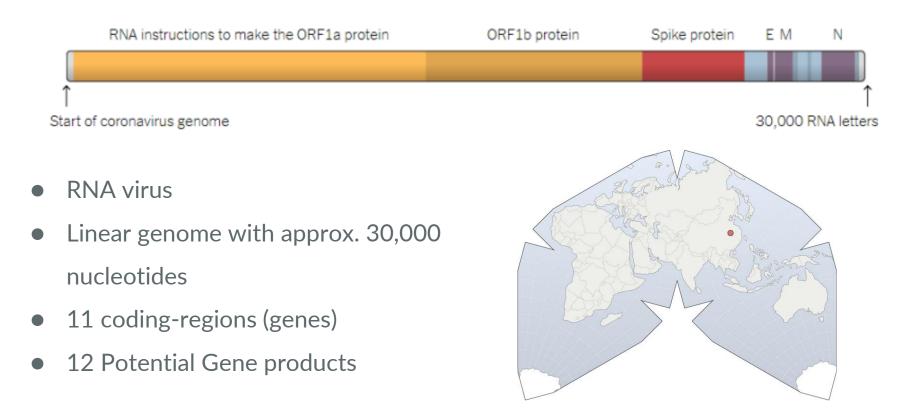
Analysis of SARS-CoV-2 Genomic Diversity

Jordyn Brooks and Abigail Thornton

SARS-CoV-2 Genome



Why look at genomic diversity?

Genomic Diversity

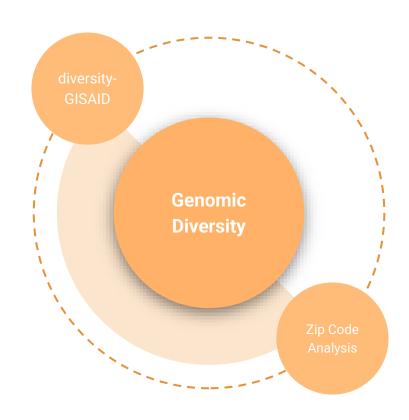
Genetic variation in entire genome of an organism

Nucleotide Diversity

Estimation of variation in DNA sequence at nucleotide level

- Gives insight to history, adaptation, and genetic structure of populations
- Emergence and spread of new variants
 - O Treatment/vaccines
 - Public health policy/response efforts
- Genomic diversity of SARS-CoV-2 increasing over time (rapid increase Jan 2021 to Dec 2022)
 - Accumulation of mutations over time

