EXCELENCIA SEVERO OCHOA

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

IRB BARCELONA

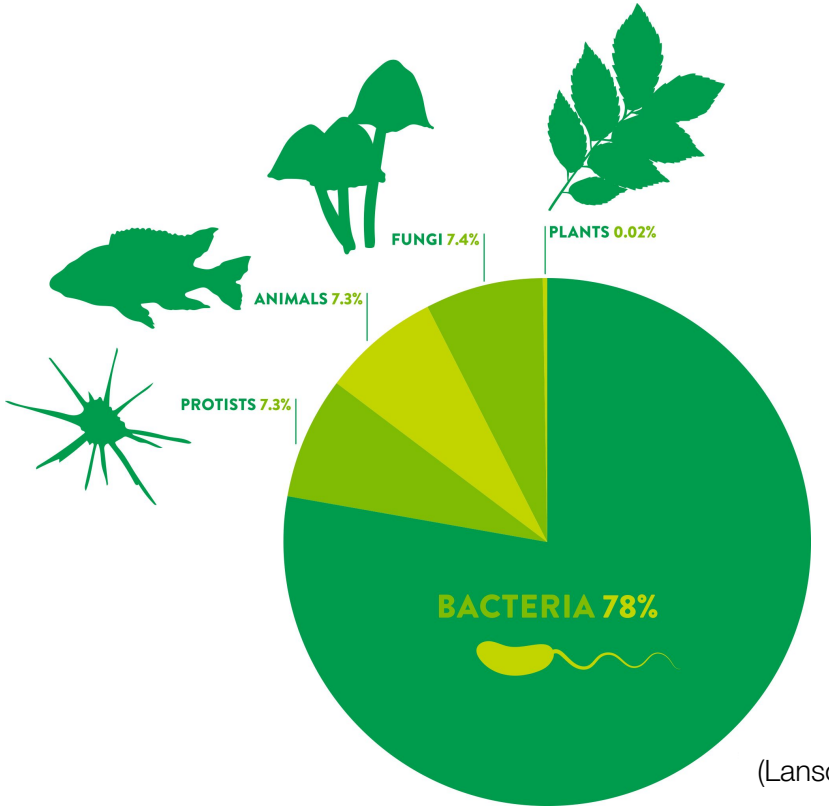
12th BSC SO Doctoral Symposium

Pervasive horizontal transfer and extensive gene duplication shape Asgard archaeal genomes

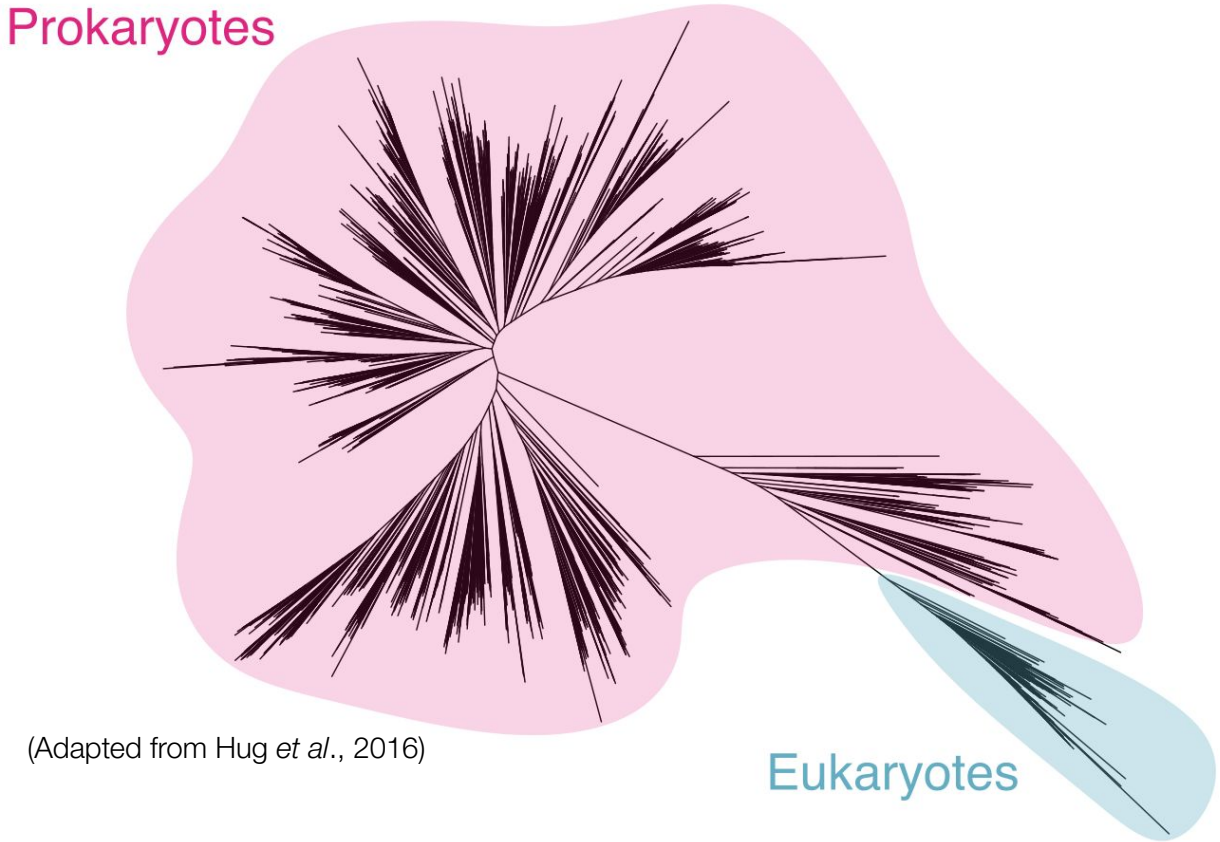
Saioa Manzano-Morales
Toni Gabaldón
Comparative Genomics - Life Sciences
Barcelona Supercomputing Center

Eukaryotes are cool…

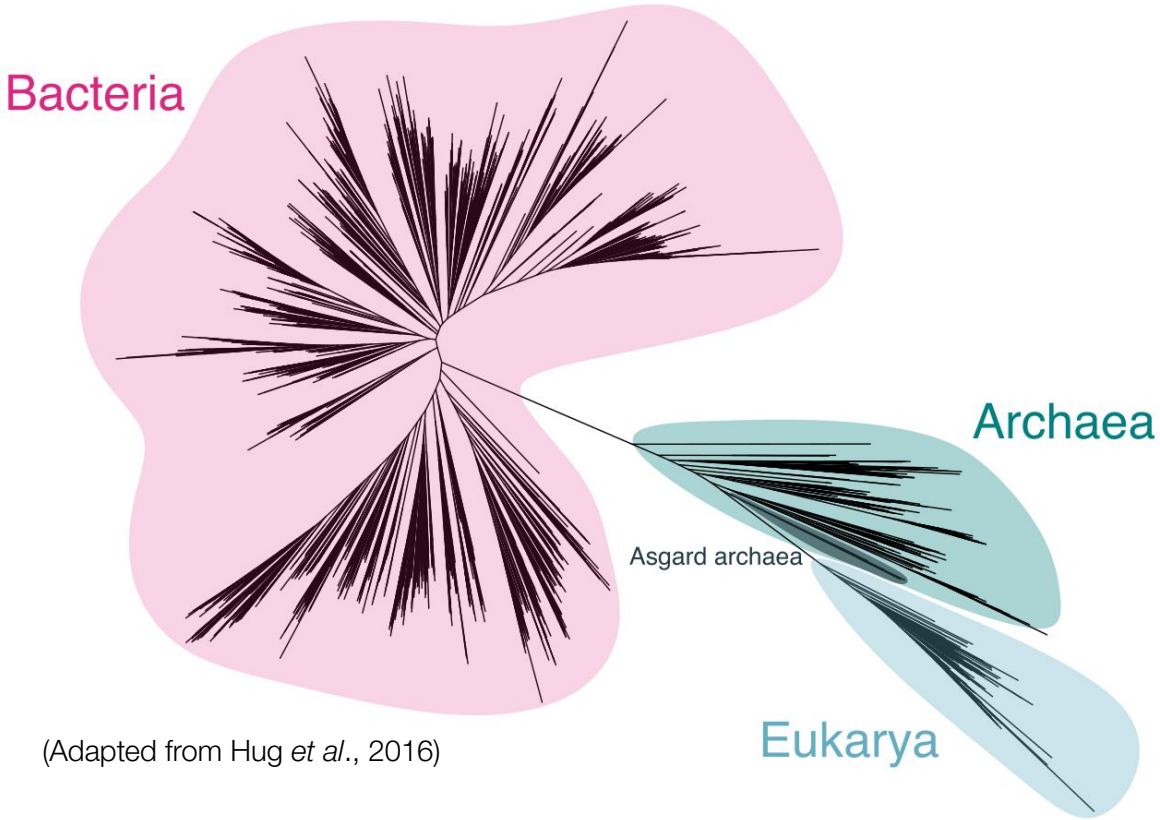
… but the vast majority of life on Earth is prokaryotic!



