# snpBMA: a package for details genetic association analysis of densely typed genetic regions

Chris Wallace

2013-05-22 Wed

## Contents

## 1 Bayesian Model Averaging and the BMA package

## 2 Priors

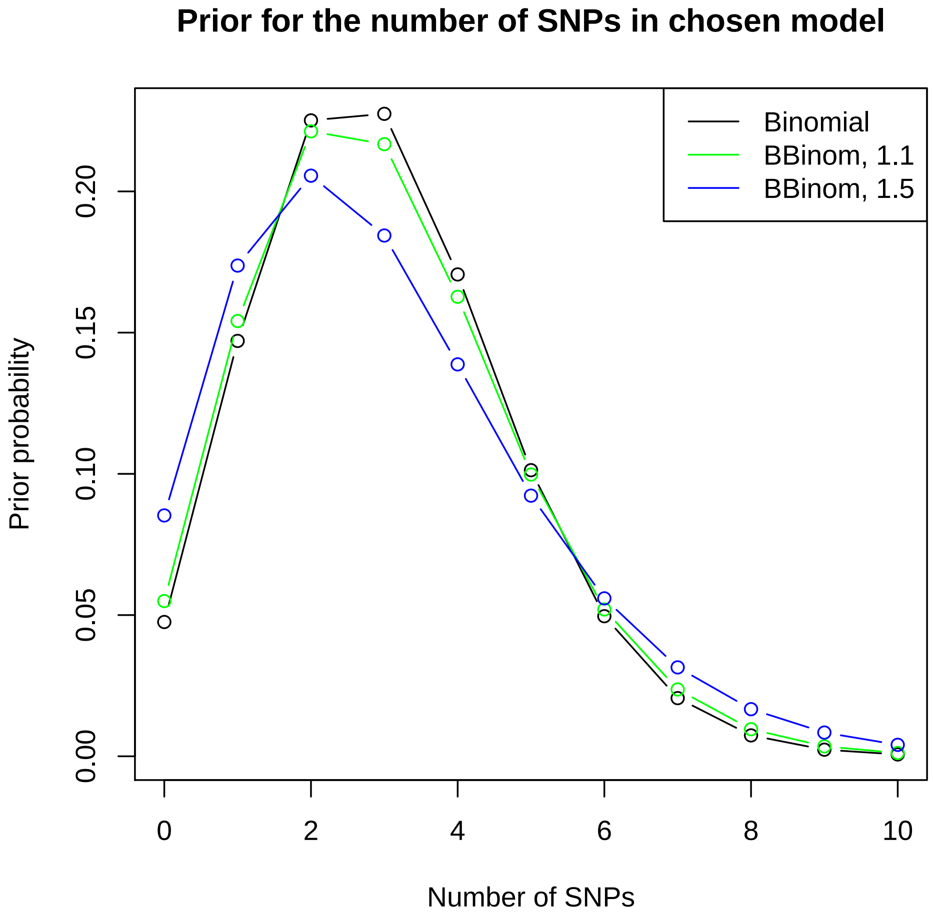
The choice of priors for SNP models with dense genotyping data is not obvious. The CRAN BMA package has as its default a prior that gives equal weight to all possible models. This seems unrealistic with genetic data - in a region of 100 SNPs, a model with all 100 should not have the same prior as a model with just one associated. An alternative is to decide a prior for the number of SNPs in each model. For example, we might specify a binomial prior

$$nsnps \sim Bin(nsnps.total, \pi)$$

where $\pi$ is chosen so that $E(nsnps)$ is some sensible value. On the other hand, a binomial prior for the number of SNPs in a model may be considered too peaked if there is relatively little prior information about the number of causal SNPs, and, particularly if the posterior model choice is sensitive to this prior, it can be useful to consider a prior with greater spread. One such choice is the beta binomial model, under which the number of SNPs follows a binomial distribution with parameters nsnps.total, $\pi$ while $\pi$ follows a beta distribution with parameters chosen so that the mean and the overdispersion (relative to a binomial distribution) are as specified. Functions exist in this package for both these models, and some examples are shown below, or, of course, you may specify your own (see below). It makes sense to specify, additionally, your prior for no SNPs being associated - this is unlikely to follow the same prior function as for one or more SNPs. This is the approach taken by [**?**].

```
> library(snpBMA)
> ## binomial prior assuming 100 SNPs in a region, 3 expected in preferred model
> ## low-ish prior (0.1) of no association in region
> p.binom <- prior.binomial(x=0:10, n=100, expected=3, value="prob", pi0=0.1)
> ## beta binomial, as above, allowing some overdispersion
> p.bb.1.1 <- prior.betabinomial(x=0:10, n=100, expected=3,
+                                  overdispersion=1.1, value="prob", pi0=0.1)
> p.bb.1.5 <- prior.betabinomial(x=0:10, n=100, expected=3,
```

```
+                                overdispersion=1.5, value="prob", pi0=0.1)
> ## plot
> plot(0:10, p.binom, type="b", main="Prior for the number of SNPs in chosen model",
+      xlab="Number of SNPs", ylab="Prior probability")
> lines(0:10, p.bb.1.1, col="green", type="b")
> lines(0:10, p.bb.1.5, col="blue", type="b")
> legend("topright",lty=rep(1,3),
+        col=c("black","green","blue"),
+        legend=c("Binomial", "BBinom, 1.1", "BBinom, 1.5"))
```



If we are prepared to assume all models with the same number of SNPs have equal priors (I pretty much am), then the simple thing is to say

$$\pi(M_{i,j}) = \frac{\pi(nsnps = i)}{\{M_{i,.}\}}$$

The number of p[ossible models grows exponentially with the number of SNPs in a model - note the plot below is on a log scale.

```
> mx <- sapply(0:10, function(i) max.models(n.snps=100, n.use=i))
> plot(0:10, log(mx), type="b", ylab="Log number of models",
+      main="Number of models for a fixed number of SNPs (log scale)",xlab="Number of SNPs")
```

As the number of possible models grows so quickly with the number of SNPs in a model, priors for individual models become very small very quickly.

```
> plot(0:10, p.bb.1.5/mx, type="b", main="Prior for each model of a given size",col="blue",
+      xlab="Number of SNPs", ylab="Prior probability")
> lines(0:10, p.bb.1.1/mx, col="green", type="b")
> lines(0:10, p.binom/mx, col="black", type="b")
> legend("topright",lty=rep(1,3),
+        col=c("black","green","blue"),
+        legend=c("Binomial", "BBinom, 1.1", "BBinom, 1.5"))
```

Instead, we suggest using the priors above to fix the relative odds of a model having $m$ SNPs to a model with zero SNPs.

```
> ## binomial prior assuming 100 SNPs in a region, 3 expected in preferred model
> odds.binom <- prior.binomial(x=0:10, n=100, expected=3, value="odds", pi0=0.1)
> ## beta binomial, as above, allowing some overdispersion
> odds.bb.1.1 <- prior.betabinomial(x=0:10, n=100, expected=3,
+                                 overdispersion=1.1, value="odds", pi0=0.1)
> odds.bb.1.5 <- prior.betabinomial(x=0:10, n=100, expected=3,
+                                 overdispersion=1.5, value="odds", pi0=0.1)
> plot(0:10, odds.binom, type="b", main="Prior odds for each model of a given size")
> lines(0:10, odds.bb.1.1, col="green", type="b")
> lines(0:10, odds.bb.1.5, col="blue", type="b")
> legend("topright",lty=rep(1,3),
+        col=c("black","green","blue"),
+        legend=c("Binomial", "BBinom, 1.1", "BBinom, 1.5"))
```

## 3 Simulate some data

We start with using some sample data from the snpStats package including 20 SNPs, and simulating a quantitative trait that depends on 3 causal SNPs.

```
> library(snpStats)
> data(for.exercise, package="snpStats")
> set.seed(12346)
> X <- snps.10[,101:120]
> n <- nrow(X)
> causal <- c("rs1555897","rs7069505")
> Y <- rnorm(n,mean=as.numeric(X[,causal[1]]))*sqrt(0.2) +
+   rnorm(n,mean=as.numeric(X[,causal[2]]))*sqrt(0.2) +
+   rnorm(n)*sqrt(0.6)
```

`X` contains some missing genotypes, but no SNPs with such a low call rate we would worry in a large study. Still, the rest of the analysis is easier to interpret for the purposes of a vignette if we fill in the missing values.

```
> summary(col.summary(X))
```

```
     Calls          Call.rate      Certain.calls      RAF         
 Min.   :984.0   Min.   :0.9840   Min.   :1     Min.   :0.04651  
 1st Qu.:988.5   1st Qu.:0.9885   1st Qu.:1     1st Qu.:0.16658  
 Median :989.0   Median :0.9890   Median :1     Median :0.41617  
 Mean   :989.7   Mean   :0.9897   Mean   :1     Mean   :0.41482  
 3rd Qu.:990.0   3rd Qu.:0.9900   3rd Qu.:1     3rd Qu.:0.62680  
 Max.   :998.0   Max.   :0.9980   Max.   :1     Max.   :0.84747  
      MAF              P.AA              P.AB              P.BB         
 Min.   :0.04651   Min.   :0.01921   Min.   :0.08898   Min.   :0.002022  
 1st Qu.:0.14523   1st Qu.:0.14170   1st Qu.:0.22626   1st Qu.:0.029575  
 Median :0.31430   Median :0.33984   Median :0.42095   Median :0.172658  
 Mean   :0.27944   Mean   :0.40774   Mean   :0.35487   Mean   :0.237383  
 3rd Qu.:0.37406   3rd Qu.:0.69520   3rd Qu.:0.47258   3rd Qu.:0.392982  
 Max.   :0.49298   Max.   :0.90900   Max.   :0.50101   Max.   :0.732323  
     z.HWE        
 Min.   :-3.5140  
 1st Qu.:-1.1135  
 Median : 0.1907  
 Mean   :-0.4489  
 3rd Qu.: 0.4224  
 Max.   : 1.1354  
```

```
> X <- impute.missing(X)
```

```
20 to impute
1 .SNPs tagged by multiple tag haplotypes (saturated model): 1
2 .SNPs tagged by multiple tag haplotypes (saturated model): 1
3 .SNPs tagged by multiple tag haplotypes (saturated model): 1
4 .SNPs tagged by a single SNP: 1
5 .SNPs tagged by a single SNP: 1
6 .SNPs tagged by a single SNP: 1
7 .SNPs tagged by a single SNP: 1
8 .SNPs tagged by multiple tag haplotypes (saturated model): 1
9 .SNPs tagged by multiple tag haplotypes (saturated model): 1
10 .SNPs tagged by multiple tag haplotypes (saturated model): 1
11 .SNPs tagged by multiple tag haplotypes (saturated model): 1
12 .SNPs tagged by multiple tag haplotypes (saturated model): 1
13 .SNPs tagged by multiple tag haplotypes (saturated model): 1
14 .SNPs tagged by multiple tag haplotypes (saturated model): 1
15 .SNPs tagged by multiple tag haplotypes (saturated model): 1
```

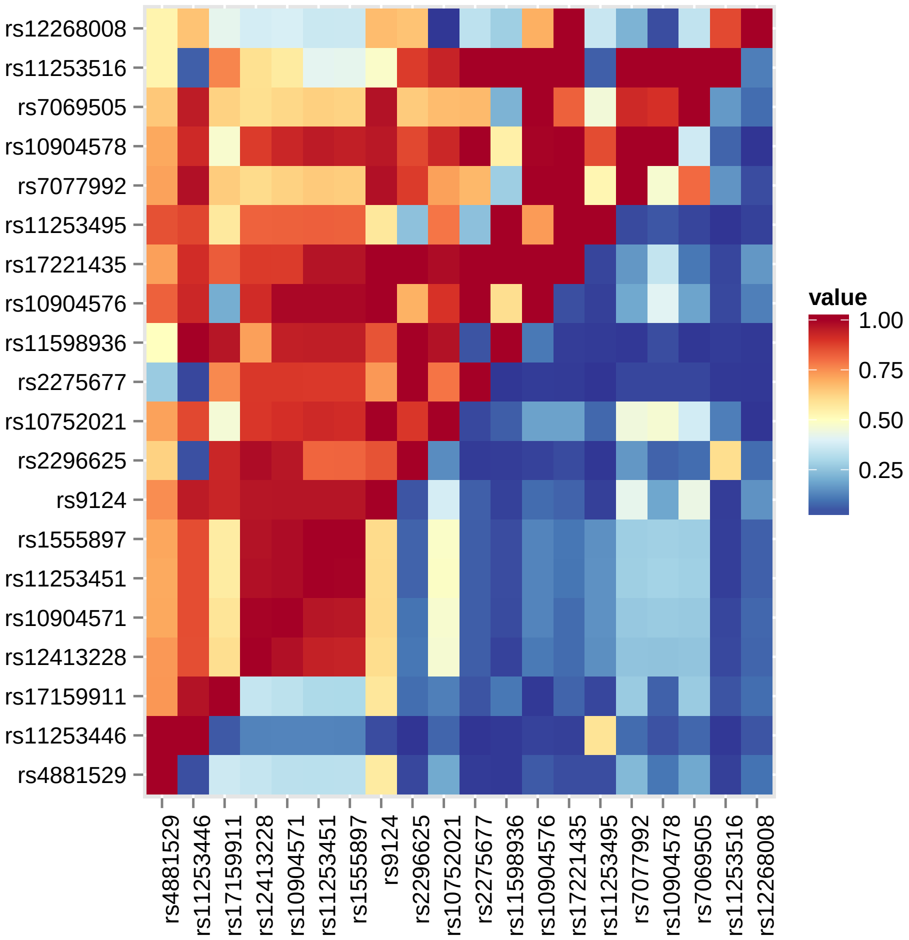
```
16 .SNPs tagged by multiple tag haplotypes (saturated model): 1
17 .SNPs tagged by multiple tag haplotypes (saturated model): 1
18 .SNPs tagged by multiple tag haplotypes (saturated model): 1
19 .SNPs tagged by multiple tag haplotypes (saturated model): 1
20 .SNPs tagged by multiple tag haplotypes (saturated model): 1

coercing object of mode  numeric  to SnpMatrix
```

```
> summary(col.summary(X))
```

```
     Calls        Call.rate Certain.calls      RAF              MAF
 Min.   :1000   Min.   :1   Min.   :1     Min.   :0.0460   Min.   :0.0460
 1st Qu.:1000   1st Qu.:1   1st Qu.:1     1st Qu.:0.1660   1st Qu.:0.1457
 Median :1000   Median :1   Median :1     Median :0.4158   Median :0.3145
 Mean   :1000   Mean   :1   Mean   :1     Mean   :0.4145   Mean   :0.2794
 3rd Qu.:1000   3rd Qu.:1   3rd Qu.:1     3rd Qu.:0.6269   3rd Qu.:0.3739
 Max.   :1000   Max.   :1   Max.   :1     Max.   :0.8465   Max.   :0.4940
      P.AA             P.AB             P.BB             z.HWE
 Min.   :0.0200   Min.   :0.0880   Min.   :0.00200   Min.   :-3.5284
 1st Qu.:0.1410   1st Qu.:0.2268   1st Qu.:0.02925   1st Qu.:-1.0185
 Median :0.3400   Median :0.4220   Median :0.17150   Median : 0.2031
 Mean   :0.4079   Mean   :0.3551   Mean   :0.23700   Mean   :-0.4348
 3rd Qu.:0.6957   3rd Qu.:0.4733   3rd Qu.:0.39275   3rd Qu.: 0.3971
 Max.   :0.9100   Max.   :0.5020   Max.   :0.73100   Max.   : 1.1292
```

Looking at the LD, we see this is a region in which D' (above the diagonal) is very high, whilst $r^2$ can be high between some SNPs, and with moderately strong $r^2 \simeq 0.7$ between two of our causal SNPs:

```
> ld <- show.ld(X=X)
```



## 4 A full BMA analysis using SNP tagging to quickly cover the model space

Bayesian model averaging approaches can be slow when the number of SNPs is very large, as the number of models grows rapidly. The simulated data are deliberately small here, so that you can compare the effect of the different ways we tackle this, which fall into three categories.