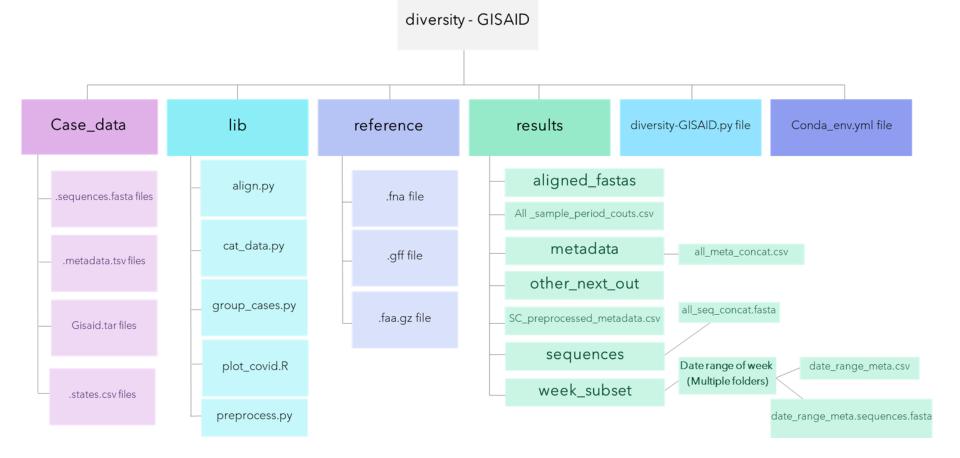
Two parts of the project



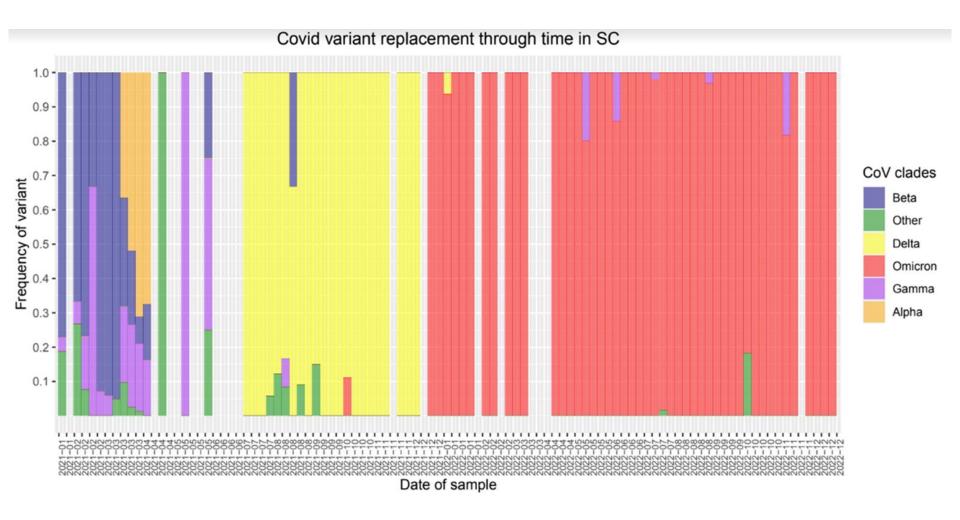
Part 1: diversity-GISAID

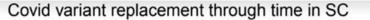
- Finds the variant frequencies per week from 2021-2022
- Finds the total number of cases of each variant per week
- Data was from:
 - The available data set on SARS-CoV-2 positivity
 - Generated through the CLIA certified clinical lab that resides in REDDI
 - O The whole genome sequence data generated from randomly selected positive saliva samples

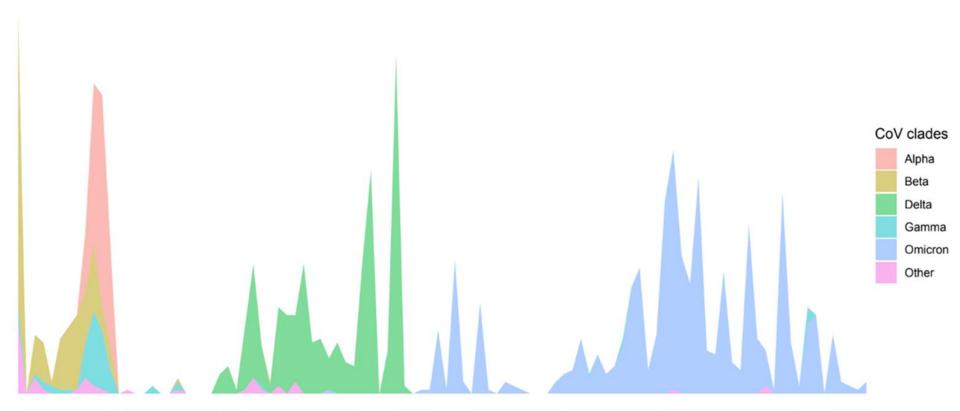
File Flow



Output



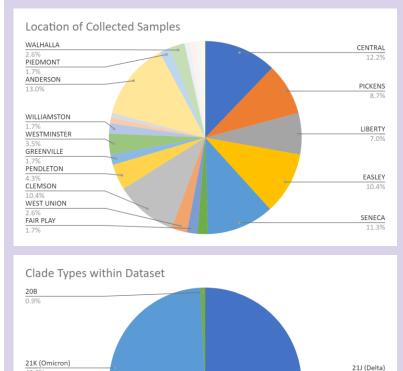


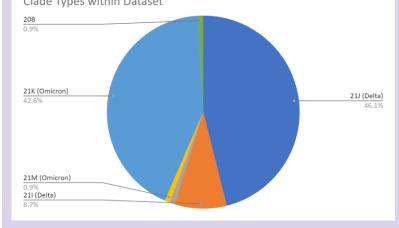


Part 2: Zip Code Analysis

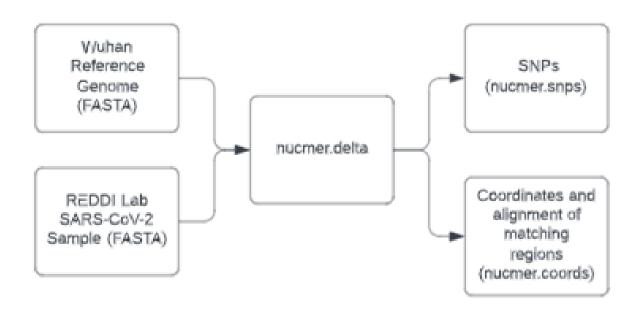
Goal: Generate visual representation of mutations and SNPs found between the Wuhan reference genome and collected COVID samples

