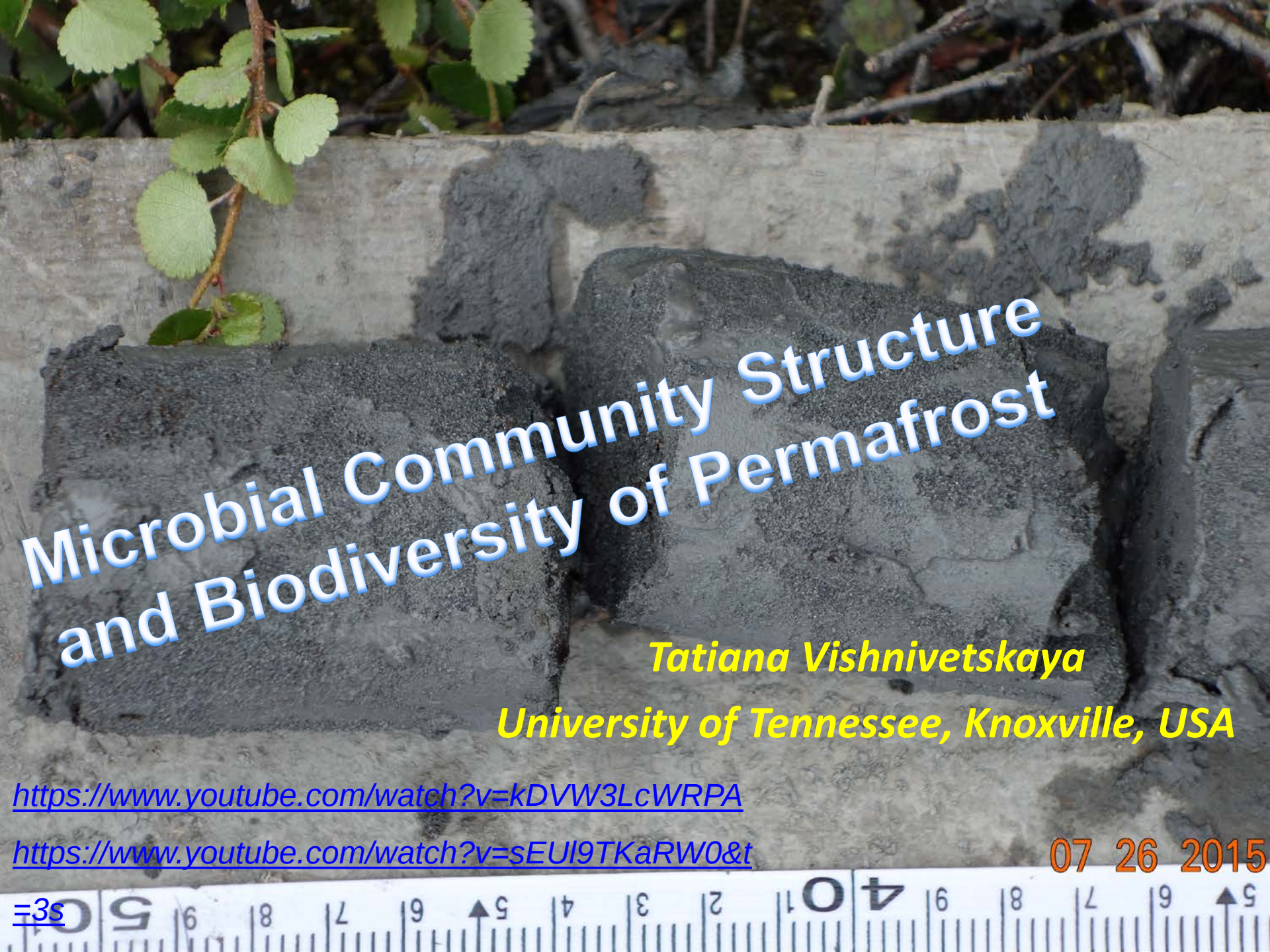


A photograph showing dark, textured microbial mats growing on a light-colored rock surface. A ruler is placed at the bottom of the frame for scale. In the top left corner, there are some green plants with serrated leaves.