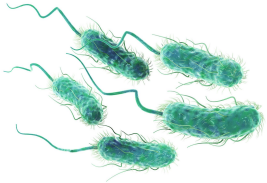
(Lanson *et al.* 2017)

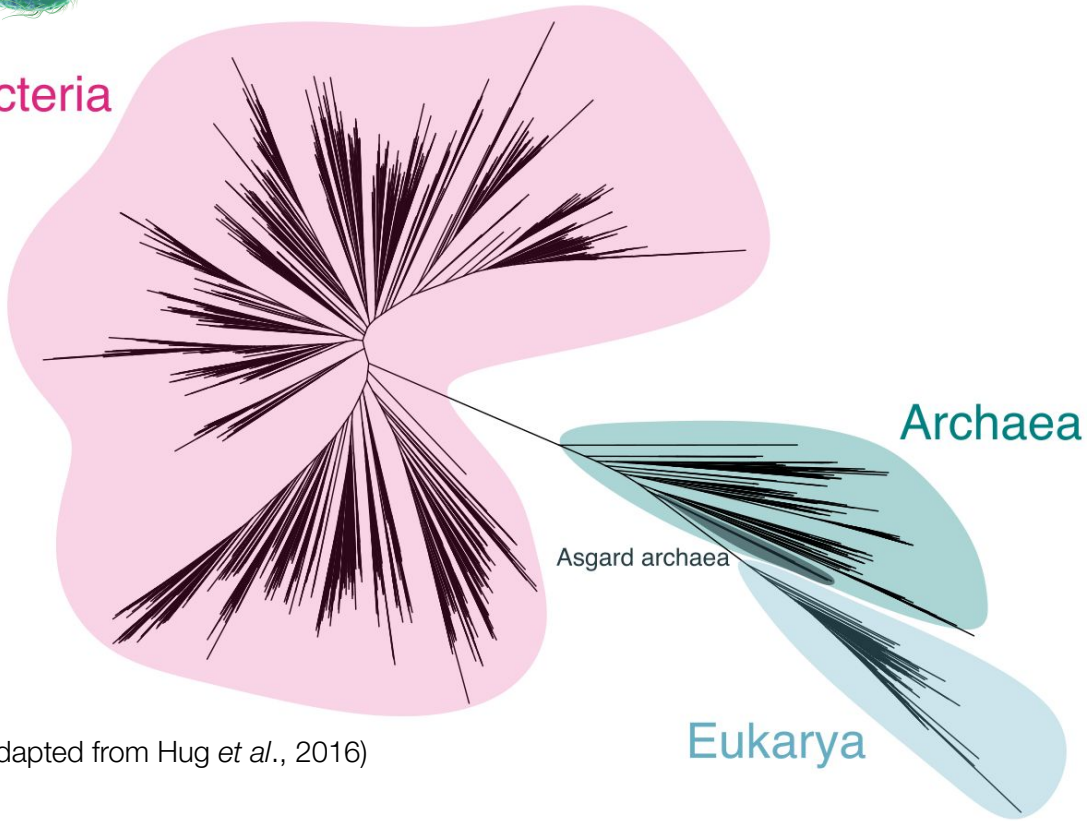


(Adapted from Hug *et al*., 2016)

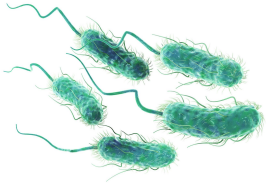


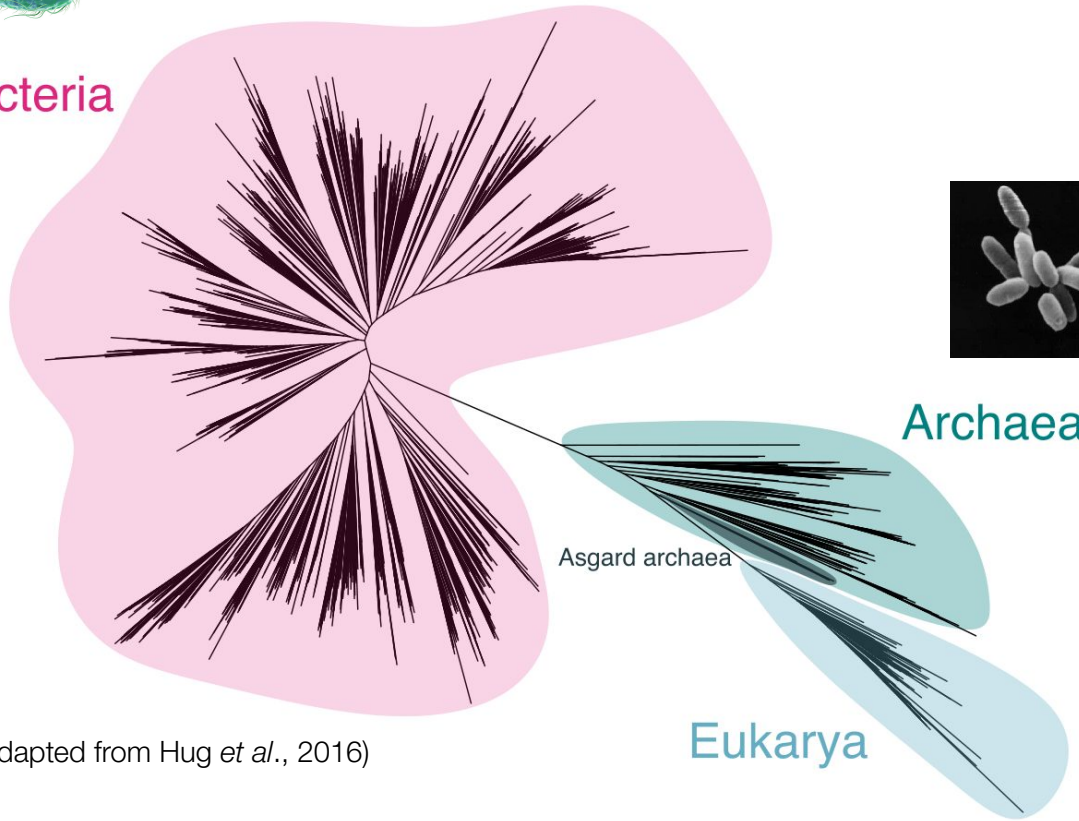
(Adapted from Hug *et al*., 2016)

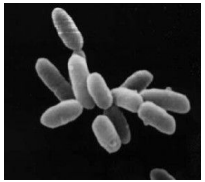




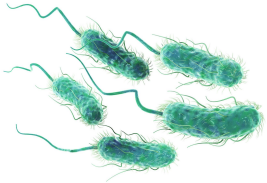
(Adapted from Hug *et al*., 2016)

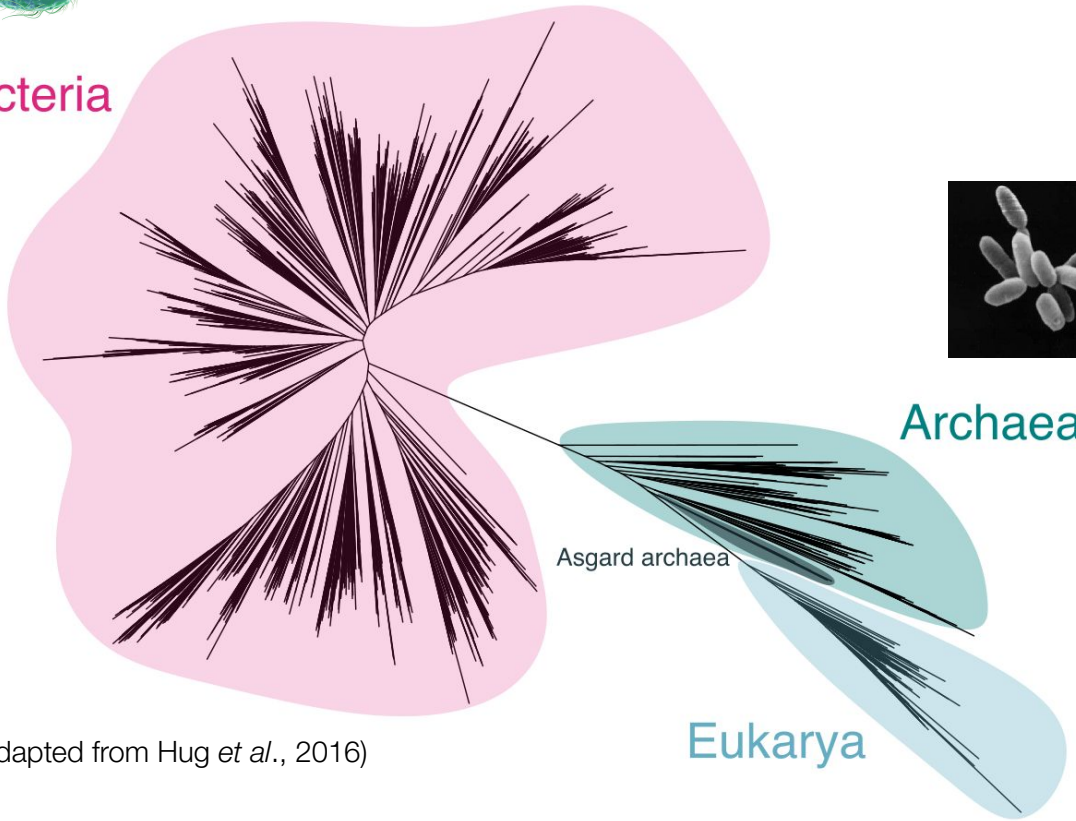


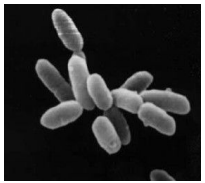




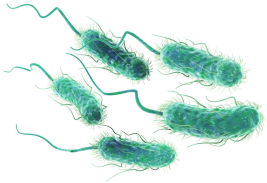
(Adapted from Hug *et al*., 2016)