- Four counties represented from upstate SC
 - Anderson, Greenville, Pickens, and
 Oconee
- Looking at difference between mutations/SNPs in more populated vs rural zip codes





MUMmer File Flow





| [P1] [SUB] [SUB] [P2] [BUFF] [DIST] [R] [Q] [LEN R] [LEN Q] [FRM] [TAGS] 3037 C T 3037 147 3037 0 0 29903 29902 1 1 1 NC_045512. 117M18E37DBC9AD1KM 4181 G T 4181 68 4181 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 7926 C T 7926 48 7926 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 8986 C T 8986 67 8986 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 8986 C T 9053 67 9053 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 10396 G T 10396 42 10396 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 11201 A G 11201 131 11201 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 11332 A G 11332 131 11332 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12111 G A 12111 124 12111 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12111 G A 12111 124 12111 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 124014 T G 14014 389 14014 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 144014 T G 14014 389 14014 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 14408 C T 14408 172 14408 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 15451 G A 15451 258 14452 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 15451 G A 15451 258 14452 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 15451 G A 15451 258 14452 0 0 29903 29902 1 1 NC_045512. | | | | | | | | | | | | | |
|---|---------|-----------|-------|-------|--------|--------|-----|-----|---------|---------|-------|--------|--------------|
| 1471 1481 | NUCMER | | | | | | | | | | | | |
| 117M18E37DBC9AD1KM 1181 | [P1] | [SUB] | [SUB] | [P2] | [BUFF] | [DIST] | [R] | [Q] | [LEN R] | [LEN Q] | [FRM] | [TAGS] | |
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| 7926 C T 7926 48 7926 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 8986 C T 8986 67 8986 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 10953 G T 9053 67 9053 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 10396 G T 10396 42 10396 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 11201 A G 11201 131 11201 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 11332 A G 11332 131 11332 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 1131 A D D D D D D D D D D D D D D D D D D | | | | 4181 | 68 | 4181 | 0 | 0 | 29903 | 29902 | 1 | 1 | NC_045512.2 |
| 117M18E37DBC9AD1KM 8986 | | | | | | | | | | | | | |
| 8986 C T 8986 67 8986 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 10396 G T 9053 67 9053 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 10396 G T 10396 42 10396 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 11201 A G 11201 131 11201 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 11332 A G 11332 131 11332 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12111 G A 12111 124 12111 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 14014 T G 14014 389 14014 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 14498 C T 14408 172 14408 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 14549 G A 15451 258 14452 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12340 A G 23403 201 6500 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12340 A G 23403 201 6500 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12560 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12560 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12560 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12560 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12560 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12560 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12560 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12560 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12560 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 12560 C G 23604 201 650 0 0 29903 29902 1 1 NC_045512. | | | | 7926 | 48 | 7926 | 0 | 0 | 29903 | 29902 | 1 | 1 | NC_045512.2 |
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| 117M18E37DBC9AD1KM 12111 | | | | 11332 | 131 | 11332 | 0 | 0 | 29903 | 29902 | 1 | 1 | NC 045512.2 |
| 12111 | | | | | | | Ū | | 23303 | 23302 | - | - | |
| 117M18E37DBC9AD1KM 14014 T G 14014 389 14014 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 14408 C T 14408 172 14408 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 15451 G A 15451 258 14452 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 23403 A G 23403 201 6500 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 23604 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 25469 C T 25469 178 4434 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 27874 C T 27874 66 2029 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28253 C A 28253 20 1650 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28253 C A 28253 20 1650 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. | 12111 | | | 12111 | 124 | 12111 | 0 | 0 | 29903 | 29902 | 1 | 1 | NC 045512.2 |
