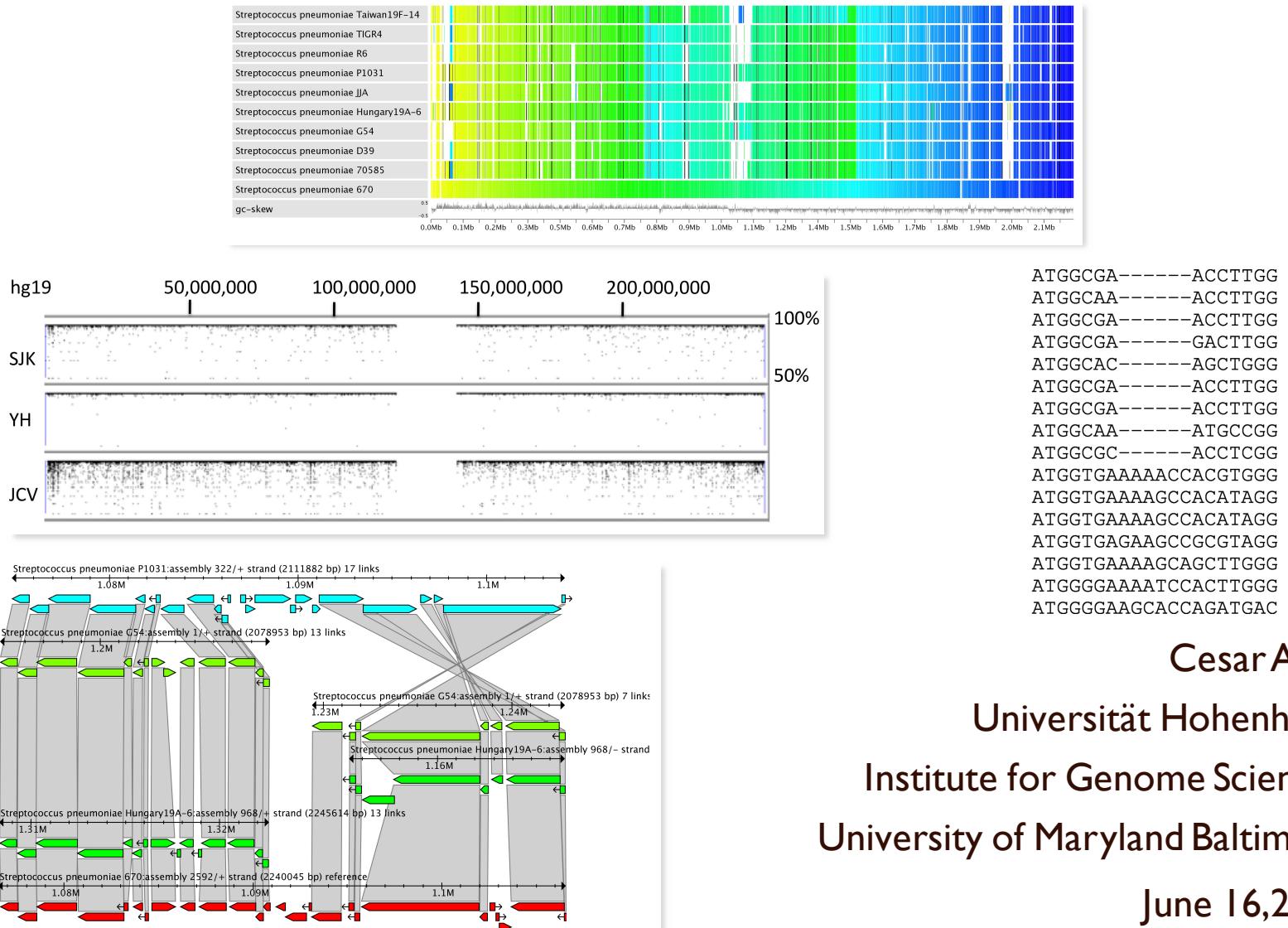


# CloVR Comparative Pipeline



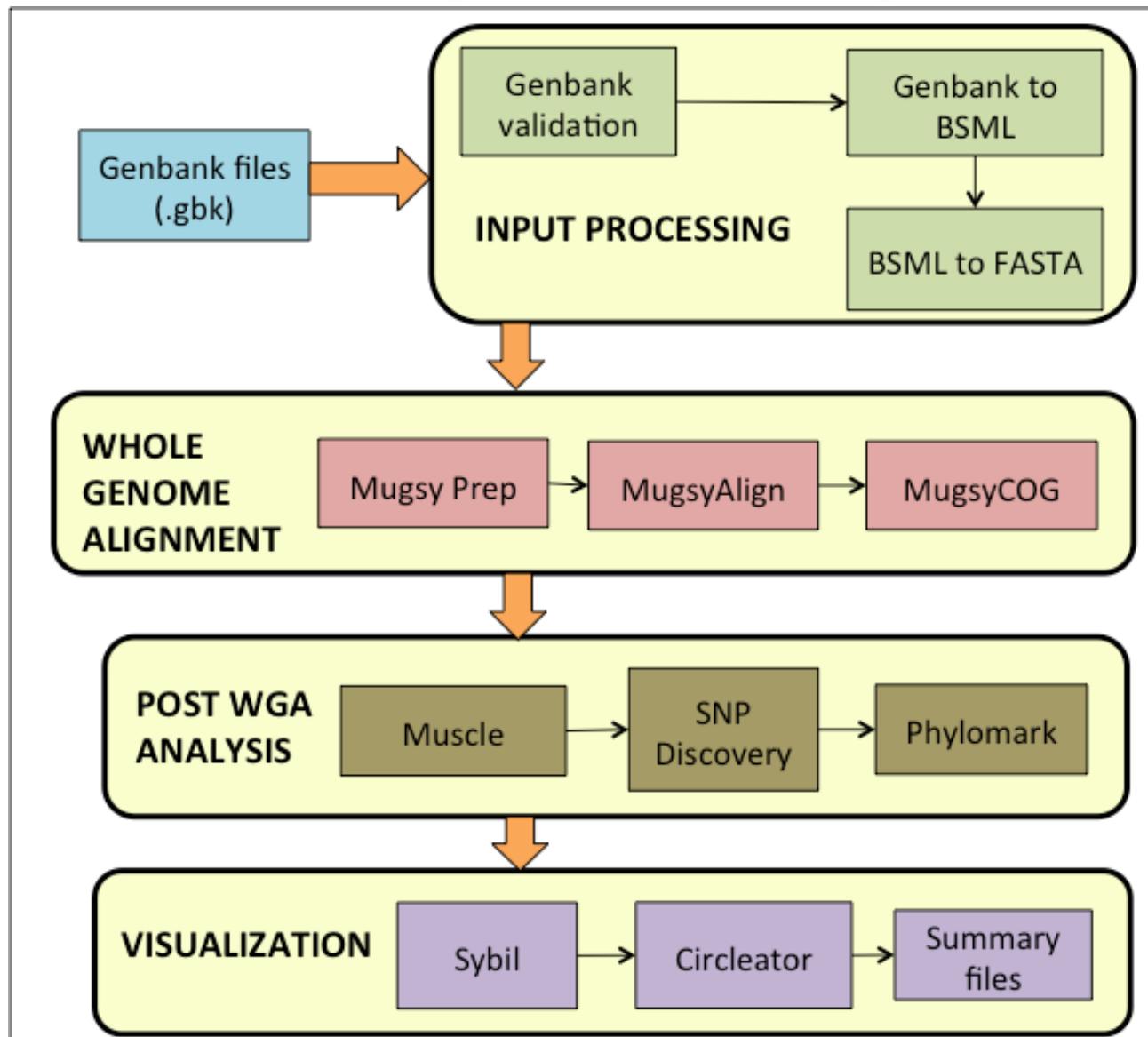
# Outline

- Pipeline Overview
- Whole Genome Alignment (WGA)
- Mugsy-Annotator
- Pipeline Outputs
  - Summary report
  - Mugsy clusters
  - SNP table
  - Visualization
    - Alignment
    - Phylomark
    - Circleator
    - Sybil

# Motivation

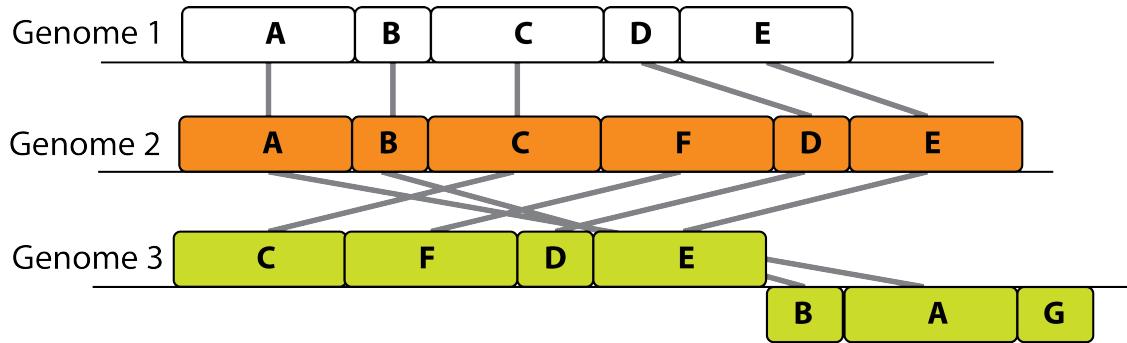
- Functional comparison of several bacterial genomes
- Reference independent analysis
- Phylogenetic trees
- SNP calling
- High throughput, completely automated

# CloVR Comparative Pipeline



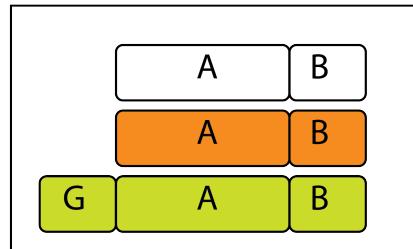
# Whole Genome Alignment

- True global alignment not possible

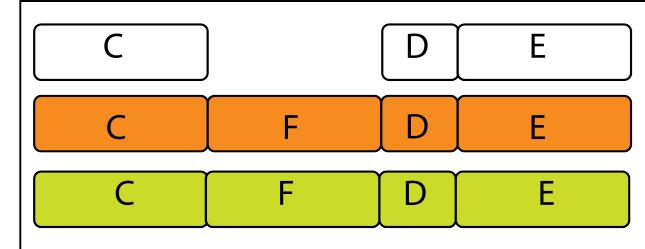


- Set of local alignments (LCBs)