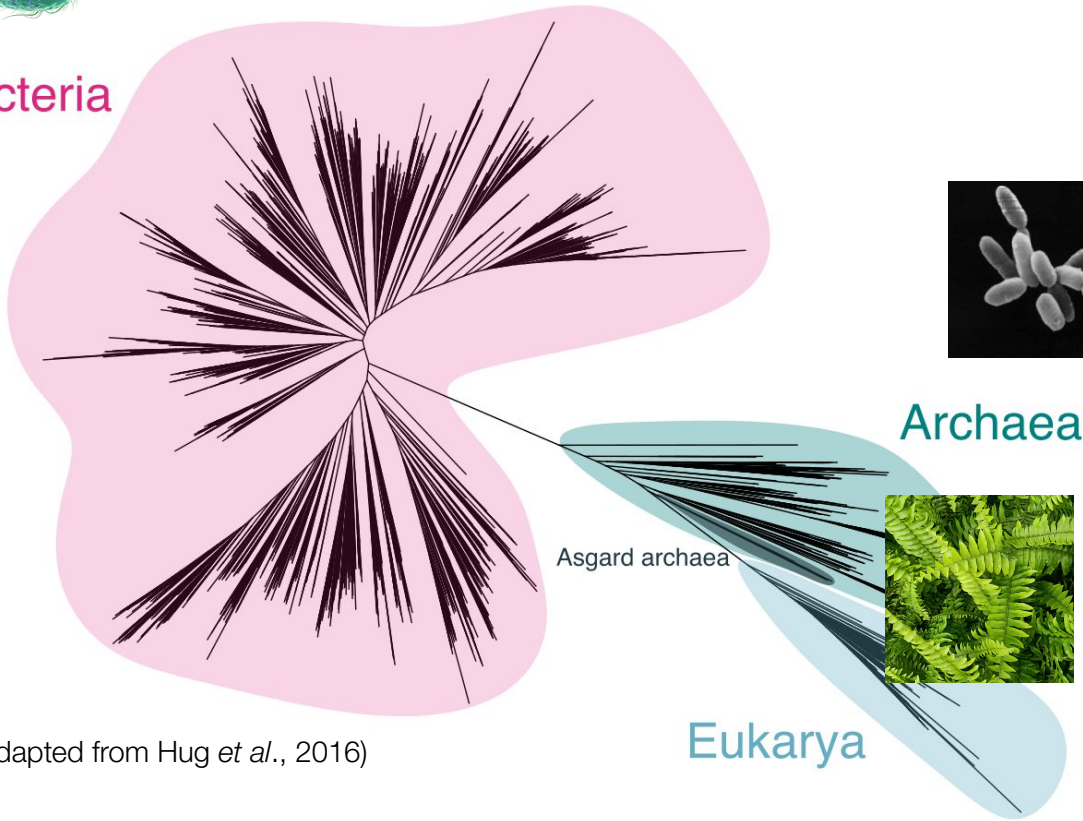


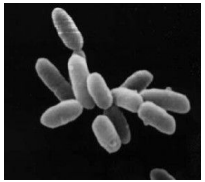




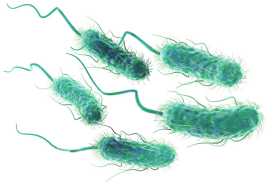
(Adapted from Hug *et al*., 2016)

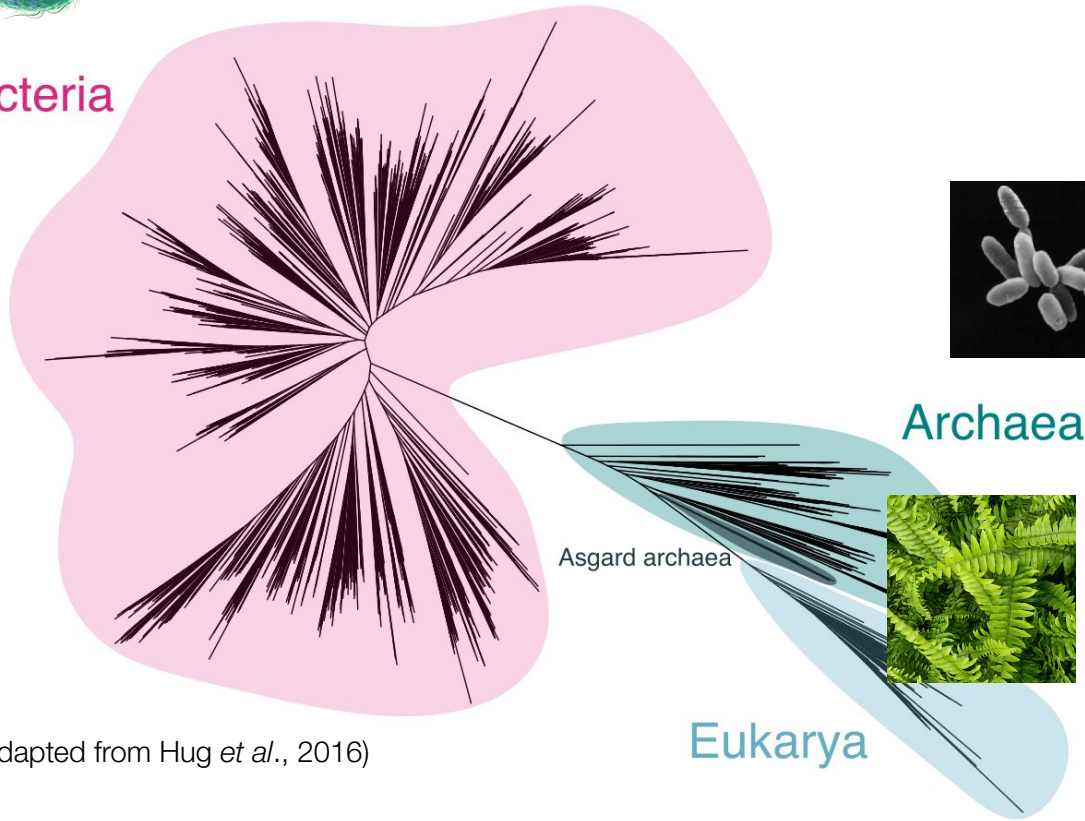


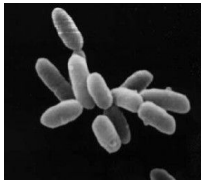




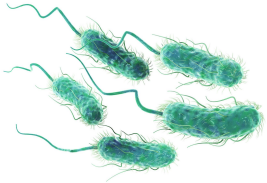
(Adapted from Hug *et al*., 2016)

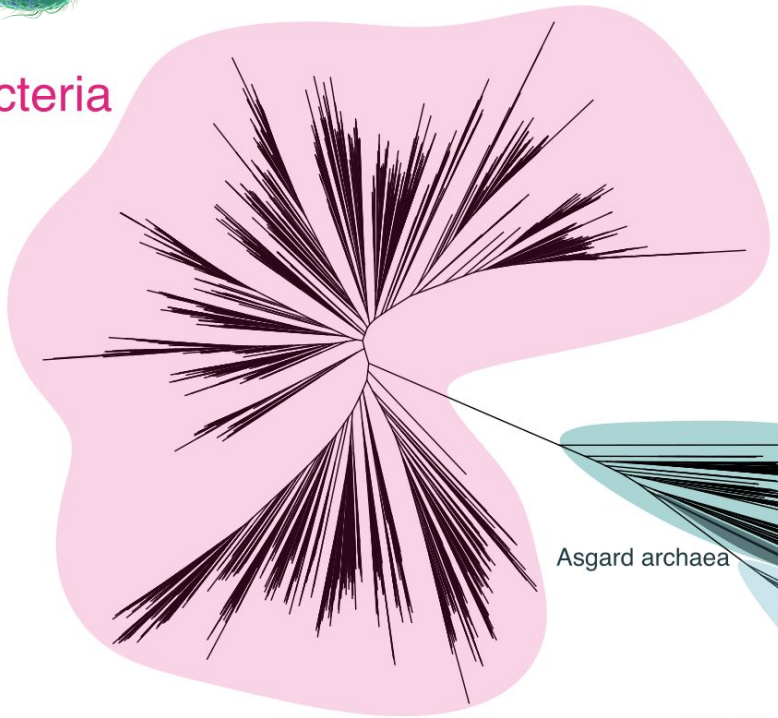


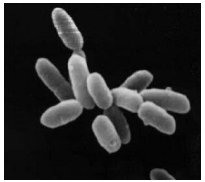


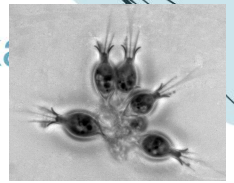


(Adapted from Hug *et al*., 2016)