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| 15451 G A 15451 258 14452 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 23403 A G 23403 201 6500 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 23604 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 25469 C T 25469 178 4434 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 27874 C T 27874 66 2029 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28253 C A 28253 20 1650 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28461 A G 28460 188 1443 0 0 29903 29902 1 1 NC_045512. | 14408 | C | T | 14408 | 172 | 14408 | 0 | 0 | 29903 | 29902 | 1 | 1 | NC_045512.2 |
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| 23403 A G 23403 201 6500 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 23604 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 25469 C T 25469 178 4434 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 27874 C T 27874 66 2029 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28253 C A 28253 20 1650 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28461 A G 28460 188 1443 0 0 29903 29902 1 1 NC_045512. | 15451 | G | Α | 15451 | 258 | 14452 | 0 | 0 | 29903 | 29902 | 1 | 1 | NC_045512.2 |
| 117M18E37DBC9AD1KM 23604 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 25469 C T 25469 178 4434 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 27874 C T 27874 66 2029 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28253 C A 28253 20 1650 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28461 A G 28460 188 1443 0 0 29903 29902 1 1 NC_045512. | 117M18 | E37DBC9AI | D1KM | | | | | | | | | | |
| 23604 C G 23604 201 6299 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 25469 C T 25469 178 4434 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 27874 C T 27874 66 2029 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28253 C A 28253 20 1650 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28461 A G 28460 188 1443 0 0 29903 29902 1 1 NC_045512. | 23403 | Α | G | 23403 | 201 | 6500 | 0 | 0 | 29903 | 29902 | 1 | 1 | NC_045512.2 |
| 117M18E37DBC9AD1KM 25469 C T 25469 178 4434 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 27874 C T 27874 66 2029 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28253 C A 28253 20 1650 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28461 A G 28460 188 1443 0 0 29903 29902 1 1 NC_045512. | | E37DBC9AI | D1KM | | | | | | | | | | |
| 25469 C T 25469 178 4434 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 27874 C T 27874 66 2029 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28253 C A 28253 20 1650 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28461 A G 28460 188 1443 0 0 29903 29902 1 1 NC_045512. | 23604 | | _ | 23604 | 201 | 6299 | 0 | 0 | 29903 | 29902 | 1 | 1 | NC_045512.2 |
| 117M18E37DBC9AD1KM 27874 C T 27874 66 2029 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28253 C A 28253 20 1650 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28461 A G 28460 188 1443 0 0 29903 29902 1 1 NC_045512. | | | | | | | | | | | | | |
| 27874 C T 27874 66 2029 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28253 C A 28253 20 1650 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28461 A G 28460 188 1443 0 0 29903 29902 1 1 NC_045512. | | | | 25469 | 178 | 4434 | 0 | 0 | 29903 | 29902 | 1 | 1 | NC_045512.2 |
| T17M18E37DBC9AD1KM 28253 C A 28253 20 1650 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28461 A G 28460 188 1443 0 0 29903 29902 1 1 NC_045512. | | | | | | | | | | | | | |
| 28253 C A 28253 20 1650 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28461 A G 28460 188 1443 0 0 29903 29902 1 1 NC_045512. | | _ | | 27874 | 66 | 2029 | 0 | 0 | 29903 | 29902 | 1 | 1 | NC_045512.2 |
| | | | | 20253 | 20 | 4650 | _ | | 20002 | 20002 | | | NC OAFFAO |
| 28273 A . 28272 20 1631 0 0 29903 29902 1 1 NC_045512. 117M18E37DBC9AD1KM 28461 A G 28460 188 1443 0 0 29903 29902 1 1 NC_045512. | | | | 28253 | 20 | 1650 | 0 | Ø | 29903 | 29902 | 1 | 1 | NC_045512.2 |
| | | | | 20272 | 20 | 1621 | 0 | 0 | 20002 | 20002 | 1 | 1 | NC QAEE12 |
| 28461 A G 28460 188 1443 0 0 29903 29902 1 1 NC_045512. | | | | 28272 | 20 | 1631 | 0 | O | 29903 | 29902 | 1 | 1 | NC_045512.2 |
| = | | | | 28460 | 188 | 1//2 | a | a | 20003 | 20002 | 1 | 1 | NC 045512 1 |
| | | | | 20400 | 100 | 1445 | 0 | U | 29903 | 2330Z | 1 | 1 | WC_045512.2 |