## Locally collinear blocks

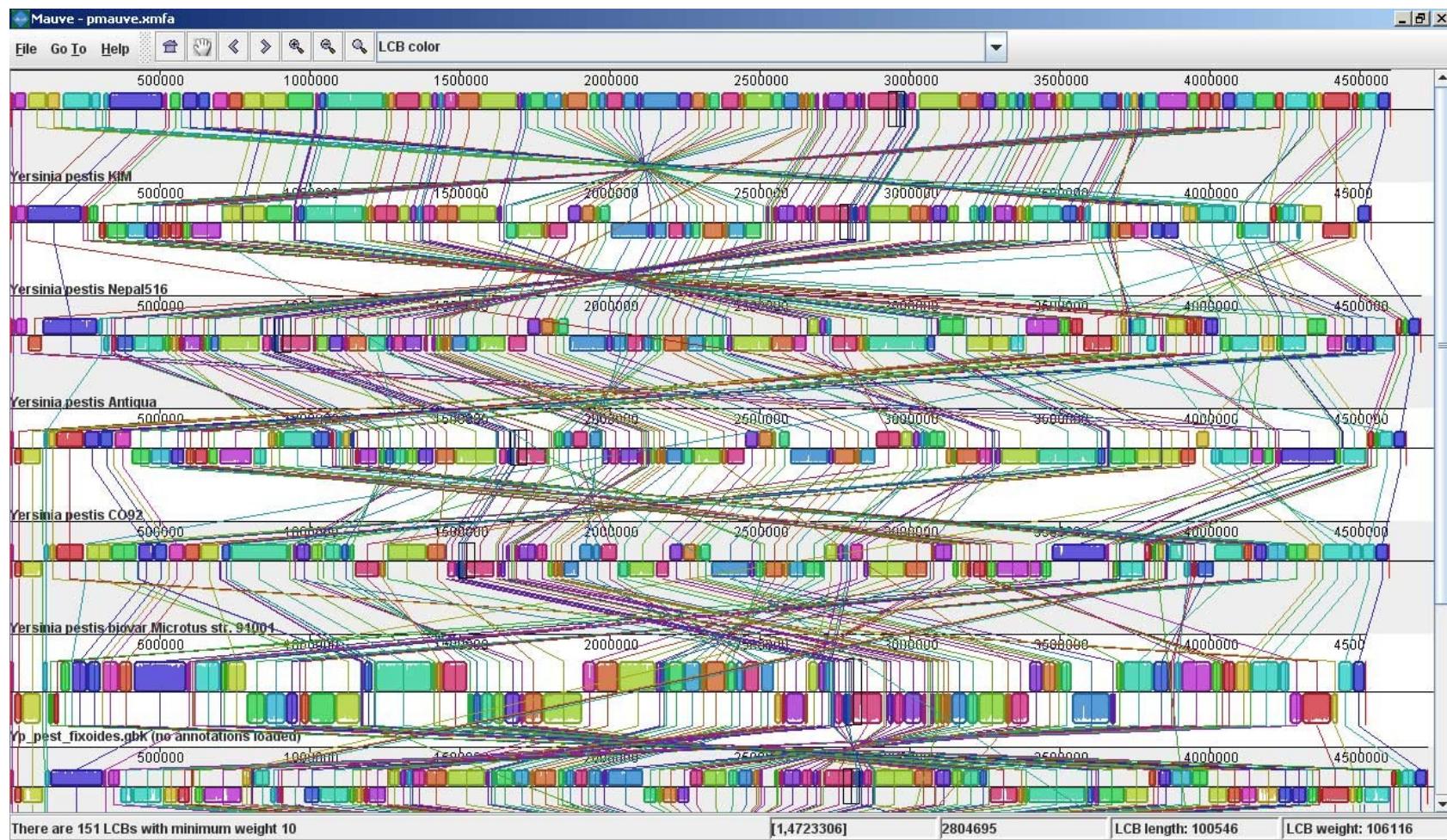


LCB 1



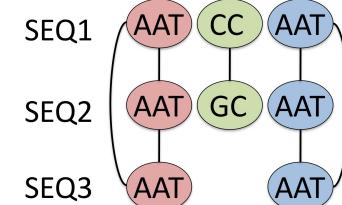
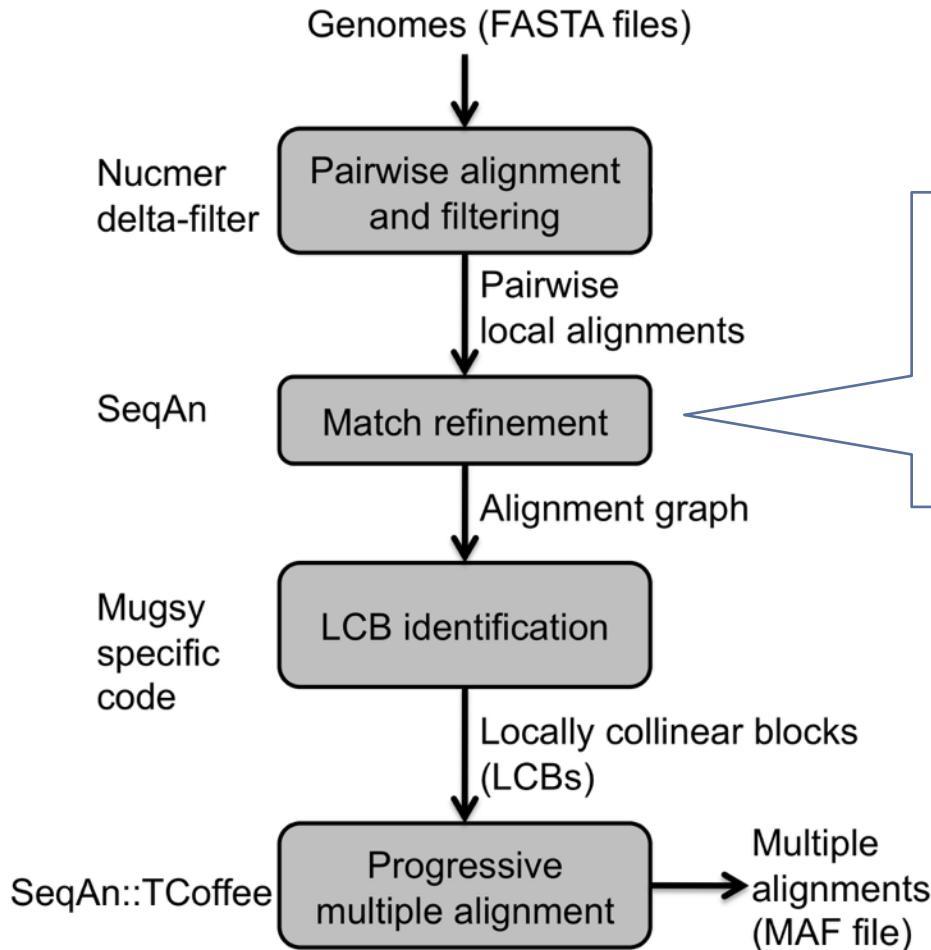
LCB 2