First, a strategy we recommend by default, is to cover the model space more rapidly by focusing on a tagging subset of SNPs, then expand to include the tagged SNPs only in the neighbourhood of supported models. Tags can be selected using the `tag` function, where `tag.threshold` sets the $r^2$ threshold used to group SNPs. This function makes use of `hclust` to do the grouping. We can see that not all of our causal SNPs will be analysed directly, but some through tags. Usually a `tag.threshold` of 0.8 might be a sensible choice, lower values will cover the model space faster, but at the risk of missing true causal variants.

```
> tags <- tag(X, tag.threshold=0.8)
> tags[causal]
```

```
   rs1555897    rs7069505
"rs12413228"  "rs7077992"
```

In this case tagging means neither causal SNP is included directly in the set of SNPs we use to build our sets of models. We start with all possible one SNP models:

```
> ## make a snpBMAdata set
> data <- make.data(X, Y,tags=tags,family="gaussian")

Keeping 1000 of 1000 samples and 16 SNPs

> ## Calculate Bayes Factors for all one SNP models
> bma.1 <- bma.nsnps(data, nsnps=1)

groups not needed, creating a model matrix of 16 x 16 .
Evaluating 16 models

> ## Summarise the SNPs with greatest support
> head(ss1 <- snp.summary(bma.1))

6 x 3 Matrix of class "dgeMatrix"
           twologB10-phi1 twologB10-phi2 twologB10-phi3
rs12413228      189.62567      188.71710      186.54791
rs10752021      180.17636      179.26334      177.09185
rs7077992       165.90851      164.98879      162.81383
rs9124          165.00678      164.08664      161.91146
rs10904578      149.16509      148.23750      146.05847
rs4881529        97.23981       96.28782       94.09615
```

Although the `bma.nsnps()` function works for any number of SNPs, it can be simpler to think of growing your BMA models from a parent generation (here, all possible one SNP models) to a child generation (here, all possible two SNP models).

```
> bma.2 <- bma.grow(data=data, bma=bma.1)

Evaluating 120 models

> bma.3 <- bma.grow(data=data, bma=bma.2)

Evaluating 560 models
```

## 4.1 Visualizing the results

It can be nice to visualize the support across these generations of models graphically. So far, we have assumed each model within a generation has an equal prior, which seems reasonable in the absence of specific information about the likely impact of each SNP. However, it doesn't seem reasonable that all models, regardless of the number of SNPs, should have equal priors. Models with smaller numbers of SNPs should be favoured. We can implement this by specifying a prior for the number of SNPs in a model. `snpBMA` has two functions to do this, or you can just create your own numeric vector.

```
>   ## assume a binomial prior for the number of SNPs with expectation of
>   ## 2 causal SNPs ie exactly the scenario simulated!
> prior.odds <- prior.binomial(1:10, n=ncol(X), expected=2, value="odds", pi0=0.1)
>   ## also consider a prior with expectation of 4 causal
>   ## SNPs to examine the effect of varying the prior
> prior.alt <- prior.binomial(1:10, n=ncol(X), expected=4, value="odds", pi0=0.1)
```