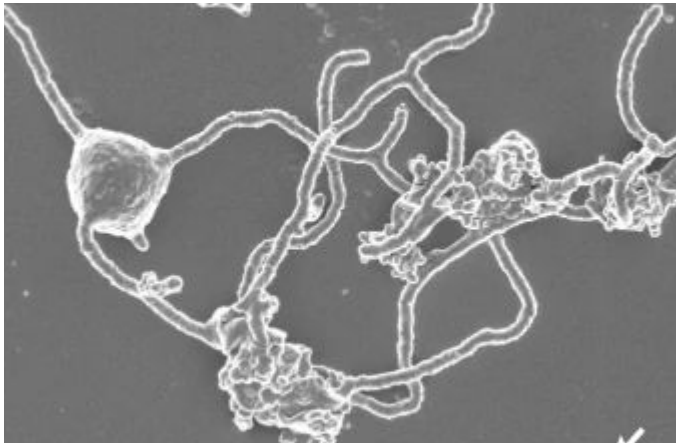




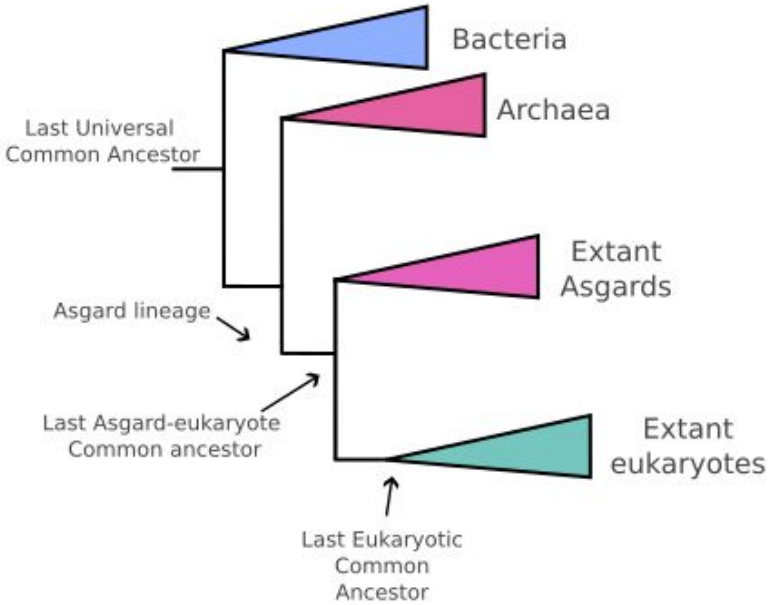


(Adapted from Hug *et al*., 2016)

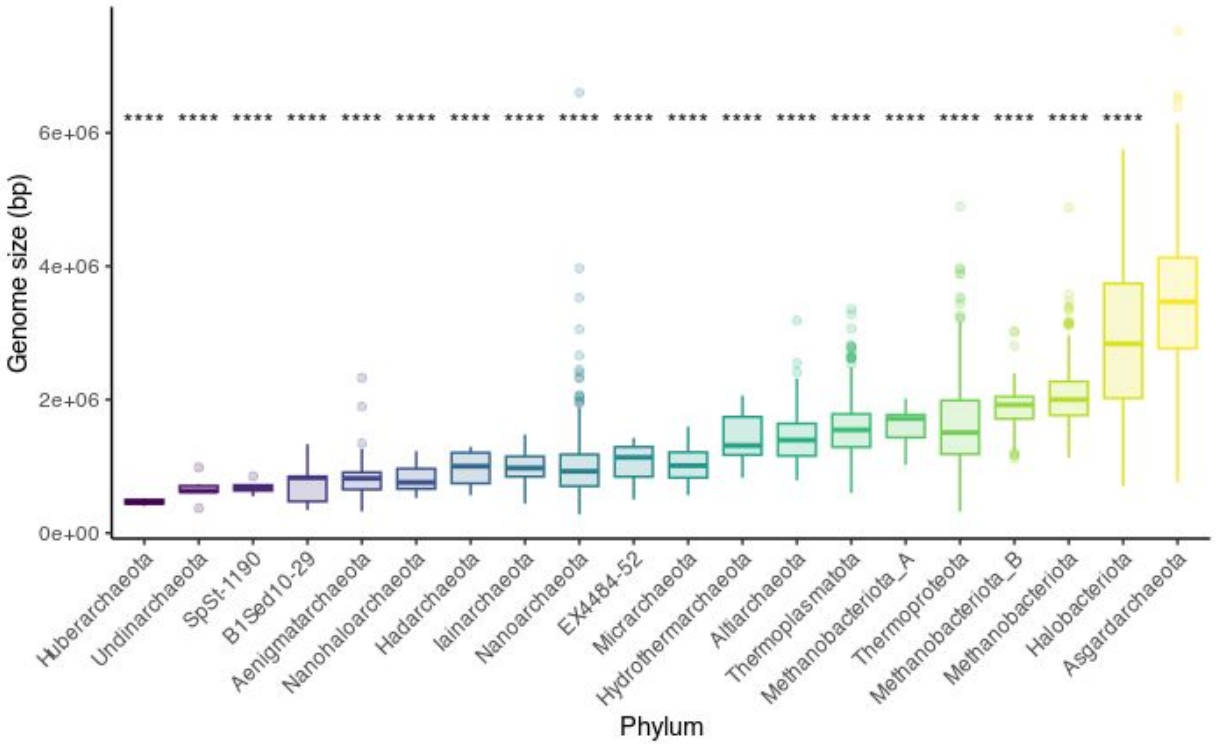
Asgard archaea have a unique phylogenetic placement



(Imachi *et al.* 2020)



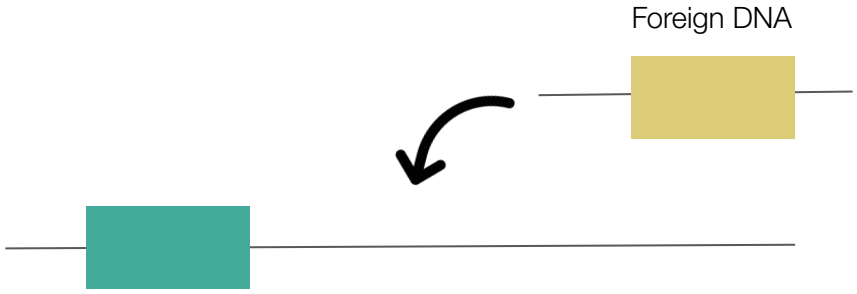
Asgard genome size is significantly larger than other archaea



