans	deltaproteobacteria	376298167	220904897	220904899	220903953	376298176
338963	bdpelocarb	Pelobacter.carbinolicus.DSM.2380	deltaproteobacteria	91207365	77544387	97181811	115502682	77544398
351604	bdgeoburan	Geobacter uraniireducens	deltaproteobacteria	148263131	148263130	148263132	148263158	148263140
197	blcampjeju	Campylobacter.jejuni.RM1221	epsilonproteobacteria	283954234	50403586	315931083	283953700	218563293
235279	blhelihepa	Helicobacter.hepaticus.ATCC.51449	epsilonproteobacteria	32265863	32265864	32265862	32266895	161546624
210	blhelipylo	Helicobacter.pylori.26695	epsilonproteobacteria	297380383	297380384	15645814	317011501	332674118
224324	bqaquiaeol	Aquifex.aeolicus.VF5	aquificae	15606946	15606945	15606947	15606747	15605616
436114	bqsulfurih	Sulfurihydrogenibium.sp.YO3AOP1	aquificae	188996249	188996250	188996248	188996220	188996239
146919	bzsalirube	Salinibacter.ruber.DSM.13855	bacteroidetes	123528578	83816068	294507788	83814159	294507051
402612	bzflavpsyc	Flavobacterium.psychrophilum.JIP0286	bacteroidetes	150025251	150025252	150025250	150025388	150025407
228908	annanoequi	Nanoarchaeum.equitans.Kin4M	nanoarcheaota	74579651	41614898	41614888	41615106	41615218
190192	ammethkand	Methanopyrus.kandleri.AV19	methanopyri	33301456	38605379	19887299	74561569	42559662
338192	aunitrmari	Nitrosopumilus.maritimus	thaumarchaeota	161527890	161528184	161527889	161527909	161528317
2287	acsulfsolf	Sulfolobus.solfataricus	crenarcheota	15897279	284174529	1814429	11134757	9910845
273063	acsulftoko	Sulfolobus.tokodaii.str.7	crenarcheota	33301580	15921652	15921650	15920620	15920641
368408	actherpend	Thermofilum.pendens.Hrk.5	crenarcheota	160174550	119719142	119719140	166983653	119719148
397948	accaldmaqu	Caldivirga.maquilingensis.IC167	crenarcheota	159042483	159041254	159042315	159041278	159040903
985053	acvulcmout	Vulcanisaeta.moutnovskia.76828	crenarcheota	323707629	323707630	323707628	323708476	323708480
572478	acvulcdist	Vulcanisaeta.distributa.DSM.14429	crenarcheota	307594168	307594169	307594167	307595037	307595041
410359	acpyrocali	Pyrobaculum.calidifontis.JCM.11548	crenarcheota	160166301	126250158	126250160	226710244	126249910
444157	actherneut	Thermoproteus.neutrophilus.V24Sta	crenarcheota	226730322	170935317	170935315	226710271	212288414
384616	acpyroisla	Pyrobaculum.islandicum.DSM.4184	crenarcheota	160166302	119673386	119673388	226710245	119674689
340102	acpyroarse	Pyrobaculum.arsenaticum.DSM.13514	crenarcheota	160166300	145283574	145283572	226710243	145284010
178306	acpyroaero	Pyrobaculum.aerophilum.str.IM2	crenarcheota	33301462	18313825	18313827	74561950	18313001
415426	achypebuty	Hyperthermus.butylicus.DSM.5456	crenarcheota	160166123	124028449	124028329	166234472	124028157
453591	acignihosp	Ignicoccus.hospitalis.KIN4.I	crenarcheota	156937969	156937968	156937970	156938061	156937755
272557	acaeropern	Aeropyrum.pernix.K1	crenarcheota	116063087	5105873	116063086	5103982	5103618
591019	acstaphell	Staphylothermus.hellenicus.DSM.12710	crenarcheota	297527346	297527347	297527345	297527385	297527410
399550	acstapmari	Staphylothermus.marinus.F1	crenarcheota	160174407	126465989	126465991	166234525	212288413
633148	actheraggr	Thermosphaera.aggregans.DSM.11486	crenarcheota	296242677	296242676	296242678	296242607	296242583
765177	acdesumuco	Desulfurococcus.mucosus.DSM.2162	crenarcheota	319753653	319753654	319753652	319753696	319753720
490899	acdesukamc	Desulfurococcus.kamchatkensis.1221n	crenarcheota	218884414	218884415	218884413	254799134	218884488
399549	acmetasedu	Metallosphaera.sedula.DSM.5348	crenarcheota	226724941	146304397	146304399	146302898	146302876
43080	acsulfisla	Sulfolobus.islandicus.L.S.2.15	crenarcheota	238620254	227828024	323477848	229582020	229582042
330779	acsulfacid	Sulfolobus.acidocaldarius.DSM.639	crenarcheota	73920756	464617	464641	3914680	76363364
583356	acigniaggr	Ignisphaera.aggregans.DSM.17230	crenarcheota	305663814	305663813	305663815	305662613	305662572
933801	acacidhosp	Acidianus.hospitalis.W1	crenarcheota	332796977	332796976	332796978	332796550	332796528
1006006	acmetacupr	Metallosphaera.cuprina.Ar4	crenarcheota	330834455	330834456	330834454	330835803	330835825
999630	actheruzon	Thermoproteus.uzoniensis.76820	crenarcheota	327311564	327311563	327311565	327311987	327311641
186497	atpyrofuri	Pyrococcus.furiosus.DSM.3638	thermococci	33301574	38605380	22257022	74535417	42559663
70601	atpyrohori	Pyrococcus.horikoshii.OT3	thermococci	6647721	6093998	6647747	3258186	6094075
272844	atpyroabys	Pyrococcus.abyssi.GE5	thermococci	11134352	5457434	5459202	13124481	5457774
69014	attherkoda	Thermococcus.kodakarensis.KOD1	thermococci	73914080	73914069	218093672	74506518	73917495
604354	atthersibi	Thermococcus.sibiricus.MM.739	thermococci	242264767	242264766	259491696	242264695	259709744
391623	attherbaro	Thermococcus.barophilus.MP	thermococci	315229958	315229957	315229959	315229879	315229856
523850	attheronnu	Thermococcus.onnurineus.NA1	thermococci	212223326	212223325	212223327	212223234	212223211
593117	atthergamm	Thermococcus.gammatolerans.EJ3	thermococci	239910098	239910097	239910099	239911591	239911614
246969	attheram4	Thermococcus.sp.AM4	thermococci	214034178	214033790	214034119	214033251	214033219
342949	atpyrona2	Pyrococcus.sp.NA2	thermococci	331033918	331033917	331033919	331033464	331033487
529709	atpyroyaya	Pyrococcus.yayanosii.CH1	thermococci	337285272	337285271	337285273	337283667	337283644
339860	abmethstad	Methanosphaera.stadmanae.DSM.3091	methanobacteria	121707540	84490054	84490052	115502674	84489708
523846	abmethferv	Methanothermus.fervidus.DSM.2088	methanobacteria	311224091	311224090	311224092	311224817	311224794

79929	abmethmarb	Methanothermobacter.marburgensis.str.Marburg	methanobacteria	304314033	304314032	304314034	304314276	304314253
187420	abmethther	Methanothermobacter.thermautotrophicus.str.Delta.H	methanobacteria	161789010	3122664	3914774	3122688	3122720
634498	abmethrumi	Methanobrevibacter.ruminantium.M1	methanobacteria	288542452	288542451	288542453	288542841	288542818
2173	abmethsmit	Methanobrevibacter.smithii.DSM.2374	methanobacteria	160166853	261349635	166223884	288869701	261350378
868132	abmethal21	Methanobacterium.sp.AL21	methanobacteria	325959971	325959970	325959972	325958554	325958531
868131	abmethswan	Methanobacterium.sp.SWAN1	methanobacteria	333824773	333824774	333824772	333825800	333825823
243232	admethjann	Methanocaldococcus.jannaschii.DSM.2661	methanococci	15668687	1710482	3334487	1710492	1710558
573063	admethinfe	Methanocaldococcus.infernus.ME	methanococci	296109681	296110106	296109682	296109298	296109263
579137	admethvulc	Methanocaldococcus.vulcanius.M7	methanococci	261403694	261403218	261403693	261402334	261403779
573064	admethferv	Methanocaldococcus.fervens.AG86	methanococci	256810652	256811381	256810653	256810624	256810689
644281	admethfs40	Methanocaldococcus.sp.FS40622	methanococci	289193264	289192634	289193263	289193214	289191591
647113	admethokin	Methanothermococcus.okinawensis.IH1	methanococci	336121021	336121523	336121022	336121768	336121494
419665	admethaeol	Methanococcus.aeolicus.Nankai3	methanococci	166219575	166230152	166223881	166234479	166233154
456320	admethvolt	Methanococcus.voltae.A3	methanococci	297620220	297620011	297620219	297619566	297619637
406327	admethvann	Methanococcus.vannielii.SB	methanococci	160369947	150399495	150400014	166234484	150399607
39152	admethmari	Methanococcus.maripaludis	methanococci	340623442	134045191	134046441	226710219	150402715
880724	admethigne	Methanotorris.igneus.Kol.5	methanococci	333910816	333910725	333910817	333910771	333911089
273116	apthervolc	Thermoplasma.volcanium.GSS1	thermoplasmata	33301581	38605428	17865549	74576027	42559678
273075	aptheracid	Thermoplasma.acidophilum.DSM.1728	thermoplasmata	16081489	38605473	16081488	16082253	16082270
263820	appicrtorr	Picrophilus.torridus.DSM.9790	thermoplasmata	61215564	48477509	48477511	48477734	48477712
333146	apferracid	Ferroplasma.acidarmanus.fer1	thermoplasmata	257076140	257076141	257076139	257076582	257076559
224325	ararchfulg	Archaeoglobus.fulgidus.DSM.4304	archaeoglobi	3914705	3914670	3914775	3914684	3914742
589924	arferrplac	Ferroglobus.placidus.DSM.10642	archaeoglobi	288930662	288931717	288930663	288931532	288931510
572546	ararchprof	Archaeoglobus.profundus.DSM.5631	archaeoglobi	284162829	284161994	284162830	284162438	284162460
693661	ararchvene	Archaeoglobus.veneficus.SNP6	archaeoglobi	327316337	327317051	327316338	327316358	327316380
192952	aqmethmaze	Methanosarcina.mazei.Go1	methanomicrobia	33301453	21227113	21227115	74523906	21228226
323259	aqmethhung	Methanospirillum.hungatei.JF1	methanomicrobia	121721394	88601954	88601952	88603477	88603499
349307	aqmethther	Methanosaeta.thermophila.PT	methanomicrobia	121694179	121693041	116666168	116666445	121693633
644295	aqmetheves	Methanohalobium.evestigatum.Z7303	methanomicrobia	298675985	298675984	298675986	298674780	298674802
547558	aqmethmahi	Methanohalophilus.mahii.DSM.5219	methanomicrobia	294494869	294494868	294494870	294495995	294496017
259564	aqmethburt	Methanococcoides.burtonii.DSM.6242	methanomicrobia	121686654	118597256	121691618	91772105	121689445
269797	aqmethbark	Methanosarcina.barkeri.str.Fusaro	methanomicrobia	91207356	72395322	72395320	115502672	72394824
188937	aqmethacet	Methanosarcina.acetivorans.C2A	methanomicrobia	33301455	38605376	22257020	74533255	42559661
410358	aqmethlabr	Methanocorpusculum.labreanum.Z	methanomicrobia	160166272	124486397	124486395	124484931	124484910
679926	aqmethpetr	Methanoplanus.petrolearius.DSM.11571	methanomicrobia	307354262	307354263	307354261	307354345	307354323
368407	aqmethmari	Methanoculleus.marisnigri.JR1	methanomicrobia	160166275	126178362	126178364	126178536	126178514
521011	aqmethpalu	Methanosphaerula.palustris.E19c	methanomicrobia	219850847	219850846	219850848	219851129	219851107
456442	aqmethboon	Methanoregula.boonei.6A8	methanomicrobia	160166257	154000343	154000341	153998649	153998627
2242	ahhalonrc1	Halobacterium.sp.NRC1.Halobacterium.salinarum	halobacteria	43533	43452	43534	226710205	15790632
348780	ahnatrphar	Natronomonas.pharaonis.DSM.2160	halobacteria	91207361	76802860	76802858	83288449	76803057
272569	ahhalomari	Haloarcula.marismortui.ATCC.43049	halobacteria	132752	132647	57015347	1350666	57015335
416348	ahhalolacu	Halorubrum.lacusprofundi.ATCC.49239	halobacteria	254799852	222480394	222480940	254799142	222480857
469382	ahhalobori	Halogeometricum.borinquense.DSM.11551	halobacteria	313125989	313125990	313125988	313125812	313125790
309800	ahhalovolc	Haloferax.volcanii.DS2	halobacteria	292656875	292656876	292656874	292656663	292656685
797209	ahhalapauc	Haladaptatus.paucihalophilus.DX253	halobacteria	322369369	322369367	322369370	322372146	322372168
795797	ahhalajeot	Halalkalicoccus.jeotgali.B3	halobacteria	300711073	300711070	300711074	300710397	300710375
547559	ahnatrmaga	Natrialba.magadii.ATCC.43099	halobacteria	289583164	289583156	289583165	289579920	289579898
543526	ahhaloturk	Haloterrigena.turkmenica.DSM.5511	halobacteria	284164797	284164794	284164798	284165514	284165492
519442	ahhaloutah	Halorhabdus.utahensis.DSM.12940	halobacteria	257051342	257051340	257051343	257053381	257053359
485914	ahhalomuko	Halomicrobium.mukohataei.DSM.12286	halobacteria	257388233	257388234	257388232	257387898	257387876
362976	ahhalowals	Haloquadratum.walsbyi.DSM.16790	halobacteria	121684711	110668816	110668799	115502663	110668741
797210	ahhaloxana	Halopiger.xanaduensis.SH6	halobacteria	336254631	336254629	336254632	336252418	336252440

txid	**short name**	**full_name**	**phylum**	**L4**	**L16uL10ae**	**L22pL17e**	**L29pL35e**	**L13**
234267	bjsoliusit	Solibacter.usitatus.Ellin6076	acidobacteria	122253083	122253089	122253087	116624194	122255563
204669	bjkorivers	Candidatus.Koribacter.versatilis.Ellin345	acidobacteria	94968255	94968261	94968259	94968262	94967592
770	bkanapmarg	Anaplasma.marginale.str.St.Maries	alphaproteobacteria	254803710	255004470	254800415	255004469	255003436
212042	bkanapphag	Anaplasma.phagocytophilum.HZ	alphaproteobacteria	109893574	115502730	109893178	88598101	123494458
283165	bkbartquin	Bartonella.quintana.str.Toulouse	alphaproteobacteria	49474403	49474397	49474399	49474396	49474262
29459	bkbrucmeli	Brucella.melitensis.16M	alphaproteobacteria	51338733	81852034	51316502	54041856	81851714
314261	bkpelaubiq	Candidatus.Pelagibacter.ubique.HTCC1062	alphaproteobacteria	91763161	91763167	91763165	91763168	91763245
269484	bkehrlcani	Ehrlichia.canis.str.Jake	alphaproteobacteria	109893593	85541806	123732197	123614828	72394576
314225	bkerytlito	Erythrobacter.litoralis.HTCC2594	alphaproteobacteria	122544174	122544175	123293710	122544176	84788482
290633	bkglucoxyd	Gluconobacter.oxydans.621H	alphaproteobacteria	58001268	58001262	58001264	58001261	161898750
290400	bkjannccs1	Jannaschia.sp.CCS1	alphaproteobacteria	89053075	89053083	89053081	89053090	161898394
266835	bkmesoloti	Mesorhizobium.loti.MAFF303099	alphaproteobacteria	13470552	13470558	13470556	13470559	13476982
323098	bknitrwino	Nitrobacter.winogradskyi.Nb255	alphaproteobacteria	109893613	85541811	109893215	123613572	162139846
279238	bknovoarom	Novosphingobium.aromaticivorans.DSM.12444	alphaproteobacteria	87199271	87199277	87199275	87199278	87201298
1063	bkrhodspha	Rhodobacter.sphaeroides.2.4.1	alphaproteobacteria	146278567	146278561	146278563	146278560	146278212
1076	bkrhodpalu	Rhodopseudomonas.palustris.CGA009	alphaproteobacteria	39936312	316933534	39936308	39936305	39935834
269796	bkrhodrubr	Rhodospirillum.rubrum.ATCC.11170	alphaproteobacteria	109893631	115502785	109893231	83594012	123526342
257363	bkricktyph	Rickettsia.typhi.str.Wilmington	alphaproteobacteria	51460150	51460144	51460146	51460143	51459744
542	bkzymomobi	Zymomonas.mobilis.subsp.Mobilis.ZM4	alphaproteobacteria	56551414	81598313	338707685	73917147	56551780
62928	bbazoaebn1	Azoarcus.sp.EbN1	betaproteobacteria	166234632	166234546	166220824	166228180	166230959
269483	bbburk383	Burkholderia.sp.383	betaproteobacteria	109893581	115502737	109893186	123569516	118573387
243365	bbchroviol	Chromobacterium.violaceum.ATCC.12472	betaproteobacteria	34499640	34499634	34499636	34499633	34499152
159087	bbdecharom	Dechloromonas.aromatica.RCB	betaproteobacteria	109893589	85541803	109893194	123628316	118573397
485	bbneisgono	Neisseria.gonorrhoeae.FA.1090	betaproteobacteria	226730698	75432358	226733490	317165383	75507276
323848	bbnitrmult	Nitrosospira.multiformis.ATCC.25196	betaproteobacteria	82701901	82701907	82701905	82701908	82701695
264198	bbralseutr	Ralstonia.eutropha.JMP134	betaproteobacteria	72120275	72120269	72120271	72120268	72117587

292415	bbthiodeni	Thiobacillus.denitrificans.ATCC.25259	betaproteobacteria	109893658	85542090	109893252	74316431	118573463
267748	btmycomobi	Mycoplasma.mobile.163K	tenericutes	47459071	47459077	47459075	47459078	47459064
243273	btmycogeni	Mycoplasma.genitalium.G37	tenericutes	12045005	12045011	12045009	12045012	12045278
134821	btureaparv	Ureaplasma.parvum.serovar.3.str.ATCC.700970	tenericutes	183508831	81624428	215274215	14195150	171920200
272633	btmycopene	Mycoplasma.penetrans.HF.2	tenericutes	26554464	26554459	26554460	26554458	26553533
265311	btmesoflor	Mesoplasma.florum.L1	tenericutes	50364939	50364945	50364943	50364946	50365310
322098	btasteyell	Aster.yellows.witches.broom.phytoplasma.AYWB	tenericutes	109893576	115502732	109893180	84789899	84789967
246194	bfcarbhydr	Carboxydothermus.hydrogenoformans.Z2901	firmicutes	109893583	85701219	109893188	123575540	118573390
49338	bfdesuhafn	Desulfitobacterium.hafniense.Y51	firmicutes	122483925	115502746	219666495	122483924	219666791
264732	bfmoorther	Moorella.thermoacetica.ATCC.39073	firmicutes	109893605	115502762	109893208	123523761	118573421
1488	bfclosacet	Clostridium.acetobutylicum.ATCC.824	firmicutes	46577285	81595892	51316516	20139602	81775431
1502	bfclosperf	Clostridium.perfringens.str.13	firmicutes	110803426	81766491	51316499	20139451	118573394
1314	bfstrepyog	Streptococcus.pyogenes.M1.GAS	firmicutes	226731433	50913446	76363878	139472935	161761300
66692	bfbaciclau	Bacillus.clausii.KSMK16	firmicutes	81601105	81601104	81679088	73917084	81679080
272558	bfbacihalo	Bacillus.halodurans.C125	firmicutes	15612698	15612704	15612702	15612705	15612731
235909	bfgeobkaus	Geobacillus.kaustophilus.HTA426	firmicutes	56418642	56418648	56418646	56418649	56418674
1590	bflactplan	Lactobacillus.plantarum.WCFS1	firmicutes	46577245	81631772	308180016	38258533	81733727
314315	bflactsake	Lactobacillus.sakei.subsp.sakei.23K	firmicutes	109893600	85701220	109893203	123563677	118573409
221109	bfoceaihey	Oceanobacillus.iheyensis.HTE831	firmicutes	46577267	81747270	51316856	34395777	81747261
851	bvfusonucl	Fusobacterium.nucleatum.subsp.nucleatum.ATCC.25586	fusobacteria	339891570	19704959	51316491	339891563	254302742
34105	bvstremoni	Streptobacillus.moniliformis	fusobacteria	269122980	269124031	269124033	269124030	269122813
62977	bgacinadp1	Acinetobacter.sp.ADP1	gammaproteobacteria	81613021	81613022	81695747	50086207	81695766
9	bgbuchaphi	Buchnera.aphidicola.str.APS	gammaproteobacteria	254803722	15617111	15617113	11134592	15616995
203907	bgblocflor	Candidatus.Blochmannia.floridanus	gammaproteobacteria	46577208	81666642	51316364	33519666	300665004
291272	bgblocpenn	Candidatus.Blochmannia.pennsylvanicus.str.BPEN	gammaproteobacteria	109893577	85541798	109893182	71891983	123641197
167879	bgcolwpsyc	Colwellia.psychrerythraea.34H	gammaproteobacteria	109893587	85541801	109893192	71144091	118573396
263	bgfrantula	Francisella.tularensis.subsp.holarctica	gammaproteobacteria	166234669	226710729	115314176	226699251	254369601
233412	bghaemducr	Haemophilus.ducreyi.35000HP	gammaproteobacteria	33149182	33149176	33149178	33149175	33148774
349521	bghahechej	Hahella.chejuensis.KCTC.2396	gammaproteobacteria	109893598	115502753	109893201	123530598	118573406
283942	bgidioloih	Idiomarina.loihiensis.L2TR	gammaproteobacteria	56180033	56180027	56180029	56180026	56178535
446	bglegipneu	Legionella.pneumophila.str.Lens	gammaproteobacteria	296105879	166199680	81680553	166228220	166230994
243233	bgmethcaps	Methylococcus.capsulatus.str.Bath	gammaproteobacteria	53803549	53803418	53803409	53803419	53804800
1229	bgnitrocea	Nitrosococcus.oceani.ATCC.19707	gammaproteobacteria	109893612	85541810	207090527	123593713	118573424
74109	bgphotprof	Photobacterium.profundum.SS9	gammaproteobacteria	81615627	90414963	51316623	54307549	90413018
228	bgpseuhalo	Pseudoalteromonas.haloplanktis.TAC125	gammaproteobacteria	109893622	85541818	109893222	332531853	332531918
317	bgpseusyri	Pseudomonas.syringae.pv.phaseolicola.1448A	gammaproteobacteria	63258481	63258475	63258477	63258474	63258054
259536	bgpsycarct	Psychrobacter.arcticus.2734	gammaproteobacteria	71038045	71038051	71038049	71038052	71039105
623	bgshigflex	Shigella.flexneri.2a.str.2457T	gammaproteobacteria	46577238	123342431	320187033	110807160	320186709
317025	bgthiocrun	Thiomicrospira.crunogena.XCL2	gammaproteobacteria	109893657	115504862	109893251	78362934	118573462
36870	bgwiggglos	Wigglesworthia.glossinidia.endosymbiont.of.Glossina.brevipalpis	gammaproteobacteria	46577256	81741596	51316838	31340348	81741814
562	bgeschcoli	Escherichia.coli	gammaproteobacteria	168988766	15803840	15803842	15803839	91074224
265606	bprhodbalt	Rhodopirellula.baltica.SH1	planctomycetacia	46577190	81660271	51316769	81660270	300664992
521674	bpplanlimn	Planctomyces.limnophilus	planctomycetacia	296120748	296120754	296120752	296120755	296123120
290434	bsborrgari	Borrelia.garinii.Pbi	spirochaetes	51598733	51598740	51598738	51598741	300664908
173	bsleptinte	Leptospira.interrogans.serovar.Copenhageni.str.Fiocruz.L1130	spirochaetes	7674299	7674212	7674240	7674282	300664956
158	bstrepdent	Treponema.denticola.ATCC.35405	spirochaetes	46577160	81570372	325473228	73917140	81700207
160	bstreppall	Treponema.pallidum.subsp.pallidum.str.Nichols	spirochaetes	6094081	6094018	6094035	6094045	6094009
243274	bhthermari	Thermotoga.maritima.MSB8	thermotogae	15644247	15644241	15644243	15644240	15644203
391009	bhthermela	Thermosipho.melanesiensis.BI429	thermotogae	150020846	150020852	150020850	150020853	150020924
216816	bcbifilong	Bifidobacterium.longum.NCC2705	actinobacteria	46576825	254799181	51316475	338753777	254798482
257309	bccorydiph	Corynebacterium.diphtheriae.NCTC.13129	actinobacteria	38233086	38233092	38233090	38233093	38233170
196164	bccoryeffi	Corynebacterium.efficiens.YS314	actinobacteria	259506792	259506786	259506788	259506785	259506723
38289	bccoryjeik	Corynebacterium.jeikeium.K411	actinobacteria	260579266	85541802	109893193	123650227	161986619
106370	bcfrancci3	Frankia.sp.CcI3	actinobacteria	109893595	115502750	109893198	86566165	118573402
281090	bcleifxyli	Leifsonia.xyli.subsp.xyli.str.CTCB07	actinobacteria	50955565	50955559	50955561	50955558	50955535
1769	bcmycolepr	Mycobacterium.leprae.TN	actinobacteria	3122749	3122692	3122713	13093547	585864
247156	bcnocafarc	Nocardia.farcinica.IFM.10152	actinobacteria	54022701	54022707	54022705	54022708	54022833
1747	bcpropacne	Propionibacterium.acnes.KPA171202	actinobacteria	50843317	340773013	340772942	340772913	340773025
100226	bcstrecoel	Streptomyces.coelicolor.A3.2	actinobacteria	21223083	21223089	21223087	21223090	21223113
269800	bctherfusc	Thermobifida.fusca.YX	actinobacteria	109893650	85542089	109893250	72163037	118573460
2039	bctropwhip	Tropheryma.whipplei.TW0827	actinobacteria	46577234	81629932	51316813	73917142	28493111
813	bychlatrac	Chlamydia.trachomatis.AHAR13	chlamydiae	339626211	339626205	255507119	76167787	300664800
83555	bychlaabor	Chlamydophila.abortus.S263	chlamydiae	81313079	333409892	81313075	73917089	333410289
340177	brchlochlo	Chlorobium.chlorochromatii.CaD3	chlorobia	109893584	115502740	109893189	78189799	78189607
194439	brchlotepi	Chlorobium.tepidum.TLS	chlorobia	21674997	21674991	21674993	21674990	21674597
243164	bxdehaethe	Dehalococcoides.ethenogenes.195	chloroflexi	109893590	85541804	109893195	123618898	123618892
255470	bxdehacbdb	Dehalococcoides.sp.CBDB1	chloroflexi	109893591	85541805	109893196	123620200	123620210
216389	bxdehabav1	Dehalococcoides.sp.BAV1	chloroflexi	189029500	189041458	189041948	189029474	189041001
479434	bxsphather	Sphaerobacter.thermophilus	chloroflexi	269837067	269837073	269837071	269837074	269837097
251221	bngloeviol	Gloeobacter.violaceus.PCC.7421	cyanobacteria	35210646	35214493	35214495	35214492	35214993
1219	bnprocmari	Prochlorococcus.marinus.subsp.marinus.str.CCMP1375	cyanobacteria	33241160	33241154	33241156	33241153	33241135
32046	bnsyneelon	Synechococcus.elongatus.PCC.6301	cyanobacteria	81301040	81301034	81301036	81301033	81301015
316279	bnsynecc99	Synechococcus.sp.CC9902	cyanobacteria	109893648	115504860	109893248	123581066	118573457
321332	bnsyneja23	Synechococcus.sp.JA23Ba.213	cyanobacteria	109893646	115502804	109893246	123501016	123502212
1148	bnsynepcc	Synechocystis.sp.PCC.6803	cyanobacteria	16329940	16329934	16329936	16329933	16329914
197221	bntherelon	Thermosynechococcus.elongatus.BP1	cyanobacteria	46577259	81744005	51316841	73917137	81743999
243230	bwdeinradi	Deinococcus.radiodurans.R1	deinococcus	15805341	15805347	15805345	15805348	161579494
274	bwtherther	Thermus.thermophilus	deinococcus	218766855	218766863	1350696	325533843	55981434
264462	bdbdelbact	Bdellovibrio.bacteriovorus.HD100	deltaproteobacteria	42524374	42524368	42524370	42524367	42522099
876	bddesudesu	Desulfovibrio desulfuricans	deltaproteobacteria	376298177	220903941	376298181	220903942	220904335
338963	bdpelocarb	Pelobacter.carbinolicus.DSM.2380	deltaproteobacteria	109893615	85541812	109893216	77544406	118573425