See the help for `prior.betabinomial` to understand the other function available, and the difference to a binomial prior.

```
> ## create a graph of BMA results so far
> results <- stack(bma.1,bma.2,bma.3)
>  g<-graphBMA(bma.list=results, priors=prior.odds)
> ## g is an igraph, so you can do all the usual stuff with it:
> g

[[1]]
[1] 696

[[2]]
[1] FALSE

[[3]]
  [1]  16  16  17  17  18  18  19  19  20  20  21  21  22  22  23  23  24  24
 [19]  25  25  26  26  27  27  28  28  29  29  30  30  31  31  32  32  33  33
 [37]  34  34  35  35  36  36  37  37  38  38  39  39  40  40  41  41  42  42
 [55]  43  43  44  44  45  45  46  46  47  47  48  48  49  49  50  50  51  51
 [73]  52  52  53  53  54  54  55  55  56  56  57  57  58  58  59  59  60  60
 [91]  61  61  62  62  63  63  64  64  65  65  66  66  67  67  68  68  69  69
[109]  70  70  71  71  72  72  73  73  74  74  75  75  76  76  77  77  78  78
[127]  79  79  80  80  81  81  82  82  83  83  84  84  85  85  86  86  87  87
[145]  88  88  89  89  90  90  91  91  92  92  93  93  94  94  95  95  96  96
[163]  97  97  98  98  99  99 100 100 101 101 102 102 103 103 104 104 105 105
[181] 106 106 107 107 108 108 109 109 110 110 111 111 112 112 113 113 114 114
[199] 115 115 116 116 117 117 118 118 119 119 120 120 121 121 122 122 123 123
[217] 124 124 125 125 126 126 127 127 128 128 129 129 130 130 131 131 132 132
[235] 133 133 134 134 135 135 136 136 136 137 137 137 138 138 138 139 139 139
[253] 140 140 140 141 141 141 142 142 142 143 143 143 144 144 144 145 145 145
[271] 146 146 146 147 147 147 148 148 148 149 149 149 150 150 150 151 151 151
[289] 152 152 152 153 153 153 154 154 154 155 155 155 156 156 156 157 157 157
[307] 158 158 158 159 159 159 160 160 160 161 161 161 162 162 162 163 163 163
[325] 164 164 164 165 165 165 166 166 166 167 167 167 168 168 168 169 169 169
[343] 170 170 170 171 171 171 172 172 172 173 173 173 174 174 174 175 175 175
[361] 176 176 176 177 177 177 178 178 178 179 179 179 180 180 180 181 181 181
[379] 182 182 182 183 183 183 184 184 184 185 185 185 186 186 186 187 187 187
[397] 188 188 188 189 189 189 190 190 190 191 191 191 192 192 192 193 193 193
```

```
 [415] 194 194 194 195 195 195 196 196 196 197 197 197 198 198 198 199 199 199
 [433] 200 200 200 201 201 201 202 202 202 203 203 203 204 204 204 205 205 205
 [451] 206 206 206 207 207 207 208 208 208 209 209 209 210 210 210 211 211 211
 [469] 212 212 212 213 213 213 214 214 214 215 215 215 216 216 216 217 217 217
 [487] 218 218 218 219 219 219 220 220 220 221 221 221 222 222 222 223 223 223
 [505] 224 224 224 225 225 225 226 226 226 227 227 227 228 228 228 229 229 229
 [523] 230 230 230 231 231 231 232 232 232 233 233 233 234 234 234 235 235 235
 [541] 236 236 236 237 237 237 238 238 238 239 239 239 240 240 240 241 241 241
 [559] 242 242 242 243 243 243 244 244 244 245 245 245 246 246 246 247 247 247
 [577] 248 248 248 249 249 249 250 250 250 251 251 251 252 252 252 253 253 253
 [595] 254 254 254 255 255 255 256 256 256 257 257 257 258 258 258 259 259 259
 [613] 260 260 260 261 261 261 262 262 262 263 263 263 264 264 264 265 265 265
 [631] 266 266 266 267 267 267 268 268 268 269 269 269 270 270 270 271 271 271
 [649] 272 272 272 273 273 273 274 274 274 275 275 275 276 276 276 277 277 277
 [667] 278 278 278 279 279 279 280 280 280 281 281 281 282 282 282 283 283 283
 [685] 284 284 284 285 285 285 286 286 286 287 287 287 288 288 288 289 289 289
 [703] 290 290 290 291 291 291 292 292 292 293 293 293 294 294 294 295 295 295
 [721] 296 296 296 297 297 297 298 298 298 299 299 299 300 300 300 301 301 301
 [739] 302 302 302 303 303 303 304 304 304 305 305 305 306 306 306 307 307 307
 [757] 308 308 308 309 309 309 310 310 310 311 311 311 312 312 312 313 313 313
 [775] 314 314 314 315 315 315 316 316 316 317 317 317 318 318 318 319 319 319
 [793] 320 320 320 321 321 321 322 322 322 323 323 323 324 324 324 325 325 325
 [811] 326 326 326 327 327 327 328 328 328 329 329 329 330 330 330 331 331 331
 [829] 332 332 332 333 333 333 334 334 334 335 335 335 336 336 336 337 337 337
 [847] 338 338 338 339 339 339 340 340 340 341 341 341 342 342 342 343 343 343
 [865] 344 344 344 345 345 345 346 346 346 347 347 347 348 348 348 349 349 349
 [883] 350 350 350 351 351 351 352 352 352 353 353 353 354 354 354 355 355 355
 [901] 356 356 356 357 357 357 358 358 358 359 359 359 360 360 360 361 361 361
 [919] 362 362 362 363 363 363 364 364 364 365 365 365 366 366 366 367 367 367
 [937] 368 368 368 369 369 369 370 370 370 371 371 371 372 372 372 373 373 373
 [955] 374 374 374 375 375 375 376 376 376 377 377 377 378 378 378 379 379 379
 [973] 380 380 380 381 381 381 382 382 382 383 383 383 384 384 384 385 385 385
 [991] 386 386 386 387 387 387 388 388 388 389 389 389 390 390 390 391 391 391
[1009] 392 392 392 393 393 393 394 394 394 395 395 395 396 396 396 397 397 397
[1027] 398 398 398 399 399 399 400 400 400 401 401 401 402 402 402 403 403 403
[1045] 404 404 404 405 405 405 406 406 406 407 407 407 408 408 408 409 409 409
[1063] 410 410 410 411 411 411 412 412 412 413 413 413 414 414 414 415 415 415
[1081] 416 416 416 417 417 417 418 418 418 419 419 419 420 420 420 421 421 421
[1099] 422 422 422 423 423 423 424 424 424 425 425 425 426 426 426 427 427 427
[1117] 428 428 428 429 429 429 430 430 430 431 431 431 432 432 432 433 433 433
[1135] 434 434 434 435 435 435 436 436 436 437 437 437 438 438 438 439 439 439
[1153] 440 440 440 441 441 441 442 442 442 443 443 443 444 444 444 445 445 445
[1171] 446 446 446 447 447 447 448 448 448 449 449 449 450 450 450 451 451 451
[1189] 452 452 452 453 453 453 454 454 454 455 455 455 456 456 456 457 457 457
[1207] 458 458 458 459 459 459 460 460 460 461 461 461 462 462 462 463 463 463
```

```
[1225] 464 464 464 465 465 465 466 466 466 467 467 467 468 468 468 469 469 469
[1243] 470 470 470 471 471 471 472 472 472 473 473 473 474 474 474 475 475 475
[1261] 476 476 476 477 477 477 478 478 478 479 479 479 480 480 480 481 481 481
[1279] 482 482 482 483 483 483 484 484 484 485 485 485 486 486 486 487 487 487
[1297] 488 488 488 489 489 489 490 490 490 491 491 491 492 492 492 493 493 493
[1315] 494 494 494 495 495 495 496 496 496 497 497 497 498 498 498 499 499 499
[1333] 500 500 500 501 501 501 502 502 502 503 503 503 504 504 504 505 505 505
[1351] 506 506 506 507 507 507 508 508 508 509 509 509 510 510 510 511 511 511
[1369] 512 512 512 513 513 513 514 514 514 515 515 515 516 516 516 517 517 517
[1387] 518 518 518 519 519 519 520 520 520 521 521 521 522 522 522 523 523 523
[1405] 524 524 524 525 525 525 526 526 526 527 527 527 528 528 528 529 529 529
[1423] 530 530 530 531 531 531 532 532 532 533 533 533 534 534 534 535 535 535
[1441] 536 536 536 537 537 537 538 538 538 539 539 539 540 540 540 541 541 541
[1459] 542 542 542 543 543 543 544 544 544 545 545 545 546 546 546 547 547 547
[1477] 548 548 548 549 549 549 550 550 550 551 551 551 552 552 552 553 553 553
[1495] 554 554 554 555 555 555 556 556 556 557 557 557 558 558 558 559 559 559
[1513] 560 560 560 561 561 561 562 562 562 563 563 563 564 564 564 565 565 565
[1531] 566 566 566 567 567 567 568 568 568 569 569 569 570 570 570 571 571 571
[1549] 572 572 572 573 573 573 574 574 574 575 575 575 576 576 576 577 577 577
[1567] 578 578 578 579 579 579 580 580 580 581 581 581 582 582 582 583 583 583
[1585] 584 584 584 585 585 585 586 586 586 587 587 587 588 588 588 589 589 589
[1603] 590 590 590 591 591 591 592 592 592 593 593 593 594 594 594 595 595 595
[1621] 596 596 596 597 597 597 598 598 598 599 599 599 600 600 600 601 601 601
[1639] 602 602 602 603 603 603 604 604 604 605 605 605 606 606 606 607 607 607
[1657] 608 608 608 609 609 609 610 610 610 611 611 611 612 612 612 613 613 613
[1675] 614 614 614 615 615 615 616 616 616 617 617 617 618 618 618 619 619 619
[1693] 620 620 620 621 621 621 622 622 622 623 623 623 624 624 624 625 625 625
[1711] 626 626 626 627 627 627 628 628 628 629 629 629 630 630 630 631 631 631
[1729] 632 632 632 633 633 633 634 634 634 635 635 635 636 636 636 637 637 637
[1747] 638 638 638 639 639 639 640 640 640 641 641 641 642 642 642 643 643 643
[1765] 644 644 644 645 645 645 646 646 646 647 647 647 648 648 648 649 649 649
[1783] 650 650 650 651 651 651 652 652 652 653 653 653 654 654 654 655 655 655
[1801] 656 656 656 657 657 657 658 658 658 659 659 659 660 660 660 661 661 661
[1819] 662 662 662 663 663 663 664 664 664 665 665 665 666 666 666 667 667 667
[1837] 668 668 668 669 669 669 670 670 670 671 671 671 672 672 672 673 673 673
[1855] 674 674 674 675 675 675 676 676 676 677 677 677 678 678 678 679 679 679
[1873] 680 680 680 681 681 681 682 682 682 683 683 683 684 684 684 685 685 685
[1891] 686 686 686 687 687 687 688 688 688 689 689 689 690 690 690 691 691 691
[1909] 692 692 692 693 693 693 694 694 694 695 695 695

[[4]]
   [1]   0   1   0   2   0   3   0   4   0   5   0   6   0   7   0   8   0   9
  [19]   0  10   0  11   0  12   0  13   0  14   0  15   1   2   1   3   1   4
  [37]   1   5   1   6   1   7   1   8   1   9   1  10   1  11   1  12   1  13
  [55]   1  14   1  15   2   3   2   4   2   5   2   6   2   7   2   8   2   9
```

```
 [73]   2  10   2  11   2  12   2  13   2  14   2  15   3   4   3   5   3   6
 [91]   3   7   3   8   3   9   3  10   3  11   3  12   3  13   3  14   3  15
[109]   4   5   4   6   4   7   4   8   4   9   4  10   4  11   4  12   4  13
[127]   4  14   4  15   5   6   5   7   5   8   5   9   5  10   5  11   5  12
[145]   5  13   5  14   5  15   6   7   6   8   6   9   6  10   6  11   6  12
[163]   6  13   6  14   6  15   7   8   7   9   7  10   7  11   7  12   7  13
[181]   7  14   7  15   8   9   8  10   8  11   8  12   8  13   8  14   8  15
[199]   9  10   9  11   9  12   9  13   9  14   9  15  10  11  10  12  10  13
[217]  10  14  10  15  11  12  11  13  11  14  11  15  12  13  12  14  12  15
[235]  13  14  13  15  14  15  16  17  31  16  18  32  16  19  33  16  20  34
[253]  16  21  35  16  22  36  16  23  37  16  24  38  16  25  39  16  26  40
[271]  16  27  41  16  28  42  16  29  43  16  30  44  17  18  45  17  19  46
[289]  17  20  47  17  21  48  17  22  49  17  23  50  17  24  51  17  25  52
[307]  17  26  53  17  27  54  17  28  55  17  29  56  17  30  57  18  19  58
[325]  18  20  59  18  21  60  18  22  61  18  23  62  18  24  63  18  25  64
[343]  18  26  65  18  27  66  18  28  67  18  29  68  18  30  69  19  20  70
[361]  19  21  71  19  22  72  19  23  73  19  24  74  19  25  75  19  26  76
[379]  19  27  77  19  28  78  19  29  79  19  30  80  20  21  81  20  22  82
[397]  20  23  83  20  24  84  20  25  85  20  26  86  20  27  87  20  28  88
[415]  20  29  89  20  30  90  21  22  91  21  23  92  21  24  93  21  25  94
[433]  21  26  95  21  27  96  21  28  97  21  29  98  21  30  99  22  23 100
[451]  22  24 101  22  25 102  22  26 103  22  27 104  22  28 105  22  29 106
[469]  22  30 107  23  24 108  23  25 109  23  26 110  23  27 111  23  28 112
[487]  23  29 113  23  30 114  24  25 115  24  26 116  24  27 117  24  28 118
[505]  24  29 119  24  30 120  25  26 121  25  27 122  25  28 123  25  29 124
[523]  25  30 125  26  27 126  26  28 127  26  29 128  26  30 129  27  28 130
[541]  27  29 131  27  30 132  28  29 133  28  30 134  29  30 135  31  32  45
[559]  31  33  46  31  34  47  31  35  48  31  36  49  31  37  50  31  38  51
[577]  31  39  52  31  40  53  31  41  54  31  42  55  31  43  56  31  44  57
[595]  32  33  58  32  34  59  32  35  60  32  36  61  32  37  62  32  38  63
[613]  32  39  64  32  40  65  32  41  66  32  42  67  32  43  68  32  44  69
[631]  33  34  70  33  35  71  33  36  72  33  37  73  33  38  74  33  39  75
[649]  33  40  76  33  41  77  33  42  78  33  43  79  33  44  80  34  35  81
[667]  34  36  82  34  37  83  34  38  84  34  39  85  34  40  86  34  41  87
[685]  34  42  88  34  43  89  34  44  90  35  36  91  35  37  92  35  38  93