Microbial Community Structure and Biodiversity of Permafrost

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University of Tennessee, Knoxville, USA

<https://www.youtube.com/watch?v=kDVW3LcWRPA>

[https://www.youtube.com/watch?v=sEUI9TKaRW0&t](https://www.youtube.com/watch?v=sEUI9TKaRW0&t=3s)

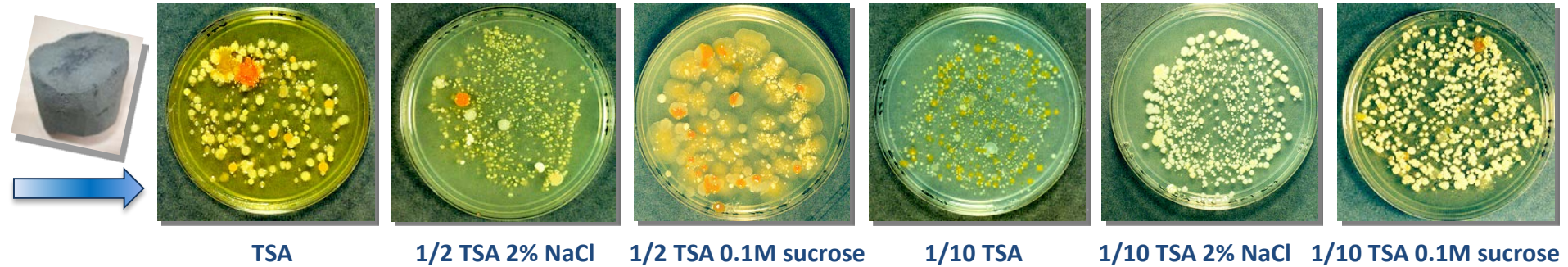
07 26 2015

Prokaryotic diversity in soil as estimated reaches between 6,400 and 38,000 species per gram (Curtis et.al., PNAS 99:16, 2002).

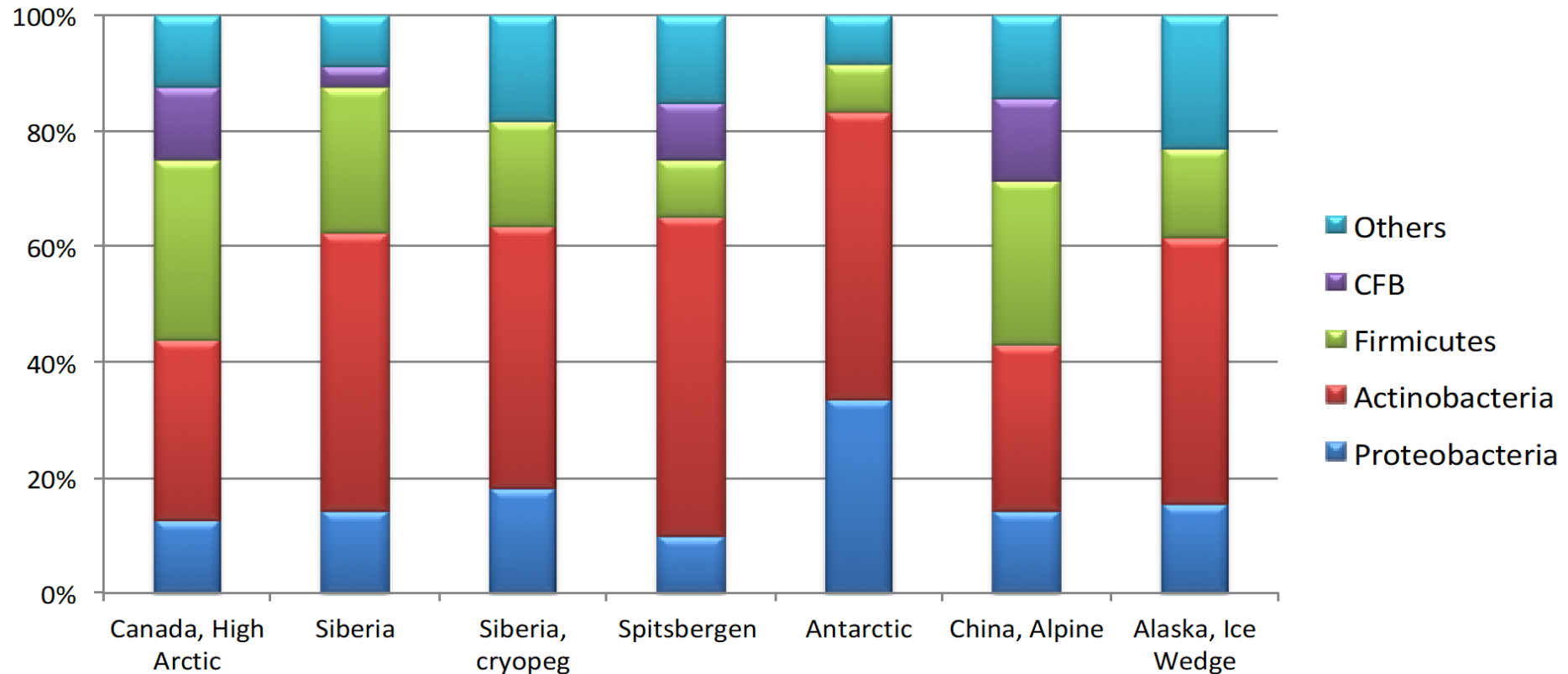
▣ **Total cell counts, microbial biomass and viable counts in permafrost**