# Whole Genome Alignment

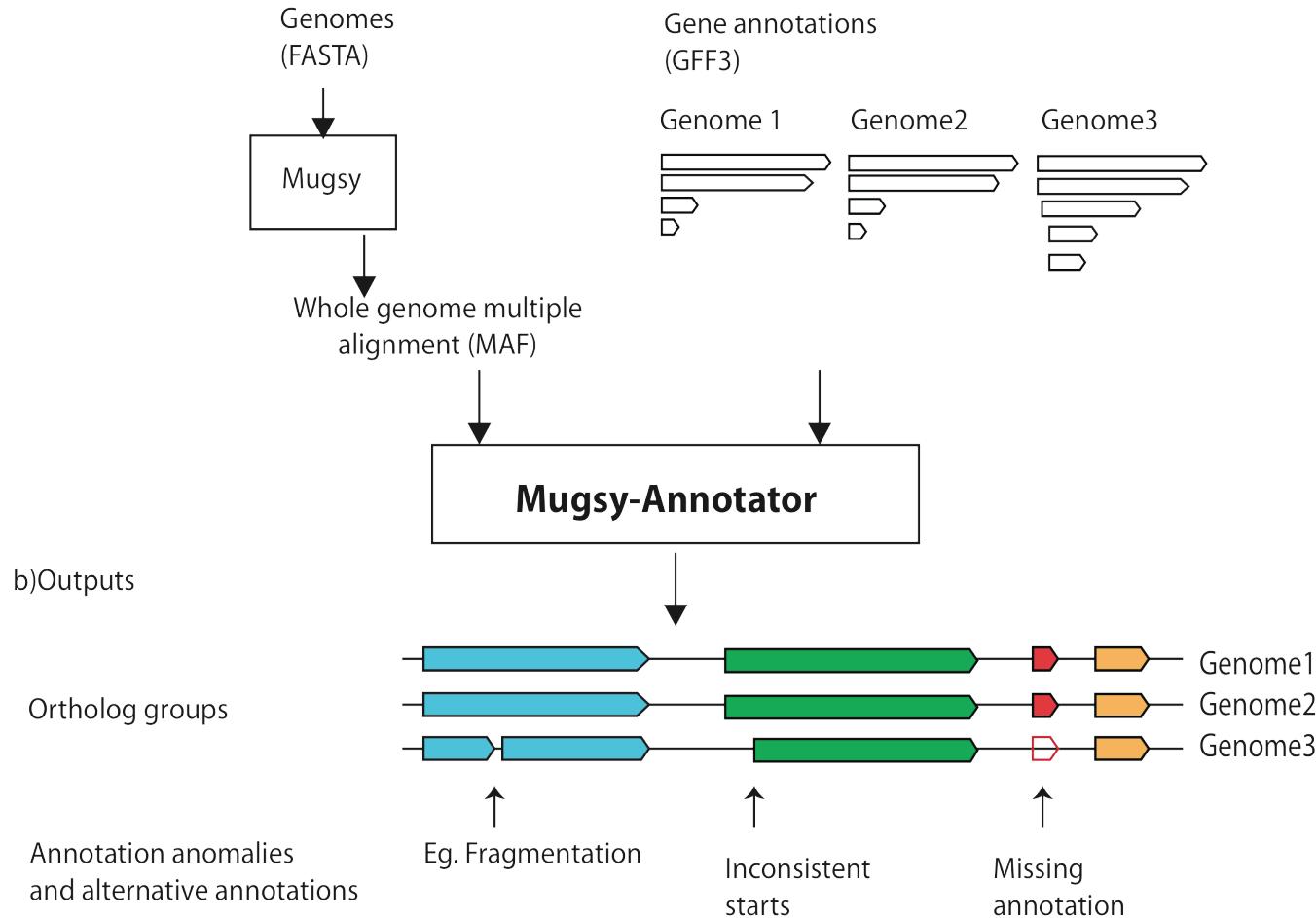


Aaron C.E. Darling, Bob Mau, Frederick R. Blatter, and Nicole T. Perna. *Genome Research.* (2004)