[703]  35  39  94  35  40  95  35  41  96  35  42  97  35  43  98  35  44  99
[721]  36  37 100  36  38 101  36  39 102  36  40 103  36  41 104  36  42 105
[739]  36  43 106  36  44 107  37  38 108  37  39 109  37  40 110  37  41 111
[757]  37  42 112  37  43 113  37  44 114  38  39 115  38  40 116  38  41 117
[775]  38  42 118  38  43 119  38  44 120  39  40 121  39  41 122  39  42 123
[793]  39  43 124  39  44 125  40  41 126  40  42 127  40  43 128  40  44 129
[811]  41  42 130  41  43 131  41  44 132  42  43 133  42  44 134  43  44 135
[829]  45  46  58  45  47  59  45  48  60  45  49  61  45  50  62  45  51  63
[847]  45  52  64  45  53  65  45  54  66  45  55  67  45  56  68  45  57  69
[865]  46  47  70  46  48  71  46  49  72  46  50  73  46  51  74  46  52  75
```

```
 [883]  46  53  76  46  54  77  46  55  78  46  56  79  46  57  80  47  48  81
 [901]  47  49  82  47  50  83  47  51  84  47  52  85  47  53  86  47  54  87
 [919]  47  55  88  47  56  89  47  57  90  48  49  91  48  50  92  48  51  93
 [937]  48  52  94  48  53  95  48  54  96  48  55  97  48  56  98  48  57  99
 [955]  49  50 100  49  51 101  49  52 102  49  53 103  49  54 104  49  55 105
 [973]  49  56 106  49  57 107  50  51 108  50  52 109  50  53 110  50  54 111
 [991]  50  55 112  50  56 113  50  57 114  51  52 115  51  53 116  51  54 117
[1009]  51  55 118  51  56 119  51  57 120  52  53 121  52  54 122  52  55 123
[1027]  52  56 124  52  57 125  53  54 126  53  55 127  53  56 128  53  57 129
[1045]  54  55 130  54  56 131  54  57 132  55  56 133  55  57 134  56  57 135
[1063]  58  59  70  58  60  71  58  61  72  58  62  73  58  63  74  58  64  75
[1081]  58  65  76  58  66  77  58  67  78  58  68  79  58  69  80  59  60  81
[1099]  59  61  82  59  62  83  59  63  84  59  64  85  59  65  86  59  66  87
[1117]  59  67  88  59  68  89  59  69  90  60  61  91  60  62  92  60  63  93
[1135]  60  64  94  60  65  95  60  66  96  60  67  97  60  68  98  60  69  99
[1153]  61  62 100  61  63 101  61  64 102  61  65 103  61  66 104  61  67 105
[1171]  61  68 106  61  69 107  62  63 108  62  64 109  62  65 110  62  66 111
[1189]  62  67 112  62  68 113  62  69 114  63  64 115  63  65 116  63  66 117
[1207]  63  67 118  63  68 119  63  69 120  64  65 121  64  66 122  64  67 123
[1225]  64  68 124  64  69 125  65  66 126  65  67 127  65  68 128  65  69 129
[1243]  66  67 130  66  68 131  66  69 132  67  68 133  67  69 134  68  69 135
[1261]  70  71  81  70  72  82  70  73  83  70  74  84  70  75  85  70  76  86
[1279]  70  77  87  70  78  88  70  79  89  70  80  90  71  72  91  71  73  92
[1297]  71  74  93  71  75  94  71  76  95  71  77  96  71  78  97  71  79  98
[1315]  71  80  99  72  73 100  72  74 101  72  75 102  72  76 103  72  77 104
[1333]  72  78 105  72  79 106  72  80 107  73  74 108  73  75 109  73  76 110
[1351]  73  77 111  73  78 112  73  79 113  73  80 114  74  75 115  74  76 116
[1369]  74  77 117  74  78 118  74  79 119  74  80 120  75  76 121  75  77 122
[1387]  75  78 123  75  79 124  75  80 125  76  77 126  76  78 127  76  79 128
[1405]  76  80 129  77  78 130  77  79 131  77  80 132  78  79 133  78  80 134
[1423]  79  80 135  81  82  91  81  83  92  81  84  93  81  85  94  81  86  95
[1441]  81  87  96  81  88  97  81  89  98  81  90  99  82  83 100  82  84 101
[1459]  82  85 102  82  86 103  82  87 104  82  88 105  82  89 106  82  90 107
[1477]  83  84 108  83  85 109  83  86 110  83  87 111  83  88 112  83  89 113
[1495]  83  90 114  84  85 115  84  86 116  84  87 117  84  88 118  84  89 119
[1513]  84  90 120  85  86 121  85  87 122  85  88 123  85  89 124  85  90 125
[1531]  86  87 126  86  88 127  86  89 128  86  90 129  87  88 130  87  89 131
[1549]  87  90 132  88  89 133  88  90 134  89  90 135  91  92 100  91  93 101
[1567]  91  94 102  91  95 103  91  96 104  91  97 105  91  98 106  91  99 107
[1585]  92  93 108  92  94 109  92  95 110  92  96 111  92  97 112  92  98 113
[1603]  92  99 114  93  94 115  93  95 116  93  96 117  93  97 118  93  98 119
[1621]  93  99 120  94  95 121  94  96 122  94  97 123  94  98 124  94  99 125
[1639]  95  96 126  95  97 127  95  98 128  95  99 129  96  97 130  96  98 131
[1657]  96  99 132  97  98 133  97  99 134  98  99 135 100 101 108 100 102 109
[1675] 100 103 110 100 104 111 100 105 112 100 106 113 100 107 114 101 102 115
```

```
[1693] 101 103 116 101 104 117 101 105 118 101 106 119 101 107 120 102 103 121
[1711] 102 104 122 102 105 123 102 106 124 102 107 125 103 104 126 103 105 127
[1729] 103 106 128 103 107 129 104 105 130 104 106 131 104 107 132 105 106 133
[1747] 105 107 134 106 107 135 108 109 115 108 110 116 108 111 117 108 112 118
[1765] 108 113 119 108 114 120 109 110 121 109 111 122 109 112 123 109 113 124
[1783] 109 114 125 110 111 126 110 112 127 110 113 128 110 114 129 111 112 130
[1801] 111 113 131 111 114 132 112 113 133 112 114 134 113 114 135 115 116 121
[1819] 115 117 122 115 118 123 115 119 124 115 120 125 116 117 126 116 118 127
[1837] 116 119 128 116 120 129 117 118 130 117 119 131 117 120 132 118 119 133
[1855] 118 120 134 119 120 135 121 122 126 121 123 127 121 124 128 121 125 129
[1873] 122 123 130 122 124 131 122 125 132 123 124 133 123 125 134 124 125 135
[1891] 126 127 130 126 128 131 126 129 132 127 128 133 127 129 134 128 129 135
[1909] 130 131 133 130 132 134 131 132 135 133 134 135

[[5]]
   [1]    0    1    2    3    4    5    6    7    8    9   10   11   12   13
  [15]   14   15   16   17   18   19   20   21   22   23   24   25   26   27
  [29]   28   29   30   31   32   33   34   35   36   37   38   39   40   41
  [43]   42   43   44   45   46   47   48   49   50   51   52   53   54   55
  [57]   56   57   58   59   60   61   62   63   64   65   66   67   68   69
  [71]   70   71   72   73   74   75   76   77   78   79   80   81   82   83
  [85]   84   85   86   87   88   89   90   91   92   93   94   95   96   97
  [99]   98   99  100  101  102  103  104  105  106  107  108  109  110  111
 [113]  112  113  114  115  116  117  118  119  120  121  122  123  124  125
 [127]  126  127  128  129  130  131  132  133  134  135  136  137  138  139
 [141]  140  141  142  143  144  145  146  147  148  149  150  151  152  153
 [155]  154  155  156  157  158  159  160  161  162  163  164  165  166  167
 [169]  168  169  170  171  172  173  174  175  176  177  178  179  180  181
 [183]  182  183  184  185  186  187  188  189  190  191  192  193  194  195
 [197]  196  197  198  199  200  201  202  203  204  205  206  207  208  209
 [211]  210  211  212  213  214  215  216  217  218  219  220  221  222  223
 [225]  224  225  226  227  228  229  230  231  232  233  234  235  236  237
 [239]  238  239  240  241  242  243  244  245  246  247  248  249  250  251
 [253]  252  253  254  255  256  257  258  259  260  261  262  263  264  265
 [267]  266  267  268  269  270  271  272  273  274  275  276  277  278  279
 [281]  280  281  282  283  284  285  286  287  288  289  290  291  292  293
 [295]  294  295  296  297  298  299  300  301  302  303  304  305  306  307
 [309]  308  309  310  311  312  313  314  315  316  317  318  319  320  321
 [323]  322  323  324  325  326  327  328  329  330  331  332  333  334  335
 [337]  336  337  338  339  340  341  342  343  344  345  346  347  348  349
 [351]  350  351  352  353  354  355  356  357  358  359  360  361  362  363
 [365]  364  365  366  367  368  369  370  371  372  373  374  375  376  377
 [379]  378  379  380  381  382  383  384  385  386  387  388  389  390  391
 [393]  392  393  394  395  396  397  398  399  400  401  402  403  404  405
 [407]  406  407  408  409  410  411  412  413  414  415  416  417  418  419
```

```
 [421]  420  421  422  423  424  425  426  427  428  429  430  431  432  433
 [435]  434  435  436  437  438  439  440  441  442  443  444  445  446  447
 [449]  448  449  450  451  452  453  454  455  456  457  458  459  460  461
 [463]  462  463  464  465  466  467  468  469  470  471  472  473  474  475
 [477]  476  477  478  479  480  481  482  483  484  485  486  487  488  489
 [491]  490  491  492  493  494  495  496  497  498  499  500  501  502  503
 [505]  504  505  506  507  508  509  510  511  512  513  514  515  516  517
 [519]  518  519  520  521  522  523  524  525  526  527  528  529  530  531
 [533]  532  533  534  535  536  537  538  539  540  541  542  543  544  545
 [547]  546  547  548  549  550  551  552  553  554  555  556  557  558  559
 [561]  560  561  562  563  564  565  566  567  568  569  570  571  572  573
 [575]  574  575  576  577  578  579  580  581  582  583  584  585  586  587
 [589]  588  589  590  591  592  593  594  595  596  597  598  599  600  601
 [603]  602  603  604  605  606  607  608  609  610  611  612  613  614  615
 [617]  616  617  618  619  620  621  622  623  624  625  626  627  628  629
 [631]  630  631  632  633  634  635  636  637  638  639  640  641  642  643
 [645]  644  645  646  647  648  649  650  651  652  653  654  655  656  657
 [659]  658  659  660  661  662  663  664  665  666  667  668  669  670  671
 [673]  672  673  674  675  676  677  678  679  680  681  682  683  684  685
 [687]  686  687  688  689  690  691  692  693  694  695  696  697  698  699
 [701]  700  701  702  703  704  705  706  707  708  709  710  711  712  713
 [715]  714  715  716  717  718  719  720  721  722  723  724  725  726  727
 [729]  728  729  730  731  732  733  734  735  736  737  738  739  740  741
 [743]  742  743  744  745  746  747  748  749  750  751  752  753  754  755
 [757]  756  757  758  759  760  761  762  763  764  765  766  767  768  769
 [771]  770  771  772  773  774  775  776  777  778  779  780  781  782  783
 [785]  784  785  786  787  788  789  790  791  792  793  794  795  796  797
 [799]  798  799  800  801  802  803  804  805  806  807  808  809  810  811
 [813]  812  813  814  815  816  817  818  819  820  821  822  823  824  825
 [827]  826  827  828  829  830  831  832  833  834  835  836  837  838  839
 [841]  840  841  842  843  844  845  846  847  848  849  850  851  852  853
 [855]  854  855  856  857  858  859  860  861  862  863  864  865  866  867
 [869]  868  869  870  871  872  873  874  875  876  877  878  879  880  881
 [883]  882  883  884  885  886  887  888  889  890  891  892  893  894  895
 [897]  896  897  898  899  900  901  902  903  904  905  906  907  908  909
 [911]  910  911  912  913  914  915  916  917  918  919  920  921  922  923
 [925]  924  925  926  927  928  929  930  931  932  933  934  935  936  937
 [939]  938  939  940  941  942  943  944  945  946  947  948  949  950  951
 [953]  952  953  954  955  956  957  958  959  960  961  962  963  964  965
 [967]  966  967  968  969  970  971  972  973  974  975  976  977  978  979
 [981]  980  981  982  983  984  985  986  987  988  989  990  991  992  993
 [995]  994  995  996  997  998  999 1000 1001 1002 1003 1004 1005 1006 1007
[1009] 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021
[1023] 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035
[1037] 1036 1037 1038 1039 1040 1041 1042 1043 1044 1045 1046 1047 1048 1049
```

```
[1051] 1050 1051 1052 1053 1054 1055 1056 1057 1058 1059 1060 1061 1062 1063
[1065] 1064 1065 1066 1067 1068 1069 1070 1071 1072 1073 1074 1075 1076 1077
[1079] 1078 1079 1080 1081 1082 1083 1084 1085 1086 1087 1088 1089 1090 1091
[1093] 1092 1093 1094 1095 1096 1097 1098 1099 1100 1101 1102 1103 1104 1105
[1107] 1106 1107 1108 1109 1110 1111 1112 1113 1114 1115 1116 1117 1118 1119
[1121] 1120 1121 1122 1123 1124 1125 1126 1127 1128 1129 1130 1131 1132 1133
[1135] 1134 1135 1136 1137 1138 1139 1140 1141 1142 1143 1144 1145 1146 1147
[1149] 1148 1149 1150 1151 1152 1153 1154 1155 1156 1157 1158 1159 1160 1161
[1163] 1162 1163 1164 1165 1166 1167 1168 1169 1170 1171 1172 1173 1174 1175
[1177] 1176 1177 1178 1179 1180 1181 1182 1183 1184 1185 1186 1187 1188 1189