351604	bdgeoburan	Geobacter uraniireducens	deltaproteobacteria	148263141	148263147	148263145	304359809	148263122
197	blcampjeju	Campylobacter.jejuni.RM1221	epsilonproteobacteria	121612191	81624155	68248470	283953690	57238503
235279	blhelihepa	Helicobacter.hepaticus.ATCC.51449	epsilonproteobacteria	32266878	32266884	32266882	32266885	32265997
210	blhelipylo	Helicobacter.pylori.26695	epsilonproteobacteria	261838637	325998178	325998180	315587200	226702868
224324	bqaquiaeol	Aquifex.aeolicus.VF5	aquificae	15605617	15605623	15605621	15607133	15606909
436114	bqsulfurih	Sulfurihydrogenibium.sp.YO3AOP1	aquificae	188996238	188996232	188996234	188996231	188997629
146919	bzsalirube	Salinibacter.ruber.DSM.13855	bacteroidetes	109893635	294507058	109893235	294507059	294505851
402612	bzflavpsyc	Flavobacterium.psychrophilum.JIP0286	bacteroidetes	150025406	150025400	150025402	150025399	150024559
228908	annanoequi	Nanoarchaeum.equitans.Kin4M	nanoarcheaota	46396577	41615235	41614997	73917113	74580046
190192	ammethkand	Methanopyrus.kandleri.AV19	methanopyri	46396647	22096064	50401087	22096063	74572564
338192	aunitrmari	Nitrosopumilus.maritimus	thaumarchaeota	161528316	161527957	161528313	161528311	161527934
2287	acsulfsolf	Sulfolobus.solfataricus	crenarcheota	11134368	18202635	284174943	14195110	300664888
273063	acsulftoko	Sulfolobus.tokodaii.str.7	crenarcheota	15920640	20978621	15920636	20532232	74573298
368408	actherpend	Thermofilum.pendens.Hrk.5	crenarcheota	119719147	119719460	215274928	119719403	119719196
397948	accaldmaqu	Caldivirga.maquilingensis.IC167	crenarcheota	159040902	159041538	159042485	159041516	159042428
985053	acvulcmout	Vulcanisaeta.moutnovskia.76828	crenarcheota	323708481	323707619	323707929	323707989	323707687
572478	acvulcdist	Vulcanisaeta.distributa.DSM.14429	crenarcheota	307595042	307594158	307594668	307594500	307594232
410359	acpyrocali	Pyrobaculum.calidifontis.JCM.11548	crenarcheota	126249911	126250319	126248892	126248888	126250423
444157	actherneut	Thermoproteus.neutrophilus.V24Sta	crenarcheota	170934491	226700015	215274876	170934424	226705045
384616	acpyroisla	Pyrobaculum.islandicum.DSM.4184	crenarcheota	119674690	119673837	119674627	119674623	119673617
340102	acpyroarse	Pyrobaculum.arsenaticum.DSM.13514	crenarcheota	145284011	145284190	145282774	145282772	145284291
178306	acpyroaero	Pyrobaculum.aerophilum.str.IM2	crenarcheota	46396650	18314160	18312876	20139512	74572760
415426	achypebuty	Hyperthermus.butylicus.DSM.5456	crenarcheota	124028158	124028492	124028160	124028162	124027417
453591	acignihosp	Ignicoccus.hospitalis.KIN4.I	crenarcheota	156937756	156937789	156937382	156937384	156936980
272557	acaeropern	Aeropyrum.pernix.K1	crenarcheota	116062269	5104095	5104004	116062340	5105435
591019	acstaphell	Staphylothermus.hellenicus.DSM.12710	crenarcheota	297527409	297526180	297527402	297527400	297527610
399550	acstapmari	Staphylothermus.marinus.F1	crenarcheota	126465914	126465535	126465921	126465923	126465717
633148	actheraggr	Thermosphaera.aggregans.DSM.11486	crenarcheota	296242584	296241781	296242590	296242592	296243117
765177	acdesumuco	Desulfurococcus.mucosus.DSM.2162	crenarcheota	319753719	319752597	319753713	319753711	319753888
490899	acdesukamc	Desulfurococcus.kamchatkensis.1221n	crenarcheota	218884487	218884722	218884481	218884479	218884672
399549	acmetasedu	Metallosphaera.sedula.DSM.5348	crenarcheota	146302877	146304613	146302881	146302883	146304890
43080	acsulfisla	Sulfolobus.islandicus.L.S.2.15	crenarcheota	238619863	229581632	229582037	238619869	238620501
330779	acsulfacid	Sulfolobus.acidocaldarius.DSM.639	crenarcheota	76363365	76363355	76363359	76363361	73920755
583356	acigniaggr	Ignisphaera.aggregans.DSM.17230	crenarcheota	305662571	305663453	305662596	305662598	305662636
933801	acacidhosp	Acidianus.hospitalis.W1	crenarcheota	332796529	332796905	332796533	332796535	332796344
1006006	acmetacupr	Metallosphaera.cuprina.Ar4	crenarcheota	330835824	330834282	330835820	330835818	330834011
999630	actheruzon	Thermoproteus.uzoniensis.76820	crenarcheota	327311644	327310073	327311909	327311858	327311716
186497	atpyrofuri	Pyrococcus.furiosus.DSM.3638	thermococci	46396648	18203517	50401088	22096065	74572629
70601	atpyrohori	Pyrococcus.horikoshii.OT3	thermococci	6094080	6093995	6094034	11182432	6094007
272844	atpyroabys	Pyrococcus.abyssi.GE5	thermococci	5457773	13431824	5457769	14195164	5457964
69014	attherkoda	Thermococcus.kodakarensis.KOD1	thermococci	73917535	218094051	73914087	73917122	74506499
604354	atthersibi	Thermococcus.sibiricus.MM.739	thermococci	259491578	259645501	242264677	259646780	242264728
391623	attherbaro	Thermococcus.barophilus.MP	thermococci	315229857	315229819	315229861	315229863	315229897
523850	attheronnu	Thermococcus.onnurineus.NA1	thermococci	212223212	212223208	212223216	212223218	212223253
593117	atthergamm	Thermococcus.gammatolerans.EJ3	thermococci	259491577	239911621	239911609	239911607	239911575
246969	attheram4	Thermococcus.sp.AM4	thermococci	214033128	214033123	214032921	214033248	214032927
342949	atpyrona2	Pyrococcus.sp.NA2	thermococci	331033486	331034355	331033482	331033480	331033325
529709	atpyroyaya	Pyrococcus.yayanosii.CH1	thermococci	337283645	337284456	337283649	337283651	337283751
339860	abmethstad	Methanosphaera.stadmanae.DSM.3091	methanobacteria	109893604	84489148	84489703	84489701	84489666
523846	abmethferv	Methanothermus.fervidus.DSM.2088	methanobacteria	311224795	311224073	311224799	311224801	311224830
79929	abmethmarb	Methanothermobacter.marburgensis.str.Marburg	methanobacteria	304314254	304315247	304314258	304314260	304314289
187420	abmethther	Methanothermobacter.thermautotrophicus.str.Delta.H	methanobacteria	3122746	6093993	3122686	3122708	7388076
634498	abmethrumi	Methanobrevibacter.ruminantium.M1	methanobacteria	288542819	288543864	288542823	288542825	288542877
2173	abmethsmit	Methanobrevibacter.smithii.DSM.2374	methanobacteria	261350379	261350155	261350383	261350385	261350419
868132	abmethal21	Methanobacterium.sp.AL21	methanobacteria	325958532	325958137	325958536	325958538	325958567
868131	abmethswan	Methanobacterium.sp.SWAN1	methanobacteria	333825822	333826376	333825818	333825816	333825787
243232	admethjann	Methanocaldococcus.jannaschii.DSM.2661	methanococci	1710567	2500357	1710517	1710528	3334486
573063	admethinfe	Methanocaldococcus.infernus.ME	methanococci	296109264	296110054	296109316	296109314	296109378
579137	admethvulc	Methanocaldococcus.vulcanius.M7	methanococci	261403780	261403062	261402352	261402350	261403743
573064	admethferv	Methanocaldococcus.fervens.AG86	methanococci	256810688	256810738	256810642	256810640	256810441
644281	admethfs40	Methanocaldococcus.sp.FS40622	methanococci	289191590	289191804	289193196	289193198	289191578
647113	admethokin	Methanothermococcus.okinawensis.IH1	methanococci	336121493	336122153	336121750	336121752	336121977
419665	admethaeol	Methanococcus.aeolicus.Nankai3	methanococci	226730685	166229741	215274831	166228222	150014222
456320	admethvolt	Methanococcus.voltae.A3	methanococci	297619638	297618814	297619584	297619582	297618747
406327	admethvann	Methanococcus.vannielii.SB	methanococci	150399608	150399350	150399465	150399467	150399386
39152	admethmari	Methanococcus.maripaludis	methanococci	134045078	340624604	159905653	150402574	340624635
880724	admethigne	Methanotorris.igneus.Kol.5	methanococci	333911090	333910650	333910789	333910787	333910740
273116	apthervolc	Thermoplasma.volcanium.GSS1	thermoplasmata	46396652	18202322	13541160	20139596	74575397
273075	aptheracid	Thermoplasma.acidophilum.DSM.1728	thermoplasmata	16082269	16082585	16082265	16082663	16081555
263820	appicrtorr	Picrophilus.torridus.DSM.9790	thermoplasmata	48477713	48477787	48477717	73917118	48477395
333146	apferracid	Ferroplasma.acidarmanus.fer1	thermoplasmata	257076560	257076631	257076564	257076566	257076120
224325	ararchfulg	Archaeoglobus.fulgidus.DSM.4304	archaeoglobi	3914743	6093991	6094032	3914730	3914669
589924	arferrplac	Ferroglobus.placidus.DSM.10642	archaeoglobi	288931511	288931299	288931515	288931517	288932316
572546	ararchprof	Archaeoglobus.profundus.DSM.5631	archaeoglobi	284162459	284162564	284162455	284162453	284161254
693661	ararchvene	Archaeoglobus.veneficus.SNP6	archaeoglobi	327316379	327317151	327316375	327316373	327316975
192952	aqmethmaze	Methanosarcina.mazei.Go1	methanomicrobia	21228227	23822032	21228231	21228233	20906271
323259	aqmethhung	Methanospirillum.hungatei.JF1	methanomicrobia	88603498	88601407	88603494	88603492	88604130
349307	aqmethther	Methanosaeta.thermophila.PT	methanomicrobia	121694875	116664953	121694871	121693631	116665246
644295	aqmetheves	Methanohalobium.evestigatum.Z7303	methanomicrobia	298674801	298674453	298674797	298674795	298674288
547558	aqmethmahi	Methanohalophilus.mahii.DSM.5219	methanomicrobia	294496016	294496379	294496012	294496010	294496191
259564	aqmethburt	Methanococcoides.burtonii.DSM.6242	methanomicrobia	121691984	121684329	121689444	91772090	118573416

269797	aqmethbark	Methanosarcina.barkeri.str.Fusaro	methanomicrobia	72394823	72396059	72394819	72394817	72396113
188937	aqmethacet	Methanosarcina.acetivorans.C2A	methanomicrobia	46396645	22096059	50401086	22096057	74572521
410358	aqmethlabr	Methanocorpusculum.labreanum.Z	methanomicrobia	124484911	124485206	124484915	124484917	124486062
679926	aqmethpetr	Methanoplanus.petrolearius.DSM.11571	methanomicrobia	307354324	307354416	307354328	307354330	307352914
368407	aqmethmari	Methanoculleus.marisnigri.JR1	methanomicrobia	166234684	126178798	126178519	126178521	126179748
521011	aqmethpalu	Methanosphaerula.palustris.E19c	methanomicrobia	219851108	254798389	219851112	219851114	219852955
456442	aqmethboon	Methanoregula.boonei.6A8	methanomicrobia	166234683	153998829	153998632	153998634	154000311
2242	ahhalonrc1	Halobacterium.sp.NRC1.Halobacterium.salinarum	halobacteria	46396658	18202995	43551	2425183	68053237
348780	ahnatrphar	Natronomonas.pharaonis.DSM.2160	halobacteria	109893609	121698544	76803062	121695366	118573422
272569	ahhalomari	Haloarcula.marismortui.ATCC.43049	halobacteria	57015333	57015378	132786	132842	132658
416348	ahhalolacu	Halorubrum.lacusprofundi.ATCC.49239	halobacteria	222480856	222478496	222480852	222480850	222480233
469382	ahhalobori	Halogeometricum.borinquense.DSM.11551	halobacteria	313125791	313127427	313125795	313125797	313126015
309800	ahhalovolc	Haloferax.volcanii.DS2	halobacteria	292656684	292654660	292656680	292656678	292656896
797209	ahhalapauc	Haladaptatus.paucihalophilus.DX253	halobacteria	322372167	322370084	322372163	322372161	322369532
795797	ahhalajeot	Halalkalicoccus.jeotgali.B3	halobacteria	300710376	300712276	300710380	300710382	300711109
547559	ahnatrmaga	Natrialba.magadii.ATCC.43099	halobacteria	289579899	289581802	289579903	289579905	289580109
543526	ahhaloturk	Haloterrigena.turkmenica.DSM.5511	halobacteria	284165493	284163582	284165497	284165499	284165820
519442	ahhaloutah	Halorhabdus.utahensis.DSM.12940	halobacteria	257053360	257053608	257053364	257053366	257053583
485914	ahhalomuko	Halomicrobium.mukohataei.DSM.12286	halobacteria	257387877	257386719	257387881	257387883	257388634
362976	ahhalowals	Haloquadratum.walsbyi.DSM.16790	halobacteria	121687180	121687426	110668736	110668734	118573407
797210	ahhaloxana	Halopiger.xanaduensis.SH6	halobacteria	336252439	336253041	336252435	336252433	336252150

txid	short name	full_name	phylum	L5pL11e	L24pL26e	L14pL23e	L6pL9e	L23
234267	bjsoliusit	Solibacter.usitatus.Ellin6076	acidobacteria	116624190	122253093	122253092	122253097	116624200
204669	bjkorivers	Candidatus.Koribacter.versatilis.Ellin345	acidobacteria	94968266	94968265	94968264	94968269	94968256
770	bkanapmarg	Anaplasma.marginale.str.St.Maries	alphaproteobacteria	254995167	81677624	254798523	254995164	254995177
212042	bkanapphag	Anaplasma.phagocytophilum.HZ	alphaproteobacteria	88597774	109893259	123763824	88598404	88598996
283165	bkbartquin	Bartonella.quintana.str.Toulouse	alphaproteobacteria	49474392	49474393	49474394	49474389	49474402
29459	bkbrucmeli	Brucella.melitensis.16M	alphaproteobacteria	50400784	46396980	81852032	225852715	81852035
314261	bkpelaubiq	Candidatus.Pelagibacter.ubique.HTCC1062	alphaproteobacteria	91763172	91763171	91763170	91763175	91763162
269484	bkehrlcani	Ehrlichia.canis.str.Jake	alphaproteobacteria	109893683	109893278	123745840	72394354	72394367
314225	bkerytlito	Erythrobacter.litoralis.HTCC2594	alphaproteobacteria	84787536	123293714	123005020	123099513	84787546
290633	bkglucoxyd	Gluconobacter.oxydans.621H	alphaproteobacteria	58001257	58001258	58001259	58001254	58001267
290400	bkjannccs1	Jannaschia.sp.CCS1	alphaproteobacteria	89053094	89053093	89053092	89053097	89053076
266835	bkmesoloti	Mesorhizobium.loti.MAFF303099	alphaproteobacteria	13470563	13470562	13470561	13470566	13470553
323098	bknitrwino	Nitrobacter.winogradskyi.Nb255	alphaproteobacteria	74420438	109893300	119361698	118573630	74420428
279238	bknovoarom	Novosphingobium.aromaticivorans.DSM.12444	alphaproteobacteria	87199282	87199281	87199280	87199285	87199272
1063	bkrhodspha	Rhodobacter.sphaeroides.2.4.1	alphaproteobacteria	332560152	146278557	146278558	146278553	332560142
1076	bkrhodpalu	Rhodopseudomonas.palustris.CGA009	alphaproteobacteria	39936301	39936302	90424927	39936298	39936311
269796	bkrhodrubr	Rhodospirillum.rubrum.ATCC.11170	alphaproteobacteria	83594008	109893318	119361718	118573644	83594018
257363	bkricktyph	Rickettsia.typhi.str.Wilmington	alphaproteobacteria	51460139	51460140	51460141	51460136	51460149
542	bkzymomobi	Zymomonas.mobilis.subsp.Mobilis.ZM4	alphaproteobacteria	81677229	56551423	338707680	56551427	338707688
62928	bbazoaebn1	Azoarcus.sp.EbN1	betaproteobacteria	166199934	166222027	166199651	166218311	189042279
269483	bbburk383	Burkholderia.sp.383	betaproteobacteria	109893671	109893266	119361662	119366024	123770095
243365	bbchroviol	Chromobacterium.violaceum.ATCC.12472	betaproteobacteria	34499629	34499630	34499631	34499626	34499639
159087	bbdecharom	Dechloromonas.aromatica.RCB	betaproteobacteria	109893679	109893274	119361670	118573601	123733393
485	bbneisgono	Neisseria.gonorrhoeae.FA.1090	betaproteobacteria	75507302	75507301	218546956	240015081	291042779
323848	bbnitrmult	Nitrosospira.multiformis.ATCC.25196	betaproteobacteria	82701912	82701911	82701910	82701915	82701902
264198	bbralseutr	Ralstonia.eutropha.JMP134	betaproteobacteria	72120264	72120265	72120266	72120261	72120274
292415	bbthiodeni	Thiobacillus.denitrificans.ATCC.25259	betaproteobacteria	74316435	109893338	119361740	119366651	74316425
267748	btmycomobi	Mycoplasma.mobile.163K	tenericutes	47459082	47459081	47459080	47459085	47459072
243273	btmycogeni	Mycoplasma.genitalium.G37	tenericutes	12045016	12045015	12045014	12045019	12045006
134821	btureaparv	Ureaplasma.parvum.serovar.3.str.ATCC.700970	tenericutes	50401293	46397051	81789064	13357806	81858616
272633	btmycopene	Mycoplasma.penetrans.HF.2	tenericutes	26554453	26554454	26554455	26554450	26554463
265311	btmesoflor	Mesoplasma.florum.L1	tenericutes	50364950	50364949	50364948	50364953	50364940
322098	btasteyell	Aster.yellows.witches.broom.phytoplasma.AYWB	tenericutes	109893666	109893261	123725336	84789892	123725335
246194	bfcarbhydr	Carboxydothermus.hydrogenoformans.Z2901	firmicutes	109893673	109893268	119361665	118573596	123756729
49338	bfdesuhafn	Desulfitobacterium.hafniense.Y51	firmicutes	89893229	89893228	123397898	219666505	219666492
264732	bfmoorther	Moorella.thermoacetica.ATCC.39073	firmicutes	109893694	109893291	119361694	118573624	123725620
1488	bfclosacet	Clostridium.acetobutylicum.ATCC.824	firmicutes	50400788	46397003	81775426	81775427	81854744
1502	bfclosperf	Clostridium.perfringens.str.13	firmicutes	50400783	46396975	81766492	81766493	81849147
1314	bfstrepyog	Streptococcus.pyogenes.M1.GAS	firmicutes	226731342	50913450	50913449	50913454	50913441
66692	bfbaciclau	Bacillus.clausii.KSMK16	firmicutes	81679085	81679086	81679087	81679084	81679089
272558	bfbacihalo	Bacillus.halodurans.C125	firmicutes	15612709	15612708	15612707	15612712	15612699
235909	bfgeobkaus	Geobacillus.kaustophilus.HTA426	firmicutes	56418653	56418652	56418651	56418656	56418643
1590	bflactplan	Lactobacillus.plantarum.WCFS1	firmicutes	50400761	46396874	81733732	81733731	81841050
314315	bflactsake	Lactobacillus.sakei.subsp.sakei.23K	firmicutes	109893690	109893286	123728620	118573617	123769662
221109	bfoceaihey	Oceanobacillus.iheyensis.HTE831	firmicutes	50400765	46396922	81747269	81747267	81846165
851	bvfusonucl	Fusobacterium.nucleatum.subsp.nucleatum.ATCC.25586	fusobacteria	254303408	339891560	254303410	254303405	296329218
34105	bvstremoni	Streptobacillus.moniliformis	fusobacteria	269124026	269124027	269124028	269124023	269122981
62977	bgacinadp1	Acinetobacter.sp.ADP1	gammaproteobacteria	50086203	81695749	81695748	81695751	50086213
9	bgbuchaphi	Buchnera.aphidicola.str.APS	gammaproteobacteria	15617106	254800988	254798537	161353756	15617116
203907	bgblocflor	Candidatus.Blochmannia.floridanus	gammaproteobacteria	50400750	46396804	81713097	33519673	81836090
291272	bgblocpenn	Candidatus.Blochmannia.pennsylvanicus.str.BPEN	gammaproteobacteria	109893667	109893262	123734160	71891990	123775292
167879	bgcolwpsyc	Colwellia.psychrerythraea.34H	gammaproteobacteria	71146484	109893272	119361668	118573599	71145646
263	bgfrantula	Francisella.tularensis.subsp.holarctica	gammaproteobacteria	187932131	226734447	226705503	254368637	156501622
233412	bghaemducr	Haemophilus.ducreyi.35000HP	gammaproteobacteria	33149167	33149168	33149169	33149164	33149181
349521	bghahechej	Hahella.chejuensis.KCTC.2396	gammaproteobacteria	109893688	109893284	119361680	118573611	123726256
283942	bgidioloih	Idiomarina.loihiensis.L2TR	gammaproteobacteria	56180014	56180015	56180016	56180011	56180032
446	bglegipneu	Legionella.pneumophila.str.Lens	gammaproteobacteria	52840586	166222066	81680552	166220031	307609140