# Mugsy



# Mugsy Annotator



# Summary Report

Locus Id	Species	Strain	Genome Length(in Mbp)	#scaffolds/contigs	#CDS	#uniqueCDS
-						
NC_003116	Neisseria meningitidis Z2491	Z2491	2.18	1	1909	127
NC_008767	Neisseria meningitidis FAM18	FAM18	2.19	1	1917	83
NC_003112	Neisseria meningitidis MC58	MC58	2.27	1	2063	265
NC_010120	Neisseria meningitidis 053442	053442	2.15	1	2020	149
NC_013016	Neisseria meningitidis alpha14	alpha14	2.15	1	1872	135

Core genome length (in Kbp) : 1775.67

Number of core clusters : 1460

## References:

- 
1. CloVR Angiuoli S.V., Matalka M., Gussman A., Galens K., Vangala M., Riley D., Arze C., White J.R., White O., and Fricke W.F. (2011). CloVR: A virtual machine for automated and portable sequence analysis from the desktop using cloud computing. *BMC Bioinformatics*, 12(1):356. PMID: 21878105
  2. Mugsy Angiuoli S.V., Salzberg S.L. (2011). Mugsy: fast multiple alignment of closely related whole genomes. *Bioinformatics*, 27(3):334-42. doi: 10.1093/bioinformatics/btq665. PMID: 21148543
  3. Pan-genome annotation Angiuoli S.V., Dunning Hotopp J.C., Salzberg S.L., Tettelin H. (2011). Improving pan-genome annotation using whole genome multiple alignment. *BMC Bioinformatics*, 12:272. doi: 10.1186/1471-2105-12-272. PMID: 21718539
  4. Phylomark, phylogenetic tree generation Sahl J.W., Matalka M.N., Rasko D.A. (2012). Phylomark, a tool to identify conserved phylogenetic markers from whole-genome alignments. *Appl Environ Microbiol*, 78(14):4884-92. doi: 10.1128/AEM.00929-12. PMID: 22582056

# Mugsy Clusters

COG = 2, size 2, connections = 0, perfect = 0;

NC\_003112.NMB1768

NC\_010120.NMCC\_1333

COG = 4, size 4, connections = 0, perfect = 0;

NC\_008767.NMC0527

NC\_003112.NMB0585

NC\_010120.NMCC\_0531

NC\_013016.NMO\_0470

COG = 6, size 2, connections = 0, perfect = 0;

NC\_003116.NMA0688

NC\_008767.NMC0450

COG = 8, size 8, connections = 0, perfect = 0;

NC\_013016.NMO\_0398

NC\_003112.NMB0504

NC\_003112.NMB0514

NC\_003112.NMB0515

NC\_003116.NMA0695

NC\_008767.NMC0444

NC\_008767.NMC0456

NC\_010120.NMCC\_0457

COG = 10, size 5, connections = 0, perfect = 0;

NC\_013016.NMO\_0592

NC\_003112.NMB0700

NC\_003116.NMA0905

NC\_008767.NMC0651

NC\_010120.NMCC\_0659

COG = 12, size 2, connections = 0, perfect = 0;