[1191] 1190 1191 1192 1193 1194 1195 1196 1197 1198 1199 1200 1201 1202 1203
[1205] 1204 1205 1206 1207 1208 1209 1210 1211 1212 1213 1214 1215 1216 1217
[1219] 1218 1219 1220 1221 1222 1223 1224 1225 1226 1227 1228 1229 1230 1231
[1233] 1232 1233 1234 1235 1236 1237 1238 1239 1240 1241 1242 1243 1244 1245
[1247] 1246 1247 1248 1249 1250 1251 1252 1253 1254 1255 1256 1257 1258 1259
[1261] 1260 1261 1262 1263 1264 1265 1266 1267 1268 1269 1270 1271 1272 1273
[1275] 1274 1275 1276 1277 1278 1279 1280 1281 1282 1283 1284 1285 1286 1287
[1289] 1288 1289 1290 1291 1292 1293 1294 1295 1296 1297 1298 1299 1300 1301
[1303] 1302 1303 1304 1305 1306 1307 1308 1309 1310 1311 1312 1313 1314 1315
[1317] 1316 1317 1318 1319 1320 1321 1322 1323 1324 1325 1326 1327 1328 1329
[1331] 1330 1331 1332 1333 1334 1335 1336 1337 1338 1339 1340 1341 1342 1343
[1345] 1344 1345 1346 1347 1348 1349 1350 1351 1352 1353 1354 1355 1356 1357
[1359] 1358 1359 1360 1361 1362 1363 1364 1365 1366 1367 1368 1369 1370 1371
[1373] 1372 1373 1374 1375 1376 1377 1378 1379 1380 1381 1382 1383 1384 1385
[1387] 1386 1387 1388 1389 1390 1391 1392 1393 1394 1395 1396 1397 1398 1399
[1401] 1400 1401 1402 1403 1404 1405 1406 1407 1408 1409 1410 1411 1412 1413
[1415] 1414 1415 1416 1417 1418 1419 1420 1421 1422 1423 1424 1425 1426 1427
[1429] 1428 1429 1430 1431 1432 1433 1434 1435 1436 1437 1438 1439 1440 1441
[1443] 1442 1443 1444 1445 1446 1447 1448 1449 1450 1451 1452 1453 1454 1455
[1457] 1456 1457 1458 1459 1460 1461 1462 1463 1464 1465 1466 1467 1468 1469
[1471] 1470 1471 1472 1473 1474 1475 1476 1477 1478 1479 1480 1481 1482 1483
[1485] 1484 1485 1486 1487 1488 1489 1490 1491 1492 1493 1494 1495 1496 1497
[1499] 1498 1499 1500 1501 1502 1503 1504 1505 1506 1507 1508 1509 1510 1511
[1513] 1512 1513 1514 1515 1516 1517 1518 1519 1520 1521 1522 1523 1524 1525
[1527] 1526 1527 1528 1529 1530 1531 1532 1533 1534 1535 1536 1537 1538 1539
[1541] 1540 1541 1542 1543 1544 1545 1546 1547 1548 1549 1550 1551 1552 1553
[1555] 1554 1555 1556 1557 1558 1559 1560 1561 1562 1563 1564 1565 1566 1567
[1569] 1568 1569 1570 1571 1572 1573 1574 1575 1576 1577 1578 1579 1580 1581
[1583] 1582 1583 1584 1585 1586 1587 1588 1589 1590 1591 1592 1593 1594 1595
[1597] 1596 1597 1598 1599 1600 1601 1602 1603 1604 1605 1606 1607 1608 1609
[1611] 1610 1611 1612 1613 1614 1615 1616 1617 1618 1619 1620 1621 1622 1623
[1625] 1624 1625 1626 1627 1628 1629 1630 1631 1632 1633 1634 1635 1636 1637
[1639] 1638 1639 1640 1641 1642 1643 1644 1645 1646 1647 1648 1649 1650 1651
[1653] 1652 1653 1654 1655 1656 1657 1658 1659 1660 1661 1662 1663 1664 1665
[1667] 1666 1667 1668 1669 1670 1671 1672 1673 1674 1675 1676 1677 1678 1679
```

```
[1681] 1680 1681 1682 1683 1684 1685 1686 1687 1688 1689 1690 1691 1692 1693
[1695] 1694 1695 1696 1697 1698 1699 1700 1701 1702 1703 1704 1705 1706 1707
[1709] 1708 1709 1710 1711 1712 1713 1714 1715 1716 1717 1718 1719 1720 1721
[1723] 1722 1723 1724 1725 1726 1727 1728 1729 1730 1731 1732 1733 1734 1735
[1737] 1736 1737 1738 1739 1740 1741 1742 1743 1744 1745 1746 1747 1748 1749
[1751] 1750 1751 1752 1753 1754 1755 1756 1757 1758 1759 1760 1761 1762 1763
[1765] 1764 1765 1766 1767 1768 1769 1770 1771 1772 1773 1774 1775 1776 1777
[1779] 1778 1779 1780 1781 1782 1783 1784 1785 1786 1787 1788 1789 1790 1791
[1793] 1792 1793 1794 1795 1796 1797 1798 1799 1800 1801 1802 1803 1804 1805
[1807] 1806 1807 1808 1809 1810 1811 1812 1813 1814 1815 1816 1817 1818 1819
[1821] 1820 1821 1822 1823 1824 1825 1826 1827 1828 1829 1830 1831 1832 1833
[1835] 1834 1835 1836 1837 1838 1839 1840 1841 1842 1843 1844 1845 1846 1847
[1849] 1848 1849 1850 1851 1852 1853 1854 1855 1856 1857 1858 1859 1860 1861
[1863] 1862 1863 1864 1865 1866 1867 1868 1869 1870 1871 1872 1873 1874 1875
[1877] 1876 1877 1878 1879 1880 1881 1882 1883 1884 1885 1886 1887 1888 1889
[1891] 1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903
[1905] 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917
[1919] 1918 1919

[[6]]
   [1]    0    2    4    6    8   10   12   14   16   18   20   22   24   26
  [15]   28    1   30   32   34   36   38   40   42   44   46   48   50   52
  [29]   54   56    3   31   58   60   62   64   66   68   70   72   74   76
  [43]   78   80   82    5   33   59   84   86   88   90   92   94   96   98
  [57]  100  102  104  106    7   35   61   85  108  110  112  114  116  118
  [71]  120  122  124  126  128    9   37   63   87  109  130  132  134  136
  [85]  138  140  142  144  146  148   11   39   65   89  111  131  150  152
  [99]  154  156  158  160  162  164  166   13   41   67   91  113  133  151
 [113]  168  170  172  174  176  178  180  182   15   43   69   93  115  135
 [127]  153  169  184  186  188  190  192  194  196   17   45   71   95  117
 [141]  137  155  171  185  198  200  202  204  206  208   19   47   73   97
 [155]  119  139  157  173  187  199  210  212  214  216  218   21   49   75
 [169]   99  121  141  159  175  189  201  211  220  222  224  226   23   51
 [183]   77  101  123  143  161  177  191  203  213  221  228  230  232   25
 [197]   53   79  103  125  145  163  179  193  205  215  223  229  234  236
 [211]   27   55   81  105  127  147  165  181  195  207  217  225  231  235
 [225]  238   29   57   83  107  129  149  167  183  197  209  219  227  233
 [239]  237  239  240  243  246  249  252  255  258  261  264  267  270  273
 [253]  276  279  241  282  285  288  291  294  297  300  303  306  309  312
 [267]  315  318  244  283  321  324  327  330  333  336  339  342  345  348
 [281]  351  354  247  286  322  357  360  363  366  369  372  375  378  381
 [295]  384  387  250  289  325  358  390  393  396  399  402  405  408  411
 [309]  414  417  253  292  328  361  391  420  423  426  429  432  435  438
 [323]  441  444  256  295  331  364  394  421  447  450  453  456  459  462
 [337]  465  468  259  298  334  367  397  424  448  471  474  477  480  483
```

```
[351]  486  489  262  301  337  370  400  427  451  472  492  495  498  501
[365]  504  507  265  304  340  373  403  430  454  475  493  510  513  516
[379]  519  522  268  307  343  376  406  433  457  478  496  511  525  528
[393]  531  534  271  310  346  379  409  436  460  481  499  514  526  537
[407]  540  543  274  313  349  382  412  439  463  484  502  517  529  538
[421]  546  549  277  316  352  385  415  442  466  487  505  520  532  541
[435]  547  552  280  319  355  388  418  445  469  490  508  523  535  544
[449]  550  553  242  555  558  561  564  567  570  573  576  579  582  585
[463]  588  591  245  556  594  597  600  603  606  609  612  615  618  621
[477]  624  627  248  559  595  630  633  636  639  642  645  648  651  654
[491]  657  660  251  562  598  631  663  666  669  672  675  678  681  684
[505]  687  690  254  565  601  634  664  693  696  699  702  705  708  711
[519]  714  717  257  568  604  637  667  694  720  723  726  729  732  735
[533]  738  741  260  571  607  640  670  697  721  744  747  750  753  756
[547]  759  762  263  574  610  643  673  700  724  745  765  768  771  774
[561]  777  780  266  577  613  646  676  703  727  748  766  783  786  789
[575]  792  795  269  580  616  649  679  706  730  751  769  784  798  801
[589]  804  807  272  583  619  652  682  709  733  754  772  787  799  810
[603]  813  816  275  586  622  655  685  712  736  757  775  790  802  811
[617]  819  822  278  589  625  658  688  715  739  760  778  793  805  814
[631]  820  825  281  592  628  661  691  718  742  763  781  796  808  817
[645]  823  826  284  557  828  831  834  837  840  843  846  849  852  855
[659]  858  861  287  560  829  864  867  870  873  876  879  882  885  888
[673]  891  894  290  563  832  865  897  900  903  906  909  912  915  918
[687]  921  924  293  566  835  868  898  927  930  933  936  939  942  945
[701]  948  951  296  569  838  871  901  928  954  957  960  963  966  969
[715]  972  975  299  572  841  874  904  931  955  978  981  984  987  990
[729]  993  996  302  575  844  877  907  934  958  979  999 1002 1005 1008
[743] 1011 1014  305  578  847  880  910  937  961  982 1000 1017 1020 1023
[757] 1026 1029  308  581  850  883  913  940  964  985 1003 1018 1032 1035
[771] 1038 1041  311  584  853  886  916  943  967  988 1006 1021 1033 1044
[785] 1047 1050  314  587  856  889  919  946  970  991 1009 1024 1036 1045
[799] 1053 1056  317  590  859  892  922  949  973  994 1012 1027 1039 1048
[813] 1054 1059  320  593  862  895  925  952  976  997 1015 1030 1042 1051
[827] 1057 1060  323  596  830 1062 1065 1068 1071 1074 1077 1080 1083 1086
[841] 1089 1092  326  599  833 1063 1095 1098 1101 1104 1107 1110 1113 1116
[855] 1119 1122  329  602  836 1066 1096 1125 1128 1131 1134 1137 1140 1143
[869] 1146 1149  332  605  839 1069 1099 1126 1152 1155 1158 1161 1164 1167
[883] 1170 1173  335  608  842 1072 1102 1129 1153 1176 1179 1182 1185 1188
[897] 1191 1194  338  611  845 1075 1105 1132 1156 1177 1197 1200 1203 1206
[911] 1209 1212  341  614  848 1078 1108 1135 1159 1180 1198 1215 1218 1221
[925] 1224 1227  344  617  851 1081 1111 1138 1162 1183 1201 1216 1230 1233
[939] 1236 1239  347  620  854 1084 1114 1141 1165 1186 1204 1219 1231 1242
[953] 1245 1248  350  623  857 1087 1117 1144 1168 1189 1207 1222 1234 1243
[967] 1251 1254  353  626  860 1090 1120 1147 1171 1192 1210 1225 1237 1246
```

```
 [981] 1252 1257  356  629  863 1093 1123 1150 1174 1195 1213 1228 1240 1249
 [995] 1255 1258  359  632  866 1064 1260 1263 1266 1269 1272 1275 1278 1281
[1009] 1284 1287  362  635  869 1067 1261 1290 1293 1296 1299 1302 1305 1308
[1023] 1311 1314  365  638  872 1070 1264 1291 1317 1320 1323 1326 1329 1332
[1037] 1335 1338  368  641  875 1073 1267 1294 1318 1341 1344 1347 1350 1353
[1051] 1356 1359  371  644  878 1076 1270 1297 1321 1342 1362 1365 1368 1371
[1065] 1374 1377  374  647  881 1079 1273 1300 1324 1345 1363 1380 1383 1386
[1079] 1389 1392  377  650  884 1082 1276 1303 1327 1348 1366 1381 1395 1398
[1093] 1401 1404  380  653  887 1085 1279 1306 1330 1351 1369 1384 1396 1407
[1107] 1410 1413  383  656  890 1088 1282 1309 1333 1354 1372 1387 1399 1408
[1121] 1416 1419  386  659  893 1091 1285 1312 1336 1357 1375 1390 1402 1411
[1135] 1417 1422  389  662  896 1094 1288 1315 1339 1360 1378 1393 1405 1414
[1149] 1420 1423  392  665  899 1097 1262 1425 1428 1431 1434 1437 1440 1443
[1163] 1446 1449  395  668  902 1100 1265 1426 1452 1455 1458 1461 1464 1467
[1177] 1470 1473  398  671  905 1103 1268 1429 1453 1476 1479 1482 1485 1488
[1191] 1491 1494  401  674  908 1106 1271 1432 1456 1477 1497 1500 1503 1506
[1205] 1509 1512  404  677  911 1109 1274 1435 1459 1480 1498 1515 1518 1521
[1219] 1524 1527  407  680  914 1112 1277 1438 1462 1483 1501 1516 1530 1533
[1233] 1536 1539  410  683  917 1115 1280 1441 1465 1486 1504 1519 1531 1542
[1247] 1545 1548  413  686  920 1118 1283 1444 1468 1489 1507 1522 1534 1543
[1261] 1551 1554  416  689  923 1121 1286 1447 1471 1492 1510 1525 1537 1546
[1275] 1552 1557  419  692  926 1124 1289 1450 1474 1495 1513 1528 1540 1549
[1289] 1555 1558  422  695  929 1127 1292 1427 1560 1563 1566 1569 1572 1575
[1303] 1578 1581  425  698  932 1130 1295 1430 1561 1584 1587 1590 1593 1596
[1317] 1599 1602  428  701  935 1133 1298 1433 1564 1585 1605 1608 1611 1614
[1331] 1617 1620  431  704  938 1136 1301 1436 1567 1588 1606 1623 1626 1629
[1345] 1632 1635  434  707  941 1139 1304 1439 1570 1591 1609 1624 1638 1641
[1359] 1644 1647  437  710  944 1142 1307 1442 1573 1594 1612 1627 1639 1650
[1373] 1653 1656  440  713  947 1145 1310 1445 1576 1597 1615 1630 1642 1651
[1387] 1659 1662  443  716  950 1148 1313 1448 1579 1600 1618 1633 1645 1654
[1401] 1660 1665  446  719  953 1151 1316 1451 1582 1603 1621 1636 1648 1657
[1415] 1663 1666  449  722  956 1154 1319 1454 1562 1668 1671 1674 1677 1680