243233	bgmethcaps	Methylococcus.capsulatus.str.Bath	gammaproteobacteria	53803423	53803422	53803421	53803432	53803406
1229	bgnitrocea	Nitrosococcus.oceani.ATCC.19707	gammaproteobacteria	76884089	109893299	123593714	118573629	76884099
74109	bgphotprof	Photobacterium.profundum.SS9	gammaproteobacteria	50401235	90414967	81697534	81697532	81697535
228	bgpseuhalo	Pseudoalteromonas.haloplanktis.TAC125	gammaproteobacteria	332533202	332533203	119361706	332533199	332531859
317	bgpseusyri	Pseudomonas.syringae.pv.phaseolicola.1448A	gammaproteobacteria	63258470	330966900	63258472	66047760	63258480
259536	bgpsycarct	Psychrobacter.arcticus.2734	gammaproteobacteria	71038056	71038055	71038054	71038059	71038046
623	bgshigflex	Shigella.flexneri.2a.str.2457T	gammaproteobacteria	335573247	335573246	83287890	84028084	83287916
317025	bgthiocrun	Thiomicrospira.crunogena.XCL2	gammaproteobacteria	109893740	109893337	119361739	118573665	123741668
36870	bgwiggglos	Wigglesworthia.glossinidia.endosymbiont.of.Glossina.brevipalpis	gammaproteobacteria	50401265	46396908	81741595	32491307	81844439
562	bgeschcoli	Escherichia.coli	gammaproteobacteria	15803835	15803836	168988772	15803832	15803845
265606	bprhodbalt	Rhodopirellula.baltica.SH1	planctomycetacia	50401252	46396792	81712448	81712447	81835353
521674	bpplanlimn	Planctomyces.limnophilus	planctomycetacia	296120759	296120758	296120757	296120762	296120749
290434	bsborrgari	Borrelia.garinii.Pbi	spirochaetes	51598745	51598744	51598743	51598748	51598735
173	bsleptinte	Leptospira.interrogans.serovar.Copenhageni.str.Fiocruz.L1130	spirochaetes	26454653	26454668	26454669	6831632	26454670
158	bstrepdent	Treponema.denticola.ATCC.35405	spirochaetes	50401242	81700214	81700215	81700213	42526281
160	bstreppall	Treponema.pallidum.subsp.pallidum.str.Nichols	spirochaetes	291059608	6094043	6094013	6094092	6094038
243274	bhthermari	Thermotoga.maritima.MSB8	thermotogae	15644236	15644237	15644238	15644233	15644246
391009	bhthermela	Thermosipho.melanesiensis.BI429	thermotogae	150020857	150020856	150020855	150020860	150020847
216816	bcbifilong	Bifidobacterium.longum.NCC2705	actinobacteria	50400769	239621021	81753581	254806194	81847233
257309	bccorydiph	Corynebacterium.diphtheriae.NCTC.13129	actinobacteria	38233100	38233099	38233098	38233134	38233087
196164	bccoryeffi	Corynebacterium.efficiens.YS314	actinobacteria	259506780	259506781	161485993	259506764	259506791
38289	bccoryjeik	Corynebacterium.jeikeium.K411	actinobacteria	260579248	109893273	123761825	260579242	68536921
106370	bcfrancci3	Frankia.sp.CcI3	actinobacteria	109893685	109893281	123751491	118573606	123737802
281090	bcleifxyli	Leifsonia.xyli.subsp.xyli.str.CTCB07	actinobacteria	50955554	50955555	50955556	50955552	50955564
1769	bcmycolepr	Mycobacterium.leprae.TN	actinobacteria	3122750	3122715	3122677	3122751	3122712
247156	bcnocafarc	Nocardia.farcinica.IFM.10152	actinobacteria	54022743	54022742	54022741	54022756	54022702
1747	bcpropacne	Propionibacterium.acnes.KPA171202	actinobacteria	340772950	313818008	313836034	313837964	50843316
100226	bcstrecoel	Streptomyces.coelicolor.A3.2	actinobacteria	21223094	21223093	21223092	21223097	21223084
269800	bctherfusc	Thermobifida.fusca.YX	actinobacteria	72163033	109893336	123747092	118573664	72163043
2039	bctropwhip	Tropheryma.whipplei.TW0827	actinobacteria	28493509	46396854	81722675	28476549	28493519
813	bychlatrac	Chlamydia.trachomatis.AHAR13	chlamydiae	339626200	296435122	255507114	144612	339626210
83555	bychlaabor	Chlamydophila.abortus.S263	chlamydiae	333409897	81313070	81313071	81313067	81313078
340177	brchlochlo	Chlorobium.chlorochromatii.CaD3	chlorobia	78189795	109893269	119361666	119366028	78189805
194439	brchlotepi	Chlorobium.tepidum.TLS	chlorobia	21674986	21674987	21674988	21674983	21674996
243164	bxdehaethe	Dehalococcoides.ethenogenes.195	chloroflexi	109893680	109893275	119361671	118573602	123759719
255470	bxdehacbdb	Dehalococcoides.sp.CBDB1	chloroflexi	109893681	109893276	123732542	118573603	123746192
216389	bxdehabav1	Dehalococcoides.sp.BAV1	chloroflexi	189042902	189042320	189041043	189042943	189042290
479434	bxsphather	Sphaerobacter.thermophilus	chloroflexi	269837078	269837077	269837076	269837081	269837068
251221	bngloeviol	Gloeobacter.violaceus.PCC.7421	cyanobacteria	35214488	35214489	35214490	35214485	35210647
1219	bnprocmari	Prochlorococcus.marinus.subsp.marinus.str.CCMP1375	cyanobacteria	33241149	33241150	33241151	33241147	33241159
32046	bnsyneelon	Synechococcus.elongatus.PCC.6301	cyanobacteria	81301029	81301030	81301031	81301027	81301039
316279	bnsynecc99	Synechococcus.sp.CC9902	cyanobacteria	109893737	109893334	123757083	118573662	123729906
321332	bnsyneja23	Synechococcus.sp.JA23Ba.213	cyanobacteria	86610040	109893332	119361737	118573660	86610030
1148	bnsynepcc	Synechocystis.sp.PCC.6803	cyanobacteria	339273024	16329930	16329931	16329927	16329939
197221	bntherelon	Thermosynechococcus.elongatus.BP1	cyanobacteria	50401267	46396911	81744004	81744003	81845015
243230	bwdeinradi	Deinococcus.radiodurans.R1	deinococcus	15805352	15805351	15805350	161579484	15805342
274	bwtherther	Thermus.thermophilus	deinococcus	333967328	333967329	55981651	46199615	325533871
264462	bdbdelbact	Bdellovibrio.bacteriovorus.HD100	deltaproteobacteria	42524364	42522508	42524365	42524362	42524373
876	bddesudesu	Desulfovibrio desulfuricans	deltaproteobacteria	220903946	376298187	376298186	376298191	220903936
338963	bdpelocarb	Pelobacter.carbinolicus.DSM.2380	deltaproteobacteria	77544410	109893302	119361700	118573632	77544400
351604	bdgeoburan	Geobacter uraniireducens	deltaproteobacteria	148263151	148263150	148263149	148263154	148263142
197	blcampjeju	Campylobacter.jejuni.RM1221	epsilonproteobacteria	166199956	46397050	123336587	283953697	166987000
235279	blhelihepa	Helicobacter.hepaticus.ATCC.51449	epsilonproteobacteria	32266889	32266888	32266887	32266892	32266879
210	blhelipylo	Helicobacter.pylori.26695	epsilonproteobacteria	226731293	261840023	317178048	332674103	54041836
224324	bqaquiaeol	Aquifex.aeolicus.VF5	aquificae	15606754	15606755	15606756	15606751	15605618
436114	bqsulfurih	Sulfurihydrogenibium.sp.YO3AOP1	aquificae	188996227	188996228	188996229	188996224	188996237
146919	bzsalirube	Salinibacter.ruber.DSM.13855	bacteroidetes	294507063	294507062	294507061	294507066	294507053
402612	bzflavpsyc	Flavobacterium.psychrophilum.JIP0286	bacteroidetes	150025395	150025396	150025397	150025392	150025405
228908	annanoequi	Nanoarchaeum.equitans.Kin4M	nanoarcheaota	41614891	46397672	74579994	41615035	74579991
190192	ammethkand	Methanopyrus.kandleri.AV19	methanopyri	50400780	46397695	74572573	74572572	74560919
338192	aunitrmari	Nitrosopumilus.maritimus	thaumarchaeota	161528305	161528307	161528308	161528302	161528315
2287	acsulfsolf	Sulfolobus.solfataricus	crenarcheota	11134362	11134767	11134769	11134358	74542155
273063	acsulftoko	Sulfolobus.tokodaii.str.7	crenarcheota	15920629	46397698	74574758	15920626	15920639
368408	actherpend	Thermofilum.pendens.Hrk.5	crenarcheota	119719160	119719162	119719400	119719521	119719146
397948	accaldmaqu	Caldivirga.maquilingensis.IC167	crenarcheota	159042386	159042388	159041894	159042392	159040901
985053	acvulcmout	Vulcanisaeta.moutnovskia.76828	crenarcheota	323708066	323706821	323707069	323708834	323708482
572478	acvulcdist	Vulcanisaeta.distributa.DSM.14429	crenarcheota	307594425	307595642	307596037	307595417	307595043
410359	acpyrocali	Pyrobaculum.calidifontis.JCM.11548	crenarcheota	126250324	126250074	126250110	126250031	126249912
444157	actherneut	Thermoproteus.neutrophilus.V24Sta	crenarcheota	170934583	170935212	170935258	170935177	170934492
384616	acpyroisla	Pyrobaculum.islandicum.DSM.4184	crenarcheota	119673684	119673481	119673435	119673530	119674691
340102	acpyroarse	Pyrobaculum.arsenaticum.DSM.13514	crenarcheota	145284185	145283698	145283651	145283548	145284012
178306	acpyroaero	Pyrobaculum.aerophilum.str.IM2	crenarcheota	18314167	46397697	74572699	18313300	18313003
415426	achypebuty	Hyperthermus.butylicus.DSM.5456	crenarcheota	124028168	166222061	166232525	124028171	124028159
453591	acignihosp	Ignicoccus.hospitalis.KIN4.I	crenarcheota	156938198	166222062	156938195	156938067	156937757
272557	acaeropern	Aeropyrum.pernix.K1	crenarcheota	116062337	5103997	5103998	5103989	116062270
591019	acstaphell	Staphylothermus.hellenicus.DSM.12710	crenarcheota	297527394	297527396	297527397	297527391	297527408
399550	acstapmari	Staphylothermus.marinus.F1	crenarcheota	126465929	218547136	166232710	126465932	126465915
633148	actheraggr	Thermosphaera.aggregans.DSM.11486	crenarcheota	296242598	296242596	296242595	296242601	296242585
765177	acdesumuco	Desulfurococcus.mucosus.DSM.2162	crenarcheota	319753705	319753707	319753708	319753702	319753718
490899	acdesukamc	Desulfurococcus.kamchatkensis.1221n	crenarcheota	218884473	218884475	218884476	218884470	218884486
399549	acmetasedu	Metallosphaera.sedula.DSM.5348	crenarcheota	146302889	218547096	146302886	146302892	146302878

43080	acsulfisla	Sulfolobus.islandicus.L.S.2.15	crenarcheota	229582029	229582031	229582032	229582026	229582040
330779	acsulfacid	Sulfolobus.acidocaldarius.DSM.639	crenarcheota	730567	73920757	119361734	3914762	121732143
583356	acigniaggr	Ignisphaera.aggregans.DSM.17230	crenarcheota	305662604	305662602	305662601	305662607	305662570
933801	acacidhosp	Acidianus.hospitalis.W1	crenarcheota	332796541	332796539	332796538	332796544	332796530
1006006	acmetacupr	Metallosphaera.cuprina.Ar4	crenarcheota	330835812	330835814	330835815	330835809	330835823
999630	actheruzon	Thermoproteus.uzoniensis.76820	crenarcheota	327310084	327310526	327311801	327311999	327311645
186497	atpyrofuri	Pyrococcus.furiosus.DSM.3638	thermococci	50401276	18893994	74572625	74572626	18894004
70601	atpyrohori	Pyrococcus.horikoshii.OT3	thermococci	6094088	14591523	3258200	3258194	6647746
272844	atpyroabys	Pyrococcus.abyssi.GE5	thermococci	5457760	13124478	5457763	5457757	5457772
69014	attherkoda	Thermococcus.kodakarensis.KOD1	thermococci	73917537	73914096	74506502	218093652	74502382
604354	atthersibi	Thermococcus.sibiricus.MM.739	thermococci	242264686	242264684	242264683	242264689	259646641
391623	attherbaro	Thermococcus.barophilus.MP	thermococci	315229870	315229868	315229867	315229873	315229858
523850	attheronnu	Thermococcus.onnurineus.NA1	thermococci	212223225	212223223	212223222	212223228	212223213
593117	atthergamm	Thermococcus.gammatolerans.EJ3	thermococci	239911600	239911602	239911603	239911597	239911612
246969	attheram4	Thermococcus.sp.AM4	thermococci	214033224	214032947	214032963	214032997	214033092
342949	atpyrona2	Pyrococcus.sp.NA2	thermococci	331033473	331033475	331033476	331033470	331033485
529709	atpyroyaya	Pyrococcus.yayanosii.CH1	thermococci	337283658	337283656	337283655	337283661	337283646
339860	abmethstad	Methanosphaera.stadmanae.DSM.3091	methanobacteria	84489694	109893290	119361693	84489691	84489706
523846	abmethferv	Methanothermus.fervidus.DSM.2088	methanobacteria	311224808	311224806	311224805	311224811	311224796
79929	abmethmarb	Methanothermobacter.marburgensis.str.Marburg	methanobacteria	304314267	304314265	304314264	304314270	304314255
187420	abmethther	Methanothermobacter.thermautotrophicus.str.Delta.H	methanobacteria	3122747	3122709	3122675	3122748	124028532
634498	abmethrumi	Methanobrevibacter.ruminantium.M1	methanobacteria	288542832	288542830	288542829	288542835	288542820
2173	abmethsmit	Methanobrevibacter.smithii.DSM.2374	methanobacteria	261350392	166222073	261350389	261350395	261350380
868132	abmethal21	Methanobacterium.sp.AL21	methanobacteria	325958545	325958543	325958542	325958548	325958533
868131	abmethswan	Methanobacterium.sp.SWAN1	methanobacteria	333825809	333825811	333825812	333825806	333825821
243232	admethjann	Methanocaldococcus.jannaschii.DSM.2661	methanococci	1710572	1710522	1710489	1710576	1710520
573063	admethinfe	Methanocaldococcus.infernus.ME	methanococci	296109307	296109309	296109310	296109304	296109265
579137	admethvulc	Methanocaldococcus.vulcanius.M7	methanococci	261402343	261402345	261402346	261402340	261403781
573064	admethferv	Methanocaldococcus.fervens.AG86	methanococci	256810633	256810635	256810636	256810630	256810687
644281	admethfs40	Methanocaldococcus.sp.FS40622	methanococci	289193205	289193203	289193202	289193208	289191589
647113	admethokin	Methanothermococcus.okinawensis.IH1	methanococci	336121759	336121757	336121756	336121762	336121492
419665	admethaeol	Methanococcus.aeolicus.Nankai3	methanococci	166216346	166222068	166232533	166220034	166987256
456320	admethvolt	Methanococcus.voltae.A3	methanococci	297619575	297619577	297619578	297619572	297619639
406327	admethvann	Methanococcus.vannielii.SB	methanococci	150399474	166222074	150399471	150399477	150399609
39152	admethmari	Methanococcus.maripaludis	methanococci	134045212	166222071	150402578	159905641	150402717
880724	admethigne	Methanotorris.igneus.Kol.5	methanococci	333910780	333910782	333910783	333910777	333911091
273116	apthervolc	Thermoplasma.volcanium.GSS1	thermoplasmata	50401284	46397000	74576031	74576030	74576033
273075	aptheracid	Thermoplasma.acidophilum.DSM.1728	thermoplasmata	16082260	16082661	16082262	16082257	16082268
263820	appicrtorr	Picrophilus.torridus.DSM.9790	thermoplasmata	48477725	74579523	74572088	48477728	48477714
333146	apferracid	Ferroplasma.acidarmanus.fer1	thermoplasmata	257076573	257076571	257076570	257076576	257076561
224325	ararchfulg	Archaeoglobus.fulgidus.DSM.4304	archaeoglobi	3914744	3914715	3914681	3914764	3914714
589924	arferrplac	Ferroglobus.placidus.DSM.10642	archaeoglobi	288931523	288931521	288931520	288931526	288931512
572546	ararchprof	Archaeoglobus.profundus.DSM.5631	archaeoglobi	284162447	284162449	284162450	284162444	284162458
693661	ararchvene	Archaeoglobus.veneficus.SNP6	archaeoglobi	327316367	327316369	327316370	327316364	327316378
192952	aqmethmaze	Methanosarcina.mazei.Go1	methanomicrobia	21228239	46397693	20906692	21228242	21228228
323259	aqmethhung	Methanospirillum.hungatei.JF1	methanomicrobia	88603486	109893289	88603489	88603483	88603497
349307	aqmethther	Methanosaeta.thermophila.PT	methanomicrobia	116666454	121693101	121694869	121693628	116666465
644295	aqmetheves	Methanohalobium.evestigatum.Z7303	methanomicrobia	298674789	298674791	298674792	298674786	298674800
547558	aqmethmahi	Methanohalophilus.mahii.DSM.5219	methanomicrobia	294496004	294496006	294496007	294496001	294496015
259564	aqmethburt	Methanococcoides.burtonii.DSM.6242	methanomicrobia	121691982	121687002	119361689	118573621	121684554
269797	aqmethbark	Methanosarcina.barkeri.str.Fusaro	methanomicrobia	72394811	72394813	72394814	72394808	72394822
188937	aqmethacet	Methanosarcina.acetivorans.C2A	methanomicrobia	50400779	46397694	74572497	74572496	74533260
410358	aqmethlabr	Methanocorpusculum.labreanum.Z	methanomicrobia	124484922	166222069	166232535	124484925	124484912
679926	aqmethpetr	Methanoplanus.petrolearius.DSM.11571	methanomicrobia	307354336	307354334	307354333	307354339	307354325
368407	aqmethmari	Methanoculleus.marisnigri.JR1	methanomicrobia	126178527	166222072	218546914	126178530	126178516
521011	aqmethpalu	Methanosphaerula.palustris.E19c	methanomicrobia	219851120	219851118	219851117	219851123	219851109
456442	aqmethboon	Methanoregula.boonei.6A8	methanomicrobia	153998640	218547094	166232534	153998643	153998629
2242	ahhalonrc1	Halobacterium.sp.NRC1.Halobacterium.salinarum	halobacteria	12644014	46397699	2425186	47117034	2425178
348780	ahnatrphar	Natronomonas.pharaonis.DSM.2160	halobacteria	76803070	109893297	119361696	76803073	76803059
272569	ahhalomari	Haloarcula.marismortui.ATCC.43049	halobacteria	132996	132816	132667	133008	132798
416348	ahhalolacu	Halorubrum.lacusprofundi.ATCC.49239	halobacteria	222480844	222480846	222480847	222480841	222480855
469382	ahhalobori	Halogeometricum.borinquense.DSM.11551	halobacteria	313125803	313125801	313125800	313125806	313125792
309800	ahhalovolc	Haloferax.volcanii.DS2	halobacteria	300669663	292656674	292656675	292656669	292656683
797209	ahhalapauc	Haladaptatus.paucihalophilus.DX253	halobacteria	322372155	322372157	322372158	322372152	322372166
795797	ahhalajeot	Halalkalicoccus.jeotgali.B3	halobacteria	300710388	300710386	300710385	300710391	300710377
547559	ahnatrmaga	Natrialba.magadii.ATCC.43099	halobacteria	289579911	289579909	289579908	289579914	289579900
543526	ahhaloturk	Haloterrigena.turkmenica.DSM.5511	halobacteria	284165505	284165503	284165502	284165508	284165494
519442	ahhaloutah	Halorhabdus.utahensis.DSM.12940	halobacteria	257053372	257053370	257053369	257053375	257053361
485914	ahhalomuko	Halomicrobium.mukohataei.DSM.12286	halobacteria	257387889	257387887	257387886	257387892	257387878
362976	ahhalowals	Haloquadratum.walsbyi.DSM.16790	halobacteria	110668728	121687182	119361681	110668725	110668739
797210	ahhaloxana	Halopiger.xanaduensis.SH6	halobacteria	336252427	336252429	336252430	336252424	336252438

txid	short name	full_name	phylum	L2	L18pL5e
234267	bjsoliusit	Solibacter.usitatus.Ellin6076	acidobacteria	122253085	116624186
204669	bjkorivers	Candidatus.Koribacter.versatilis.Ellin345	acidobacteria	94968257	94968270
770	bkanapmarg	Anaplasma.marginale.str.St.Maries	alphaproteobacteria	254764670	254799699
212042	bkanapphag	Anaplasma.phagocytophilum.HZ	alphaproteobacteria	115305457	88597858
283165	bkbartquin	Bartonella.quintana.str.Toulouse	alphaproteobacteria	49474401	49474388
29459	bkbrucmeli	Brucella.melitensis.16M	alphaproteobacteria	225852727	73621570
314261	bkpelaubiq	Candidatus.Pelagibacter.ubique.HTCC1062	alphaproteobacteria	91763163	91763176