Genome evolution

Increase

Duplication



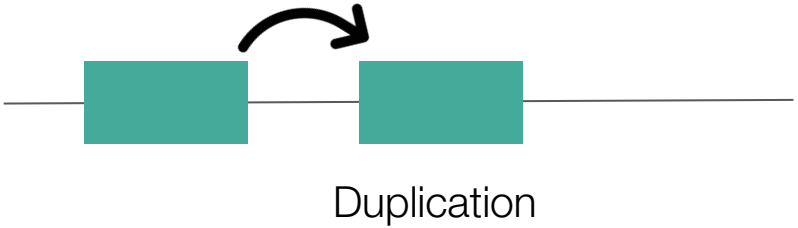
Transfer

Decrease

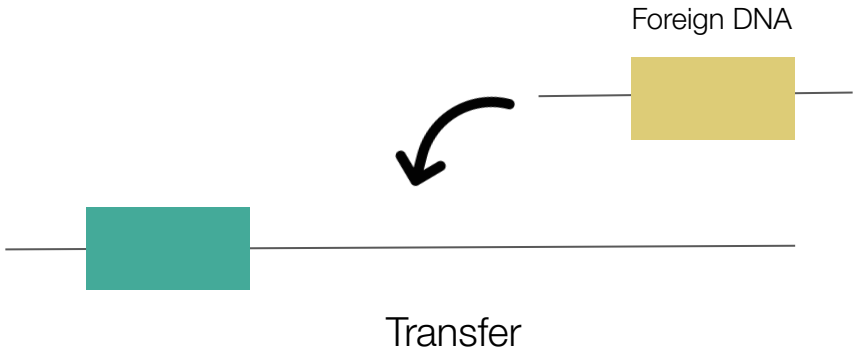
Loss

Genome evolution

Increase

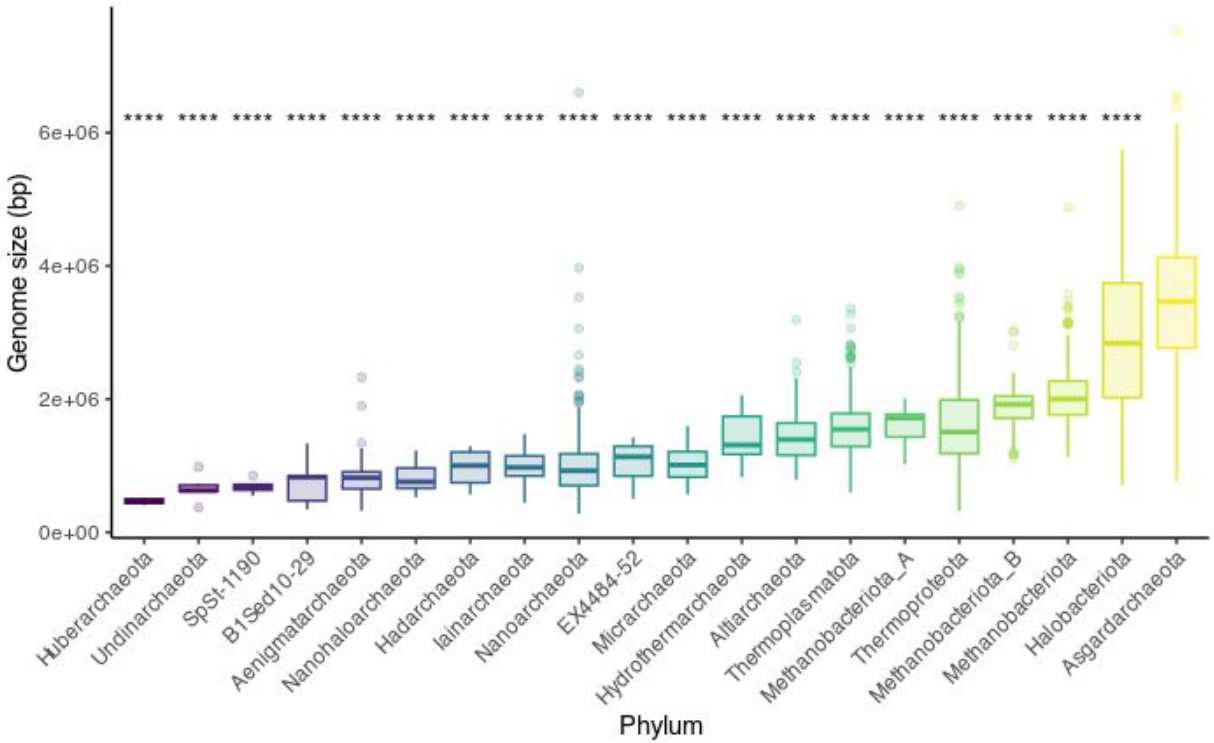


Common in **eukaryotes**



Common in **prokaryotes**

Asgard genome size is significantly larger than other archaea

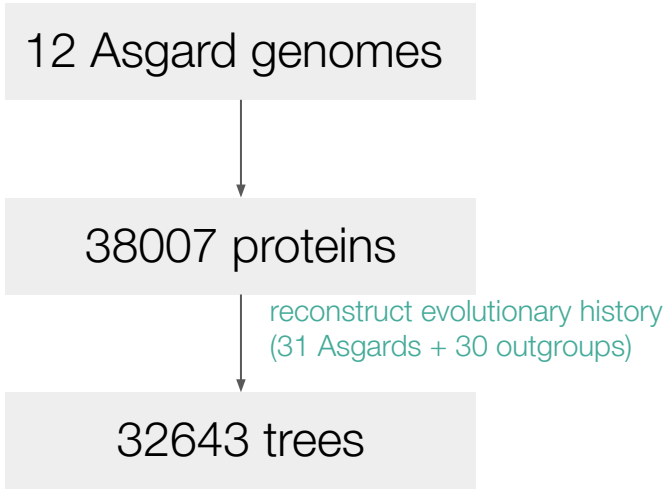


Did Asgards **expand** their genome in a **prokaryote-like** or **eukaryote-like** manner?