Region	Sample & Age, yrs	Total count, Cells/g	Biomass mg/g	Viable count, CFU/g	Reference
Siberia	Sediments 7K-3M	10^7 - 10^9	10^{-5} - 10^{-3}	10^5 - 10^8 (aerobic) 10 - 10^7 (anaerobic)	<i>Vishnivetskaya 2000; Rivkina 1998</i>
	Sands 30K	10^7 - 10^8	10^{-5} - 10^{-4}	10^2 - 10^5	<i>Vorobyova 1997</i>
	Cryopegs 120K	10^7	10^{-5}	10^2 - 10^6	<i>Gilichinsky 2005</i>
Spitsbergen	2.4K	10^9	10^{-3}	10^5	<i>Hansen 2007</i>
High Canadian Arctic	Sediments 7K	10^7	10^{-5}	10^3	<i>Steven 2007</i>
Tibet Plateau	30K	ND	ND	10^2 - 10^5	<i>Zhang 2007</i>
Antarctic	Sediments 20K-8M	10^5 – 10^6	10^{-7} - 10^{-6}	10^2 - 10^4 (aerobic) 10 - 10^3 (anaerobic)	<i>Gilichinsky 2007</i>

Cultivable Bacterial community depends on growth medium

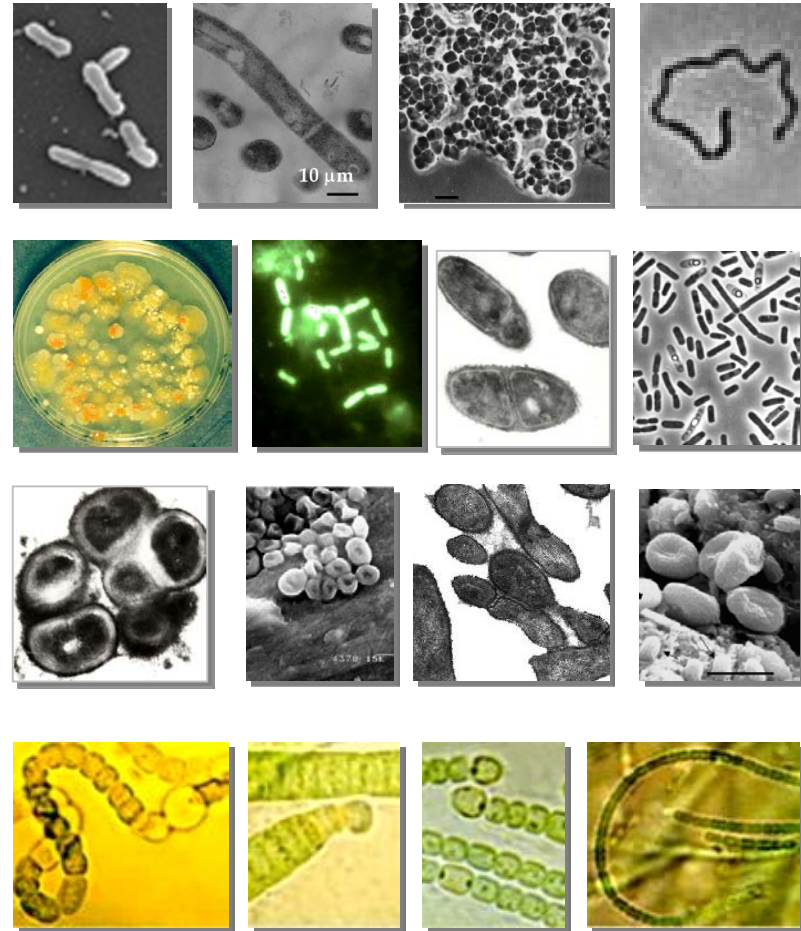


Cultivable Bacterial Community Structure Based on 16S rRNA



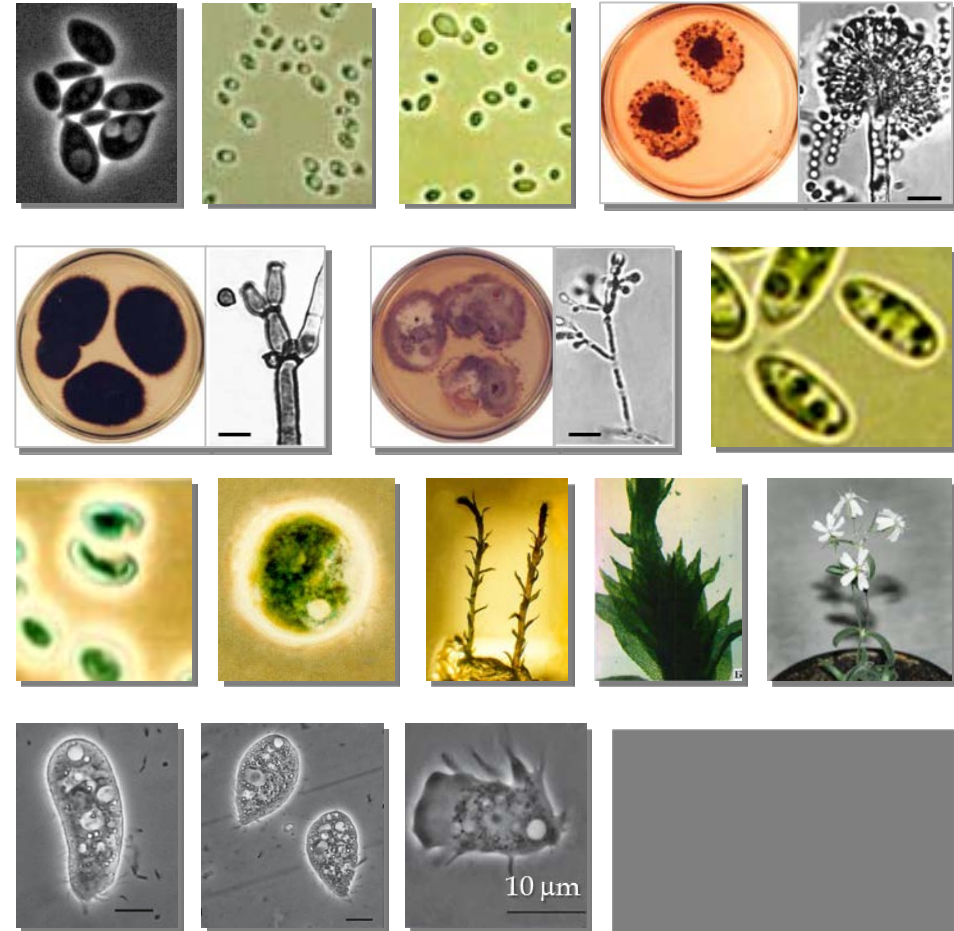
Microbial diversity isolated from permafrost