269484	bkehrlcani	Ehrlichia.canis.str.Jake	alphaproteobacteria	108862040	115504894
314225	bkerytlito	Erythrobacter.litoralis.HTCC2594	alphaproteobacteria	123005019	122544180
290633	bkglucoxyd	Gluconobacter.oxydans.621H	alphaproteobacteria	58001266	58001253
290400	bkjannccs1	Jannaschia.sp.CCS1	alphaproteobacteria	89053079	89053098
266835	bkmesoloti	Mesorhizobium.loti.MAFF303099	alphaproteobacteria	13470554	13470567
323098	bknitrwino	Nitrobacter.winogradskyi.Nb255	alphaproteobacteria	115305488	74420442
279238	bknovoarom	Novosphingobium.aromaticivorans.DSM.12444	alphaproteobacteria	87199273	87199286
1063	bkrhodspha	Rhodobacter.sphaeroides.2.4.1	alphaproteobacteria	146278565	332560156
1076	bkrhodpalu	Rhodopseudomonas.palustris.CGA009	alphaproteobacteria	39936310	73621683
269796	bkrhodrubr	Rhodospirillum.rubrum.ATCC.11170	alphaproteobacteria	118597470	83594004
257363	bkricktyph	Rickettsia.typhi.str.Wilmington	alphaproteobacteria	51460148	51460135
542	bkzymomobi	Zymomonas.mobilis.subsp.Mobilis.ZM4	alphaproteobacteria	338707687	56551428
62928	bbazoaebn1	Azoarcus.sp.EbN1	betaproteobacteria	160419204	166218500
269483	bbburk383	Burkholderia.sp.383	betaproteobacteria	115305463	115504876
243365	bbchroviol	Chromobacterium.violaceum.ATCC.12472	betaproteobacteria	34499638	34499625
159087	bbdecharom	Dechloromonas.aromatica.RCB	betaproteobacteria	115305469	115504886
485	bbneisgono	Neisseria.gonorrhoeae.FA.1090	betaproteobacteria	226702969	73621628
323848	bbnitrmult	Nitrosospira.multiformis.ATCC.25196	betaproteobacteria	82701903	82701916
264198	bbralseutr	Ralstonia.eutropha.JMP134	betaproteobacteria	72120273	72120260
292415	bbthiodeni	Thiobacillus.denitrificans.ATCC.25259	betaproteobacteria	118572971	74316439
267748	btmycomobi	Mycoplasma.mobile.163K	tenericutes	47459073	47459086
243273	btmycogeni	Mycoplasma.genitalium.G37	tenericutes	12045007	12045020
134821	btureaparv	Ureaplasma.parvum.serovar.3.str.ATCC.700970	tenericutes	42559309	73621725
272633	btmycopene	Mycoplasma.penetrans.HF.2	tenericutes	26554462	26554449
265311	btmesoflor	Mesoplasma.florum.L1	tenericutes	50364941	50364954
322098	btasteyell	Aster.yellows.witches.broom.phytoplasma.AYWB	tenericutes	115305459	115504869
246194	bfcarbhydr	Carboxydothermus.hydrogenoformans.Z2901	firmicutes	115305465	115504879
49338	bfdesuhafn	Desulfitobacterium.hafniense.Y51	firmicutes	219666493	219666506
264732	bfmoorther	Moorella.thermoacetica.ATCC.39073	firmicutes	115305481	115504914
1488	bfclosacet	Clostridium.acetobutylicum.ATCC.824	firmicutes	42559290	73621582
1502	bfclosperf	Clostridium.perfringens.str.13	firmicutes	48474239	73621583
1314	bfstrepyog	Streptococcus.pyogenes.M1.GAS	firmicutes	50913442	94993460
66692	bfbaciclau	Bacillus.clausii.KSMK16	firmicutes	81822271	73621558
272558	bfbacihalo	Bacillus.halodurans.C125	firmicutes	15612700	15612713
235909	bfgeobkaus	Geobacillus.kaustophilus.HTA426	firmicutes	56418644	56418657
1590	bflactplan	Lactobacillus.plantarum.WCFS1	firmicutes	42559236	73621607
314315	bflactsake	Lactobacillus.sakei.subsp.sakei.23K	firmicutes	115305476	115504905
221109	bfoceaihey	Oceanobacillus.iheyensis.HTE831	firmicutes	42559258	73621633
851	bvfusonucl	Fusobacterium.nucleatum.subsp.nucleatum.ATCC.25586	fusobacteria	339891568	339891555
34105	bvstremoni	Streptobacillus.moniliformis	fusobacteria	269124035	269124022
62977	bgacinadp1	Acinetobacter.sp.ADP1	gammaproteobacteria	81392281	50086199
9	bgbuchaphi	Buchnera.aphidicola.str.APS	gammaproteobacteria	254764682	311087890
203907	bgblocflor	Candidatus.Blochmannia.floridanus	gammaproteobacteria	42559208	73621576
291272	bgblocpenn	Candidatus.Blochmannia.pennsylvanicus.str.BPEN	gammaproteobacteria	115305460	115504871
167879	bgcolwpsyc	Colwellia.psychrerythraea.34H	gammaproteobacteria	115305468	71145835
263	bgfrantula	Francisella.tularensis.subsp.holarctica	gammaproteobacteria	166229154	156501635
233412	bghaemducr	Haemophilus.ducreyi.35000HP	gammaproteobacteria	33149180	33149163
349521	bghahechej	Hahella.chejuensis.KCTC.2396	gammaproteobacteria	115305475	115504899
283942	bgidioloih	Idiomarina.loihiensis.L2TR	gammaproteobacteria	56180031	56180010
446	bglegipneu	Legionella.pneumophila.str.Lens	gammaproteobacteria	160358578	54293337
243233	bgmethcaps	Methylococcus.capsulatus.str.Bath	gammaproteobacteria	53757168	53803433
1229	bgnitrocea	Nitrosococcus.oceani.ATCC.19707	gammaproteobacteria	207090837	76884085
74109	bgphotprof	Photobacterium.profundum.SS9	gammaproteobacteria	81828877	90414972
228	bgpseuhalo	Pseudoalteromonas.haloplanktis.TAC125	gammaproteobacteria	115305494	332533198
317	bgpseusyri	Pseudomonas.syringae.pv.phaseolicola.1448A	gammaproteobacteria	63258479	63258466
259536	bgpsycarct	Psychrobacter.arcticus.2734	gammaproteobacteria	71038047	71038060
623	bgshigflex	Shigella.flexneri.2a.str.2457T	gammaproteobacteria	42560213	68062042
317025	bgthiocrun	Thiomicrospira.crunogena.XCL2	gammaproteobacteria	118572970	115502816
36870	bgwiggglos	Wigglesworthia.glossinidia.endosymbiont.of.Glossina.brevipalpis	gammaproteobacteria	42559247	73621730
562	bgeschcoli	Escherichia.coli	gammaproteobacteria	168988764	168988776
265606	bprhodbalt	Rhodopirellula.baltica.SH1	planctomycetacia	327540581	32475074
521674	bpplanlimn	Planctomyces.limnophilus	planctomycetacia	296120750	296120763
290434	bsborrgari	Borrelia.garinii.Pbi	spirochaetes	51598736	51598749
173	bsleptinte	Leptospira.interrogans.serovar.Copenhageni.str.Fiocruz.L1130	spirochaetes	5163207	6831620
158	bstrepdent	Treponema.denticola.ATCC.35405	spirochaetes	81570373	73621722
160	bstreppall	Treponema.pallidum.subsp.pallidum.str.Nichols	spirochaetes	6094047	6094023
243274	bhthermari	Thermotoga.maritima.MSB8	thermotogae	15644245	15644232
391009	bhthermela	Thermosipho.melanesiensis.BI429	thermotogae	150020848	150020861
216816	bcbifilong	Bifidobacterium.longum.NCC2705	actinobacteria	42559262	296184286
257309	bccorydiph	Corynebacterium.diphtheriae.NCTC.13129	actinobacteria	38233088	38233135
196164	bccoryeffi	Corynebacterium.efficiens.YS314	actinobacteria	25027081	25027107
38289	bccoryjeik	Corynebacterium.jeikeium.K411	actinobacteria	109894941	260579241
106370	bcfrancci3	Frankia.sp.CcI3	actinobacteria	108862041	115504896
281090	bcleifxyli	Leifsonia.xyli.subsp.xyli.str.CTCB07	actinobacteria	50955563	50955551
1769	bcmycolepr	Mycobacterium.leprae.TN	actinobacteria	3122721	3122693
247156	bcnocafarc	Nocardia.farcinica.IFM.10152	actinobacteria	54022703	54022757
1747	bcpropacne	Propionibacterium.acnes.KPA171202	actinobacteria	340772758	314970536
100226	bcstrecoel	Streptomyces.coelicolor.A3.2	actinobacteria	21223085	21223098
269800	bctherfusc	Thermobifida.fusca.YX	actinobacteria	118572969	72163029
2039	bctropwhip	Tropheryma.whipplei.TW0827	actinobacteria	42559225	28493506
813	bychlatrac	Chlamydia.trachomatis.AHAR13	chlamydiae	7674258	255348890

83555	bychlaabor	Chlamydophila.abortus.S263	chlamydiae	81313077	73621578
340177	brchlochlo	Chlorobium.chlorochromatii.CaD3	chlorobia	115305466	78189791
194439	brchlotepi	Chlorobium.tepidum.TLS	chlorobia	21674995	21674982
243164	bxdehaethe	Dehalococcoides.ethenogenes.195	chloroflexi	115305470	115504887
255470	bxdehacbdb	Dehalococcoides.sp.CBDB1	chloroflexi	115305471	115504888
216389	bxdehabav1	Dehalococcoides.sp.BAV1	chloroflexi	189042572	189041550
479434	bxsphather	Sphaerobacter.thermophilus	chloroflexi	269837069	269837082
251221	bngloeviol	Gloeobacter.violaceus.PCC.7421	cyanobacteria	35211466	35214484
1219	bnprocmari	Prochlorococcus.marinus.subsp.marinus.str.CCMP1375	cyanobacteria	33241158	73621670
32046	bnsyneelon	Synechococcus.elongatus.PCC.6301	cyanobacteria	81301038	81301026
316279	bnsynecc99	Synechococcus.sp.CC9902	cyanobacteria	118572967	115502813
321332	bnsyneja23	Synechococcus.sp.JA23Ba.213	cyanobacteria	115305498	86610043
1148	bnsynepcc	Synechocystis.sp.PCC.6803	cyanobacteria	16329938	16329926
197221	bntherelon	Thermosynechococcus.elongatus.BP1	cyanobacteria	42559249	73621716
243230	bwdeinradi	Deinococcus.radiodurans.R1	deinococcus	15805343	15807106
274	bwtherther	Thermus.thermophilus	deinococcus	325533854	325533866
264462	bdbdelbact	Bdellovibrio.bacteriovorus.HD100	deltaproteobacteria	42524372	42524361
876	bddesudesu	Desulfovibrio desulfuricans	deltaproteobacteria	376298179	220903950
338963	bdpelocarb	Pelobacter.carbinolicus.DSM.2380	deltaproteobacteria	115305490	77544414
351604	bdgeoburan	Geobacter uraniireducens	deltaproteobacteria	148263143	148263155
197	blcampjeju	Campylobacter.jejuni.RM1221	epsilonproteobacteria	205355718	205355705
235279	blhelihepa	Helicobacter.hepaticus.ATCC.51449	epsilonproteobacteria	32266880	32266893
210	blhelipylo	Helicobacter.pylori.26695	epsilonproteobacteria	317009999	317011503
224324	bqaquiaeol	Aquifex.aeolicus.VF5	aquificae	15605619	15606750
436114	bqsulfurih	Sulfurihydrogenibium.sp.YO3AOP1	aquificae	188996236	188996223
146919	bzsalirube	Salinibacter.ruber.DSM.13855	bacteroidetes	294507054	83814539
402612	bzflavpsyc	Flavobacterium.psychrophilum.JIP0286	bacteroidetes	150025404	150025391
228908	annanoequi	Nanoarchaeum.equitans.Kin4M	nanoarcheaota	42559182	41614871
190192	ammethkand	Methanopyrus.kandleri.AV19	methanopyri	42559275	161485665
338192	aunitrmari	Nitrosopumilus.maritimus	thaumarchaeota	161527614	161527906
2287	acsulfsolf	Sulfolobus.solfataricus	crenarcheota	11134366	284174929
273063	acsulftoko	Sulfolobus.tokodaii.str.7	crenarcheota	15621421	15920623
368408	actherpend	Thermofilum.pendens.Hrk.5	crenarcheota	160358630	119719155
397948	accaldmaqu	Caldivirga.maquilingensis.IC167	crenarcheota	159041843	159040602
985053	acvulcmout	Vulcanisaeta.moutnovskia.76828	crenarcheota	323708934	323707336
572478	acvulcdist	Vulcanisaeta.distributa.DSM.14429	crenarcheota	307595536	307596406
410359	acpyrocali	Pyrobaculum.calidifontis.JCM.11548	crenarcheota	160358612	126248519
444157	actherneut	Thermoproteus.neutrophilus.V24Sta	crenarcheota	226703012	226723389
384616	acpyroisla	Pyrobaculum.islandicum.DSM.4184	crenarcheota	160358613	119674760
340102	acpyroarse	Pyrobaculum.arsenaticum.DSM.13514	crenarcheota	160358611	145283971
178306	acpyroaero	Pyrobaculum.aerophilum.str.IM2	crenarcheota	42559284	18313098
415426	achypebuty	Hyperthermus.butylicus.DSM.5456	crenarcheota	160358575	166218557
453591	acignihosp	Ignicoccus.hospitalis.KIN4.I	crenarcheota	166229155	166218558
272557	acaeropern	Aeropyrum.pernix.K1	crenarcheota	5103609	5103986
591019	acstaphell	Staphylothermus.hellenicus.DSM.12710	crenarcheota	297527407	297527388
399550	acstapmari	Staphylothermus.marinus.F1	crenarcheota	160358621	126465935
633148	actheraggr	Thermosphaera.aggregans.DSM.11486	crenarcheota	296242586	296242604
765177	acdesumuco	Desulfurococcus.mucosus.DSM.2162	crenarcheota	319753717	319753699
490899	acdesukamc	Desulfurococcus.kamchatkensis.1221n	crenarcheota	254764699	218884467
399549	acmetasedu	Metallosphaera.sedula.DSM.5348	crenarcheota	172046890	172046895
43080	acsulfisla	Sulfolobus.islandicus.L.S.2.15	crenarcheota	259646810	229582023
330779	acsulfacid	Sulfolobus.acidocaldarius.DSM.639	crenarcheota	76363362	3914679
583356	acigniaggr	Ignisphaera.aggregans.DSM.17230	crenarcheota	305662567	305662610
933801	acacidhosp	Acidianus.hospitalis.W1	crenarcheota	332796531	332796547
1006006	acmetacupr	Metallosphaera.cuprina.Ar4	crenarcheota	330835822	330835806
999630	actheruzon	Thermoproteus.uzoniensis.76820	crenarcheota	327311480	327311547
186497	atpyrofuri	Pyrococcus.furiosus.DSM.3638	thermococci	42559276	73621677
70601	atpyrohori	Pyrococcus.horikoshii.OT3	thermococci	6647722	3258189
272844	atpyroabys	Pyrococcus.abyssi.GE5	thermococci	12585331	5457754
69014	attherkoda	Thermococcus.kodakarensis.KOD1	thermococci	218094397	57641457
604354	atthersibi	Thermococcus.sibiricus.MM.739	thermococci	242264675	259646120
391623	attherbaro	Thermococcus.barophilus.MP	thermococci	315229859	315229876
523850	attheronnu	Thermococcus.onnurineus.NA1	thermococci	226703013	212223231
593117	atthergamm	Thermococcus.gammatolerans.EJ3	thermococci	259646812	239911594
246969	attheram4	Thermococcus.sp.AM4	thermococci	214033205	214033203
342949	atpyrona2	Pyrococcus.sp.NA2	thermococci	331033484	331033467
529709	atpyroyaya	Pyrococcus.yayanosii.CH1	thermococci	337283647	337283664
339860	abmethstad	Methanosphaera.stadmanae.DSM.3091	methanobacteria	115305480	115504913
523846	abmethferv	Methanothermus.fervidus.DSM.2088	methanobacteria	311224797	311224814
79929	abmethmarb	Methanothermobacter.marburgensis.str.Marburg	methanobacteria	304314256	304314273
187420	abmethther	Methanothermobacter.thermautotrophicus.str.Delta.H	methanobacteria	3122698	3122687
634498	abmethrumi	Methanobrevibacter.ruminantium.M1	methanobacteria	288542821	288542838
2173	abmethsmit	Methanobrevibacter.smithii.DSM.2374	methanobacteria	160358587	261350398
868132	abmethal21	Methanobacterium.sp.AL21	methanobacteria	325958534	325958551
868131	abmethswan	Methanobacterium.sp.SWAN1	methanobacteria	333825820	333825803
243232	admethjann	Methanocaldococcus.jannaschii.DSM.2661	methanococci	3334483	1710502
573063	admethinfe	Methanocaldococcus.infernus.ME	methanococci	296109266	296109301
579137	admethvulc	Methanocaldococcus.vulcanius.M7	methanococci	261403782	261402337
573064	admethferv	Methanocaldococcus.fervens.AG86	methanococci	256810686	256810627
644281	admethfs40	Methanocaldococcus.sp.FS40622	methanococci	289191588	289193211
647113	admethokin	Methanothermococcus.okinawensis.IH1	methanococci	336121491	336121765

419665	admethaeol	Methanococcus.aeolicus.Nankai3	methanococci	160358581	166218563
456320	admethvolt	Methanococcus.voltae.A3	methanococci	297619640	297619569
406327	admethvann	Methanococcus.vannielii.SB	methanococci	166229158	166218571
39152	admethmari	Methanococcus.maripaludis	methanococci	159905508	226723348
880724	admethigne	Methanotorris.igneus.Kol.5	methanococci	333911092	333910774
273116	apthervolc	Thermoplasma.volcanium.GSS1	thermoplasmata	42559289	73621721
273075	aptheracid	Thermoplasma.acidophilum.DSM.1728	thermoplasmata	16082267	73621718
263820	appicrtorr	Picrophilus.torridus.DSM.9790	thermoplasmata	74567863	48477731
333146	apferracid	Ferroplasma.acidarmanus.fer1	thermoplasmata	257076562	257076579
224325	ararchfulg	Archaeoglobus.fulgidus.DSM.4304	archaeoglobi	3914724	161511071
589924	arferrplac	Ferroglobus.placidus.DSM.10642	archaeoglobi	288931513	288931529
572546	ararchprof	Archaeoglobus.profundus.DSM.5631	archaeoglobi	284162457	284162441
693661	ararchvene	Archaeoglobus.veneficus.SNP6	archaeoglobi	327316377	327316361
192952	aqmethmaze	Methanosarcina.mazei.Go1	methanomicrobia	42559270	161485668
323259	aqmethhung	Methanospirillum.hungatei.JF1	methanomicrobia	115305479	115504911
349307	aqmethther	Methanosaeta.thermophila.PT	methanomicrobia	121694873	121693626
644295	aqmetheves	Methanohalobium.evestigatum.Z7303	methanomicrobia	298674799	298674783
547558	aqmethmahi	Methanohalophilus.mahii.DSM.5219	methanomicrobia	294496014	294495998
259564	aqmethburt	Methanococcoides.burtonii.DSM.6242	methanomicrobia	121687005	121689443
269797	aqmethbark	Methanosarcina.barkeri.str.Fusaro	methanomicrobia	115305478	72394805
188937	aqmethacet	Methanosarcina.acetivorans.C2A	methanomicrobia	42559274	73621617
410358	aqmethlabr	Methanocorpusculum.labreanum.Z	methanomicrobia	160358583	166218565
679926	aqmethpetr	Methanoplanus.petrolearius.DSM.11571	methanomicrobia	307354326	307354342
368407	aqmethmari	Methanoculleus.marisnigri.JR1	methanomicrobia	160358585	166218568
521011	aqmethpalu	Methanosphaerula.palustris.E19c	methanomicrobia	254764712	219851126
456442	aqmethboon	Methanoregula.boonei.6A8	methanomicrobia	160358582	166218564
2242	ahhalonrc1	Halobacterium.sp.NRC1.Halobacterium.salinarum	halobacteria	226702942	12644298
348780	ahnatrphar	Natronomonas.pharaonis.DSM.2160	halobacteria	115305485	115504919
272569	ahhalomari	Haloarcula.marismortui.ATCC.43049	halobacteria	57015334	132729
416348	ahhalolacu	Halorubrum.lacusprofundi.ATCC.49239	halobacteria	254764706	222480838
469382	ahhalobori	Halogeometricum.borinquense.DSM.11551	halobacteria	313125793	313125809
309800	ahhalovolc	Haloferax.volcanii.DS2	halobacteria	292656682	300669662
797209	ahhalapauc	Haladaptatus.paucihalophilus.DX253	halobacteria	322372165	322372149
795797	ahhalajeot	Halalkalicoccus.jeotgali.B3	halobacteria	300710378	300710394
547559	ahnatrmaga	Natrialba.magadii.ATCC.43099	halobacteria	289579901	289579917
543526	ahhaloturk	Haloterrigena.turkmenica.DSM.5511	halobacteria	284165495	284165511
519442	ahhaloutah	Halorhabdus.utahensis.DSM.12940	halobacteria	257053362	257053378
485914	ahhalomuko	Halomicrobium.mukohataei.DSM.12286	halobacteria	257387879	257387895
362976	ahhalowals	Haloquadratum.walsbyi.DSM.16790	halobacteria	121684725	115504900
797210	ahhaloxana	Halopiger.xanaduensis.SH6	halobacteria	336252437	336252421