[1429] 1683 1686  452  725  959 1157 1322 1457 1565 1669 1689 1692 1695 1698
[1443] 1701 1704  455  728  962 1160 1325 1460 1568 1672 1690 1707 1710 1713
[1457] 1716 1719  458  731  965 1163 1328 1463 1571 1675 1693 1708 1722 1725
[1471] 1728 1731  461  734  968 1166 1331 1466 1574 1678 1696 1711 1723 1734
[1485] 1737 1740  464  737  971 1169 1334 1469 1577 1681 1699 1714 1726 1735
[1499] 1743 1746  467  740  974 1172 1337 1472 1580 1684 1702 1717 1729 1738
[1513] 1744 1749  470  743  977 1175 1340 1475 1583 1687 1705 1720 1732 1741
[1527] 1747 1750  473  746  980 1178 1343 1478 1586 1670 1752 1755 1758 1761
[1541] 1764 1767  476  749  983 1181 1346 1481 1589 1673 1753 1770 1773 1776
[1555] 1779 1782  479  752  986 1184 1349 1484 1592 1676 1756 1771 1785 1788
[1569] 1791 1794  482  755  989 1187 1352 1487 1595 1679 1759 1774 1786 1797
[1583] 1800 1803  485  758  992 1190 1355 1490 1598 1682 1762 1777 1789 1798
[1597] 1806 1809  488  761  995 1193 1358 1493 1601 1685 1765 1780 1792 1801
```

```
[1611] 1807 1812  491  764  998 1196 1361 1496 1604 1688 1768 1783 1795 1804
[1625] 1810 1813  494  767 1001 1199 1364 1499 1607 1691 1754 1815 1818 1821
[1639] 1824 1827  497  770 1004 1202 1367 1502 1610 1694 1757 1816 1830 1833
[1653] 1836 1839  500  773 1007 1205 1370 1505 1613 1697 1760 1819 1831 1842
[1667] 1845 1848  503  776 1010 1208 1373 1508 1616 1700 1763 1822 1834 1843
[1681] 1851 1854  506  779 1013 1211 1376 1511 1619 1703 1766 1825 1837 1846
[1695] 1852 1857  509  782 1016 1214 1379 1514 1622 1706 1769 1828 1840 1849
[1709] 1855 1858  512  785 1019 1217 1382 1517 1625 1709 1772 1817 1860 1863
[1723] 1866 1869  515  788 1022 1220 1385 1520 1628 1712 1775 1820 1861 1872
[1737] 1875 1878  518  791 1025 1223 1388 1523 1631 1715 1778 1823 1864 1873
[1751] 1881 1884  521  794 1028 1226 1391 1526 1634 1718 1781 1826 1867 1876
[1765] 1882 1887  524  797 1031 1229 1394 1529 1637 1721 1784 1829 1870 1879
[1779] 1885 1888  527  800 1034 1232 1397 1532 1640 1724 1787 1832 1862 1890
[1793] 1893 1896  530  803 1037 1235 1400 1535 1643 1727 1790 1835 1865 1891
[1807] 1899 1902  533  806 1040 1238 1403 1538 1646 1730 1793 1838 1868 1894
[1821] 1900 1905  536  809 1043 1241 1406 1541 1649 1733 1796 1841 1871 1897
[1835] 1903 1906  539  812 1046 1244 1409 1544 1652 1736 1799 1844 1874 1892
[1849] 1908 1911  542  815 1049 1247 1412 1547 1655 1739 1802 1847 1877 1895
[1863] 1909 1914  545  818 1052 1250 1415 1550 1658 1742 1805 1850 1880 1898
[1877] 1912 1915  548  821 1055 1253 1418 1553 1661 1745 1808 1853 1883 1901
[1891] 1910 1917  551  824 1058 1256 1421 1556 1664 1748 1811 1856 1886 1904
[1905] 1913 1918  554  827 1061 1259 1424 1559 1667 1751 1814 1859 1889 1907
[1919] 1916 1919

[[7]]
  [1]    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
 [16]    0    0    2    4    6    8   10   12   14   16   18   20   22   24   26
 [31]   28   30   32   34   36   38   40   42   44   46   48   50   52   54   56
 [46]   58   60   62   64   66   68   70   72   74   76   78   80   82   84   86
 [61]   88   90   92   94   96   98  100  102  104  106  108  110  112  114  116
 [76]  118  120  122  124  126  128  130  132  134  136  138  140  142  144  146
 [91]  148  150  152  154  156  158  160  162  164  166  168  170  172  174  176
[106]  178  180  182  184  186  188  190  192  194  196  198  200  202  204  206
[121]  208  210  212  214  216  218  220  222  224  226  228  230  232  234  236
[136]  238  240  243  246  249  252  255  258  261  264  267  270  273  276  279
[151]  282  285  288  291  294  297  300  303  306  309  312  315  318  321  324
[166]  327  330  333  336  339  342  345  348  351  354  357  360  363  366  369
[181]  372  375  378  381  384  387  390  393  396  399  402  405  408  411  414
[196]  417  420  423  426  429  432  435  438  441  444  447  450  453  456  459
[211]  462  465  468  471  474  477  480  483  486  489  492  495  498  501  504
[226]  507  510  513  516  519  522  525  528  531  534  537  540  543  546  549
[241]  552  555  558  561  564  567  570  573  576  579  582  585  588  591  594
[256]  597  600  603  606  609  612  615  618  621  624  627  630  633  636  639
[271]  642  645  648  651  654  657  660  663  666  669  672  675  678  681  684
[286]  687  690  693  696  699  702  705  708  711  714  717  720  723  726  729
```

```
[301]  732  735  738  741  744  747  750  753  756  759  762  765  768  771  774
[316]  777  780  783  786  789  792  795  798  801  804  807  810  813  816  819
[331]  822  825  828  831  834  837  840  843  846  849  852  855  858  861  864
[346]  867  870  873  876  879  882  885  888  891  894  897  900  903  906  909
[361]  912  915  918  921  924  927  930  933  936  939  942  945  948  951  954
[376]  957  960  963  966  969  972  975  978  981  984  987  990  993  996  999
[391] 1002 1005 1008 1011 1014 1017 1020 1023 1026 1029 1032 1035 1038 1041 1044
[406] 1047 1050 1053 1056 1059 1062 1065 1068 1071 1074 1077 1080 1083 1086 1089
[421] 1092 1095 1098 1101 1104 1107 1110 1113 1116 1119 1122 1125 1128 1131 1134
[436] 1137 1140 1143 1146 1149 1152 1155 1158 1161 1164 1167 1170 1173 1176 1179
[451] 1182 1185 1188 1191 1194 1197 1200 1203 1206 1209 1212 1215 1218 1221 1224
[466] 1227 1230 1233 1236 1239 1242 1245 1248 1251 1254 1257 1260 1263 1266 1269
[481] 1272 1275 1278 1281 1284 1287 1290 1293 1296 1299 1302 1305 1308 1311 1314
[496] 1317 1320 1323 1326 1329 1332 1335 1338 1341 1344 1347 1350 1353 1356 1359
[511] 1362 1365 1368 1371 1374 1377 1380 1383 1386 1389 1392 1395 1398 1401 1404
[526] 1407 1410 1413 1416 1419 1422 1425 1428 1431 1434 1437 1440 1443 1446 1449
[541] 1452 1455 1458 1461 1464 1467 1470 1473 1476 1479 1482 1485 1488 1491 1494
[556] 1497 1500 1503 1506 1509 1512 1515 1518 1521 1524 1527 1530 1533 1536 1539
[571] 1542 1545 1548 1551 1554 1557 1560 1563 1566 1569 1572 1575 1578 1581 1584
[586] 1587 1590 1593 1596 1599 1602 1605 1608 1611 1614 1617 1620 1623 1626 1629
[601] 1632 1635 1638 1641 1644 1647 1650 1653 1656 1659 1662 1665 1668 1671 1674
[616] 1677 1680 1683 1686 1689 1692 1695 1698 1701 1704 1707 1710 1713 1716 1719
[631] 1722 1725 1728 1731 1734 1737 1740 1743 1746 1749 1752 1755 1758 1761 1764
[646] 1767 1770 1773 1776 1779 1782 1785 1788 1791 1794 1797 1800 1803 1806 1809
[661] 1812 1815 1818 1821 1824 1827 1830 1833 1836 1839 1842 1845 1848 1851 1854
[676] 1857 1860 1863 1866 1869 1872 1875 1878 1881 1884 1887 1890 1893 1896 1899
[691] 1902 1905 1908 1911 1914 1917 1920

[[8]]
  [1]    0   15   30   45   60   75   90  105  120  135  150  165  180  195  210
 [16]  225  240  254  268  282  296  310  324  338  352  366  380  394  408  422
 [31]  436  450  464  478  492  506  520  534  548  562  576  590  604  618  632
 [46]  646  660  674  688  702  716  730  744  758  772  786  800  814  828  842
 [61]  856  870  884  898  912  926  940  954  968  982  996 1010 1024 1038 1052
 [76] 1066 1080 1094 1108 1122 1136 1150 1164 1178 1192 1206 1220 1234 1248 1262
 [91] 1276 1290 1304 1318 1332 1346 1360 1374 1388 1402 1416 1430 1444 1458 1472
[106] 1486 1500 1514 1528 1542 1556 1570 1584 1598 1612 1626 1640 1654 1668 1682
[121] 1696 1710 1724 1738 1752 1766 1780 1794 1808 1822 1836 1850 1864 1878 1892
[136] 1906 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[151] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[166] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[181] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[196] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[211] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[226] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
```

```
[241] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[256] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[271] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[286] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[301] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[316] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[331] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[346] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[361] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[376] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[391] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[406] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[421] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[436] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[451] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[466] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[481] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[496] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[511] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[526] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[541] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[556] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[571] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[586] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[601] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[616] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[631] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[646] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[661] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[676] 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920 1920
[691] 1920 1920 1920 1920 1920 1920 1920

[[9]]
[[9]][[1]]
[1] 1 0 1

[[9]][[2]]
named list()

[[9]][[3]]
[[9]][[3]]$name
  [1] "M1-rs4881529"
  [2] "M1-rs11253446"
  [3] "M1-rs17159911"
  [4] "M1-rs12413228"
```

```
 [5] "M1-rs9124"
 [6] "M1-rs2296625"
 [7] "M1-rs10752021"
 [8] "M1-rs2275677"
 [9] "M1-rs11598936"
[10] "M1-rs10904576"
[11] "M1-rs17221435"
[12] "M1-rs11253495"
[13] "M1-rs7077992"
[14] "M1-rs10904578"
[15] "M1-rs11253516"
[16] "M1-rs12268008"
[17] "M2-rs4881529-rs11253446"
[18] "M2-rs4881529-rs17159911"
[19] "M2-rs4881529-rs12413228"
[20] "M2-rs4881529-rs9124"
[21] "M2-rs4881529-rs2296625"
[22] "M2-rs4881529-rs10752021"
[23] "M2-rs4881529-rs2275677"
[24] "M2-rs4881529-rs11598936"
[25] "M2-rs4881529-rs10904576"
[26] "M2-rs4881529-rs17221435"
[27] "M2-rs4881529-rs11253495"
[28] "M2-rs4881529-rs7077992"
[29] "M2-rs4881529-rs10904578"
[30] "M2-rs4881529-rs11253516"
[31] "M2-rs4881529-rs12268008"
[32] "M2-rs11253446-rs17159911"
[33] "M2-rs11253446-rs12413228"
[34] "M2-rs11253446-rs9124"
[35] "M2-rs11253446-rs2296625"
[36] "M2-rs11253446-rs10752021"
[37] "M2-rs11253446-rs2275677"
[38] "M2-rs11253446-rs11598936"
[39] "M2-rs11253446-rs10904576"
[40] "M2-rs11253446-rs17221435"
[41] "M2-rs11253446-rs11253495"
[42] "M2-rs11253446-rs7077992"
[43] "M2-rs11253446-rs10904578"
[44] "M2-rs11253446-rs11253516"
[45] "M2-rs11253446-rs12268008"
[46] "M2-rs17159911-rs12413228"
[47] "M2-rs17159911-rs9124"
[48] "M2-rs17159911-rs2296625"
[49] "M2-rs17159911-rs10752021"
```

```
[50] "M2-rs17159911-rs2275677"
[51] "M2-rs17159911-rs11598936"
[52] "M2-rs17159911-rs10904576"
[53] "M2-rs17159911-rs17221435"
[54] "M2-rs17159911-rs11253495"
[55] "M2-rs17159911-rs7077992"
[56] "M2-rs17159911-rs10904578"
[57] "M2-rs17159911-rs11253516"
[58] "M2-rs17159911-rs12268008"
[59] "M2-rs12413228-rs9124"
[60] "M2-rs12413228-rs2296625"
[61] "M2-rs12413228-rs10752021"
[62] "M2-rs12413228-rs2275677"
[63] "M2-rs12413228-rs11598936"
[64] "M2-rs12413228-rs10904576"
[65] "M2-rs12413228-rs17221435"
[66] "M2-rs12413228-rs11253495"
[67] "M2-rs12413228-rs7077992"
[68] "M2-rs12413228-rs10904578"
[69] "M2-rs12413228-rs11253516"
[70] "M2-rs12413228-rs12268008"
[71] "M2-rs9124-rs2296625"
[72] "M2-rs9124-rs10752021"
[73] "M2-rs9124-rs2275677"
[74] "M2-rs9124-rs11598936"
[75] "M2-rs9124-rs10904576"
[76] "M2-rs9124-rs17221435"
[77] "M2-rs9124-rs11253495"
[78] "M2-rs9124-rs7077992"
[79] "M2-rs9124-rs10904578"
[80] "M2-rs9124-rs11253516"
[81] "M2-rs9124-rs12268008"