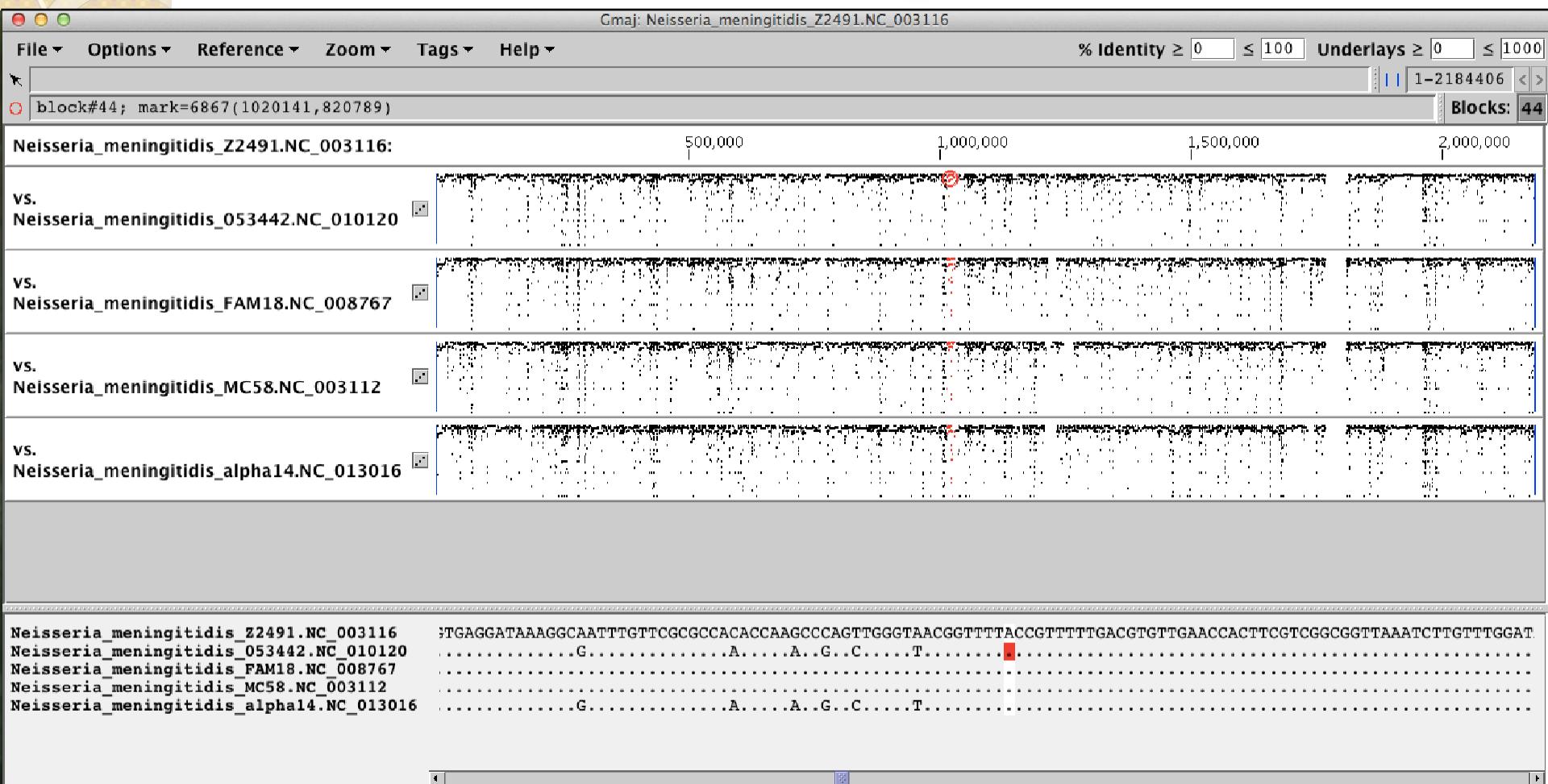
NC\_013016.NMO\_0169

NC\_003112.NMB1998

# SNP Identification

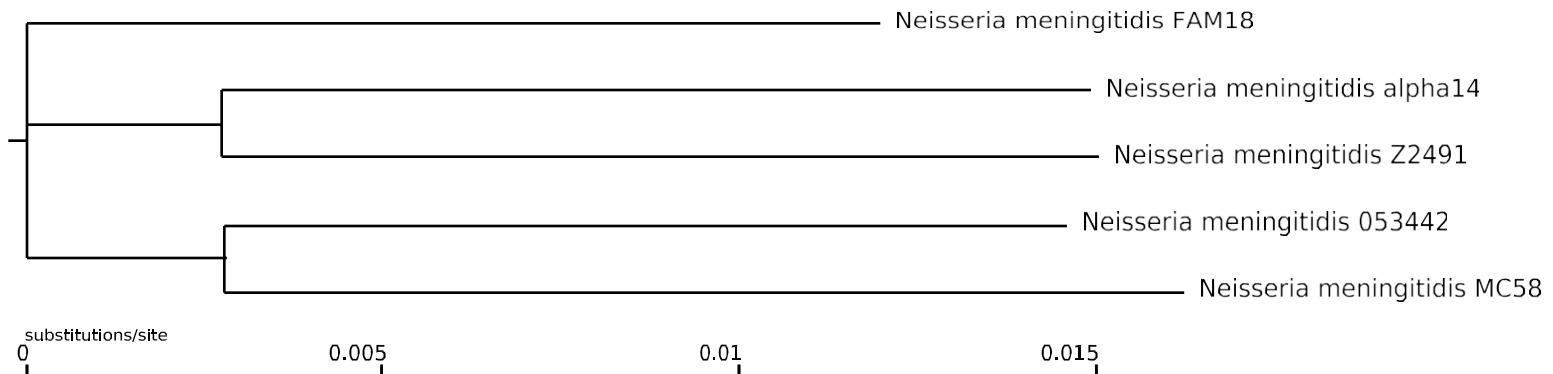
| Neisseria_meningitidis |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| NC_010120              | 305725 T               | NC_008767              | 306034 C               | NC_003112              |                        |                        |                        |
| NC_010120              | 305767 T               | NC_008767              | 306076 G               | NC_003112              |                        |                        |                        |
| NC_010120              | 305844 C               | NC_008767              | 306154 G               | NC_003112              |                        |                        |                        |
| NC_010120              | 305914 G               | NC_008767              | 306223 G               | NC_003112              |                        |                        |                        |
| NC_010120              | 305942 T               | NC_008767              | 306251 T               | NC_003112              |                        |                        |                        |
| NC_010120              | 305948 A               | NC_008767              | 306257 G               | NC_003112              |                        |                        |                        |
| NC_010120              | 306105 C               | NC_008767              | 306414 G               | NC_003112              |                        |                        |                        |
| NC_010120              | 306106 C               | NC_008767              | 306415 G               | NC_003112              |                        |                        |                        |
| NC_010120              | 306107 T               | NC_008767              | 306416 G               | NC_003112              |                        |                        |                        |
| NC_010120              | 306108 T               | NC_008767              | 306417 C               | NC_003112              |                        |                        |                        |
| NC_010120              | 306121 G               | NC_008767              | 306430 T               | NC_003112              |                        |                        |                        |
| NC_010120              | 306124 T               | NC_008767              | 306433 C               | NC_003112              |                        |                        |                        |
| NC_010120              | 306125 A               | NC_008767              | 306434 G               | NC_003112              |                        |                        |                        |
| NC_010120              | 306126 A               | NC_008767              | 306435 G               | NC_003112              |                        |                        |                        |
| NC_010120              | 306127 A               | NC_008767              | 306436 T               | NC_003112              |                        |                        |                        |
| NC_010120              | 306129 A               | NC_008767              | 306438 C               | NC_003112              |                        |                        |                        |
| NC_010120              | 306131 C               | NC_008767              | 306440 G               | NC_003112              |                        |                        |                        |
| NC_010120              | 306135 T               | NC_008767              | 306444 C               | NC_003112              |                        |                        |                        |
| NC_010120              | 306154 A               | NC_008767              | 306463 G               | NC_003112              |                        |                        |                        |
| NC_010120              | 306175 C               | NC_008767              | 306484 T               | NC_003112              |                        |                        |                        |
| NC_010120              | 306193 C               | NC_008767              | 306502 T               | NC_003112              |                        |                        |                        |
| NC_010120              | 306208 G               | NC_008767              | 306517 C               | NC_003112              |                        |                        |                        |
| NC_010120              | 306210 G               | NC_008767              | 306519 A               | NC_003112              |                        |                        |                        |