Universal 23S:

taxID	name	phylum	short name	Accession
234267	Solibacter.usitatus.Ellin6076	acidobacteria	bjsoliusit	ARB
770	Anaplasma.marginale.str.St.Maries	alphaproteobacteria	bkanapmarg	ARB
212042	Anaplasma.phagocytophilum.HZ	alphaproteobacteria	bkanapphag	ARB
283165	Bartonella.quintana.str.Toulouse	alphaproteobacteria	bkbartquin	ARB
29459	Brucella.melitensis.16M	alphaproteobacteria	bkbrucmeli	ARB
314261	Candidatus.Pelagibacter.ubique.HTCC1062	alphaproteobacteria	bkpelaubiq	ARB
269484	Ehrlichia.canis.str.Jake	alphaproteobacteria	bkehrlcani	ARB
314225	Erythrobacter.litoralis.HTCC2594	alphaproteobacteria	bkerytlito	ARB
290633	Gluconobacter.oxydans.621H	alphaproteobacteria	bkglucoxyd	ARB
290400	Jannaschia.sp.CCS1	alphaproteobacteria	bkjannccs1	ARB
266835	Mesorhizobium.loti.MAFF303099	alphaproteobacteria	bkmesoloti	ARB
222891	Neorickettsia.sennetsu.str.Miyayama	alphaproteobacteria	bkneorsenn	ARB
323098	Nitrobacter.winogradskyi.Nb255	alphaproteobacteria	bknitrwino	ARB
279238	Novosphingobium.aromaticivorans.DSM.12444	alphaproteobacteria	bknovoarom	ARB
1063	Rhodobacter.sphaeroides.2.4.1	alphaproteobacteria	bkrhodspha	ARB
1076	Rhodopseudomonas.palustris.CGA009	alphaproteobacteria	bkrhodpalu	ARB
269796	Rhodospirillum.rubrum.ATCC.11170	alphaproteobacteria	bkrhodrubr	ARB
257363	Rickettsia.typhi.str.Wilmington	alphaproteobacteria	bkricktyph	ARB
542	Zymomonas.mobilis.subsp.Mobilis.ZM4	alphaproteobacteria	bkzymomobi	ARB
62928	Azoarcus.sp.EbN1	betaproteobacteria	bbazoaebn1	ref|NC_008702.1|
269483	Burkholderia.sp.383	betaproteobacteria	bbburk383	ref|NC_007509.1|
243365	Chromobacterium.violaceum.ATCC.12472	betaproteobacteria	bbchroviol	ARB
159087	Dechloromonas.aromatica.RCB	betaproteobacteria	bbdecharom	ARB
485	Neisseria.gonorrhoeae.FA.1090	betaproteobacteria	bbneisgono	ARB
323848	Nitrosospira.multiformis.ATCC.25196	betaproteobacteria	bbnitrmult	ARB
264198	Ralstonia.eutropha.JMP134	betaproteobacteria	bbralseutr	ARB
292415	Thiobacillus.denitrificans.ATCC.25259	betaproteobacteria	bbthiodeni	ARB
851	Fusobacterium.nucleatum.subsp.nucleatum.ATCC.25586	fusobacteria	bvfusonucl	ARB
62977	Acinetobacter.sp.ADP1	gammaproteobacteria	bgacinadp1	ref|NC_005966.1|
9	Buchnera.aphidicola.str.APS	gammaproteobacteria	bgbuchaphi	ARB
203907	Candidatus.Blochmannia.floridanus	gammaproteobacteria	bgblocflor	ARB
291272	Candidatus.Blochmannia.pennsylvanicus.str.BPEN	gammaproteobacteria	bgblocpenn	ARB
167879	Colwellia.psychrerythraea.34H	gammaproteobacteria	bgcolwpsyc	ARB
263	Francisella.tularensis.subsp.holarctica	gammaproteobacteria	bgfrantula	ARB
233412	Haemophilus.ducreyi.35000HP	gammaproteobacteria	bghaemducr	ARB
349521	Hahella.chejuensis.KCTC.2396	gammaproteobacteria	bghahechej	ARB

283942	Idiomarina.loihiensis.L2TR	gammaproteobacteria	bgidioloih	ARB
446	Legionella.pneumophila.str.Lens	gammaproteobacteria	bglegipneu	ARB
243233	Methylococcus.capsulatus.str.Bath	gammaproteobacteria	bgmethcaps	ARB
1229	Nitrosococcus.oceani.ATCC.19707	gammaproteobacteria	bgnitrocea	ARB
74109	Photobacterium.profundum.SS9	gammaproteobacteria	bgphotprof	ARB
228	Pseudoalteromonas.haloplanktis.TAC125	gammaproteobacteria	bgpseuhalo	ARB
317	Pseudomonas.syringae.pv.phaseolicola.1448A	gammaproteobacteria	bgpseusyri	ARB
259536	Psychrobacter.arcticus.2734	gammaproteobacteria	bgpsycarct	ARB
623	Shigella.flexneri.2a.str.2457T	gammaproteobacteria	bgshigflex	ARB
317025	Thiomicrospira.crunogena.XCL2	gammaproteobacteria	bgthiocrun	ARB
36870	Wigglesworthia.glossinidia.endosymbiont.of.Glossina.brevipalpis	gammaproteobacteria	bgwigglos	ARB
562	Escherichia.coli	gammaproteobacteria	bgeschcoli	ARB
265606	Rhodopirellula.baltica.SH1	planctomycetacia	bprhodbalt	ARB
290434	Borrelia.garinii.Pbi	spirochaetes	bsborrgari	ARB
173	Leptospira.interrogans.serovar.Copenhageni.str.Fiocruz.L1130	spirochaetes	bsleptinte	ARB
158	Treponema.denticola.ATCC.35405	spirochaetes	bstrepdent	ARB
160	Treponema.pallidum.subsp.pallidum.str.Nichols	spirochaetes	bstreppall	ARB
243274	Thermotoga.maritima.MSB8	thermotogae	bhthermari	ARB
813	Chlamydia.trachomatis.AHAR13	chlamydiae	bychlatrac	ARB
83555	Chlamydophila.abortus.S263	chlamydiae	bychlaabor	ARB
340177	Chlorobium.chlorochromatii.CaD3	chlorobia	brchlochlo	ARB
264462	Bdellovibrio.bacteriovorus.HD100	deltaproteobacteria	bdbdelbact	ARB
338963	Pelobacter.carbinolicus.DSM.2380	deltaproteobacteria	bdpelocarb	ARB
197	Campylobacter.jejuni.RM1221	epsilonproteobacteria	blcampjeju	ARB
235279	Helicobacter.hepaticus.ATCC.51449	epsilonproteobacteria	blhelihepa	ARB
210	Helicobacter.pylori.26695	epsilonproteobacteria	blhelipylo	ARB
224324	Aquifex.aeolicus.VF5	aquificae	bqaquiaeol	ARB
553178	Porphyromonas.gingivalis.W83	bacteroidetes	bzporpging	ARB
146919	Salinibacter.ruber.DSM.13855	bacteroidetes	bzsalirube	ARB
267748	Mycoplasma.mobile.163K	tenericutes	btmycomobi	ARB
243273	Mycoplasma.genitalium.G37	tenericutes	btmycogeni	ARB
134821	Ureaplasma.parvum.serovar.3.str.ATCC.700970	tenericutes	btureaparv	ARB
272633	Mycoplasma.penetrans.HF.2	tenericutes	btmycopene	ARB
265311	Mesoplasma.florum.L1	tenericutes	btmesoflor	ARB
322098	Aster.yellows.witches.broom.phytoplasma.AYWB	tenericutes	btasteyell	ARB
246194	Carboxydothermus.hydrogenoformans.Z2901	firmicutes	bfcarbhydr	ARB
49338	Desulfitobacterium.hafniense.Y51	firmicutes	bfdesuhafn	ARB
264732	Moorella.thermoacetica.ATCC.39073	firmicutes	bfmoorther	ARB
1488	Clostridium.acetobutylicum.ATCC.824	firmicutes	bfclosacet	ARB
1502	Clostridium.perfringens.str.13	firmicutes	bfclosperf	ARB
1314	Streptococcus.pyogenes.M1.GAS	firmicutes	bfstrepyog	ARB
66692	Bacillus.clausii.KSMK16	firmicutes	bfbaciclau	ARB
272558	Bacillus.halodurans.C125	firmicutes	bfbacihalo	ARB
235909	Geobacillus.kaustophilus.HTA426	firmicutes	bfgeobkaus	ARB
1590	Lactobacillus.plantarum.WCFS1	firmicutes	bflactplan	ARB
314315	Lactobacillus.sakei.subsp.sakei.23K	firmicutes	bflactsake	ARB
221109	Oceanobacillus.iheyensis.HTE831	firmicutes	bfoceaihey	ARB
216816	Bifidobacterium.longum.NCC2705	actinobacteria	bcbifilong	ARB
257309	Corynebacterium.diphtheriae.NCTC.13129	actinobacteria	bccorydiph	ARB
196164	Corynebacterium.efficiens.YS314	actinobacteria	bccoryeffi	ARB
38289	Corynebacterium.jeikeium.K411	actinobacteria	bccoryjeik	ARB
106370	Frankia.sp.CcI3	actinobacteria	bcfrancci3	ARB
281090	Leifsonia.xyli.subsp.xyli.str.CTCB07	actinobacteria	bcleifxyli	ARB
1769	Mycobacterium.leprae.TN	actinobacteria	bcmycolepr	ARB
247156	Nocardia.farcinica.IFM.10152	actinobacteria	bcnocafarc	ARB
1747	Propionibacterium.acnes.KPA171202	actinobacteria	bcpropacne	ARB
100226	Streptomyces.coelicolor.A3.2	actinobacteria	bcstrecoel	ARB
269800	Thermobifida.fusca.YX	actinobacteria	bctherfusc	ARB
2039	Tropheryma.whipplei.TW0827	actinobacteria	bctropwhip	ARB
243164	Dehalococcoides.ethenogenes.195	chloroflexi	bxdehaethe	ARB
255470	Dehalococcoides.sp.CBDB1	chloroflexi	bxdehacbdb	gi|73747956:47731-50680
216389	Dehalococcoides.sp.BAV1	chloroflexi	bxdehabav1	ref|NC_009455.1|
479434	Sphaerobacter.thermophilus	chloroflexi	bxsphather	ARB
251221	Gloeobacter.violaceus.PCC.7421	cyanobacteria	bngloeviol	ARB
1219	Prochlorococcus.marinus.subsp.marinus.str.CCMP1375	cyanobacteria	bnprocmari	ARB
32046	Synechococcus.elongatus.PCC.6301	cyanobacteria	bnsyneelon	ARB
316279	Synechococcus.sp.CC9902	cyanobacteria	bnsynecc99	ref|NC_007513.1|
321332	Synechococcus.sp.JA23Ba.213	cyanobacteria	bnsyneja23	gi|86607503:1449625-1452432
1148	Synechocystis.sp.PCC.6803	cyanobacteria	bnsynepcc	ref|NC_017052.1|
197221	Thermosynechococcus.elongatus.BP1	cyanobacteria	bntherelon	ARB
243230	Deinococcus.radiodurans.R1	deinococcus	bwdeinradi	gi|15805042:2245319-2248200
274	Thermus.thermophilus	deinococcus	bwtherther	ARB
204669	Candidatus.Koribacter.versatilis.Ellin345	acidobacteria	bjkorivers	ARB
34105	Streptobacillus.moniliformis	fusobacteria	bvstremoni	ARB
521674	Planctomyces.limnophilus	planctomycetacia	bpplanlimn	ARB
391009	Thermosipho.melanesiensis.BI429	thermotogae	bhthermela	ARB
194439	Chlorobium.tepidum.TLS	chlorobia	brchlotepi	ARB
436114	Sulfurihydrogenibium.sp.YO3AOP1	aquificae	bqsulfurih	ARB
402612	Flavobacterium.psychrophilum.JIP0286	bacteroidetes	bzflavpsyc	ARB
876	Desulfovibrio desulfuricans	deltaproteobacteria	bddesudesu	ARB

351604	Geobacter uraniireducens	deltaproteobacteria	bdgeoburan	ARB
338192	Nitrosopumilus.maritimus	thaumarchaeota	aunitrmari	ARB
228908	Nanoarchaeum.equitans.Kin4M	nanoarcheaota	annanoequi	ARB
190192	Methanopyrus.kandleri.AV19	methanopyri	ammethkand	ARB
2287	Sulfolobus.solfataricus	crenarcheota	acsulfsolf	ARB
273063	Sulfolobus.tokodaii.str.7	crenarcheota	acsulftoko	ARB
368408	Thermofilum.pendens.Hrk.5	crenarcheota	actherpend	ARB
397948	Caldivirga.maquilingensis.IC167	crenarcheota	accaldmaqu	ARB
985053	Vulcanisaeta.moutnovskia.76828	crenarcheota	acvulcmout	ARB
572478	Vulcanisaeta.distributa.DSM.14429	crenarcheota	acvulcdist	ARB
410359	Pyrobaculum.calidifontis.JCM.11548	crenarcheota	acpyrocali	ARB
444157	Thermoproteus.neutrophilus.V24Sta	crenarcheota	actherneut	ARB
384616	Pyrobaculum.islandicum.DSM.4184	crenarcheota	acpyroisla	ARB
340102	Pyrobaculum.arsenaticum.DSM.13514	crenarcheota	acpyroarse	ARB
178306	Pyrobaculum.aerophilum.str.IM2	crenarcheota	acpyroaero	ARB
415426	Hyperthermus.butylicus.DSM.5456	crenarcheota	achypebuty	ARB
453591	Ignicoccus.hospitalis.KIN4.I	crenarcheota	acignihosp	ARB
272557	Aeropyrum.pernix.K1	crenarcheota	acaeropern	ARB
591019	Staphylothermus.hellenicus.DSM.12710	crenarcheota	acstaphell	ARB
399550	Staphylothermus.marinus.F1	crenarcheota	acstapmari	ARB
633148	Thermosphaera.aggregans.DSM.11486	crenarcheota	actheraggr	ARB
765177	Desulfurococcus.mucosus.DSM.2162	crenarcheota	acdesumuco	ARB
490899	Desulfurococcus.kamchatkensis.1221n	crenarcheota	acdesukamc	ARB
399549	Metallosphaera.sedula.DSM.5348	crenarcheota	acmetasedu	ARB
43080	Sulfolobus.islandicus.L.S.2.15	crenarcheota	acsulfisla	ARB
330779	Sulfolobus.acidocaldarius.DSM.639	crenarcheota	acsulfacid	ARB
583356	Ignisphaera.aggregans.DSM.17230	crenarcheota	acigniaggr	ARB
933801	Acidianus.hospitalis.W1	crenarcheota	acacidhosp	ARB
1006006	Metallosphaera.cuprina.Ar4	crenarcheota	acmetacupr	ARB
999630	Thermoproteus.uzoniensis.76820	crenarcheota	actheruzon	ARB
186497	Pyrococcus.furiosus.DSM.3638	thermococci	atpyrofuri	ARB
70601	Pyrococcus.horikoshii.OT3	thermococci	atpyrohori	ARB
272844	Pyrococcus.abyssi.GE5	thermococci	atpyroabys	ARB
69014	Thermococcus.kodakarensis.KOD1	thermococci	attherkoda	ARB
604354	Thermococcus.sibiricus.MM.739	thermococci	atthersibi	ARB
391623	Thermococcus.barophilus.MP	thermococci	attherbaro	ARB
523850	Thermococcus.onnurineus.NA1	thermococci	attheronnu	ARB
593117	Thermococcus.gammatolerans.EJ3	thermococci	atthergamm	ARB
246969	Thermococcus.sp.AM4	thermococci	attheram4	ref|NC_016051.1
342949	Pyrococcus.sp.NA2	thermococci	atpyrona2	gi|332157643:655451-658491
529709	Pyrococcus.yayanosii.CH1	thermococci	atpyroyaya	gi|337283511:1483916-1486945
339860	Methanosphaera.stadmanae.DSM.3091	methanobacteria	abmethstad	ARB
523846	Methanothermus.fervidus.DSM.2088	methanobacteria	abmethferv	ARB
79929	Methanothermobacter.marburgensis.str.Marburg	methanobacteria	abmethmarb	ARB
187420	Methanothermobacter.thermautotrophicus.str.Delta.H	methanobacteria	abmethther	ARB
634498	Methanobrevibacter.ruminantium.M1	methanobacteria	abmethrumi	ARB
2173	Methanobrevibacter.smithii.DSM.2374	methanobacteria	abmethsmit	ARB
868132	Methanobacterium.sp.AL21	methanobacteria	abmethal21	gi|325957759:492367-495329
868131	Methanobacterium.sp.SWAN1	methanobacteria	abmethswan	ARB
243232	Methanocaldococcus.jannaschii.DSM.2661	methanococci	admethjann	ARB
573063	Methanocaldococcus.infernus.ME	methanococci	admethinfe	ARB
579137	Methanocaldococcus.vulcanius.M7	methanococci	admethvulc	ARB
573064	Methanocaldococcus.fervens.AG86	methanococci	admethferv	ARB
644281	Methanocaldococcus.sp.FS40622	methanococci	admethfs40	gi|289191496:101520-104520
647113	Methanothermococcus.okinawensis.IH1	methanococci	admethokin	ARB
419665	Methanococcus.aeolicus.Nankai3	methanococci	admethaeol	ARB
456320	Methanococcus.voltae.A3	methanococci	admethvolt	ARB
406327	Methanococcus.vannielii.SB	methanococci	admethvann	ARB
39152	Methanococcus.maripaludis	methanococci	admethmari	ARB
880724	Methanotorris.igneus.Kol.5	methanococci	admethigne	ARB
273116	Thermoplasma.volcanium.GSS1	thermoplasmata	apthervolc	ARB
273075	Thermoplasma.acidophilum.DSM.1728	thermoplasmata	aptheracid	ARB
263820	Picrophilus.torridus.DSM.9790	thermoplasmata	appicrtorr	ARB
333146	Ferroplasma.acidarmanus.fer1	thermoplasmata	apferracid	ARB
224325	Archaeoglobus.fulgidus.DSM.4304	archaeoglobi	ararchfulg	ARB
589924	Ferroglobus.placidus.DSM.10642	archaeoglobi	arferrplac	ARB
572546	Archaeoglobus.profundus.DSM.5631	archaeoglobi	ararchprof	ARB
693661	Archaeoglobus.veneficus.SNP6	archaeoglobi	ararchvene	ARB
192952	Methanosarcina.mazei.Go1	methanomicrobia	aqmethmaze	ARB
323259	Methanospirillum.hungatei.JF1	methanomicrobia	aqmethhung	ARB
349307	Methanosaeta.thermophila.PT	methanomicrobia	aqmethther	ARB
644295	Methanohalobium.evestigatum.Z7303	methanomicrobia	aqmetheves	ARB
547558	Methanohalophilus.mahii.DSM.5219	methanomicrobia	aqmethmahi	ARB
259564	Methanococcoides.burtonii.DSM.6242	methanomicrobia	aqmethburt	ARB
269797	Methanosarcina.barkeri.str.Fusaro	methanomicrobia	aqmethbark	ARB
188937	Methanosarcina.acetivorans.C2A	methanomicrobia	aqmethacet	ARB
410358	Methanocorpusculum.labreanum.Z	methanomicrobia	aqmethlabr	ARB
679926	Methanoplanus.petrolearius.DSM.11571	methanomicrobia	aqmethpetr	ARB
368407	Methanoculleus.marisnigri.JR1	methanomicrobia	aqmethmari	ARB
521011	Methanosphaerula.palustris.E19c	methanomicrobia	aqmethpalu	ARB

456442	Methanoregula.boonei.6A8	methanomicrobia	aqmethboon	ARB
2242	Halobacterium.sp.NRC1.Halobacterium.salinarum	halobacteria	ahhalonrc1	ARB
348780	Natronomonas.pharaonis.DSM.2160	halobacteria	ahnatrphar	ARB
272569	Haloarcula.marismortui.ATCC.43049	halobacteria	ahhalomari	ARB
416348	Halorubrum.lacusprofundi.ATCC.49239	halobacteria	ahhalolacu	ARB
469382	Halogeometricum.borinquense.DSM.11551	halobacteria	ahhalobori	ARB
309800	Haloferax.volcanii.DS2	halobacteria	ahhalovolc	ARB
797209	Haladaptatus.paucihalophilus.DX253	halobacteria	ahhalapauc	ARB
795797	Halalkalicoccus.jeotgali.B3	halobacteria	ahhalajeot	ARB
547559	Natrialba.magadii.ATCC.43099	halobacteria	ahnatrmaga	ARB
543526	Haloterrigena.turkmenica.DSM.5511	halobacteria	ahhaloturk	ARB
519442	Halorhabdus.utahensis.DSM.12940	halobacteria	ahhaloutah	ARB
485914	Halomicrobium.mukohataei.DSM.12286	halobacteria	ahhalomuko	ARB
362976	Haloquadratum.walsbyi.DSM.16790	halobacteria	ahhalowals	ARB
797210	Halopiger.xanaduensis.SH6	halobacteria	ahhaloxana	gi|336252096:422886-425792

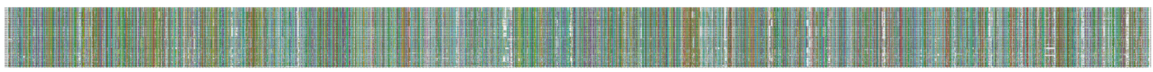
APPENDIX C

TAXA SUBSETS AND MULTIPLE SEQUENCE ALIGNMENTS

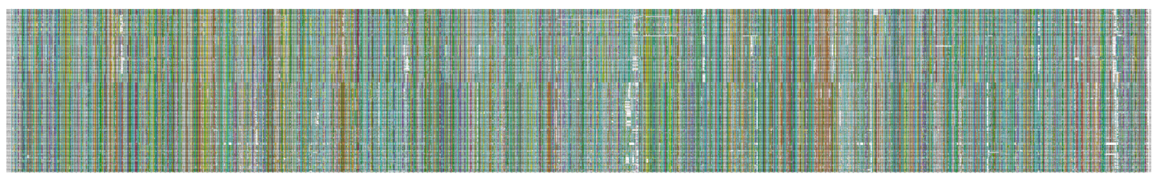
Taxa subset membership data are available here:
https://github.com/jgstern/STORI/raw/master/STORI-setup.xls

Multiple sequence alignments are available here:
https://github.com/jgstern/STORI/raw/master/alignments_trees.zip

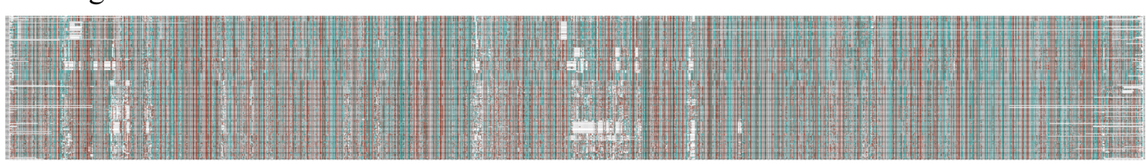
Bacterial + Universal concatenated protein alignment:



Universal concatenated protein alignment:



23S alignment:



APPENDIX D

PAML & PHASE OPTIMIZED TOPOLOGIES

(Archaeal topologies follow Gribaldo & Brochier, 2009):
(also at: https://github.com/jgstern/STORI/raw/master/alignments_trees.zip)

Models fit to the Universal alignment data (Table 3, second column):
T-I (This study; MrBayes analysis of Universal Protein Alignment):