[82] "M2-rs2296625-rs10752021"
[83] "M2-rs2296625-rs2275677"
[84] "M2-rs2296625-rs11598936"
[85] "M2-rs2296625-rs10904576"
[86] "M2-rs2296625-rs17221435"
[87] "M2-rs2296625-rs11253495"
[88] "M2-rs2296625-rs7077992"
[89] "M2-rs2296625-rs10904578"
[90] "M2-rs2296625-rs11253516"
[91] "M2-rs2296625-rs12268008"
[92] "M2-rs10752021-rs2275677"
[93] "M2-rs10752021-rs11598936"
[94] "M2-rs10752021-rs10904576"
```

```
 [95] "M2-rs10752021-rs17221435"
 [96] "M2-rs10752021-rs11253495"
 [97] "M2-rs10752021-rs7077992"
 [98] "M2-rs10752021-rs10904578"
 [99] "M2-rs10752021-rs11253516"
[100] "M2-rs10752021-rs12268008"
[101] "M2-rs2275677-rs11598936"
[102] "M2-rs2275677-rs10904576"
[103] "M2-rs2275677-rs17221435"
[104] "M2-rs2275677-rs11253495"
[105] "M2-rs2275677-rs7077992"
[106] "M2-rs2275677-rs10904578"
[107] "M2-rs2275677-rs11253516"
[108] "M2-rs2275677-rs12268008"
[109] "M2-rs11598936-rs10904576"
[110] "M2-rs11598936-rs17221435"
[111] "M2-rs11598936-rs11253495"
[112] "M2-rs11598936-rs7077992"
[113] "M2-rs11598936-rs10904578"
[114] "M2-rs11598936-rs11253516"
[115] "M2-rs11598936-rs12268008"
[116] "M2-rs10904576-rs17221435"
[117] "M2-rs10904576-rs11253495"
[118] "M2-rs10904576-rs7077992"
[119] "M2-rs10904576-rs10904578"
[120] "M2-rs10904576-rs11253516"
[121] "M2-rs10904576-rs12268008"
[122] "M2-rs17221435-rs11253495"
[123] "M2-rs17221435-rs7077992"
[124] "M2-rs17221435-rs10904578"
[125] "M2-rs17221435-rs11253516"
[126] "M2-rs17221435-rs12268008"
[127] "M2-rs11253495-rs7077992"
[128] "M2-rs11253495-rs10904578"
[129] "M2-rs11253495-rs11253516"
[130] "M2-rs11253495-rs12268008"
[131] "M2-rs7077992-rs10904578"
[132] "M2-rs7077992-rs11253516"
[133] "M2-rs7077992-rs12268008"
[134] "M2-rs10904578-rs11253516"
[135] "M2-rs10904578-rs12268008"
[136] "M2-rs11253516-rs12268008"
[137] "M3-rs4881529-rs11253446-rs17159911"
[138] "M3-rs4881529-rs11253446-rs12413228"
[139] "M3-rs4881529-rs11253446-rs9124"
```

```
[140] "M3-rs4881529-rs11253446-rs2296625"
[141] "M3-rs4881529-rs11253446-rs10752021"
[142] "M3-rs4881529-rs11253446-rs2275677"
[143] "M3-rs4881529-rs11253446-rs11598936"
[144] "M3-rs4881529-rs11253446-rs10904576"
[145] "M3-rs4881529-rs11253446-rs17221435"
[146] "M3-rs4881529-rs11253446-rs11253495"
[147] "M3-rs4881529-rs11253446-rs7077992"
[148] "M3-rs4881529-rs11253446-rs10904578"
[149] "M3-rs4881529-rs11253446-rs11253516"
[150] "M3-rs4881529-rs11253446-rs12268008"
[151] "M3-rs4881529-rs17159911-rs12413228"
[152] "M3-rs4881529-rs17159911-rs9124"
[153] "M3-rs4881529-rs17159911-rs2296625"
[154] "M3-rs4881529-rs17159911-rs10752021"
[155] "M3-rs4881529-rs17159911-rs2275677"
[156] "M3-rs4881529-rs17159911-rs11598936"
[157] "M3-rs4881529-rs17159911-rs10904576"
[158] "M3-rs4881529-rs17159911-rs17221435"
[159] "M3-rs4881529-rs17159911-rs11253495"
[160] "M3-rs4881529-rs17159911-rs7077992"
[161] "M3-rs4881529-rs17159911-rs10904578"
[162] "M3-rs4881529-rs17159911-rs11253516"
[163] "M3-rs4881529-rs17159911-rs12268008"
[164] "M3-rs4881529-rs12413228-rs9124"
[165] "M3-rs4881529-rs12413228-rs2296625"
[166] "M3-rs4881529-rs12413228-rs10752021"
[167] "M3-rs4881529-rs12413228-rs2275677"
[168] "M3-rs4881529-rs12413228-rs11598936"
[169] "M3-rs4881529-rs12413228-rs10904576"
[170] "M3-rs4881529-rs12413228-rs17221435"
[171] "M3-rs4881529-rs12413228-rs11253495"
[172] "M3-rs4881529-rs12413228-rs7077992"
[173] "M3-rs4881529-rs12413228-rs10904578"
[174] "M3-rs4881529-rs12413228-rs11253516"
[175] "M3-rs4881529-rs12413228-rs12268008"
[176] "M3-rs4881529-rs9124-rs2296625"
[177] "M3-rs4881529-rs9124-rs10752021"
[178] "M3-rs4881529-rs9124-rs2275677"
[179] "M3-rs4881529-rs9124-rs11598936"
[180] "M3-rs4881529-rs9124-rs10904576"
[181] "M3-rs4881529-rs9124-rs17221435"
[182] "M3-rs4881529-rs9124-rs11253495"
[183] "M3-rs4881529-rs9124-rs7077992"
[184] "M3-rs4881529-rs9124-rs10904578"
```

```
[185] "M3-rs4881529-rs9124-rs11253516"
[186] "M3-rs4881529-rs9124-rs12268008"
[187] "M3-rs4881529-rs2296625-rs10752021"
[188] "M3-rs4881529-rs2296625-rs2275677"
[189] "M3-rs4881529-rs2296625-rs11598936"
[190] "M3-rs4881529-rs2296625-rs10904576"
[191] "M3-rs4881529-rs2296625-rs17221435"
[192] "M3-rs4881529-rs2296625-rs11253495"
[193] "M3-rs4881529-rs2296625-rs7077992"
[194] "M3-rs4881529-rs2296625-rs10904578"
[195] "M3-rs4881529-rs2296625-rs11253516"
[196] "M3-rs4881529-rs2296625-rs12268008"
[197] "M3-rs4881529-rs10752021-rs2275677"
[198] "M3-rs4881529-rs10752021-rs11598936"
[199] "M3-rs4881529-rs10752021-rs10904576"
[200] "M3-rs4881529-rs10752021-rs17221435"
[201] "M3-rs4881529-rs10752021-rs11253495"
[202] "M3-rs4881529-rs10752021-rs7077992"
[203] "M3-rs4881529-rs10752021-rs10904578"
[204] "M3-rs4881529-rs10752021-rs11253516"
[205] "M3-rs4881529-rs10752021-rs12268008"
[206] "M3-rs4881529-rs2275677-rs11598936"
[207] "M3-rs4881529-rs2275677-rs10904576"
[208] "M3-rs4881529-rs2275677-rs17221435"
[209] "M3-rs4881529-rs2275677-rs11253495"
[210] "M3-rs4881529-rs2275677-rs7077992"
[211] "M3-rs4881529-rs2275677-rs10904578"
[212] "M3-rs4881529-rs2275677-rs11253516"
[213] "M3-rs4881529-rs2275677-rs12268008"
[214] "M3-rs4881529-rs11598936-rs10904576"
[215] "M3-rs4881529-rs11598936-rs17221435"
[216] "M3-rs4881529-rs11598936-rs11253495"
[217] "M3-rs4881529-rs11598936-rs7077992"
[218] "M3-rs4881529-rs11598936-rs10904578"
[219] "M3-rs4881529-rs11598936-rs11253516"
[220] "M3-rs4881529-rs11598936-rs12268008"
[221] "M3-rs4881529-rs10904576-rs17221435"
[222] "M3-rs4881529-rs10904576-rs11253495"
[223] "M3-rs4881529-rs10904576-rs7077992"
[224] "M3-rs4881529-rs10904576-rs10904578"
[225] "M3-rs4881529-rs10904576-rs11253516"
[226] "M3-rs4881529-rs10904576-rs12268008"
[227] "M3-rs4881529-rs17221435-rs11253495"
[228] "M3-rs4881529-rs17221435-rs7077992"
[229] "M3-rs4881529-rs17221435-rs10904578"
```

```
[230] "M3-rs4881529-rs17221435-rs11253516"
[231] "M3-rs4881529-rs17221435-rs12268008"
[232] "M3-rs4881529-rs11253495-rs7077992"
[233] "M3-rs4881529-rs11253495-rs10904578"
[234] "M3-rs4881529-rs11253495-rs11253516"
[235] "M3-rs4881529-rs11253495-rs12268008"
[236] "M3-rs4881529-rs7077992-rs10904578"
[237] "M3-rs4881529-rs7077992-rs11253516"
[238] "M3-rs4881529-rs7077992-rs12268008"
[239] "M3-rs4881529-rs10904578-rs11253516"
[240] "M3-rs4881529-rs10904578-rs12268008"
[241] "M3-rs4881529-rs11253516-rs12268008"
[242] "M3-rs11253446-rs17159911-rs12413228"
[243] "M3-rs11253446-rs17159911-rs9124"
[244] "M3-rs11253446-rs17159911-rs2296625"
[245] "M3-rs11253446-rs17159911-rs10752021"
[246] "M3-rs11253446-rs17159911-rs2275677"
[247] "M3-rs11253446-rs17159911-rs11598936"
[248] "M3-rs11253446-rs17159911-rs10904576"
[249] "M3-rs11253446-rs17159911-rs17221435"
[250] "M3-rs11253446-rs17159911-rs11253495"
[251] "M3-rs11253446-rs17159911-rs7077992"
[252] "M3-rs11253446-rs17159911-rs10904578"
[253] "M3-rs11253446-rs17159911-rs11253516"
[254] "M3-rs11253446-rs17159911-rs12268008"
[255] "M3-rs11253446-rs12413228-rs9124"
[256] "M3-rs11253446-rs12413228-rs2296625"
[257] "M3-rs11253446-rs12413228-rs10752021"
[258] "M3-rs11253446-rs12413228-rs2275677"
[259] "M3-rs11253446-rs12413228-rs11598936"
[260] "M3-rs11253446-rs12413228-rs10904576"
[261] "M3-rs11253446-rs12413228-rs17221435"
[262] "M3-rs11253446-rs12413228-rs11253495"
[263] "M3-rs11253446-rs12413228-rs7077992"
[264] "M3-rs11253446-rs12413228-rs10904578"
[265] "M3-rs11253446-rs12413228-rs11253516"
[266] "M3-rs11253446-rs12413228-rs12268008"
[267] "M3-rs11253446-rs9124-rs2296625"
[268] "M3-rs11253446-rs9124-rs10752021"
[269] "M3-rs11253446-rs9124-rs2275677"
[270] "M3-rs11253446-rs9124-rs11598936"
[271] "M3-rs11253446-rs9124-rs10904576"
[272] "M3-rs11253446-rs9124-rs17221435"
[273] "M3-rs11253446-rs9124-rs11253495"
[274] "M3-rs11253446-rs9124-rs7077992"
```

```
[275] "M3-rs11253446-rs9124-rs10904578"
[276] "M3-rs11253446-rs9124-rs11253516"
[277] "M3-rs11253446-rs9124-rs12268008"
[278] "M3-rs11253446-rs2296625-rs10752021"
[279] "M3-rs11253446-rs2296625-rs2275677"
[280] "M3-rs11253446-rs2296625-rs11598936"
[281] "M3-rs11253446-rs2296625-rs10904576"
[282] "M3-rs11253446-rs2296625-rs17221435"
[283] "M3-rs11253446-rs2296625-rs11253495"
[284] "M3-rs11253446-rs2296625-rs7077992"
[285] "M3-rs11253446-rs2296625-rs10904578"
[286] "M3-rs11253446-rs2296625-rs11253516"
[287] "M3-rs11253446-rs2296625-rs12268008"
[288] "M3-rs11253446-rs10752021-rs2275677"
[289] "M3-rs11253446-rs10752021-rs11598936"
[290] "M3-rs11253446-rs10752021-rs10904576"
[291] "M3-rs11253446-rs10752021-rs17221435"
[292] "M3-rs11253446-rs10752021-rs11253495"
[293] "M3-rs11253446-rs10752021-rs7077992"
[294] "M3-rs11253446-rs10752021-rs10904578"
[295] "M3-rs11253446-rs10752021-rs11253516"
[296] "M3-rs11253446-rs10752021-rs12268008"
[297] "M3-rs11253446-rs2275677-rs11598936"
[298] "M3-rs11253446-rs2275677-rs10904576"
[299] "M3-rs11253446-rs2275677-rs17221435"
[300] "M3-rs11253446-rs2275677-rs11253495"
[301] "M3-rs11253446-rs2275677-rs7077992"
[302] "M3-rs11253446-rs2275677-rs10904578"
[303] "M3-rs11253446-rs2275677-rs11253516"
[304] "M3-rs11253446-rs2275677-rs12268008"
[305] "M3-rs11253446-rs11598936-rs10904576"
[306] "M3-rs11253446-rs11598936-rs17221435"
[307] "M3-rs11253446-rs11598936-rs11253495"
[308] "M3-rs11253446-rs11598936-rs7077992"
[309] "M3-rs11253446-rs11598936-rs10904578"
[310] "M3-rs11253446-rs11598936-rs11253516"
[311] "M3-rs11253446-rs11598936-rs12268008"
[312] "M3-rs11253446-rs10904576-rs17221435"
[313] "M3-rs11253446-rs10904576-rs11253495"
[314] "M3-rs11253446-rs10904576-rs7077992"
[315] "M3-rs11253446-rs10904576-rs10904578"
[316] "M3-rs11253446-rs10904576-rs11253516"
[317] "M3-rs11253446-rs10904576-rs12268008"
[318] "M3-rs11253446-rs17221435-rs11253495"
[319] "M3-rs11253446-rs17221435-rs7077992"
```

```
[320] "M3-rs11253446-rs17221435-rs10904578"
[321] "M3-rs11253446-rs17221435-rs11253516"
[322] "M3-rs11253446-rs17221435-rs12268008"
[323] "M3-rs11253446-rs11253495-rs7077992"
[324] "M3-rs11253446-rs11253495-rs10904578"
[325] "M3-rs11253446-rs11253495-rs11253516"
[326] "M3-rs11253446-rs11253495-rs12268008"
[327] "M3-rs11253446-rs7077992-rs10904578"
[328] "M3-rs11253446-rs7077992-rs11253516"
[329] "M3-rs11253446-rs7077992-rs12268008"
[330] "M3-rs11253446-rs10904578-rs11253516"
[331] "M3-rs11253446-rs10904578-rs12268008"
[332] "M3-rs11253446-rs11253516-rs12268008"
[333] "M3-rs17159911-rs12413228-rs9124"
[334] "M3-rs17159911-rs12413228-rs2296625"
[335] "M3-rs17159911-rs12413228-rs10752021"
[336] "M3-rs17159911-rs12413228-rs2275677"
[337] "M3-rs17159911-rs12413228-rs11598936"
[338] "M3-rs17159911-rs12413228-rs10904576"
[339] "M3-rs17159911-rs12413228-rs17221435"
[340] "M3-rs17159911-rs12413228-rs11253495"
[341] "M3-rs17159911-rs12413228-rs7077992"
[342] "M3-rs17159911-rs12413228-rs10904578"
[343] "M3-rs17159911-rs12413228-rs11253516"
[344] "M3-rs17159911-rs12413228-rs12268008"
[345] "M3-rs17159911-rs9124-rs2296625"
[346] "M3-rs17159911-rs9124-rs10752021"
[347] "M3-rs17159911-rs9124-rs2275677"
[348] "M3-rs17159911-rs9124-rs11598936"
[349] "M3-rs17159911-rs9124-rs10904576"
[350] "M3-rs17159911-rs9124-rs17221435"
[351] "M3-rs17159911-rs9124-rs11253495"
[352] "M3-rs17159911-rs9124-rs7077992"
[353] "M3-rs17159911-rs9124-rs10904578"
[354] "M3-rs17159911-rs9124-rs11253516"
[355] "M3-rs17159911-rs9124-rs12268008"
[356] "M3-rs17159911-rs2296625-rs10752021"
[357] "M3-rs17159911-rs2296625-rs2275677"
[358] "M3-rs17159911-rs2296625-rs11598936"
[359] "M3-rs17159911-rs2296625-rs10904576"
[360] "M3-rs17159911-rs2296625-rs17221435"
[361] "M3-rs17159911-rs2296625-rs11253495"
[362] "M3-rs17159911-rs2296625-rs7077992"
[363] "M3-rs17159911-rs2296625-rs10904578"
[364] "M3-rs17159911-rs2296625-rs11253516"
```

```
[365] "M3-rs17159911-rs2296625-rs12268008"
[366] "M3-rs17159911-rs10752021-rs2275677"
[367] "M3-rs17159911-rs10752021-rs11598936"
[368] "M3-rs17159911-rs10752021-rs10904576"
[369] "M3-rs17159911-rs10752021-rs17221435"
[370] "M3-rs17159911-rs10752021-rs11253495"
[371] "M3-rs17159911-rs10752021-rs7077992"
[372] "M3-rs17159911-rs10752021-rs10904578"