PROKARYOTIC



Archaea, Bacteria, Cyanobacteria

EUKARYOTIC



Yeasts, Fungi, Green Algae, Moss, Vascular Plant, Protista, Nematode

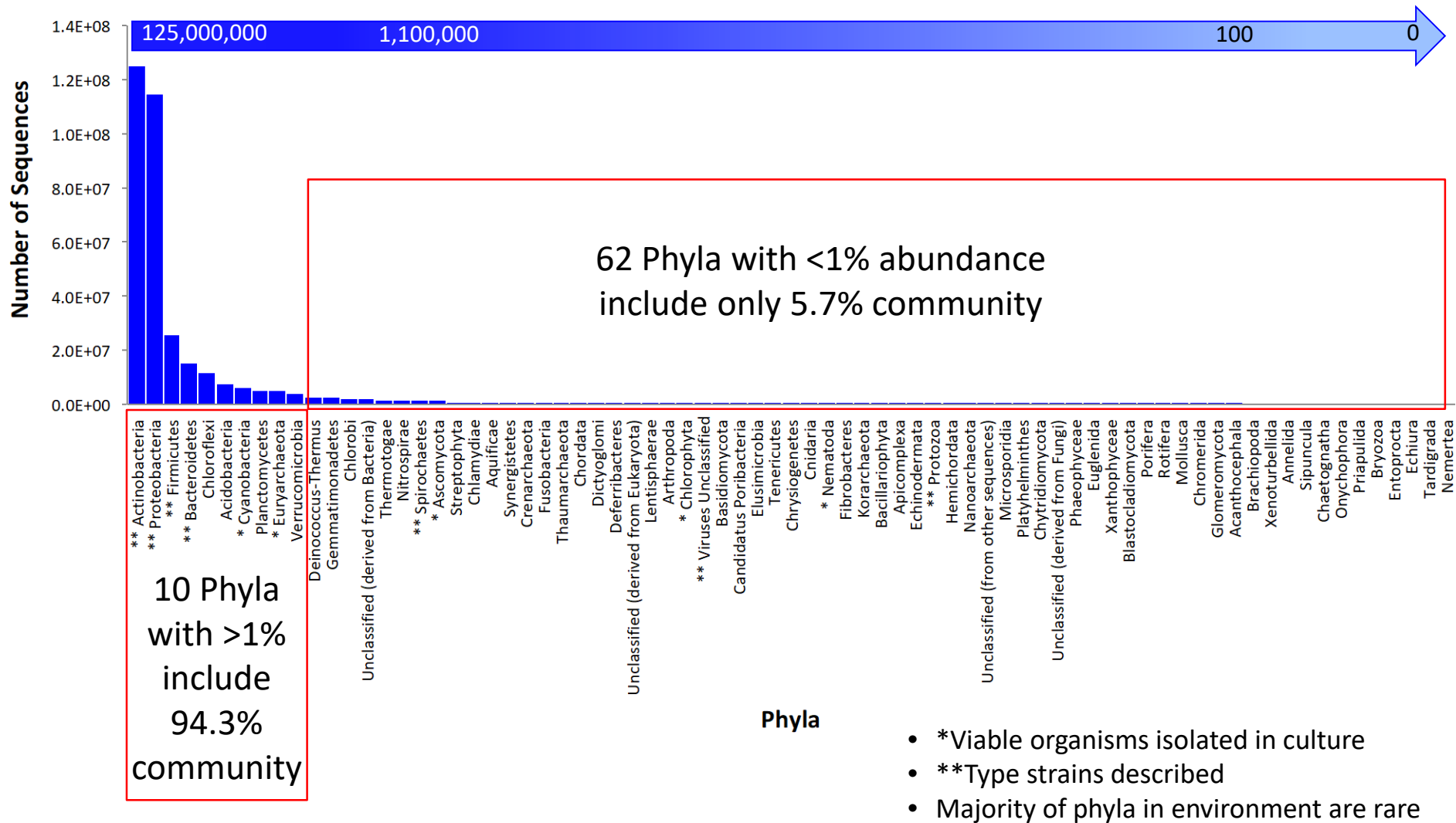
Type Strains Isolated from Permafrost

Location	Age, x1000 yrs	Cultured microorganisms determined as a new species
Kolyma-Indigirka Lowland, Russia	5-1000	<u>Methanogenic Archaea:</u> <i>Methanobacterim veterum</i> sp. nov.; <i>Methanobacterium arcticum</i> sp. nov. <u>Prokaryotes:</u> <i>Carnobacterium inihbens</i> subsp. <i>gilichinskyi</i>; <i>Exiguobacterium sibircum</i> sp. nov.; <i>Sphaerochaeta associata</i> sp.nov.; <i>Psychrobacter arcticus</i> sp. nov. <u>Eukaryotes, Protista:</u> <i>Flamella pleistocenica</i>; <i>Flamella beringiania</i> <u>Giant viruses:</u> <i>Pythovirus sibericum</i>; <i>Mollivirus sibericum</i>
Gydanskiy Peninsula, Russia	8-34	<u>Prokaryotes:</u> <i>Microbacterium</i> sp. Gd 4-13 <u>Eukaryotes, Protista:</u> <i>Phalansterium arcticum</i>
Mys Chukochii, Cryopeg, Russia	100-120	<u>Prokaryotes:</u> <i>Psychrobacter cryohalolentis</i> sp. nov.; <i>Psychrobacter muriicola</i> sp. nov.; <i>Clostridium algorithilum</i> sp. nov.