((((((ammethkand: 0.349075, ((((admethinfe: 0.098190, (admethvulc: 0.041955, ((admethjann: 0.006833, admethfs40: 0.005780): 0.007927, admethferv: 0.020406): 0.011563): 0.035412): 0.070395, (admethigne: 0.051085, ((admethvolt: 0.126022, (admethvann: 0.063124, admethmari: 0.058707): 0.045097): 0.087627, (admethokin: 0.049339, admethaeol: 0.113349): 0.059000): 0.097637): 0.065350): 0.214994, (((apthervolc: 0.115106, aptheracid: 0.087639): 0.166493, (appicrtorr: 0.135311, apferracid: 0.210388): 0.139446): 0.492610, ((arferrplac: 0.112604, (ararchprof: 0.116511, (ararchvene: 0.147406, ararchfulg: 0.131376): 0.035970): 0.034061): 0.252140, (((aqmethlabr: 0.293564, ((aqmethpetr: 0.211598, aqmethmari: 0.186191): 0.038152, (aqmethhung: 0.239472, (aqmethpalu: 0.173649, aqmethboon: 0.185131): 0.045423): 0.041118): 0.045752): 0.211485, (aqmethther: 0.358256, ((aqmetheves: 0.226739, (aqmethmahi: 0.187461, aqmethburt: 0.139297): 0.044606): 0.052375, (aqmethbark: 0.051288, (aqmethmaze: 0.029602, 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(bnsynecc99: 0.087401, bnprocmari: 0.114016): 0.207133): 0.054470): 0.034115): 0.078230): 0.058634, bngloeviol: 0.250835): 0.264701): 0.060780, (((bfclosperf: 0.132232, bfclosacet: 0.135220): 0.197159, ((bfmoorther: 0.205308, bfdesuhafn: 0.222434): 0.040106, bfcarbhydr: 0.201985): 0.046449): 0.029674, ((((btmycomobi: 0.461092, (btureaparv: 0.284245, (btmycopene: 0.287984, btmycogeni: 0.422037): 0.067898): 0.234083): 0.079890, btmesoflor: 0.335899): 0.099552, btasteyell: 0.408008): 0.123028, (bfgeobkaus: 0.091164, ((bfstrepyog: 0.178421, (bflactsake: 0.121955, bflactplan: 0.156778): 0.062277): 0.118940, (bfoceaihey: 0.149369, (bfbacihalo: 0.058387, bfbaciclau: 0.088036): 0.054571): 0.042252): 0.038764): 0.071994): 0.081127): 0.061944): 0.033170, (((((bzsalirube: 0.464277, bzflavpsyc: 0.587609): 0.093268, (brchlotepi: 0.109933, brchlochlo: 0.136575): 0.324019): 0.112054, ((bsleptinte: 0.512342, ((bstreppall: 0.260208, bstrepdent: 0.144226): 0.205348, bsborrgari: 0.410141): 0.194938): 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0.112750): 0.107224, (acignihosp: 0.323303, (achypebuty: 0.203177, acaeropern: 0.309014): 0.051733): 0.064648): 0.048912, (acigniaggr: 0.445426, (((acsulfsolf: 0.023979, acsulfisla: 0.036163): 0.153094, (acsulftoko: 0.132520, acsulfacid: 0.168154): 0.059624): 0.031668, ((acmetasedu: 0.074700, acmetacupr: 0.107674): 0.166631, acacidhosp: 0.157184): 0.042759): 0.257794): 0.053015): 0.115143): 0.110049): 0.089787, (annanoequi: 0.732820, ((attheronnu: 0.036463, (attherkoda: 0.023652, (atthergamm: 0.009936, attheram4: 0.009855): 0.021385): 0.018711): 0.047481, ((atthersibi: 0.129680, attherbaro: 0.031896): 0.020579, (atpyroyaya: 0.027110, (atpyrofuri: 0.026195, (atpyrona2: 0.015239, (atpyrohori: 0.021109, atpyroabys: 0.017254): 0.008027): 0.010168): 0.013976): 0.054491): 0.022108): 0.236217): 0.045190): 0.054079): 0.044667): 0.151161, abmethferv: 0.179308): 0.098688, (abmethther: 0.022678, abmethmarb: 0.015132): 0.091543): 0.057588, (abmethsmit: 0.130464, abmethrumi: 0.115929): 0.111179): 0.059356, abmethstad: 0.233754): 0.063016, abmethswan: 0.096302, abmethal21: 0.109078);

T-II (This study; RAxML analysis of Universal Protein Alignment):

((((((ammethkand: 0.348339, ((((admethinfe: 0.098084, (admethvulc: 0.041833, ((admethjann: 0.006818, admethfs40: 0.005764): 0.007908, admethferv: 0.020355): 0.011560): 0.035176): 0.070161, (admethigne: 0.051024, ((admethvolt: 0.125703, (admethvann: 0.062965, admethmari: 0.058554): 0.045012): 0.087415, (admethokin: 0.049226, admethaeol: 0.113077): 0.058805): 0.097364): 0.065271): 0.214163, (((apthervolc: 0.114792, aptheracid: 0.087448): 0.166114, (appicrtorr: 0.134929, apferracid: 0.209870): 0.139076): 0.491054, ((arferrplac: 0.112190, (ararchprof: 0.116210, (ararchvene: 0.147042, ararchfulg: 0.131070): 0.035887): 0.034123): 0.251782, (((aqmethlabr: 0.292814, ((aqmethpetr: 0.211040, aqmethmari: 0.185762): 0.038070, (aqmethhung: 0.238875, (aqmethpalu: 0.173216, aqmethboon: 0.184664): 0.045327): 0.040990): 0.045632): 0.211033, (aqmethther: 0.357455, ((aqmetheves: 0.226160, (aqmethmahi: 0.186977, aqmethburt: 0.138966): 0.044505): 0.052257, (aqmethbark: 0.051163, (aqmethmaze: 0.029527, aqmethacet: 0.025559): 0.023970): 0.150670): 0.149871): 0.054609): 0.035005, ((ahnatrmaga: 0.034250, (ahhaloxana: 0.034322, ahhaloturk: 0.037927): 0.015548): 0.072833, ((ahnatrphar: 0.126764, (ahhaloutah: 0.122614, (ahhalomuko: 0.082952, ahhalomari: 0.090814): 0.034465): 0.042248): 0.033830, ((ahhalonrc1: 0.175834, (ahhalolacu: 0.134254, (ahhalovolc: 0.090180, (ahhalowals: 0.146965, ahhalobori: 0.057990): 0.025871): 0.038333): 0.040583): 0.024323, (ahhalapauc: 0.114086, ahhalajeot: 0.147382): 0.024830): 0.026703): 0.030238): 0.428949): 0.101710): 0.045799): 0.058353): 0.035123, ((((((bhthermela: 0.174358, bhthermari: 0.120982): 0.193498, ((bwdeinradi: 0.310956, bwtherther: 0.232014): 0.232617, ((bvfusonucl: 0.180971, bvstremoni: 0.263137): 0.264558, (((((bfgeobkaus: 0.090970, ((bfoceaihey: 0.149105, (bfbacihalo: 0.058202, bfbaciclau: 0.087873): 0.054393): 0.042246, (bfstrepyog: 0.178105, (bflactplan: 0.156343, bflactsake: 0.121687): 0.062062): 0.118340): 0.038836): 0.072100, (btasteyell: 0.405670, (btmesoflor: 0.333005, (btmycomobi: 0.458209, (btmycogeni: 0.419851, (btmycopene: 0.306524, btureaparv: 0.298885): 0.047568): 0.230747): 0.079688): 0.100063): 0.124101): 0.081035, ((bfcarbhydr: 0.201350, (bfdesuhafn: 0.221858, bfmoorther: 0.204887): 0.040074): 0.046139, (bfclosperf: 0.132022, bfclosacet: 0.134770): 0.197105): 0.029509): 0.061810, ((bngloeviol: 0.249765, (bnsyneja23: 0.211583, ((bnsynepcc: 0.194562, ((bnprocmari: 0.113757, bnsynecc99: 0.087146): 0.206704, bnsyneelon: 0.109364): 0.054436): 0.034128, bntherelon: 0.161723): 0.077717): 0.058759): 0.263545, ((bxdehaethe: 0.015106, (bxdehabav1: 0.001600, bxdehacbdb: 0.000004): 0.020899): 0.450453, bxsphather: 0.314128): 0.098698): 0.060957): 0.031627, (((bcbifilong: 0.283708, ((bctropwhip: 0.386038, bcleifxyli: 0.129686): 0.113148, ((bctherfusc: 0.220101, (bcstrecoel: 0.148382, (bcfrancci3: 0.181020, ((bcnocafarc: 0.094679, bcmycolepr: 0.161065): 0.025526, (bccoryjeik: 0.071000, (bccoryeffi: 0.069719, bccorydiph: 0.057857): 0.047544): 0.137917): 0.083032): 0.048654): 0.023694): 0.045415, bcpropacne: 0.256175): 0.025216): 0.051913): 0.252847, ((((bpplanlimn: 0.433602, bprhodbalt: 0.327920): 0.266963, (bychlaabor: 0.088175, bychlatrac: 0.086009): 0.603438): 0.075537, (((bstreppall: 0.259488, bstrepdent: 0.143939): 0.204831, bsborrgari: 0.408954): 0.194588, bsleptinte: 0.510951): 0.090536): 0.041853, ((bzflavpsyc: 0.586339, bzsalirube: 0.463148): 0.092858, (brchlochlo: 0.136335, brchlotepi: 0.109583): 0.322884): 0.111729): 0.028470): 0.027830, ((bjsoliusit: 0.257571, bjkorivers: 0.298742): 0.281944, (((bdgeoburan: 0.235928, bdpelocarb: 0.208449): 0.135031, (bdbdelbact: 0.490792, bddesudesu: 0.379928): 0.084449): 0.058092, ((blcampjeju: 0.179631, (blhelihepa: 0.125413, blhelipylo: 0.170339): 0.142869): 0.464872, (((bkpelaubiq: 0.605845, (((bkanapmarg: 0.159982, bkanapphag: 0.134559): 0.172701, bkehrlcani: 0.219364): 0.452175, bkricktyph: 0.405610): 0.068994): 0.072250, ((bkglucoxyd: 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0.235258): 0.043302, bglegipneu: 0.325456): 0.019749): 0.055703, ((bbchroviol: 0.092858, bbneisgono: 0.165248): 0.053146, ((bbnitrmult: 0.181441, bbthiodeni: 0.151447): 0.047890, ((bbburk383: 0.071183, bbralseutr: 0.095245): 0.106439, (bbdecharom: 0.106982, bbazoaebn1: 0.103027): 0.048406): 0.028932): 0.047627): 0.131432): 0.201755): 0.062024): 0.048513): 0.028458): 0.044430): 0.031903): 0.028863): 0.050690): 0.045418): 0.049091, (bqaquiaeol: 0.272776, bqsulfurih: 0.315435): 0.150525): 1.206693, aunitrmari: 0.860835): 0.026875, ((actherpend: 0.362311, ((actheruzon: 0.176598, (acpyrocali: 0.066771, ((actherneut: 0.083788, acpyroisla: 0.067067): 0.030225, (acpyroarse: 0.082844, acpyroaero: 0.054574): 0.020701): 0.037794): 0.115926): 0.147160, ((acvulcmout: 0.060024, acvulcdist: 0.033173): 0.203249, accaldmaqu: 0.329728): 0.085352): 0.170634): 0.107094, ((((acstapmari: 0.017465, acstaphell: 0.022411): 0.162967, (actheraggr: 0.152257, (acdesumuco: 0.068483, acdesukamc: 0.082611): 0.091617): 0.112084): 0.106722, (acignihosp: 0.322072, (achypebuty: 0.202589, acaeropern: 0.308182): 0.052065): 0.064871): 0.048959, (acigniaggr: 0.443902, (((acsulfsolf: 0.023921, acsulfisla: 0.036075): 0.152743, (acsulftoko: 0.132314, acsulfacid: 0.167608): 0.059473): 0.031052, ((acmetasedu: 0.074679, acmetacupr: 0.107228): 0.166241, acacidhosp: 0.156862): 0.042990): 0.257275): 0.052653): 0.113682): 0.107833): 0.091766, (annanoequi: 0.730353, ((attheronnu: 0.036374, (attherkoda: 0.023591, (atthergamm: 0.009914, attheram4: 0.009829): 0.021333): 0.018662): 0.047472, ((atthersibi: 0.129339, attherbaro: 0.031852): 0.020519, (atpyroyaya: 0.027038, (atpyrofuri: 0.026124, (atpyrona2: 0.015199, (atpyrohori: 0.021056, atpyroabys: 0.017212): 0.008007): 0.010152): 0.013936): 0.054348): 0.021962): 0.236314): 0.044467): 0.053722): 0.045093): 0.150439, abmethferv: 0.178597): 0.098793, (abmethther: 0.022615, abmethmarb: 0.015103): 0.091209): 0.057467, (abmethsmit: 0.130125, abmethrumi: 0.115667): 0.110930): 0.059250, abmethstad: 0.233224): 0.062799, abmethswan: 0.096076, abmethal21: 0.108813);

T-III (This study; MrBayes analysis 23S Universal Alignment):

((((((ammethkand: 0.343289, ((((admethinfe: 0.096650, (admethvulc: 0.041208, ((admethjann: 0.006711, admethfs40: 0.005681): 0.007790, admethferv: 0.020050): 0.011369): 0.034578): 0.069134, (admethigne: 0.050273, ((admethvolt: 0.123787, (admethvann: 0.061995, admethmari: 0.057665): 0.044362): 0.086085, (admethokin: 0.048475, admethaeol: 0.111337): 0.057923): 0.095894): 0.064189): 0.210780, (((apthervolc: 0.113067, aptheracid: 0.086089): 0.163655, (appicrtorr: 0.132881, apferracid: 0.206568): 0.136828): 0.483493, ((arferrplac: 0.110344, (ararchprof: 0.114463, (ararchvene: 0.144692, ararchfulg: 0.128983): 0.035364): 0.033607): 0.248130, (((aqmethlabr: 0.287958, ((aqmethpetr: 0.207693, aqmethmari: 0.182779): 0.037534, (aqmethhung: 0.235188, (aqmethpalu: 0.170649, aqmethboon: 0.181741): 0.044641): 0.040292): 0.045041): 0.207715, (aqmethther: 0.351712, ((aqmetheves: 0.222655, (aqmethmahi: 0.184033, aqmethburt: 0.136742): 0.043785): 0.051373, (aqmethbark: 0.050383, (aqmethmaze: 0.029062, aqmethacet: 0.025166): 0.023585): 0.148445): 0.147644): 0.053681): 0.034481, ((ahnatrmaga: 0.033718, (ahhaloxana: 0.033792, ahhaloturk: 0.037352): 0.015326): 0.071570, ((ahnatrphar: 0.124766, (ahhaloutah: 0.120673, (ahhalomuko: 0.081672, ahhalomari: 0.089407): 0.033958): 0.041594): 0.033295, ((ahhalonrc1: 0.173083, (ahhalolacu: 0.132171, (ahhalovolc: 0.088797, (ahhalowals: 0.144709, ahhalobori: 0.057111): 0.025429): 0.037753): 0.039988): 0.023896, (ahhalapauc: 0.112326, ahhalajeot: 0.145037): 0.024441): 0.026331): 0.029859): 0.422373): 0.100071): 0.045025): 0.057406): 0.034011, (((((bhthermela: 0.173727, bhthermari: 0.116833): 0.153308, ((bqsulfurih: 0.311429, bqaquiaeol: 0.267952): 0.194364, ((bwtherther: 0.223611, bwdeinradi: 0.309235): 0.223776, (((bnsyneja23: 0.209939, ((bntherelon: 0.160805, bnsynepcc: 0.195025): 0.025476, (bnsyneelon: 0.110306, (bnsynecc99: 0.086511, bnprocmari: 0.111297): 0.203170): 0.054710): 0.079684): 0.054773, bngloeviol: 0.248320): 0.290676, (((bxsphather: 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T-IV (Battistuzzi & Hedges, 2009):

((((((ammethkand: 0.347882, ((((admethinfe: 0.097921, (admethvulc: 0.041786, ((admethjann: 0.006808, admethfs40: 0.005759):
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T-V (Wu & Eisen, 2008):

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T-VI (Ciccarelli et al., 2006):

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Models fit to the Bacterial + Universal alignment data (Table 3, third column):
T-I (This study; MrBayes analysis of Bacterial+Universal Protein Alignment):
(((bwtherther: 0.254276, bwdeinradi: 0.376165): 0.259786, ((bqsulfurih: 0.316997, bqaquiaeol: 0.283823): 0.222610, (bhthermela: 0.198755, bhthermari: 0.144684): 0.247567): 0.049887): 0.048281, ((((bxsphather: 0.344821, (bxdehaethe: 0.017998, (bxdehacbdb: 0.000848, bxdehabav1: 0.001598): 0.022908): 0.516713): 0.099972, ((bnsyneja23: 0.229811, (bntherelon: 0.171147, (bnsynepcc: 0.220683, (bnsyneelon: 0.127617, (bnsynecc99: 0.093814, bnprocmari: 0.137148): 0.229720): 0.049408): 0.032521): 0.083227): 0.066831, bngloeviol: 0.281660): 0.321849): 0.062799, (((bfclosperf: 0.136840, bfclosacet: 0.148628): 0.223647, ((bfmoorther: 0.233051, bfdesuhafn: 0.234606): 0.045022, bfcarbhydr: 0.225262): 0.050427): 0.034829, ((((btmycomobi: 0.519238, (btureaparv: 0.311629, (btmycopene: 0.383217, btmycogeni: 0.497573): 0.060117): 0.262457): 0.087640, btmesoflor: 0.372830): 0.122151, btasteyell: 0.500884): 0.131079, (bfgeobkaus: 0.113420, ((bfstrepyog: 0.187810, (bflactsake: 0.125796, bflactplan: 0.171323): 0.070134): 0.134044, (bfoceaihey: 0.169740, (bfbacihalo: 0.061383, bfbaciclau: 0.088303): 0.062542): 0.040498): 0.038059): 0.078072): 0.090327): 0.062396): 0.036786, (((((bzsalirube: 0.482968, bzflavpsyc: 0.657978): 0.119186, (brchlotepi: 0.117888, brchlochlo: 0.147302): 0.356408): 0.123593, ((bsleptinte: 0.592094, ((bstreppall: 0.288347, bstrepdent: 0.163769): 0.233261, bsborrgari: 0.475867): 0.192629): 0.101739, ((bychlatrac: 0.096824, bychlaabor: 0.089865): 0.695370, (bprhodbalt: 0.380424, bpplanlimn: 0.498708): 0.316890): 0.076887): 0.037874): 0.030955, (((bctropwhip: 0.435999, bcleifxyli: 0.146639): 0.120164, (bcpropacne: 0.282755, ((bctherfusc: 0.227768, bcstrecoel: 0.166324): 0.031804, (bcfrancci3: 0.194151, ((bcnocafarc: 0.099468, bcmycolepr: 0.180291): 0.036634, (bccoryjeik: 0.084317, (bccoryeffi: 0.076395, bccorydiph: 0.062336): 0.044373): 0.163832): 0.094783): 0.046448): 0.041737): 0.040358): 0.063672, bcbifilong: 0.319170): 0.299138): 0.030706, ((bjsoliusit: 0.278499, bjkorivers: 0.322994): 0.326657, (((bdpelocarb: 0.227110, bdgeoburan: 0.254899): 0.154007, (bddesudesu: 0.437212, bdbdelbact: 0.586360): 0.074783): 0.057548, (((blhelipylo: 0.175186, blhelihepa: 0.135432): 0.152589, blcampjeju: 0.200794): 0.475690, ((((bkrhodrubr: 0.240629, bkglucoxyd: 0.280870): 0.052761, ((bkzymomobi: 0.154612, (bknovoarom: 0.097662, bkerytlito: 0.127585): 0.073642): 0.181464, ((bkrhodspha: 0.106968, bkjannccs1: 0.147039): 0.199815, ((bkrhodpalu: 0.059065, bknitrwino: 0.070463): 0.178806, (bkmesoloti: 0.119354, (bkbrucmeli: 0.065727, bkbartquin: 0.160488): 0.038063): 0.095997): 0.072383): 0.040650): 0.032735): 0.096812, (bkpelaubiq: 0.617618, (bkricktyph: 0.458286, (bkehrlcani: 0.228812, (bkanapphag: 0.139142, bkanapmarg: 0.166868): 0.183103): 0.474295): 0.078231): 0.073814): 0.174347, ((((bgnitrocea: 0.285710, bgmethcaps: 0.246237): 0.043498, bglegipneu: 0.345338): 0.027255, ((bgthiocrun: 0.280148, bgfrantula: 0.342423): 0.045768, ((bgidioloih: 0.144261, ((bgpseuhalo: 0.118268, bgcolwpsyc: 0.168299): 0.031981, (bgphotprof: 0.115356, (bghaemducr: 0.120714, ((bgshigflex: 0.001211, bgeschcoli: 0.005273): 0.042489, (bgbuchaphi: 0.237353, (bgwiggglos: 0.433484, (bgblocpenn: 0.160059, bgblocflor: 0.295964): 0.168929): 0.098523): 0.153777): 0.032578): 0.063739): 0.038795): 0.030026): 0.090426, ((bgpseusyri: 0.204020, bghahechej: 0.177217): 0.045523, (bgpsycarct: 0.193099, bgacinadp1: 0.148264): 0.171981): 0.030978): 0.028580): 0.033378): 0.061344, ((bbneisgono: 0.166757, bbchroviol: 0.094470): 0.066041, ((bbthiodeni: 0.167953, bbnitrmult: 0.186259): 0.046468, ((bbralseutr: 0.102538, bbburk383: 0.086073): 0.122996, (bbdecharom: 0.122711, bbazoaebn1: 0.111365): 0.044897): 0.028194): 0.046971): 0.137019): 0.202960): 0.072603): 0.055057): 0.029986): 0.034951): 0.036944): 0.030866, (bvstremoni: 0.306998, bvfusonucl: 0.201070): 0.304779);

T-II (This study; RAxML analysis of Bacterial+Universal Protein Alignment):
((bhthermela: 0.199093, bhthermari: 0.145090): 0.248024, ((bwdeinradi: 0.376817, bwtherther: 0.254974): 0.260391, ((bvfusonucl: 0.201388, bvstremoni: 0.307640): 0.305791, (((((bfgeobkaus: 0.113547, ((bfoceaihey: 0.170174, (bfbacihalo: 0.061492, bfbaciclau: 0.088517): 0.062653): 0.040698, (bfstrepyog: 0.188219, (bflactplan: 0.171662, bflactsake: 0.126100): 0.070283): 0.134149): 0.038241): 0.078736, (btasteyell: 0.501269, (btmesoflor: 0.371828, (btmycomobi: 0.518133, (btmycogeni: 0.493854, (btmycopene: 0.401192, btureaparv: 0.315589): 0.059810): 0.247316): 0.088170): 0.123035): 0.132291): 0.090259, ((bfcarbhydr: 0.225608, (bfdesuhafn: 0.235302, bfmoorther: 0.233329): 0.045119): 0.050414, (bfclosperf: 0.137143, bfclosacet: 0.148899): 0.224171): 0.034767): 0.062473, ((bngloeviol: 0.282188, (bnsyneja23: 0.230316, ((bnsynepcc: 0.221185, ((bnprocmari: 0.137399, bnsynecc99: 0.094041): 0.230218, bnsyneelon: 0.127862): 0.049451): 0.032580, bntherelon: 0.171560): 0.083325): 0.067033): 0.322410, ((bxdehaethe: 0.018037, (bxdehabav1: 0.001602, bxdehacbdb: 0.000850): 0.022954): 0.517937, bxsphather: 0.345452): 0.100093): 0.063219): 0.036611, (((bcbifilong: 0.320583, ((bctropwhip: 0.436676, bcleifxyli: 0.147142): 0.121729, ((bctherfusc: 0.227591, (bcstrecoel: 0.172864, (bcfrancci3: 0.193899, ((bcnocafarc: 0.099660, bcmycolepr: 0.181113): 0.035271, (bccoryjeik: 0.084313, (bccoryeffi: 0.076777, bccorydiph: 0.062220): 0.044520): 0.165395): 0.096275): 0.046502): 0.029573): 0.039541, bcpropacne: 0.283582): 0.039070): 0.062213): 0.298860, ((((bpplanlimn: 0.499775, bprhodbalt: 0.381234): 0.317935, (bychlaabor: 0.089734, bychlatrac: 0.097311): 0.696430): 0.077007, (((bstreppall: 0.288838, bstrepdent: 0.164229): 0.233877, bsborrgari: 0.476680): 0.192849, bsleptinte: 0.593309): 0.101959): 0.037984, ((bzflavpsyc: 0.659150, bzsalirube: 0.484412): 0.119288, (brchlochlo: 0.147437, brchlotepi: 0.118309): 0.357084): 0.123504): 0.030402): 0.031425, ((bjsoliusit: 0.278753, bjkorivers: 0.323949): 0.327106, (((bdgeoburan: 0.255459, bdpelocarb: 0.227536): 0.154402, (bdbdelbact: 0.587762, bddesudesu: 0.437837): 0.074953): 0.057712, ((blcampjeju: 0.201456, (blhelihepa: 0.135680, blhelipylo: 0.175536): 0.152633): 0.476477, (((bkpelaubiq: 0.618776, (((bkanapmarg: 0.167194, bkanapphag: 0.139449): 0.183538, bkehrlcani: 0.229198): 0.475303, bkricktyph: 0.459342): 0.078401): 0.074093, ((bkglucoxyd: 0.281457, bkrhodrubr: 0.241108): 0.052835, ((bkzymomobi: 0.154917, (bkerytlito: 0.127846, bknovoarom: 0.097868): 0.073798): 0.181845, ((bkjannccs1: 0.147330, bkrhodspha: 0.107191): 0.200259, ((bkmesoloti: 0.119590, (bkbrucmeli: 0.065877, bkbartquin: 0.160819): 0.038141): 0.096170, (bknitrwino: 0.070591, bkrhodpalu: 0.059203): 0.179193): 0.072522): 0.040761): 0.032764): 0.097012): 0.174974, ((((bgthiocrun: 0.280741, bgfrantula: 0.343090): 0.045891, ((bgidioloih: 0.144556, ((bgcolwpsyc: 0.168654, bgpseuhalo: 0.118501): 0.032056, (bgphotprof: 0.115592, (bghaemducr: 0.120950, ((bgeschcoli: 0.005284, bgshigflex: 0.001214): 0.042587, (bgbuchaphi: 0.237868, (bgwiggglos: 0.434440, (bgblocflor: 0.296579, bgblocpenn: 0.160375): 0.169288): 0.098693): 0.154055): 0.032649): 0.063874): 0.038876): 0.030095): 0.090586, ((bgacinadp1: 0.148552, bgpsycarct: 0.193544): 0.172356, (bgpseusyri: 0.204460, bghahechej: 0.177581): 0.045627): 0.031018): 0.028639): 0.033421, ((bgnitrocea: 0.286237, bgmethcaps: 0.246796): 0.043612, bglegipneu: 0.346100): 0.027246): 0.061513, ((bbchroviol: 0.094661, bbneisgono: 0.167103): 0.066261, ((bbnitrmult: 0.186632, bbthiodeni: 0.168302): 0.046577, ((bbburk383: 0.086253, bbralseutr: 0.102745): 0.123258, (bbdecharom: 0.122970, bbazoaebn1: 0.111590): 0.044988): 0.028246): 0.046979): 0.137249): 0.203103): 0.072883): 0.055164): 0.030057): 0.035454): 0.036910): 0.030926): 0.048292): 0.049853, (bqaquiaeol: 0.284530, bqsulfurih: 0.317536): 0.223182);