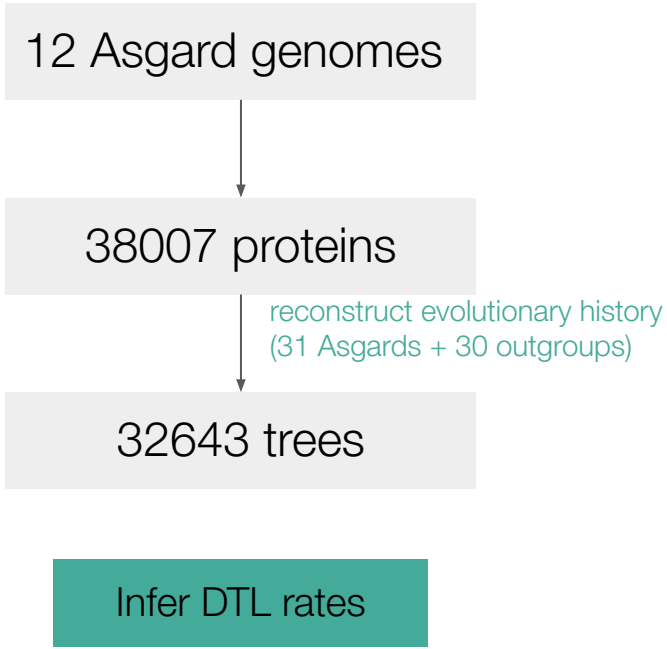
Phylogenomics workflow

12 Asgard genomes

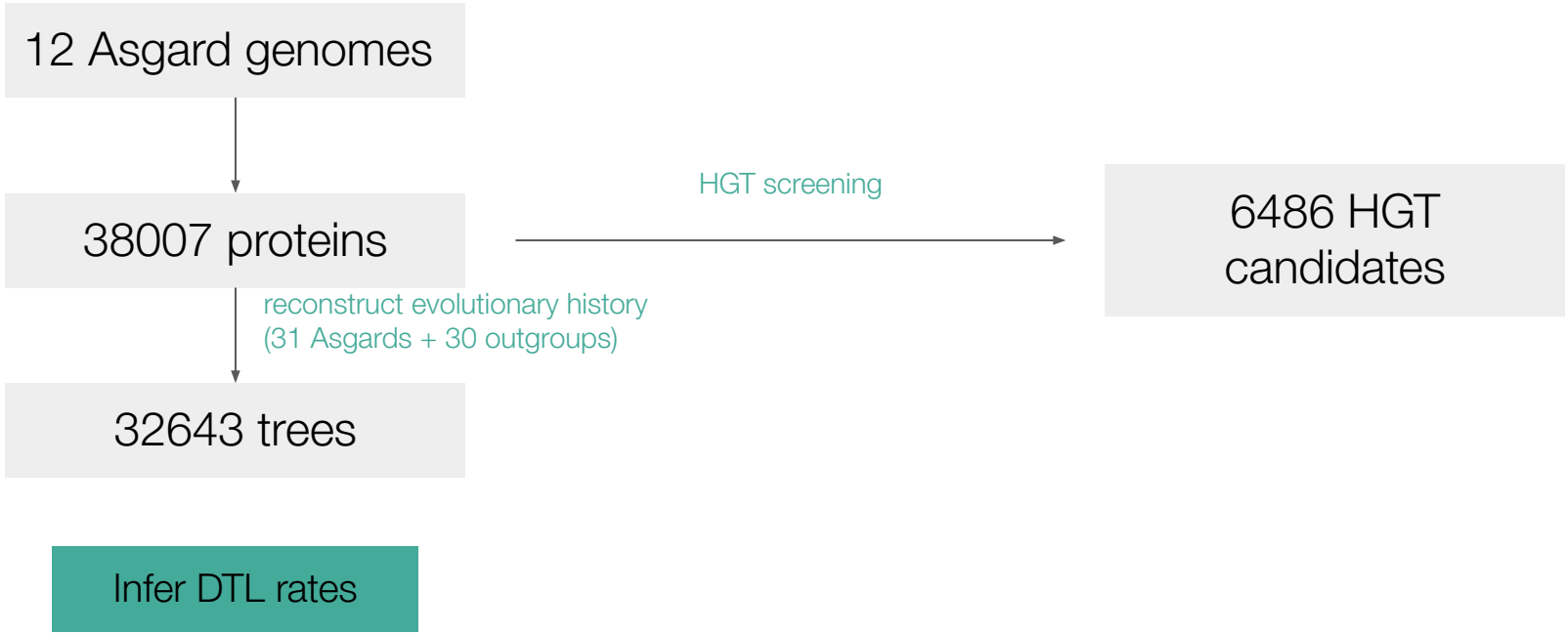
Phylogenomics workflow



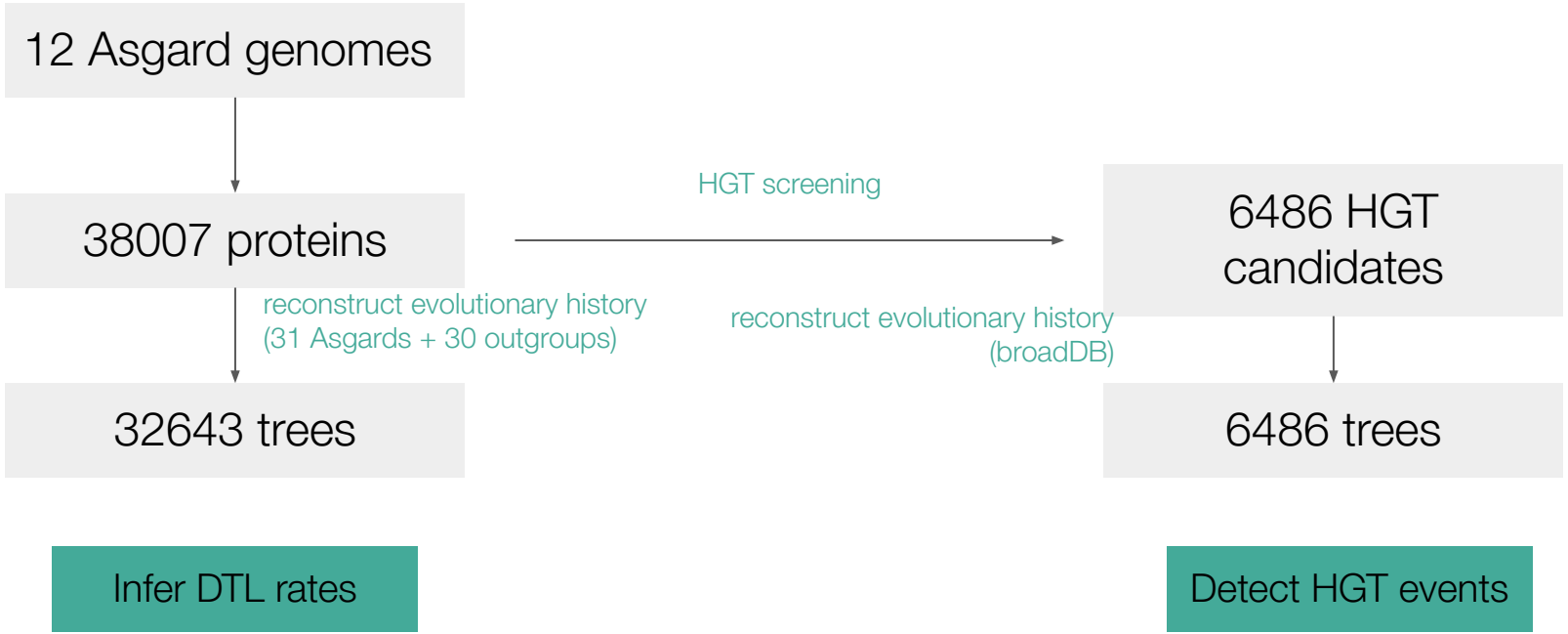
Phylogenomics workflow



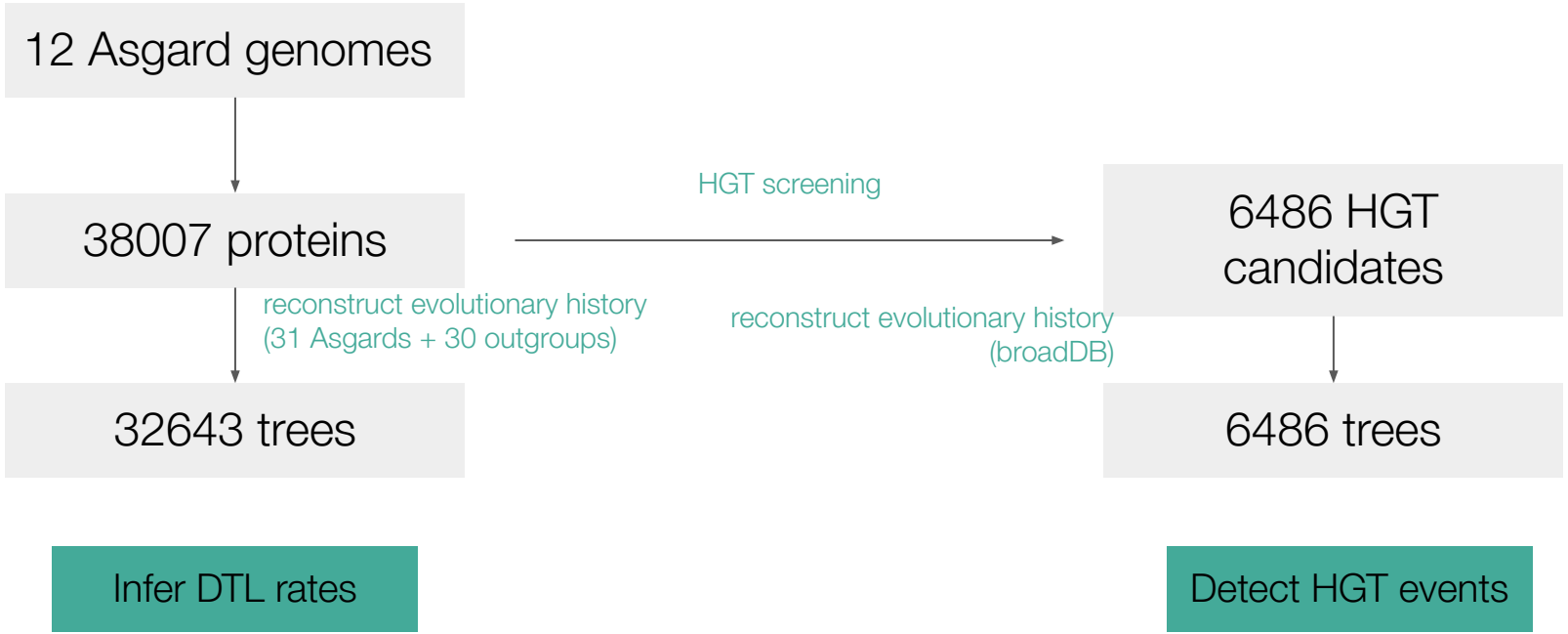
Phylogenomics workflow



Phylogenomics workflow

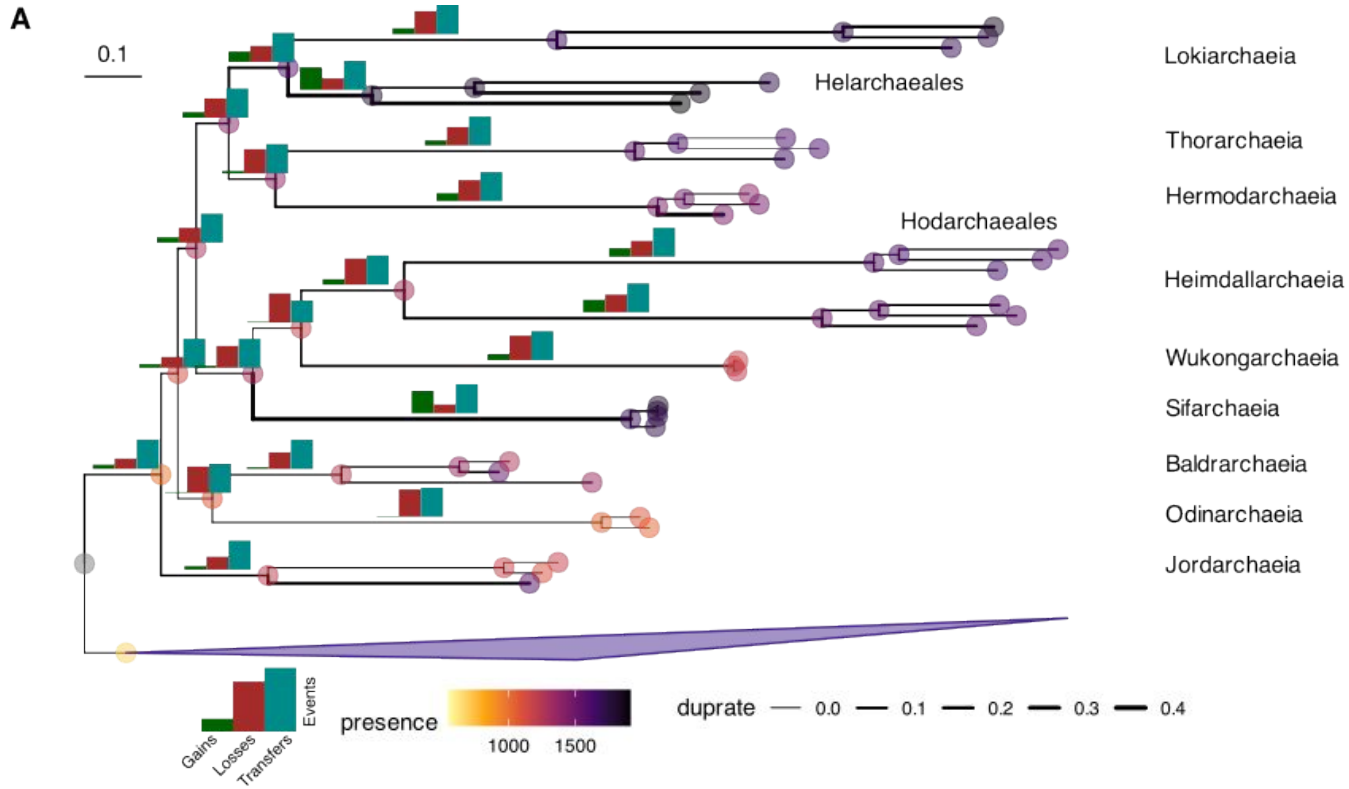


Phylogenomics workflow

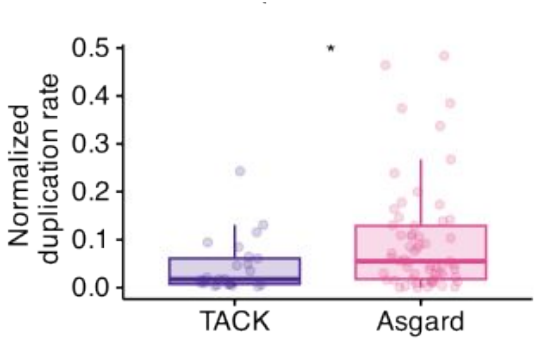


1 tree = 2h x 4 CPU

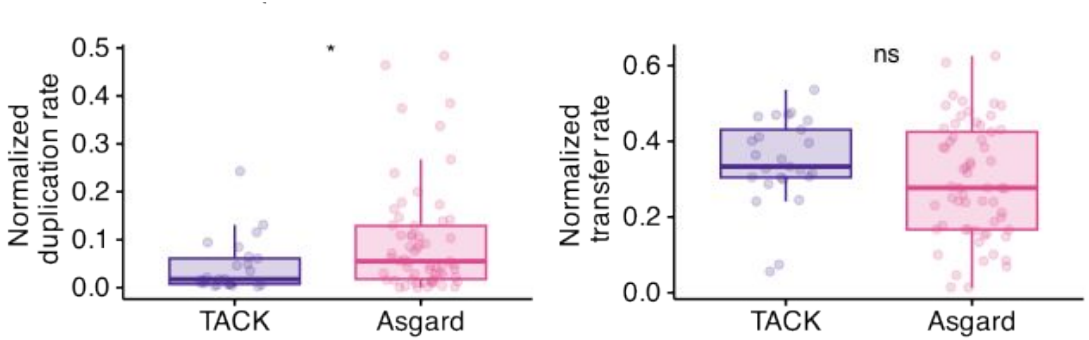
Duplication/loss played a part in the development of the lineages



Asgard archaea have significantly higher duplication rates than their prokaryotic sisters…