Yamal Peninsula, Cryopeg, Russia	100-120	<u>Prokaryotes:</u> <i>Celerinatantimonas yamalensis</i> sp. nov.; <i>Desulfovibrio gilichinskyi</i> sp. nov.
Varandey Peninsula, Cryopeg (Coast of the Barents Sea), Russia	~ 5	<u>Prokaryotes:</u> <i>Desulfovibrio arcticus</i> sp. nov.
Lena River Delta, Russia	Modern, cryosoil	<u>Methanogenic Archaea:</u> <i>Methanosarcina soligelidi</i> sp. nov.
Alaska, Fox tunnel, USA	32	<u>Prokaryotes</u> : <i>Carnobacterium pleistocenium</i> sp. nov.
Canadian High Arctic permafrost	5-7	<u>Prokaryotes:</u> <i>Planococcus halocryophilus</i> sp. nov.; <i>Tumebacillus permanentifrigoris</i> sp. nov.; <i>Clostridium tagluense</i> sp. nov,
Tibetan Plateau, (Western China)	20-30	<u>Prokaryotes</u> <i>Hymenobacter psychrotolerans</i> sp. nov.
Dry Valleys, Antarctica	15	<u>Methanogenic Archaea</u> <i>Methanosarcina lacustris</i> Ant1
Volcanic deposits, Deception Island, Antarctica	0.3	<u>Prokaryotes:</u> <i>Geobacillus</i> sp. D4455, D2355