T-III (This study; MrBayes analysis 23S Universal Alignment):

((bhthermela: 0.206021, bhthermari: 0.142170): 0.245759, (bqsulfurih: 0.322985, bqaquiaeol: 0.287937): 0.233106, ((bwtherther: 0.253515, bwdeinradi: 0.385508): 0.261733, (((bnsyneja23: 0.233682, ((bntherelon: 0.174591, bnsynepcc: 0.225869): 0.025988, (bnsyneelon: 0.131346, (bnsynecc99: 0.095250, bnprocmari: 0.138653): 0.232261): 0.051403): 0.088054): 0.064135, bngloeviol: 0.289061): 0.353949, (((bxsphather: 0.344589, (bxdehaethe: 0.019157, (bxdehacbdb: 0.000869, bxdehabav1: 0.001611): 0.022305): 0.533639): 0.107949, (bcfrancci3: 0.204349, ((((bctherfusc: 0.231472, bcstrecoel: 0.168909): 0.033286, bcpropacne: 0.310525): 0.025353, (bcnocafarc: 0.107328, (bcmycolepr: 0.172181, (bccoryeffi: 0.070495, (bccoryjeik: 0.120809, bccorydiph: 0.065064): 0.015388): 0.191420): 0.027430): 0.129542): 0.016649, ((bctropwhip: 0.447256, bcleifxyli: 0.142457): 0.104087, bcbifilong: 0.373015): 0.070939): 0.021735): 0.367505): 0.052032, (((bfclosperf: 0.136244, bfclosacet: 0.152927): 0.233664, ((bfdesuhafn: 0.252256, (bfmoorther: 0.246421, bfcarbhydr: 0.218750): 0.040938): 0.054783, ((bfstrepyog: 0.188309, (bflactsake: 0.125689, bflactplan: 0.175354): 0.072081): 0.134868, (bfgeobkaus: 0.129228, (bfoceaihey: 0.174262, (bfbacihalo: 0.061696, bfbaciclau: 0.090034): 0.061744): 0.050959): 0.024800): 0.152560): 0.021466): 0.077551, ((bvstremoni: 0.507468, ((((bvfusonucl: 0.477313, btmycomobi: 0.661565): 0.009415, (btmycopene: 0.396277, (btureaparv: 0.327100, btmycogeni: 0.515812): 0.044577): 0.386097): 0.007648, btmesoflor: 0.487117): 0.036892, btasteyell: 0.594338): 0.070721): 0.112496, ((bsleptinte: 0.598886, ((bstreppall: 0.294336, bstrepdent: 0.164076): 0.238146, bsborrgari: 0.480558): 0.203161): 0.140531, ((((bychlatrac: 0.096815, bychlaabor: 0.092362): 0.714880, (bprhodbalt: 0.390344, bpplanlimn: 0.501883): 0.317404): 0.095368, (((bzsalirube: 0.496807, bzflavpsyc: 0.660128): 0.118948, (brchlotepi: 0.122332, brchlochlo: 0.146827): 0.358281): 0.119692, (bjsoliusit: 0.279417, bjkorivers: 0.328762): 0.306689): 0.029200): 0.037592, (((blhelipylo: 0.177608, blhelihepa: 0.137093): 0.155468, blcampjeju: 0.202837): 0.511404, (((bdpelocarb: 0.230297, bdgeoburan: 0.257453): 0.158206, (bddesudesu: 0.443463, bdbdelbact: 0.592267): 0.072958): 0.056870, ((bkpelaubiq: 0.657834, (((bkrhodrubr: 0.243076, bkglucoxyd: 0.284975): 0.055447, ((bkzymomobi: 0.156750, (bknovoarom: 0.098468, bkerytlito: 0.129781): 0.074613): 0.182889, ((bkrhodspha: 0.108596, bkjannccs1: 0.148767): 0.202353, ((bkrhodpalu: 0.059816, bknitrwino: 0.071406): 0.181477, (bkmesoloti: 0.120813, (bkbrucmeli: 0.066674, bkbartquin: 0.162406): 0.038527): 0.096638): 0.074107): 0.041000): 0.031578): 0.103828, (bkricktyph: 0.464884, (bkehrlcani: 0.233449, (bkanapphag: 0.140519, bkanapmarg: 0.169478): 0.183578): 0.487237): 0.125030): 0.032258): 0.164886, ((bgthiocrun: 0.308924, ((bgnitrocea: 0.292091, bgmethcaps: 0.247711): 0.063968, ((bglegipneu: 0.337001, bgfrantula: 0.365755): 0.035883, (bgpseusyri: 0.236294, ((bghahechej: 0.210147, ((bgphotprof: 0.127973, (bgidioloih: 0.156541, (bgpseuhalo: 0.117298, bgcolwpsyc: 0.173138): 0.030876): 0.032558): 0.016895, (bghaemducr: 0.122695, ((bgshigflex: 0.001206, bgeschcoli: 0.005368): 0.044696, (bgbuchaphi: 0.240727, (bgwiggglos: 0.438306, (bgblocpenn: 0.162434, bgblocflor: 0.299551): 0.171005): 0.099777): 0.154304): 0.031103): 0.068153): 0.117979): 0.016317, (bgpsycarct: 0.196626, bgacinadp1: 0.149119): 0.188618): 0.004934): 0.050046): 0.020569): 0.030882): 0.052629, ((bbnitrmult: 0.208077, (bbralseutr: 0.103347, bbburk383: 0.088971): 0.118930): 0.032962, ((bbneisgono: 0.171064, bbchroviol: 0.094717): 0.096956, (bbdecharom: 0.142122, (bbthiodeni: 0.217858, bbazoaebn1: 0.123276): 0.014258): 0.036106): 0.008669): 0.152768): 0.210739): 0.112474): 0.019440): 0.043504): 0.018368): 0.038001): 0.023634): 0.030610): 0.024819): 0.056744): 0.051559);

T-IV (Battistuzzi & Hedges, 2009):

((((((((bnsyneja23: 0.230622, (bntherelon: 0.171268, (bnsynepcc: 0.220955, (bnsyneelon: 0.127549, (bnsynecc99: 0.093931, bnprocmari: 0.137341): 0.230224): 0.049452): 0.032682): 0.082967): 0.067319, bngloeviol: 0.281656): 0.319414, (bxsphather: 0.341376, (bxdehaethe: 0.018076, (bxdehacbdb: 0.000851, bxdehabav1: 0.001599): 0.022903): 0.521145): 0.103060): 0.060784, (((bfclosperf: 0.136909, bfclosacet: 0.148908): 0.224574, ((bfmoorther: 0.234157, bfdesuhafn: 0.234923): 0.046063, bfcarbhydr: 0.223774): 0.050672): 0.034841, ((((btmycomobi: 0.520068, (btureaparv: 0.312163, (btmycopene: 0.383623, btmycogeni: 0.498235): 0.060059): 0.262831): 0.088323, btmesoflor: 0.372679): 0.122267, btasteyell: 0.501387): 0.131435, (bfgeobkaus: 0.113902, ((bfstrepyog: 0.188096, (bflactsake: 0.126014, bflactplan: 0.171716): 0.070268): 0.133991, (bfoceaihey: 0.170216, (bfbacihalo: 0.061398, bfbaciclau: 0.088599): 0.062558): 0.041040): 0.037801): 0.077596): 0.088776): 0.064261): 0.038179, ((((bctropwhip: 0.435701, bcleifxyli: 0.147053): 0.122253, (bcpropacne: 0.284741, ((bctherfusc: 0.227619, bcstrecoel: 0.167290): 0.032490, (bcfrancci3: 0.194447, ((bcnocafarc: 0.099578, bcmycolepr: 0.180506): 0.036552, (bccoryjeik: 0.084509, (bccoryeffi: 0.076525, bccorydiph: 0.062440): 0.044361): 0.164271): 0.094874): 0.045938): 0.040943): 0.038871): 0.058327, bcbifilong: 0.326064): 0.282020, (bwtherther: 0.273979, bwdeinradi: 0.356167): 0.270128): 0.046682): 0.026196, ((((((((bgnitrocea: 0.285696, bgmethcaps: 0.247435): 0.043037, bglegipneu: 0.345591): 0.027417, ((bgthiocrun: 0.280177, bgfrantula: 0.342999): 0.046019, ((bgidioloih: 0.144579, ((bgpseuhalo: 0.118511, bgcolwpsyc: 0.168514): 0.032067, (bgphotprof: 0.115625, (bghaemducr: 0.120954, ((bgshigflex: 0.001214, bgeschcoli: 0.005281): 0.042567, (bgbuchaphi: 0.237641, (bgwigglos: 0.434048, (bgblocpenn: 0.160314, bgblocflor: 0.296340): 0.169128): 0.098649): 0.153964): 0.032587): 0.063782): 0.038780): 0.029956): 0.090283, ((bgpseusyri: 0.204110, bghahechej: 0.177695): 0.045969, (bgpsycarct: 0.193505, bgacinadp1: 0.148405): 0.171936): 0.031230): 0.028715): 0.034215): 0.060421, ((bbneisgono: 0.167184, bbchroviol: 0.094470): 0.066052, ((bbthiodeni: 0.168328, bbnitrmult: 0.186381): 0.046583, ((bbralseutr: 0.102506, bbburk383: 0.086394): 0.123307, (bbdecharom: 0.123017, bbazoaebn1: 0.111371): 0.044857): 0.028257): 0.047113): 0.137411): 0.208941, (((bkrhodrubr: 0.241626, bkglucoxyd: 0.280731): 0.053364, ((bkzymomobi: 0.154275, (bknovoarom: 0.097704, bkerytlito: 0.127926): 0.074196): 0.182227, ((bkrhodspha: 0.106927, bkjannccs1: 0.147506): 0.200610, ((bkrhodpalu: 0.059004, bknitrwino: 0.070747): 0.179132, (bkmesoloti: 0.119579, (bkbrucmeli: 0.065795, bkbartquin: 0.160800): 0.038003): 0.096122): 0.072254): 0.040129): 0.032558): 0.097569, (bkpelaubiq: 0.619811, (bkricktyph: 0.459051, (bkehrlcani: 0.229677, (bkanapphag: 0.139251, bkanapmarg: 0.167238): 0.182790): 0.474243): 0.077779): 0.074468): 0.171102): 0.114044, ((bjsoliusit: 0.281271, bjkorivers: 0.319073): 0.315058, ((bdpelocarb: 0.230393, bdgeoburan: 0.252480): 0.150201, (bddesudesu: 0.436846, bdbdelbact: 0.589467): 0.073915): 0.046925): 0.035012): 0.022848, ((blhelipylo: 0.175346, blhelihepa: 0.135609): 0.154000, blcampjeju: 0.200248): 0.517016): 0.034015, ((((bzsalirube: 0.487293, bzflavpsyc: 0.654662): 0.116545, (brchlotepi: 0.118779, brchlochlo: 0.146952): 0.356495): 0.096833, (bychlatrac: 0.097283, bychlaabor: 0.089690): 0.746443): 0.048451, ((bprhodbalt: 0.380724, bpplanlimn: 0.502139): 0.382342, (bsleptinte: 0.592517, ((bstreppall: 0.289896, bstrepdent: 0.163158): 0.238582, bsborrgari: 0.472538): 0.190048): 0.104249): 0.029435): 0.044432): 0.029337): 0.031500, (bvstremoni: 0.304677, bvfusonucl: 0.204489): 0.303804): 0.078541, (bqsulfurih: 0.317351, bqaquiaeol: 0.284468): 0.223096, (bhthermela: 0.199481, bhthermari: 0.144494): 0.250030);

T-V (Wu & Eisen, 2008):

(((((((((bbneisgono: 0.167502, bbchroviol: 0.095280): 0.066429, ((bbthiodeni: 0.168994, bbnitrmult: 0.187379): 0.046768, ((bbralseutr: 0.103100, bbburk383: 0.086667): 0.123738, (bbdecharom: 0.123513, bbazoaebn1: 0.112013): 0.045108): 0.028418): 0.047207): 0.137518, (((bgnitrocea: 0.287393, bgmethcaps: 0.248028): 0.043512, bglegipneu: 0.347020): 0.026961, ((bgthiocrun: 0.281490, bgfrantula: 0.344470): 0.046245, ((bgidioloih: 0.145042, ((bgpseuhalo: 0.118998, bgcolwpsyc: 0.169353): 0.032202, (bgphotprof: 0.116123, (bghaemducr: 0.121504, ((bgshigflex: 0.001217, bgeschcoli: 0.005306): 0.042790, (bgbuchaphi: 0.238649, (bgwiggglos: 0.436038, (bgblocpenn: 0.161015, bgblocflor: 0.297810): 0.169875): 0.099167): 0.154681): 0.032720): 0.064098): 0.038991): 0.030208): 0.090916, ((bgpseusyri: 0.205271, bghahechej: 0.178333): 0.046121, (bgpsycarct: 0.194307, bgacinadp1: 0.149219): 0.172715): 0.031179): 0.029071): 0.034241): 0.061457): 0.209042, (((bkrhodrubr: 0.242438, bkglucoxyd: 0.282159): 0.053657, ((bkzymomobi: 0.155438, (bknovoarom: 0.098205, bkerytlito: 0.128387): 0.074152): 0.182506, ((bkrhodspha: 0.107546, bkjannccs1: 0.148006): 0.201223, ((bkrhodpalu: 0.059294, bknitrwino: 0.070981): 0.180126, (bkmesoloti: 0.120026, (bkbrucmeli: 0.066026, bkbartquin: 0.161511): 0.038294): 0.096399): 0.072906): 0.040591): 0.032850): 0.099054, (bkpelaubiq: 0.621119, (bkricktyph: 0.460104, (bkehrlcani: 0.230274, (bkanapphag: 0.139806, bkanapmarg: 0.168013): 0.184066): 0.477024): 0.078079): 0.073609): 0.171263): 0.075698, ((blhelipylo: 0.175885, blhelihepa: 0.136590): 0.152215, blcampjeju: 0.203443): 0.482229): 0.054903, ((bjsoliusit: 0.281440, bjkorivers: 0.321996): 0.316310, ((bdpelocarb: 0.232172, bdgeoburan: 0.252122): 0.152494, (bddesudesu: 0.436464, bdbdelbact: 0.592009): 0.076300): 0.048493): 0.037896): 0.045793, ((((bzflavpsyc: 0.656717, bzsalirube: 0.489949): 0.121297, (brchlochlo: 0.146948, brchlotepi: 0.119919): 0.356504): 0.116268, (bsleptinte: 0.590954, ((bstreppall: 0.290938, bstrepdent: 0.163825): 0.238810, bsborrgari: 0.476190): 0.196642): 0.107880): 0.031412, ((bychlaabor: 0.090039, bychlatrac: 0.097854): 0.705736, (bpplanlimn: 0.504316, bprhodbalt: 0.379923): 0.321106): 0.091467): 0.035191): 0.029069, (((((((btmycomobi: 0.524432, (btureaparv: 0.317907, (btmycopene: 0.387560, btmycogeni: 0.498418): 0.057224): 0.260856): 0.078625, btmesoflor: 0.381746): 0.107131, btasteyell: 0.519238): 0.131080, (bvfusonucl: 0.201031, bvstremoni: 0.307895): 0.278086): 0.058705, ((bfgeobkaus: 0.114223, ((bfstrepyog: 0.188362, (bflactsake: 0.125904, bflactplan: 0.173106): 0.070471): 0.137445, (bfoceaihey: 0.173321, (bfbacihalo: 0.061697, bfbaciclau: 0.088921): 0.060441): 0.039112): 0.037990): 0.140532, ((bfclosperf: 0.137664, bfclosacet: 0.149438): 0.222654, ((bfmoorther: 0.237376, bfdesuhafn: 0.233901): 0.044481, bfcarbhydr: 0.225700): 0.052146): 0.039056): 0.048674): 0.048503, (((bnsyneja23: 0.229998, (bntherelon: 0.171873, (bnsynepcc: 0.222335, (bnsyneelon: 0.128318, (bnsynecc99: 0.094355, bnprocmari: 0.137965): 0.231137): 0.049409): 0.032814): 0.084679): 0.068004, bngloeviol: 0.282019): 0.321135, (bxsphather: 0.343467, (bxdehaethe: 0.018455, (bxdehacbdb: 0.000856, bxdehabav1: 0.001605): 0.022705): 0.520162): 0.103805): 0.066223): 0.028505, (((bctropwhip: 0.438482, bcleifxyli: 0.147288): 0.122555, (bcpropacne: 0.285718, ((bctherfusc: 0.229266, bcstrecoel: 0.167597): 0.032353, (bcfrancci3: 0.195133, ((bcnocafarc: 0.100060, bcmycolepr: 0.181366): 0.036781, (bccoryjeik: 0.084867, (bccoryeffi: 0.076875, bccorydiph: 0.062715): 0.044582): 0.164910): 0.095603): 0.046382): 0.041233): 0.038761): 0.060871, bcbifilong: 0.325259): 0.315897): 0.021869): 0.072498, (bqaquiaeol: 0.286420, bqsulfurih: 0.317934): 0.247012): 0.034060, (bhthermela: 0.199781, bhthermari: 0.145994): 0.256796, (bwdeinradi: 0.386784, bwtherther: 0.247818): 0.252272);

T-VI (Ciccarelli et al., 2006):

((((((bprhodbalt: 0.384654, bpplanlimn: 0.499091): 0.381370, (bsleptinte: 0.589455, ((bstreppall: 0.289053, bstrepdent: 0.163786): 0.230953, bsborrgari: 0.479003): 0.194579): 0.104279): 0.041666, (((bctropwhip: 0.436099, bcleifxyli: 0.147284): 0.118975, (bcpropacne: 0.283096, ((bctherfusc: 0.227737, bcstrecoel: 0.166848): 0.031690, (bcfrancci3: 0.194464, ((bcnocafarc: 0.099716, bcmycolepr: 0.180437): 0.036726, (bccoryjeik: 0.084512, (bccoryeffi: 0.076480, bccorydiph: 0.062483): 0.044402): 0.163947): 0.094958): 0.046831): 0.041865): 0.040698): 0.065548, bcbifilong: 0.318574): 0.298417): 0.017353, (((brchlotepi: 0.116766, brchlochlo: 0.149024): 0.354782, (bzsalirube: 0.483970, bzflavpsyc: 0.659808): 0.119803): 0.095407, (bychlatrac: 0.099464, bychlaabor: 0.087536): 0.763933): 0.056644): 0.044250, (((((bdpelocarb: 0.230274, bdgeoburan: 0.252105): 0.151669, (bddesudesu: 0.436170, bdbdelbact: 0.589578): 0.077276): 0.048757, (bjsoliusit: 0.282565, bjkorivers: 0.319121): 0.317451): 0.030636, (((blhelipylo: 0.175755, blhelihepa: 0.135420): 0.151598, blcampjeju: 0.202236): 0.475937, ((((bkrhodrubr: 0.240848, bkglucoxyd: 0.281491): 0.053175, ((bkzymomobi: 0.154772, (bknovoarom: 0.097734, bkerytlito: 0.127882): 0.073827): 0.182005, ((bkrhodspha: 0.106931, bkjannccs1: 0.147486): 0.200435, ((bkrhodpalu: 0.059061, bknitrwino: 0.070617): 0.178703, (bkmesoloti: 0.119595, (bkbrucmeli: 0.065670, bkbartquin: 0.160851): 0.038114): 0.096441): 0.072244): 0.040385): 0.032936): 0.098538, (bkpelaubiq: 0.618487, (bkricktyph: 0.458418, (bkehrlcani: 0.229649, (bkanapphag: 0.139103, bkanapmarg: 0.167355): 0.182830): 0.475098): 0.077550): 0.073332): 0.167893, (((bbneisgono: 0.166894, bbchroviol: 0.094730): 0.066008, ((bbthiodeni: 0.168282, bbnitrmult: 0.186396): 0.046491, ((bbralseutr: 0.102632, bbburk383: 0.086281): 0.123112, (bbdecharom: 0.122944, bbazoaebn1: 0.111501): 0.045055): 0.028233): 0.047300): 0.137308, (((bgnitrocea: 0.286237, bgmethcaps: 0.246825): 0.043680, bglegipneu: 0.345396): 0.026984, ((bgthiocrun: 0.280645, bgfrantula: 0.342634): 0.045912, ((bgidioloih: 0.144498, ((bgpseuhalo: 0.118505, bgcolwpsyc: 0.168537): 0.032092, (bgphotprof: 0.115620, (bghaemducr: 0.120939, ((bgshigflex: 0.001216, bgeschcoli: 0.005279): 0.042584, (bgbuchaphi: 0.237743, (bgwigglos: 0.434140, (bgblocpenn: 0.160436, bgblocflor: 0.296347): 0.169081): 0.098715): 0.153990): 0.032600): 0.063854): 0.038815): 0.030012): 0.090376, ((bgpseusyri: 0.204277, bghahechej: 0.177628): 0.045806, (bgpsycarct: 0.193401, bgacinadp1: 0.148527): 0.172277): 0.031067): 0.028848): 0.033683): 0.060807): 0.209249): 0.078614): 0.062546): 0.060190, ((((bxsphather: 0.339139, (bxdehaethe: 0.018934, (bxdehacbdb: 0.000851, bxdehabav1: 0.001600): 0.022058): 0.523301): 0.123467, (bwtherther: 0.265244, bwdeinradi: 0.365312): 0.269012): 0.020224, ((bnsyneja23: 0.229636, (bntherelon: 0.170029, (bnsynepcc: 0.221392, (bnsyneelon: 0.127314, (bnsynecc99: 0.093899, bnprocmari: 0.137436): 0.230393): 0.049469): 0.033430): 0.084575): 0.066299, bngloeviol: 0.282504): 0.342590): 0.054704, (((bhthermela: 0.199852, bhthermari: 0.144478): 0.249700, (bqsulfurih: 0.320041, bqaquiaeol: 0.281639): 0.224630): 0.078978, (bvstremoni: 0.304629, bvfusonucl: 0.204311): 0.306215): 0.030190): 0.020847): 0.006726): 0.091091, ((bfclosperf: 0.137840, bfclosacet: 0.148079): 0.221400, ((bfmoorther: 0.234994, bfdesuhafn: 0.234152): 0.045186, bfcarbhydr: 0.224550): 0.053654): 0.038962, ((((btmycomobi: 0.520783, (btureaparv: 0.311981, (btmycopene: 0.384323, btmycogeni: 0.498092): 0.060213): 0.262424): 0.087079, btmesoflor: 0.374517): 0.123121, btasteyell: 0.501088): 0.127862, (bfgeobkaus: 0.114267, ((bfstrepyog: 0.187874, (bflactsake: 0.126013, bflactplan: 0.171793): 0.070463): 0.134139, (bfoceaihey: 0.170606, (bfbacihalo: 0.061638, bfbaciclau: 0.088417): 0.062368): 0.040456): 0.038045): 0.080454): 0.085497);