# Visualization - Alignment



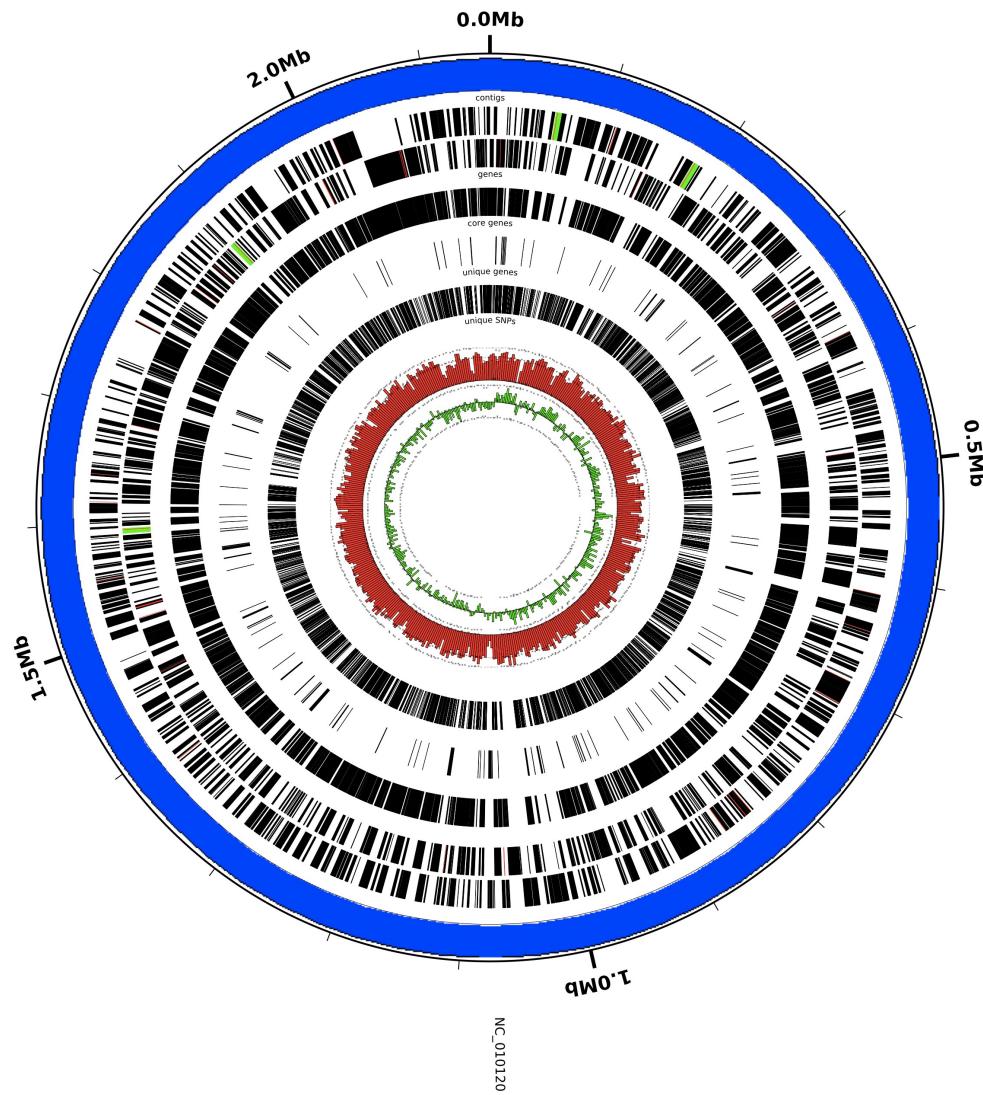
- gmaj (<http://globin.bx.psu.edu/dist/gmaj/>)
- Patched version available (<http://cb2.igs.umaryland.edu/gmaj.zip>)