Permafrost Metagenomes

Total number of permafrost metagenomes = 37

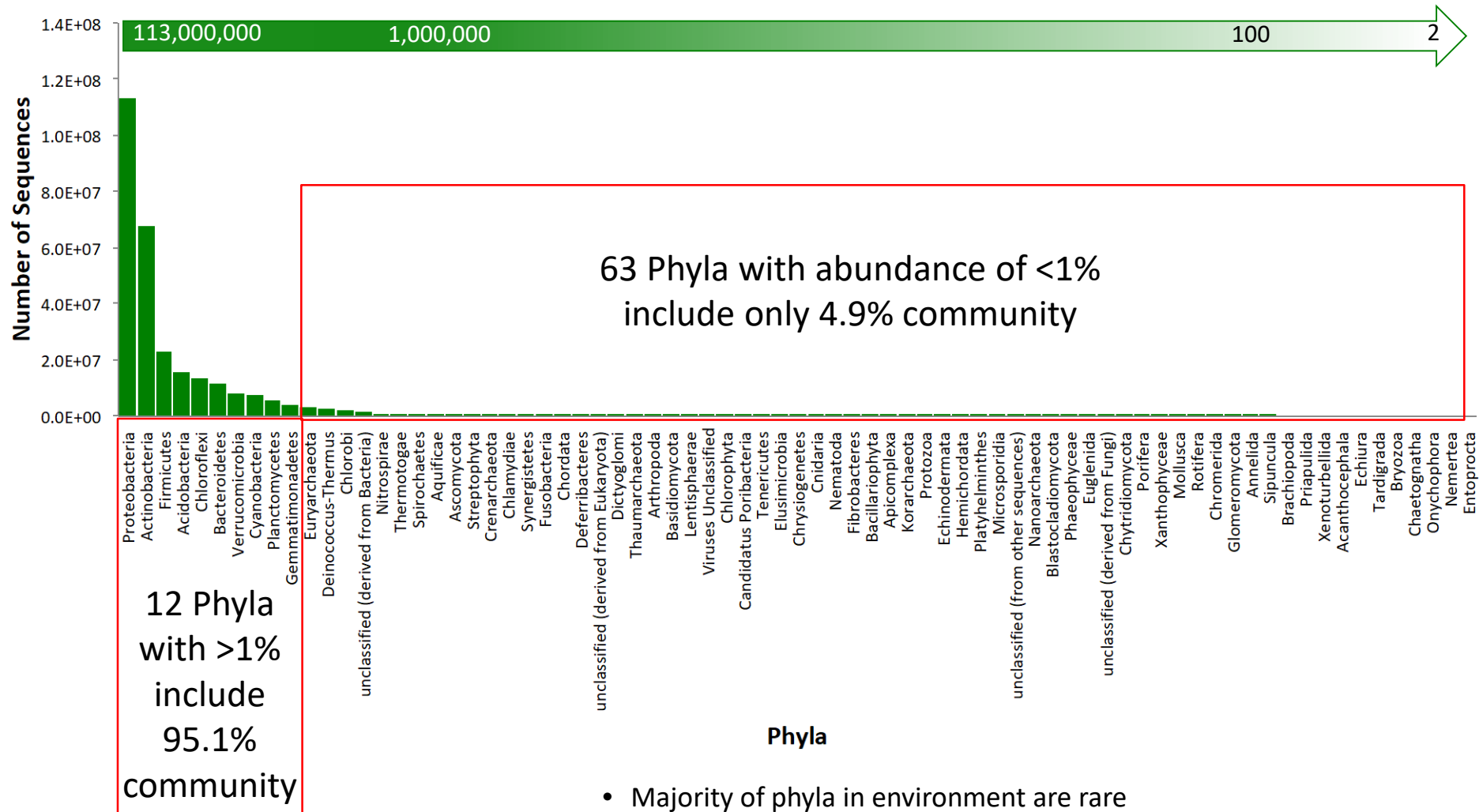
Total number of sequences = 3.39+E08



Active Layer Metagenomes

Total number of metagenomes from active layer = 26

Total number of sequences = 2.89+E08



- Majority of phyla in environment are rare
- Permafrost community represents subset of active layer community