Models fit to the 23S alignment data (Table 3, fourth column):

T-I (This study; MrBayes analysis of Universal Protein Alignment):

(annanoequi:0.2844,((attheronnu:0.0122,(attherkoda:0.0070,(attheram4:0.0007,atthergamm:0.0021):0.0050):0.0086):0.
0153,((attherbaro:0.0106,atthersibi:0.0472):0.0061,(atpyroyaya:0.0027,(atpyrofuri:0.0029,(atpyrona2:0.0060,(atpyroab
ys:0.0029,atpyrohori:0.0031):0.0000):0.0031):0.0069):0.0214):0.0048):0.0823,(((ammethkand:0.1040,(abmethferv:0.0
345,((abmethmarb:0.0026,abmethther:0.0031):0.0538,((abmethrumi:0.0580,abmethsmit:0.0483):0.0596,(abmethstad:0.
1502,(abmethal21:0.0374,abmethswan:0.0302):0.0400):0.0077):0.0506):0.0968):0.1242):0.0245,(((admethinfe:0.0329,
(admethvulc:0.0298,(admethferv:0.0096,(admethfs40:0.0023,admethjann:0.0054):0.0011):0.0029):0.0047):0.0192,(ad
methigne:0.0074,((admethaeol:0.0526,admethokin:0.0067):0.0162,(admethvolt:0.0535,(admethmari:0.0124,admethvan
n:0.0161):0.0156):0.0509):0.1046):0.0309):0.0909,(((apferracid:0.0937,appicrtorr:0.0451):0.0628,(aptheracid:0.0257,a
pthervolc:0.0096):0.0416):0.3801,((arferrplac:0.0181,(ararchprof:0.0328,(ararchfulg:0.0419,ararchvene:0.0264):0.0187
):0.0040):0.0986,(((aqmethlabr:0.1338,((aqmethmari:0.0618,aqmethpetr:0.1055):0.0239,(aqmethhung:0.1059,(aqmethb
oon:0.0736,aqmethpalu:0.0658):0.0246):0.0084):0.0269):0.1320,(aqmethther:0.1296,((aqmethbark:0.0178,(aqmethacet
:0.0180,aqmethmaze:0.1230):0.0025):0.0528,(aqmetheves:0.1075,(aqmethburt:0.0515,aqmethmahi:0.0630):0.0180):0.
0110):0.0906):0.0257):0.1853,((ahnatrmaga:0.0239,(ahhaloturk:0.0429,ahhaloxana:0.0267):0.0048):0.0600,((ahnatrpha
r:0.0749,(ahhaloutah:0.0665,(ahhalomari:0.0728,ahhalomuko:0.0778):0.0200):0.0157):0.0251,((ahhalajeot:0.0562,ahha
lapauc:0.0745):0.0109,(ahhalonrc1:0.0866,(ahhalolacu:0.0886,(ahhalovolc:0.0650,(ahhalobori:0.0420,ahhalowals:0.09
84):0.0181):0.0216):0.0322):0.0074):0.0025):0.0000):0.2845):0.1089):0.0407):0.0456):0.0312):0.0052,(((actherpend:0.
0919,((accaldmaqu:0.0910,(acvulcdist:0.0043,acvulcmout:0.0194):0.0245):0.0268,(actheruzon:0.0250,(acpyrocali:0.02
98,((acpyroaero:0.0078,acpyroarse:0.0104):0.0018,(acpyroisla:0.0038,actherneut:0.0071):0.0032):0.0006):0.0163):0.03
80):0.0513):0.0416,((acigniaggr:0.0765,((acacidhosp:0.0401,(acmetacupr:0.0259,acmetasedu:0.0098):0.0754):0.0165,(
(acsulfacid:0.0679,acsulftoko:0.0341):0.0296,(acsulfisla:0.0042,acsulfsolf:0.0356):0.0721):0.0077):0.1316):0.0084,((a
cignihosp:0.0725,(acaeropern:0.0465,achypebuty:0.0395):0.0074):0.0090,((acstaphell:0.0072,acstapmari:0.0036):0.028
4,(actheraggr:0.0319,(acdesukamc:0.0168,acdesumuco:0.0094):0.0119):0.0302):0.0263):0.0191):0.0370):0.0865,(aunit
rmari:0.5437,((bvfusonucl:0.2267,bvstremoni:0.2274):0.1648,(((bwdeinradi:0.1912,bwtherther:0.1135):0.1166,((bhther
mari:0.0383,bhthermela:0.0768):0.1396,(bqaquiaeol:0.1371,bqsulfurih:0.1363):0.1470):0.0360):0.0539,((((bxsphather:
0.1869,(bxdehaethe:0.0052,(bxdehabav1:0.0004,bxdehacbdb:0.0000):0.0055):0.1698):0.0915,(bngloeviol:0.0652,(bnsy
neja23:0.0799,(bntherelon:0.0643,(bnsynepcc:0.0863,(bnsyneelon:0.0548,(bnprocmari:0.0429,bnsynecc99:0.0334):0.0
647):0.0162):0.0059):0.0314):0.0172):0.1887):0.0293,(((bfclosacet:0.0861,bfclosperf:0.0601):0.1075,(bfcarbhydr:0.09
19,(bfdesuhafn:0.1147,bfmoorther:0.0853):0.0164):0.0343):0.0217,((btasteyell:0.1808,(btmesoflor:0.0984,(btmycomob
i:0.1281,(btureaparv:0.1024,(btmycogeni:0.1559,btmycopene:0.0923):0.0071):0.1247):0.0319):0.0832):0.1391,(bfgeob
kaus:0.0590,((bfoceaihey:0.0643,(bfbaciclau:0.0434,bfbacihalo:0.0255):0.0321):0.0144,(bfstrepyog:0.1089,(bflactplan:
0.0648,bflactsake:0.0508):0.0255):0.0636):0.0128):0.0512):0.0124):0.0652):0.0126,(((bcbifilong:0.1517,((bcleifxyli:0.
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.1069):0.0978):0.0719,((bpplanlimn:0.1213,bprhodbalt:0.1244):0.1964,(bychlaabor:0.0356,bychlatrac:0.0293):0.2582):
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oli:0.0026,bgshigflex:0.0026):0.0316,(bgbuchaphi:0.0943,(bgwiggglos:0.0774,(bgblocflor:0.0596,bgblocpenn:0.0326):
0.0292):0.0162):0.0329):0.0106):0.0212):0.0186):0.0065):0.0442):0.0173):0.0094):0.0405):0.0799):0.0593):0.0064):0.
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T-II (This study; RAxML analysis of Universal Protein Alignment):

(annanoequi:0.2795,((attheronnu:0.0121,(attherkoda:0.0069,(attheram4:0.0007,atthergamm:0.0021):0.0049):0.0085):0.0148,((attherbaro:0.0106,atthersibi:0.0466):0.0060,(atpyroyaya:0.0027,(atpyrofuri:0.0028,(atpyrona2:0.0060,(atpyroabys:0.0029,atpyrohori:0.0031):0.0000):0.0031):0.0068):0.0212):0.0050):0.0815,(((ammethkand:0.1027,(abmethferv:0.0340,((abmethmarb:0.0026,abmethther:0.0031):0.0531,((abmethrumi:0.0574,abmethsmit:0.0478):0.0589,(abmethstad:0.1486,(abmethal21:0.0370,abmethswan:0.0299):0.0396):0.0076):0.0500):0.0958):0.1225):0.0244,(((admethinfe:0.0325,(admethvulc:0.0295,(admethferv:0.0095,(admethfs40:0.0022,admethjann:0.0053):0.0011):0.0029):0.0046):0.0193,(admethigne:0.0070,((admethaeol:0.0521,admethokin:0.0066):0.0160,(admethvolt:0.0529,(admethmari:0.0122,admethvann:0.0159):0.0154):0.0504):0.1037):0.0305):0.0900,(((apferracid:0.0926,appicrtorr:0.0446):0.0622,(aptheracid:0.0254,apthervolc:0.0095):0.0409):0.3744,((arferrplac:0.0179,(ararchprof:0.0324,(ararchfulg:0.0414,ararchvene:0.0260):0.0185):0.0039):0.0975,(((aqmethlabr:0.1324,((aqmethmari:0.0611,aqmethpetr:0.1043):0.0236,(aqmethhung:0.1046,(aqmethboon:0.0728,aqmethpalu:0.0652):0.0244):0.0083):0.0264):0.1306,(aqmethther:0.1278,((aqmethbark:0.0176,(aqmethacet:0.0178,aqmethmaze:0.1215):0.0025):0.0522,(aqmetheves:0.1063,(aqmethburt:0.0509,aqmethmahi:0.0623):0.0178):0.0109):0.0896):0.0255):0.1826,((ahnatrmaga:0.0237,(ahhaloturk:0.0424,ahhaloxana:0.0264):0.0048):0.0593,((ahnatrphar:0.0740,(ahhaloutah:0.0658,(ahhalomari:0.0720,ahhalomuko:0.0769):0.0198):0.0156):0.0248,((ahhalajeot:0.0556,ahhalapauc:0.0736):0.0108,(ahhalonrc1:0.0856,(ahhalolacu:0.0875,(ahhalovolc:0.0642,(ahhalobori:0.0415,ahhalowals:0.0972):0.0180):0.0214):0.0318):0.0073):0.0024):0.0000):0.2812):0.1069):0.0402):0.0446):0.0308):0.0052,(((actherpend:0.0912,((accaldmaqu:0.0899,(acvulcdist:0.0043,acvulcmout:0.0192):0.0241):0.0267,(actheruzon:0.0247,(acpyrocali:0.0295,((acpyroaero:0.0077,acpyroarse:0.0103):0.0018,(acpyroisla:0.0037,actherneut:0.0071):0.0031):0.0006):0.0161):0.0374):0.0504):0.0414,((acigniaggr:0.0754,((acacidhosp:0.0397,(acmetacupr:0.0256,acmetasedu:0.0097):0.0745):0.0162,((acsulfacid:0.0671,acsulftoko:0.0337):0.0293,(acsulfisla:0.0042,acsulfsolf:0.0352):0.0713):0.0076):0.1300):0.0088,((acignihosp:0.0716,(acaeropern:0.0459,achypebuty:0.0390):0.0073):0.0089,((acstaphell:0.0071,acstapmari:0.0036):0.0281,(actheraggr:0.0316,(acdesukamc:0.0166,acdesumuco:0.0093):0.0118):0.0299):0.0260):0.0185):0.0362):0.0896,(aunitrmari:0.5486,((bqaquiaeol:0.1222,bqsulfurih:0.1473):0.1137,((bhthermari:0.0367,bhthermela:0.0773):0.1267,((bwdeinradi:0.1922,bwtherther:0.1078):0.1100,((bvfusonucl:0.2217,bvstremoni:0.2260):0.1610,((((bxsphather:0.1858,(bxdehaethe:0.0051,(bxdehabav1:0.0004,bxdehacbdb:0.0000):0.0054):0.1664):0.0910,(bngloeviol:0.0648,(bnsyneja23:0.0789,(bntherelon:0.0636,(bnsynepcc:0.0853,(bnsyneelon:0.0542,(bnprocmari:0.0424,bnsynecc99:0.0330):0.0640):0.0160):0.0058):0.0309):0.0168):0.1854):0.0308,(((bfclosacet:0.0853,bfclosperf:0.0593):0.1054,(bfcarbhydr:0.0908,(bfdesuhafn:0.1133,bfmoorther:0.0844):0.0163):0.0346):0.0212,((btasteyell:0.1785,(btmesoflor:0.0966,(btmycomobi:0.1287,(btmycogeni:0.1423,(btmycopene:0.0903,btureaparv:0.1011):0.0195):0.1147):0.0295):0.0827):0.1363,(bfgeobkaus:0.0586,((bfoceaihey:0.0637,(bfbaciclau:0.0428,bfbacihalo:0.0253):0.0316):0.0142,(bfstrepyog:0.1076,(bflactplan:0.0641,bflactsake:0.0502):0.0252):0.0627):0.0124):0.0513):0.0123):0.0644):0.0095,(((bcbifilong:0.1502,((bcleifxyli:0.0452,bctropwhip:0.0963):0.0566,(bcpropacne:0.1603,(bctherfusc:0.1200,(bcstrecoel:0.0946,(bcfrancci3:0.0619,((bcmycolepr:0.1026,bcnocafarc:0.0526):0.0189,(bccoryjeik:0.0477,(bccorydiph:0.0382,bccoryeffi:0.0737):0.0195):0.0667):0.0436):0.0074):0.0056):0.0118):0.0164):0.0031):0.1903,(((brchlochlo:0.0288,brchlotepi:0.0336):0.1892,(bzflavpsyc:0.1872,bzsalirube:0.1985):0.0808):0.0974,((bsleptinte:0.2164,(bsborrgari:0.1161,(bstrepdent:0.0689,bstreppall:0.0864):0.1058):0.0969):0.0712,((bpplanlimn:0.1200,bprhodbalt:0.1225):0.1939,(bychlaabor:0.0353,bychlatrac:0.0290):0.2546):0.0532):0.0182):0.0096):0.0026,((bjkorivers:0.0839,bjsoliusit:0.0990):0.2106,(((bdbdelbact:0.1822,bddesudesu:0.1570):0.0351,(bdgeoburan:0.0730,bdpelocarb:0.0458):0.0446):0.0531,((blcampjeju:0.1514,(blhelihepa:0.0346,blhelipylo:0.0626):0.0653):0.2115,(((bkpelaubiq:0.1833,(bkricktyph:0.0889,(bkehrlcani:0.0545,(bkanapmarg:0.0295,bkanapphag:0.0163):0.0185):0.0955):0.0409):0.0083,((bkglucoxyd:0.1112,bkrhodrubr:0.0808):0.0287,((bkzymomobi:0.0762,(bkerytlito:0.0482,bknovoarom:0.0314):0.0271):0.0715,((bkjannccs1:0.0660,bkrhodspha:0.0823):0.0669,((bknitrwino:0.0267,bkrhodpalu:0.0161):0.0781,(bkmesoloti:0.0495,(bkbartquin:0.0517,bkbrucmeli:0.0629):0.0203):0.0387):0.0263):0.0247):0.0118):0.0150):0.1117,(((bbchroviol:0.0286,bbneisgono:0.0673):0.0264,((bbnitrmult:0.0720,bbthiodeni:0.0615):0.0209,((bbazoaebn1:0.0498,bbdecharom:0.0500):0.0150,(bbburk383:0.0216,bbralseutr:0.0300):0.0606):0.0000):0.0131):0.0839,((bglegipneu:0.1096,(bgmethcap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T-III (This study; MrBayes analysis 23S Universal Alignment):

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ys:0.0030,atpyrohori:0.0031):0.0000):0.0032):0.0070):0.0218):0.0051):0.0836,(((ammethkand:0.1062,(abmethferv:0.0
347,((abmethmarb:0.0027,abmethther:0.0031):0.0546,((abmethrumi:0.0587,abmethsmit:0.0490):0.0603,(abmethstad:0.
1522,(abmethal21:0.0380,abmethswan:0.0307):0.0406):0.0079):0.0513):0.0987):0.1261):0.0253,(((admethinfe:0.0335,
(admethvulc:0.0303,(admethferv:0.0098,(admethfs40:0.0023,admethjann:0.0055):0.0011):0.0030):0.0047):0.0198,(ad
methigne:0.0072,((admethaeol:0.0531,admethokin:0.0070):0.0165,(admethvolt:0.0543,(admethmari:0.0125,admethvan
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pthervolc:0.0096):0.0420):0.3862,((arferrplac:0.0184,(ararchprof:0.0334,(ararchfulg:0.0425,ararchvene:0.0268):0.0189
):0.0040):0.1005,(((aqmethlabr:0.1358,((aqmethmari:0.0627,aqmethpetr:0.1071):0.0243,(aqmethhung:0.1076,(aqmethb
oon:0.0748,aqmethpalu:0.0667):0.0249):0.0084):0.0273):0.1341,(aqmethther:0.1316,((aqmethbark:0.0180,(aqmethacet
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99):0.0185):0.0218):0.0325):0.0076):0.0025):0.0000):0.2887):0.1110):0.0409):0.0460):0.0310):0.0052,(((actherpend:0.
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(acsulfacid:0.0689,acsulftoko:0.0346):0.0301,(acsulfisla:0.0042,acsulfsolf:0.0361):0.0732):0.0079):0.1340):0.0089,((a
cignihosp:0.0736,(acaeropern:0.0472,achypebuty:0.0401):0.0076):0.0091,((acstaphell:0.0073,acstapmari:0.0036):0.028
9,(actheraggr:0.0324,(acdesukamc:0.0170,acdesumuco:0.0096):0.0121):0.0307):0.0267):0.0190):0.0375):0.0932,(aunit
rmari:0.5644,((bhthermari:0.0362,bhthermela:0.0809):0.0983,((bqaquiaeol:0.1368,bqsulfurih:0.1414):0.1411,((bwdeinr
adi:0.1981,bwtherther:0.1094):0.1105,((bngloeviol:0.0667,(bnsyneja23:0.0835,((bnsynepcc:0.0835,bntherelon:0.0585):
0.0155,(bnsyneelon:0.0549,(bnprocmari:0.0424,bnsynecc99:0.0348):0.0663):0.0151):0.0295):0.0163):0.1896,(((bxsph
ather:0.1869,(bxdehaethe:0.0053,(bxdehabav1:0.0004,bxdehacbdb:0.0000):0.0055):0.1715):0.0905,(bcfrancci3:0.0570,
((bcbifilong:0.1575,(bcleifxyli:0.0441,bctropwhip:0.1013):0.0523):0.0209,((bcpropacne:0.1601,(bcstrecoel:0.0756,bcth
erfusc:0.1014):0.0271):0.0134,(bcnocafarc:0.0559,(bcmycolepr:0.1008,(bccoryeffi:0.0626,(bccorydiph:0.0400,bccoryj
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47,bflactsake:0.0526):0.0280):0.0512,(bfgeobkaus:0.0656,(bfoceaihey:0.0672,(bfbaciclau:0.0434,bfbacihalo:0.0263):0.
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bi:0.0000,bvfusonucl:0.0374):0.1264,(btmycopene:0.0825,(btmycogeni:0.1490,btureaparv:0.0907):0.0302):0.1221):0.0
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bjkorivers:0.0876,bjsoliusit:0.1001):0.1879,((brchlochlo:0.0283,brchlotepi:0.0356):0.1888,(bzflavpsyc:0.1916,bzsaliru
be:0.2014):0.0855):0.0686):0.0299):0.0218,((blcampjeju:0.1582,(blhelihepa:0.0353,blhelipylo:0.0641):0.0639):0.1964,
(((bdbdelbact:0.1840,bddesudesu:0.1625):0.0370,(bdgeoburan:0.0736,bdpelocarb:0.0483):0.0431):0.0468,((bkpelaubiq
:0.1862,((bkricktyph:0.0906,(bkehrlcani:0.0546,(bkanapmarg:0.0301,bkanapphag:0.0168):0.0200):0.0987):0.0435,((bk
glucoxyd:0.1142,bkrhodrubr:0.0825):0.0298,((bkzymomobi:0.0781,(bkerytlito:0.0495,bknovoarom:0.0320):0.0276):0.
0736,((bkjanccs1:0.0672,bkrhodspha:0.0848):0.0681,((bknitrwino:0.0273,bkrhodpalu:0.0166):0.0797,(bkmesoloti:0.0
508,(bkbartquin:0.0529,bkbrucmeli:0.0645):0.0208):0.0402):0.0274):0.0250):0.0122):0.0181):0.0096):0.1122,(((bbnitr
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bgpseuhalo:0.0501):0.0189):0.0283):0.0222,(bghaemducr:0.0893,((bgeschcoli:0.0026,bgshigflex:0.0027):0.0295,(bgbu
chaphi:0.0940,(bgwiggglos:0.0781,(bgblocflor:0.0603,bgblocpenn:0.0330):0.0295):0.0186):0.0342):0.0113):0.0167):0.
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T-IV (Battistuzzi & Hedges, 2009):

(annanoequi:0.2823,((attheronnu:0.0122,(attherkoda:0.0070,(attheram4:0.0007,atthergamm:0.0021):0.0050):0.0085):0.
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ys:0.0029,atpyrohori:0.0031):0.0000):0.0031):0.0069):0.0213):0.0050):0.0817,(((ammethkand:0.1038,(abmethferv:0.0
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APPENDIX E

THE MOST LIKELY MODEL OF BACTERIAL AND ARCHAEAL HISTORY

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APPENDIX F

BLAST SERCHES IN ONE ITERATION OF STORI

There will be ($x - w + 1$) increments of the sliding window (size w taxa) down the master list (size x taxa). With each increment, the following BLAST searches are repeated for each of f families: each of w sequences in the window are BLASTed against each of w parent proteomes. Thus, the total number of BLAST searches in a single STORI iteration, assuming that practically all taxa in all families are assigned a protein sequence, is: $(x - w + 1)w^2f$.

APPENDIX G

REFERENCE SET BUILDING PROCEDURE

The results of triplicate runs for the supersets of 115 Bacterial, 94 Archaeal and 105 Eukaryal taxa were collated in Microsoft Excel. Non-ribosomal families were removed. Most families were present in triplicate; all 3 runs usually retrieved them successfully. A few families were only retrieved in one or two of the runs. We chose the family with the highest convergence score from each replicate family set. If families had identical scores, we chose the family with the most assignments. If families had identical scores and identical numbers of assignments, then we merged the families by using assignments from the other family in any unassigned taxa for the present family. If families had identical scores and numbers of assignments but a few differences in assignment, then we chose the family with greater sequence conservation (using NCBI's COBALT).

After choosing the families, we checked all predictions of gene absence. For every assignment of "-1", we did a BLASTP search (Bitscore cutoff = 50) of the RefSeq database for the proteins of the corresponding taxon ID, using as a query sequence the GI of an ortholog from a closely related taxon. In the case of Eukaryotic taxa, we searched the nr database, because about half of the Eukaryotic taxa in our dataset do not have complete genomes and are not represented in RefSeq. (Note – all subsamples, including from Eukaryal superset, *do* have complete genomes; see note Material and Methods.)

The retrievals used to build the reference and the retrievals used for the phylogenetic component of our study are distinct. However, their results were practically identical, and the high quality of the sequences used for tree building enables their use as additional verification for the reference set. Prior to tree inference we manually examined each family alignment, and verified proteome membership of every prokaryotic sequence using TBLASTN against the complete RefSeq genome (cutoff = 95% identity). Therefore, we used our phylogenetic data as the standard against which we corrected discrepancies with large subunit prokaryotic proteins in the reference set.

We generated a multiple sequence alignment for each family in the reference set. To check for highly divergent sequences indicative of assignment error, we inspected each alignment by eye, and built neighbor-joining gene trees using CLUSTALO and BIONJ. We removed spurious sequences from the reference set, and replaced them with a manually verified sequence, if available.

The Perl scripts that we used for benchmarking accuracy, as well as the reference and test accessions, are available at:
https://github.com/jgstern/STORI/raw/master/fig7Accuracy.zip

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