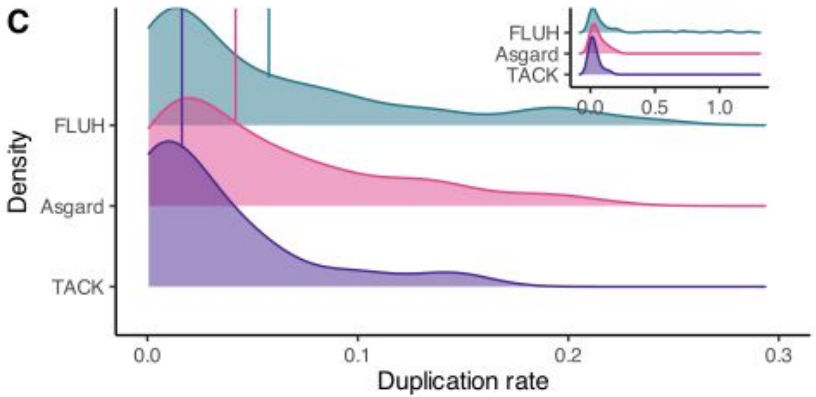


Asgard archaea have significantly higher duplication rates than their prokaryotic sisters…



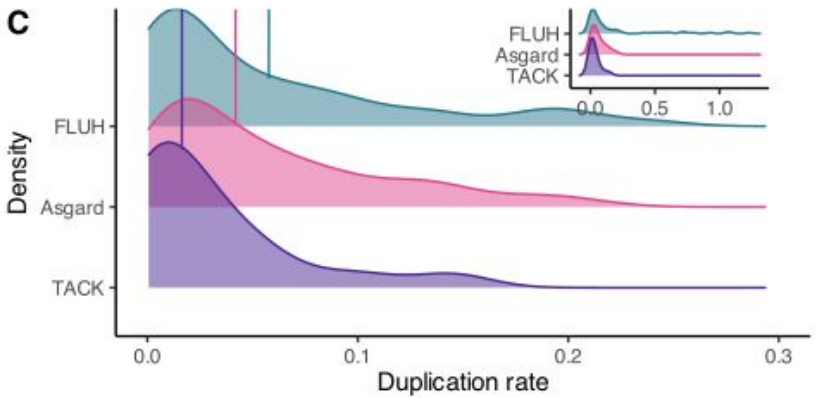
…despite comparable transfer rates!

Asgard duplication rates are an intermediate between “typical” prokaryotes and eukaryotes



FLUH: Free-Living Unicellular Heterotroph (eukaryote)

Asgard duplication rates are an intermediate between “typical” prokaryotes and eukaryotes

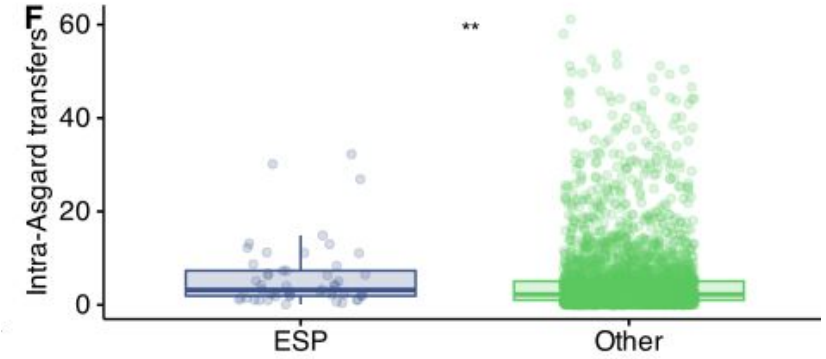


FLUH: Free-Living Unicellular Heterotroph (eukaryote)

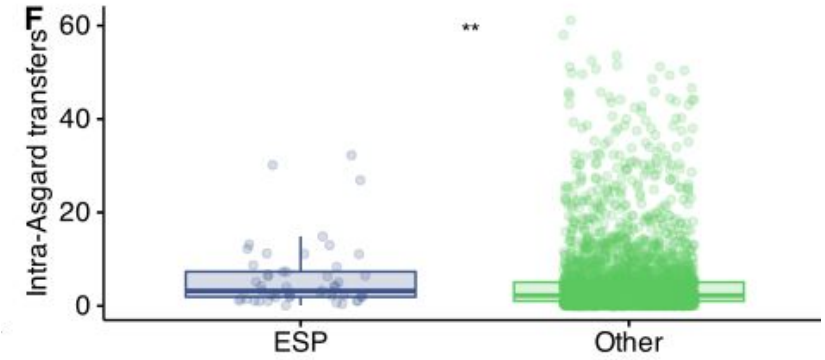
Did Asgards **expand** their genome in a **prokaryote-like** or **eukaryote-like** manner?