Permafrost: Species with abundance of > 1% (12 species)

N/N	Phylum	Class	Order	Family	Genus	Percentage from total
1	Actinobacteria	Actinobacteria (class)	Actinomycetales	Mycobacteriaceae	Mycobacterium	5.54
2	Actinobacteria	Actinobacteria (class)	Actinomycetales	Streptomycetaceae	Streptomyces	4.32
3	Actinobacteria	Actinobacteria (class)	Solirubrobacterales	Conexibacteraceae	Conexibacter	2.34
4	Actinobacteria	Actinobacteria (class)	Actinomycetales	Frankiaceae	Frankia	2.08
5	Proteobacteria	Alphaproteobacteria	Rhizobiales	Bradyrhizobiaceae	Bradyrhizobium	1.82
6	Actinobacteria	Actinobacteria (class)	Actinomycetales	Nocardioidaceae	Nocardioides	1.78
7	Proteobacteria	Alphaproteobacteria	Rhizobiales	Bradyrhizobiaceae	Rhodopseudomonas	1.74
8	Actinobacteria	Actinobacteria (class)	Actinomycetales	Nocardiaceae	Rhodococcus	1.74
9	Actinobacteria	Actinobacteria (class)	Actinomycetales	Micrococcaceae	Arthrobacter	1.29
10	Proteobacteria	Betaproteobacteria	Burkholderiales	Burkholderiaceae	Burkholderia	1.18
11	Firmicutes	Clostridia	Clostridiales	Clostridiaceae	Clostridium	1.10
12	Acidobacteria	Solibacteres	Solibacterales	Solibacteraceae	Candidatus Solibacter	1.01

Active Layer: Species with abundance of > 1% (16 species)

N/N	Phylum	Class	Order	Family	Genus	Percentage from total
1	Actinobacteria	Actinobacteria (class)	Actinomycetales	Streptomycetaceae	Streptomyces	3.34
2	Acidobacteria	Solibacteres	Solibacterales	Solibacteraceae	Candidatus Solibacter	2.74
3	Proteobacteria	Alphaproteobacteria	Rhizobiales	Bradyrhizobiaceae	Bradyrhizobium	2.66
4	Proteobacteria	Alphaproteobacteria	Rhizobiales	Bradyrhizobiaceae	Rhodopseudomonas	2.48
5	Actinobacteria	Actinobacteria (class)	Solirubrobacterales	Conexibacteraceae	Conexibacter	2.10
6	Actinobacteria	Actinobacteria (class)	Actinomycetales	Mycobacteriaceae	Mycobacterium	2.06
7	Actinobacteria	Actinobacteria (class)	Actinomycetales	Frankiaceae	Frankia	2.02
8	Proteobacteria	Betaproteobacteria	Burkholderiales	Burkholderiaceae	Burkholderia	1.67
9	Acidobacteria	unclassified (derived from Acidobacteria)	unclassified (derived from Acidobacteria)	unclassified (derived from Acidobacteria)	Candidatus Koribacter	1.34
10	Proteobacteria	Deltaproteobacteria	Desulfuromonadales	Geobacteraceae	Geobacter	1.34
11	Gemmatimonadetes	Gemmatimonadetes (class)	Gemmatimonadales	Gemmatimonadaceae	Gemmatimonas	1.24
12	Proteobacteria	Alphaproteobacteria	Rhizobiales	Bradyrhizobiaceae	Nitrobacter	1.18
13	Chloroflexi	Chloroflexi (class)	Chloroflexales	Chloroflexaceae	Roseiflexus	1.14
14	Acidobacteria	Acidobacteria (class)	Acidobacteriales	Acidobacteriaceae	Acidobacterium	1.07
15	Chloroflexi	Ktedonobacteria	Ktedonobacterales	Ktedonobacteraceae	Ktedonobacter	1.03
16	Firmicutes	Bacilli	Bacillales	Bacillaceae	Bacillus	1.02

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