COORDs

/scratch1/jkbrook/BIOE_4510/SNP_analysis/NC_045512.fa /scratch1/jkbrook/BIOE_4510/SNP_analysis/T1/117M18E37DBC9AD1KM.consensus.fa NUCMER

| [51] | [E1] | [52] | [E2] | | [LEN 2] | [% IDY] | | [LEN Q] | | [cov @] | | |
|-------|-------|-------|-------|------|---------|---------|-------|---------|------|---------|-------------|--------------------|
| 665 | 1312 | 665 | 1312 | 648 | 648 | 100.00 | 29903 | 29902 | 2.17 | 2.17 | NC 045512.2 | 117M18E37DBC9AD1KM |
| 2206 | 2568 | 2206 | 2568 | 363 | 363 | 100.00 | 29903 | 29902 | 1.21 | 1.21 | NC 045512.2 | 117M18E37DBC9AD1KM |
| 2851 | 3183 | 2851 | 3183 | 333 | 333 | 99.70 | 29903 | 29902 | 1.11 | 1.11 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 4096 | 4248 | 4096 | 4248 | 153 | 153 | 96.08 | 29903 | 29902 | 0.51 | 0.51 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 5294 | 5537 | 5294 | 5537 | 244 | 244 | 75.82 | 29903 | 29902 | 0.82 | 0.82 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 6751 | 7043 | 6751 | 7043 | 293 | 293 | 60.41 | 29903 | 29902 | 0.98 | 0.98 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 7662 | 7973 | 7662 | 7973 | 312 | 312 | 69.87 | 29903 | 29902 | 1.04 | 1.04 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 8914 | 9245 | 8914 | 9245 | 332 | 332 | 99.40 | 29903 | 29902 | 1.11 | 1.11 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 9503 | 9834 | 9503 | 9834 | 332 | 332 | 93.98 | 29903 | 29902 | 1.11 | 1.11 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 10100 | 10437 | 10100 | 10437 | 338 | 338 | 99.70 | 29903 | 29902 | 1.13 | 1.13 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 10953 | 12234 | 10953 | 12234 | 1282 | 1282 | 96.10 | 29903 | 29902 | 4.29 | 4.29 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 12453 | 12779 | 12453 | 12779 | 327 | 327 | 83.49 | 29903 | 29902 | 1.09 | 1.09 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 12902 | 13363 | 12902 | 13363 | 462 | 462 | 83.33 | 29903 | 29902 | 1.54 | 1.55 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 13626 | 14579 | 13626 | 14579 | 954 | 954 | 99.79 | 29903 | 29902 | 3.19 | 3.19 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 15194 | 16183 | 15194 | 16183 | 990 | 990 | 99.90 | 29903 | 29902 | 3.31 | 3.31 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 16771 | 17130 | 16771 | 17130 | 360 | 360 | 100.00 | 29903 | 29902 | 1.20 | 1.20 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 17407 | 17738 | 17407 | 17738 | 332 | 332 | 100.00 | 29903 | 29902 | 1.11 | 1.11 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 17994 | 18957 | 17994 | 18957 | 964 | 964 | 100.00 | 29903 | 29902 | 3.22 | 3.22 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 22543 | 22877 | 22543 | 22877 | 335 | 335 | 100.00 | 29903 | 29902 | 1.12 | 1.12 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 23145 | 23822 | 23145 | 23822 | 678 | 678 | 99.71 | 29903 | 29902 | 2.27 | 2.27 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 24417 | 24765 | 24417 | 24765 | 349 | 349 | 91.98 | 29903 | 29902 | 1.17 | 1.17 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 25004 | 25646 | 25004 | 25646 | 643 | 643 | 99.84 | 29903 | 29902 | 2.15 | 2.15 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 26220 | 26566 | 26220 | 26566 | 347 | 347 | 100.00 | 29903 | 29902 | 1.16 | 1.16 | NC_045512.2 | 117M18E37DBC9AD1KM |
| 27809 | 28756 | 27809 | 28755 | 948 | 947 | 99.58 | 29903 | 29902 | 3.17 | 3.17 | NC_045512.2 | 117M18E37DBC9AD1KM |
| | | | | | | | | | | | | |

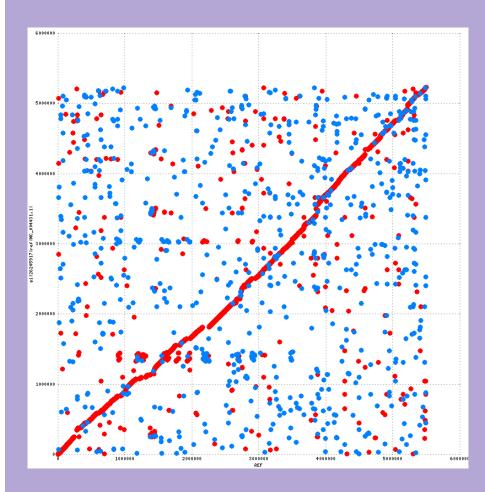
Example Mummerplot Output

X-axis = reference genome

Y-axis = query-genome

Red points/lines indicate an alignment in forward direction

Blue points/lines indicate alignment in reverse direction



References and Acknowledgements

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Thank you!!