Prokaryotic-like in their transfers, (almost) “eukaryotic-like” in their duplications

Eukaryotic Signature Proteins are more prone to intra-Asgard gene transfer

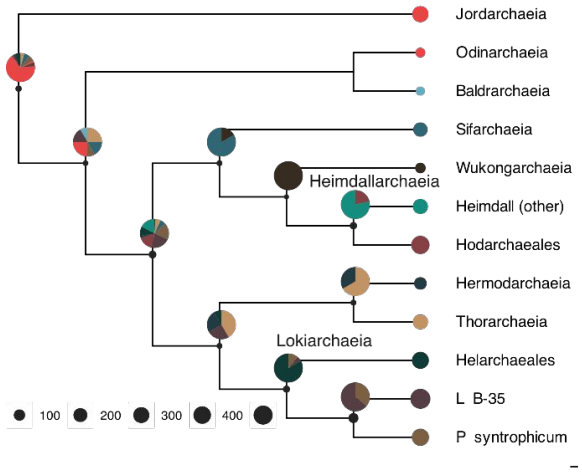


Eukaryotic Signature Proteins are more prone to intra-Asgard gene transfer

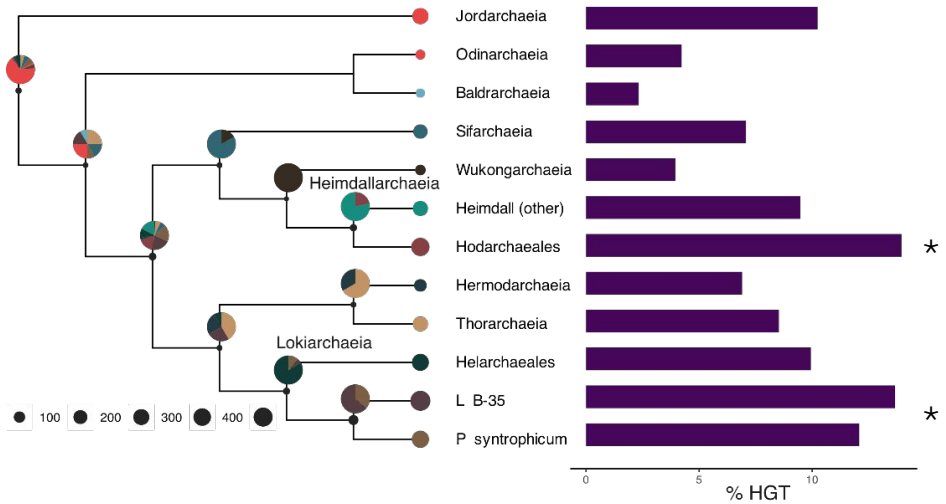


… explaining their patchy distribution across the Asgard tree

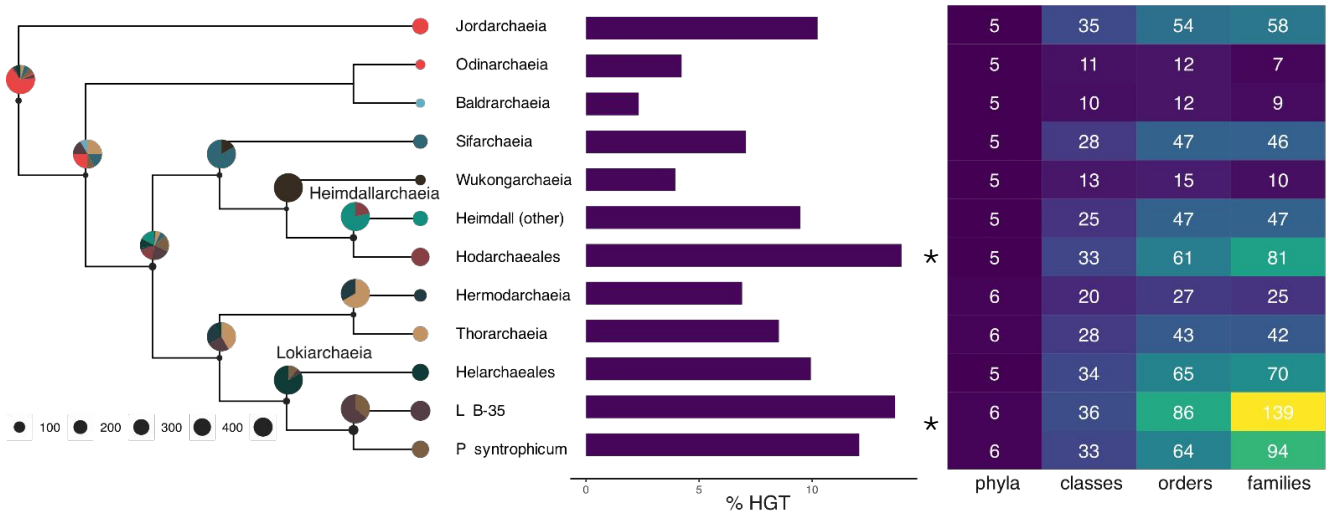
Bacteria-Asgard HGT has been a constant, on-going process across Asgard evolution…



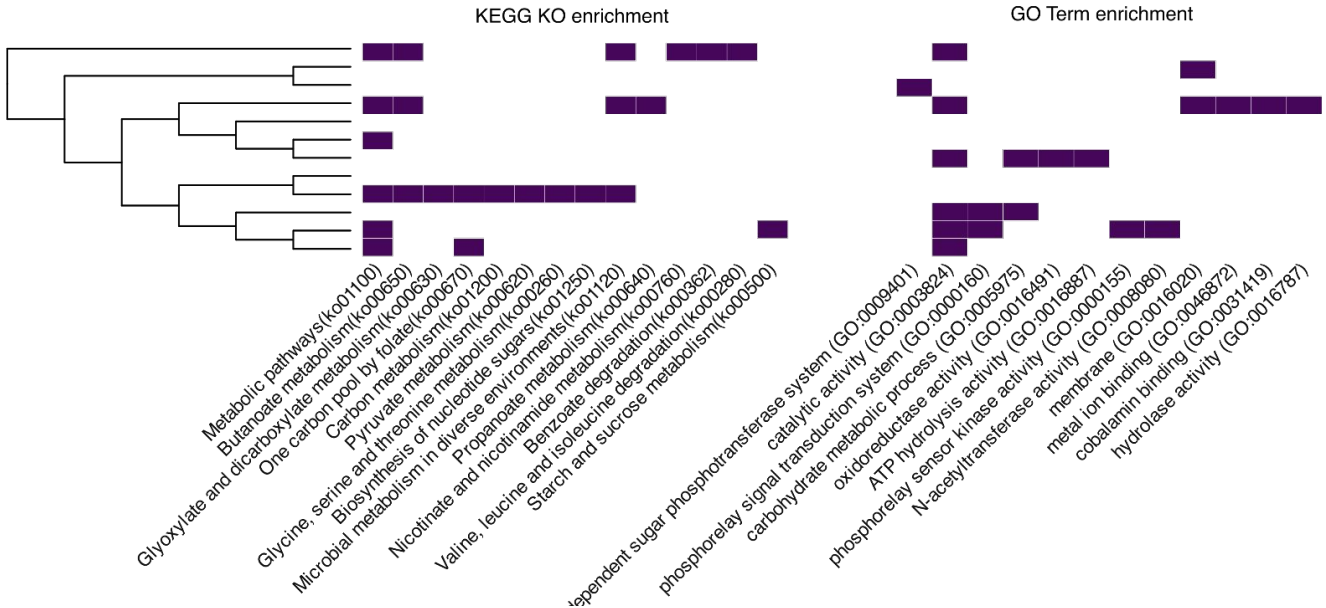
...leading to varying percentages of HGT-derived proteins across lineages…

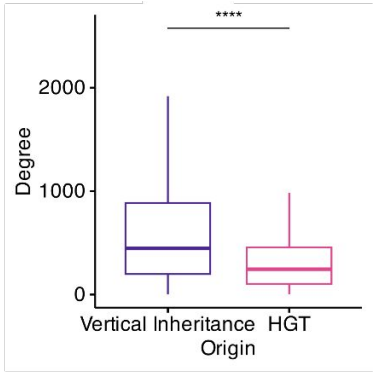


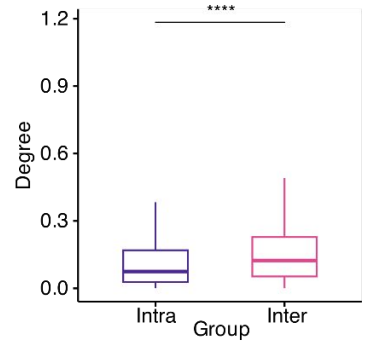
...from a variety of sources



Genes of bacterial origin are enriched in metabolic functions







… and are connected to vertically inherited genes rather than being modular

Take-home messages

- A role for both **gene duplication** and **gene transfer** in shaping Asgard archaeal genomes

Take-home messages

- A role for both **gene duplication** and **gene transfer** in shaping Asgard archaeal genomes
- Pervasive inter- and intra-domain **horizontal gene transfer** of **metabolic genes**

Take-home messages

- A role for both **gene duplication** and **gene transfer** in shaping Asgard archaeal genomes
- Pervasive inter- and intra-domain **horizontal gene transfer** of **metabolic genes**
- Integration in **PPI** network

Comparative Genomics

Toni Gabaldón

Marina
Marcet-Houben

Moisès
Bernabeu

GA: 724173

GBMF9742

12th BSC SO Doctoral Symposium

Pervasive horizontal transfer and extensive gene duplication shape Asgard archaeal genomes

Saioa Manzano-Morales
Toni Gabaldón
Comparative Genomics - Life Sciences
Barcelona Supercomputing Center