# Visualization - Phylomark/FastTree

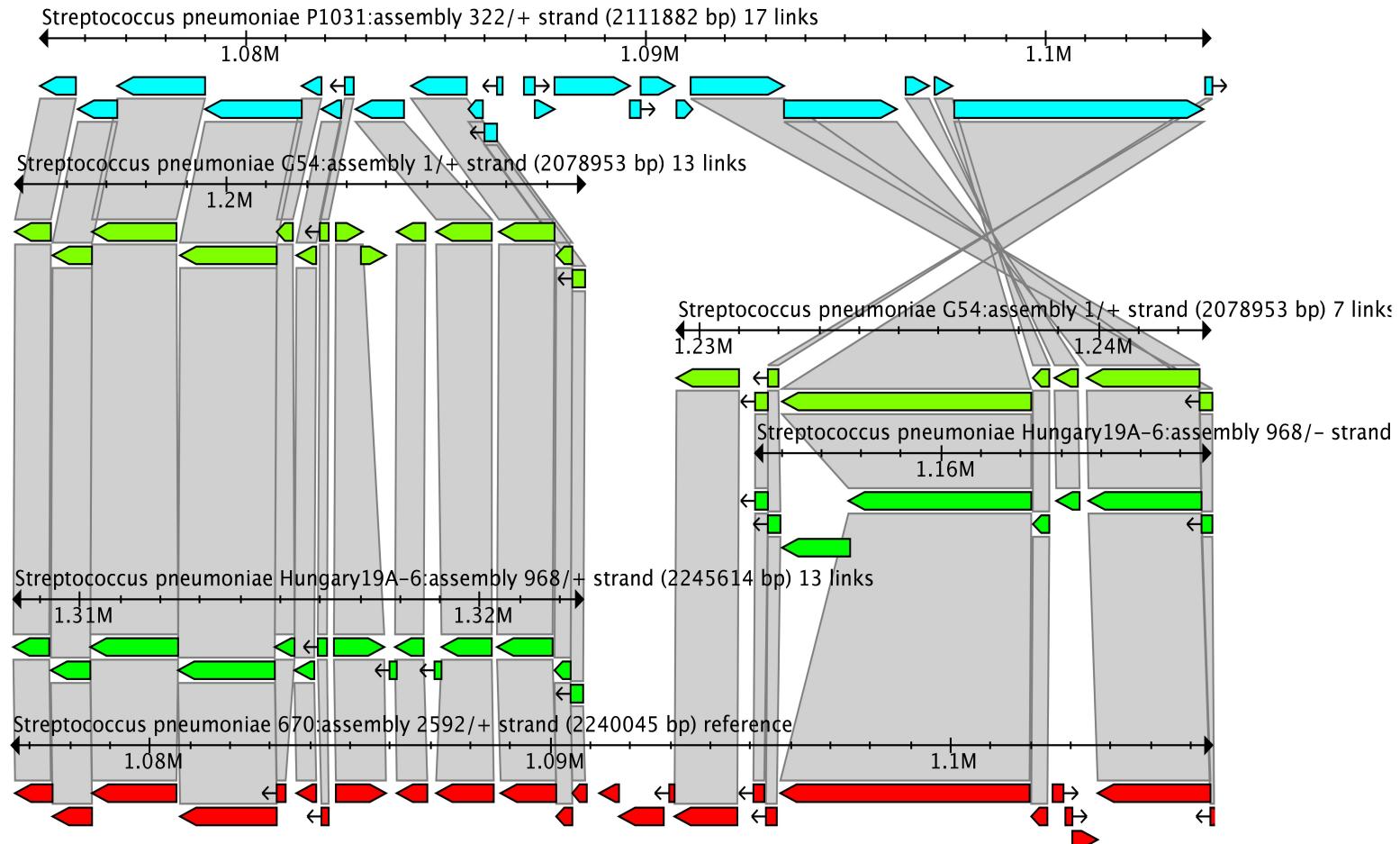


Sahl JW, Matalka MN, Rasko DA. *Appl Environ Microbiol.* (2012)  
Price M.N., Dehal P.S., Arkin A. *PLoS ONE.* (2010)

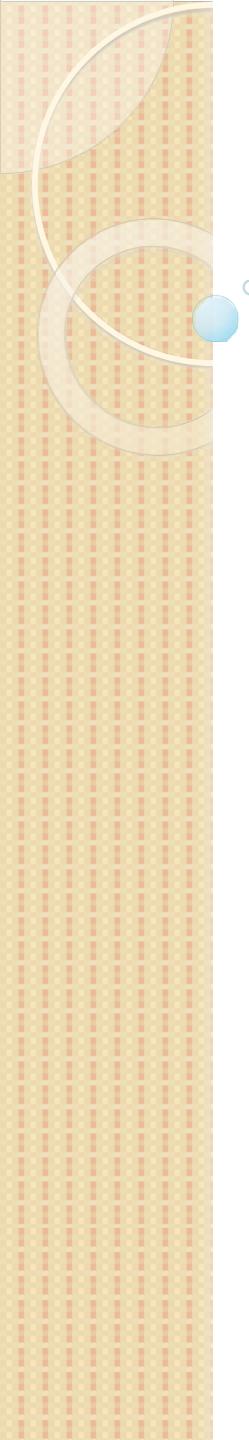
# Visualization - Circleator



# Visualization - Sybil



Riley DR, Angiuoli SV, Crabtree J, Dunning Hotopp JC, Tettelin H. *Bioinformatics* (2012)  
Crabtree J, Angiuoli SV, Wortman JR, White OR. *Methods Mol. Biol.* (2007)



# Thank You

## Questions??

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