[373] "M3-rs17159911-rs10752021-rs11253516"
[374] "M3-rs17159911-rs10752021-rs12268008"
[375] "M3-rs17159911-rs2275677-rs11598936"
[376] "M3-rs17159911-rs2275677-rs10904576"
[377] "M3-rs17159911-rs2275677-rs17221435"
[378] "M3-rs17159911-rs2275677-rs11253495"
[379] "M3-rs17159911-rs2275677-rs7077992"
[380] "M3-rs17159911-rs2275677-rs10904578"
[381] "M3-rs17159911-rs2275677-rs11253516"
[382] "M3-rs17159911-rs2275677-rs12268008"
[383] "M3-rs17159911-rs11598936-rs10904576"
[384] "M3-rs17159911-rs11598936-rs17221435"
[385] "M3-rs17159911-rs11598936-rs11253495"
[386] "M3-rs17159911-rs11598936-rs7077992"
[387] "M3-rs17159911-rs11598936-rs10904578"
[388] "M3-rs17159911-rs11598936-rs11253516"
[389] "M3-rs17159911-rs11598936-rs12268008"
[390] "M3-rs17159911-rs10904576-rs17221435"
[391] "M3-rs17159911-rs10904576-rs11253495"
[392] "M3-rs17159911-rs10904576-rs7077992"
[393] "M3-rs17159911-rs10904576-rs10904578"
[394] "M3-rs17159911-rs10904576-rs11253516"
[395] "M3-rs17159911-rs10904576-rs12268008"
[396] "M3-rs17159911-rs17221435-rs11253495"
[397] "M3-rs17159911-rs17221435-rs7077992"
[398] "M3-rs17159911-rs17221435-rs10904578"
[399] "M3-rs17159911-rs17221435-rs11253516"
[400] "M3-rs17159911-rs17221435-rs12268008"
[401] "M3-rs17159911-rs11253495-rs7077992"
[402] "M3-rs17159911-rs11253495-rs10904578"
[403] "M3-rs17159911-rs11253495-rs11253516"
[404] "M3-rs17159911-rs11253495-rs12268008"
[405] "M3-rs17159911-rs7077992-rs10904578"
[406] "M3-rs17159911-rs7077992-rs11253516"
[407] "M3-rs17159911-rs7077992-rs12268008"
[408] "M3-rs17159911-rs10904578-rs11253516"
[409] "M3-rs17159911-rs10904578-rs12268008"
```

```
[410] "M3-rs17159911-rs11253516-rs12268008"
[411] "M3-rs12413228-rs9124-rs2296625"
[412] "M3-rs12413228-rs9124-rs10752021"
[413] "M3-rs12413228-rs9124-rs2275677"
[414] "M3-rs12413228-rs9124-rs11598936"
[415] "M3-rs12413228-rs9124-rs10904576"
[416] "M3-rs12413228-rs9124-rs17221435"
[417] "M3-rs12413228-rs9124-rs11253495"
[418] "M3-rs12413228-rs9124-rs7077992"
[419] "M3-rs12413228-rs9124-rs10904578"
[420] "M3-rs12413228-rs9124-rs11253516"
[421] "M3-rs12413228-rs9124-rs12268008"
[422] "M3-rs12413228-rs2296625-rs10752021"
[423] "M3-rs12413228-rs2296625-rs2275677"
[424] "M3-rs12413228-rs2296625-rs11598936"
[425] "M3-rs12413228-rs2296625-rs10904576"
[426] "M3-rs12413228-rs2296625-rs17221435"
[427] "M3-rs12413228-rs2296625-rs11253495"
[428] "M3-rs12413228-rs2296625-rs7077992"
[429] "M3-rs12413228-rs2296625-rs10904578"
[430] "M3-rs12413228-rs2296625-rs11253516"
[431] "M3-rs12413228-rs2296625-rs12268008"
[432] "M3-rs12413228-rs10752021-rs2275677"
[433] "M3-rs12413228-rs10752021-rs11598936"
[434] "M3-rs12413228-rs10752021-rs10904576"
[435] "M3-rs12413228-rs10752021-rs17221435"
[436] "M3-rs12413228-rs10752021-rs11253495"
[437] "M3-rs12413228-rs10752021-rs7077992"
[438] "M3-rs12413228-rs10752021-rs10904578"
[439] "M3-rs12413228-rs10752021-rs11253516"
[440] "M3-rs12413228-rs10752021-rs12268008"
[441] "M3-rs12413228-rs2275677-rs11598936"
[442] "M3-rs12413228-rs2275677-rs10904576"
[443] "M3-rs12413228-rs2275677-rs17221435"
[444] "M3-rs12413228-rs2275677-rs11253495"
[445] "M3-rs12413228-rs2275677-rs7077992"
[446] "M3-rs12413228-rs2275677-rs10904578"
[447] "M3-rs12413228-rs2275677-rs11253516"
[448] "M3-rs12413228-rs2275677-rs12268008"
[449] "M3-rs12413228-rs11598936-rs10904576"
[450] "M3-rs12413228-rs11598936-rs17221435"
[451] "M3-rs12413228-rs11598936-rs11253495"
[452] "M3-rs12413228-rs11598936-rs7077992"
[453] "M3-rs12413228-rs11598936-rs10904578"
[454] "M3-rs12413228-rs11598936-rs11253516"
```

```
[455] "M3-rs12413228-rs11598936-rs12268008"
[456] "M3-rs12413228-rs10904576-rs17221435"
[457] "M3-rs12413228-rs10904576-rs11253495"
[458] "M3-rs12413228-rs10904576-rs7077992"
[459] "M3-rs12413228-rs10904576-rs10904578"
[460] "M3-rs12413228-rs10904576-rs11253516"
[461] "M3-rs12413228-rs10904576-rs12268008"
[462] "M3-rs12413228-rs17221435-rs11253495"
[463] "M3-rs12413228-rs17221435-rs7077992"
[464] "M3-rs12413228-rs17221435-rs10904578"
[465] "M3-rs12413228-rs17221435-rs11253516"
[466] "M3-rs12413228-rs17221435-rs12268008"
[467] "M3-rs12413228-rs11253495-rs7077992"
[468] "M3-rs12413228-rs11253495-rs10904578"
[469] "M3-rs12413228-rs11253495-rs11253516"
[470] "M3-rs12413228-rs11253495-rs12268008"
[471] "M3-rs12413228-rs7077992-rs10904578"
[472] "M3-rs12413228-rs7077992-rs11253516"
[473] "M3-rs12413228-rs7077992-rs12268008"
[474] "M3-rs12413228-rs10904578-rs11253516"
[475] "M3-rs12413228-rs10904578-rs12268008"
[476] "M3-rs12413228-rs11253516-rs12268008"
[477] "M3-rs9124-rs2296625-rs10752021"
[478] "M3-rs9124-rs2296625-rs2275677"
[479] "M3-rs9124-rs2296625-rs11598936"
[480] "M3-rs9124-rs2296625-rs10904576"
[481] "M3-rs9124-rs2296625-rs17221435"
[482] "M3-rs9124-rs2296625-rs11253495"
[483] "M3-rs9124-rs2296625-rs7077992"
[484] "M3-rs9124-rs2296625-rs10904578"
[485] "M3-rs9124-rs2296625-rs11253516"
[486] "M3-rs9124-rs2296625-rs12268008"
[487] "M3-rs9124-rs10752021-rs2275677"
[488] "M3-rs9124-rs10752021-rs11598936"
[489] "M3-rs9124-rs10752021-rs10904576"
[490] "M3-rs9124-rs10752021-rs17221435"
[491] "M3-rs9124-rs10752021-rs11253495"
[492] "M3-rs9124-rs10752021-rs7077992"
[493] "M3-rs9124-rs10752021-rs10904578"
[494] "M3-rs9124-rs10752021-rs11253516"
[495] "M3-rs9124-rs10752021-rs12268008"
[496] "M3-rs9124-rs2275677-rs11598936"
[497] "M3-rs9124-rs2275677-rs10904576"
[498] "M3-rs9124-rs2275677-rs17221435"
[499] "M3-rs9124-rs2275677-rs11253495"
```

```
[500] "M3-rs9124-rs2275677-rs7077992"
[501] "M3-rs9124-rs2275677-rs10904578"
[502] "M3-rs9124-rs2275677-rs11253516"
[503] "M3-rs9124-rs2275677-rs12268008"
[504] "M3-rs9124-rs11598936-rs10904576"
[505] "M3-rs9124-rs11598936-rs17221435"
[506] "M3-rs9124-rs11598936-rs11253495"
[507] "M3-rs9124-rs11598936-rs7077992"
[508] "M3-rs9124-rs11598936-rs10904578"
[509] "M3-rs9124-rs11598936-rs11253516"
[510] "M3-rs9124-rs11598936-rs12268008"
[511] "M3-rs9124-rs10904576-rs17221435"
[512] "M3-rs9124-rs10904576-rs11253495"
[513] "M3-rs9124-rs10904576-rs7077992"
[514] "M3-rs9124-rs10904576-rs10904578"
[515] "M3-rs9124-rs10904576-rs11253516"
[516] "M3-rs9124-rs10904576-rs12268008"
[517] "M3-rs9124-rs17221435-rs11253495"
[518] "M3-rs9124-rs17221435-rs7077992"
[519] "M3-rs9124-rs17221435-rs10904578"
[520] "M3-rs9124-rs17221435-rs11253516"
[521] "M3-rs9124-rs17221435-rs12268008"
[522] "M3-rs9124-rs11253495-rs7077992"
[523] "M3-rs9124-rs11253495-rs10904578"
[524] "M3-rs9124-rs11253495-rs11253516"
[525] "M3-rs9124-rs11253495-rs12268008"
[526] "M3-rs9124-rs7077992-rs10904578"
[527] "M3-rs9124-rs7077992-rs11253516"
[528] "M3-rs9124-rs7077992-rs12268008"
[529] "M3-rs9124-rs10904578-rs11253516"
[530] "M3-rs9124-rs10904578-rs12268008"
[531] "M3-rs9124-rs11253516-rs12268008"
[532] "M3-rs2296625-rs10752021-rs2275677"
[533] "M3-rs2296625-rs10752021-rs11598936"
[534] "M3-rs2296625-rs10752021-rs10904576"
[535] "M3-rs2296625-rs10752021-rs17221435"
[536] "M3-rs2296625-rs10752021-rs11253495"
[537] "M3-rs2296625-rs10752021-rs7077992"
[538] "M3-rs2296625-rs10752021-rs10904578"
[539] "M3-rs2296625-rs10752021-rs11253516"
[540] "M3-rs2296625-rs10752021-rs12268008"
[541] "M3-rs2296625-rs2275677-rs11598936"
[542] "M3-rs2296625-rs2275677-rs10904576"
[543] "M3-rs2296625-rs2275677-rs17221435"
[544] "M3-rs2296625-rs2275677-rs11253495"
```

```
[545] "M3-rs2296625-rs2275677-rs7077992"
[546] "M3-rs2296625-rs2275677-rs10904578"
[547] "M3-rs2296625-rs2275677-rs11253516"
[548] "M3-rs2296625-rs2275677-rs12268008"
[549] "M3-rs2296625-rs11598936-rs10904576"
[550] "M3-rs2296625-rs11598936-rs17221435"
[551] "M3-rs2296625-rs11598936-rs11253495"
[552] "M3-rs2296625-rs11598936-rs7077992"
[553] "M3-rs2296625-rs11598936-rs10904578"
[554] "M3-rs2296625-rs11598936-rs11253516"
[555] "M3-rs2296625-rs11598936-rs12268008"
[556] "M3-rs2296625-rs10904576-rs17221435"
[557] "M3-rs2296625-rs10904576-rs11253495"
[558] "M3-rs2296625-rs10904576-rs7077992"
[559] "M3-rs2296625-rs10904576-rs10904578"
[560] "M3-rs2296625-rs10904576-rs11253516"
[561] "M3-rs2296625-rs10904576-rs12268008"
[562] "M3-rs2296625-rs17221435-rs11253495"
[563] "M3-rs2296625-rs17221435-rs7077992"
[564] "M3-rs2296625-rs17221435-rs10904578"
[565] "M3-rs2296625-rs17221435-rs11253516"
[566] "M3-rs2296625-rs17221435-rs12268008"
[567] "M3-rs2296625-rs11253495-rs7077992"
[568] "M3-rs2296625-rs11253495-rs10904578"
[569] "M3-rs2296625-rs11253495-rs11253516"
[570] "M3-rs2296625-rs11253495-rs12268008"
[571] "M3-rs2296625-rs7077992-rs10904578"
[572] "M3-rs2296625-rs7077992-rs11253516"
[573] "M3-rs2296625-rs7077992-rs12268008"
[574] "M3-rs2296625-rs10904578-rs11253516"
[575] "M3-rs2296625-rs10904578-rs12268008"
[576] "M3-rs2296625-rs11253516-rs12268008"
[577] "M3-rs10752021-rs2275677-rs11598936"
[578] "M3-rs10752021-rs2275677-rs10904576"
[579] "M3-rs10752021-rs2275677-rs17221435"
[580] "M3-rs10752021-rs2275677-rs11253495"
[581] "M3-rs10752021-rs2275677-rs7077992"
[582] "M3-rs10752021-rs2275677-rs10904578"
[583] "M3-rs10752021-rs2275677-rs11253516"
[584] "M3-rs10752021-rs2275677-rs12268008"
[585] "M3-rs10752021-rs11598936-rs10904576"
[586] "M3-rs10752021-rs11598936-rs17221435"
[587] "M3-rs10752021-rs11598936-rs11253495"
[588] "M3-rs10752021-rs11598936-rs7077992"
[589] "M3-rs10752021-rs11598936-rs10904578"
```

```
[590] "M3-rs10752021-rs11598936-rs11253516"
[591] "M3-rs10752021-rs11598936-rs12268008"
[592] "M3-rs10752021-rs10904576-rs17221435"
[593] "M3-rs10752021-rs10904576-rs11253495"
[594] "M3-rs10752021-rs10904576-rs7077992"
[595] "M3-rs10752021-rs10904576-rs10904578"
[596] "M3-rs10752021-rs10904576-rs11253516"
[597] "M3-rs10752021-rs10904576-rs12268008"
[598] "M3-rs10752021-rs17221435-rs11253495"
[599] "M3-rs10752021-rs17221435-rs7077992"
[600] "M3-rs10752021-rs17221435-rs10904578"
[601] "M3-rs10752021-rs17221435-rs11253516"
[602] "M3-rs10752021-rs17221435-rs12268008"
[603] "M3-rs10752021-rs11253495-rs7077992"
[604] "M3-rs10752021-rs11253495-rs10904578"
[605] "M3-rs10752021-rs11253495-rs11253516"
[606] "M3-rs10752021-rs11253495-rs12268008"
[607] "M3-rs10752021-rs7077992-rs10904578"
[608] "M3-rs10752021-rs7077992-rs11253516"
[609] "M3-rs10752021-rs7077992-rs12268008"
[610] "M3-rs10752021-rs10904578-rs11253516"
[611] "M3-rs10752021-rs10904578-rs12268008"
[612] "M3-rs10752021-rs11253516-rs12268008"
[613] "M3-rs2275677-rs11598936-rs10904576"
[614] "M3-rs2275677-rs11598936-rs17221435"
[615] "M3-rs2275677-rs11598936-rs11253495"
[616] "M3-rs2275677-rs11598936-rs7077992"
[617] "M3-rs2275677-rs11598936-rs10904578"
[618] "M3-rs2275677-rs11598936-rs11253516"
[619] "M3-rs2275677-rs11598936-rs12268008"
[620] "M3-rs2275677-rs10904576-rs17221435"
[621] "M3-rs2275677-rs10904576-rs11253495"
[622] "M3-rs2275677-rs10904576-rs7077992"
[623] "M3-rs2275677-rs10904576-rs10904578"
[624] "M3-rs2275677-rs10904576-rs11253516"
[625] "M3-rs2275677-rs10904576-rs12268008"
[626] "M3-rs2275677-rs17221435-rs11253495"
[627] "M3-rs2275677-rs17221435-rs7077992"
[628] "M3-rs2275677-rs17221435-rs10904578"
[629] "M3-rs2275677-rs17221435-rs11253516"
[630] "M3-rs2275677-rs17221435-rs12268008"
[631] "M3-rs2275677-rs11253495-rs7077992"
[632] "M3-rs2275677-rs11253495-rs10904578"
[633] "M3-rs2275677-rs11253495-rs11253516"
[634] "M3-rs2275677-rs11253495-rs12268008"
```

```
[635] "M3-rs2275677-rs7077992-rs10904578"
[636] "M3-rs2275677-rs7077992-rs11253516"
[637] "M3-rs2275677-rs7077992-rs12268008"
[638] "M3-rs2275677-rs10904578-rs11253516"
[639] "M3-rs2275677-rs10904578-rs12268008"
[640] "M3-rs2275677-rs11253516-rs12268008"
[641] "M3-rs11598936-rs10904576-rs17221435"
[642] "M3-rs11598936-rs10904576-rs11253495"
[643] "M3-rs11598936-rs10904576-rs7077992"
[644] "M3-rs11598936-rs10904576-rs10904578"
[645] "M3-rs11598936-rs10904576-rs11253516"
[646] "M3-rs11598936-rs10904576-rs12268008"
[647] "M3-rs11598936-rs17221435-rs11253495"
[648] "M3-rs11598936-rs17221435-rs7077992"
[649] "M3-rs11598936-rs17221435-rs10904578"
[650] "M3-rs11598936-rs17221435-rs11253516"
[651] "M3-rs11598936-rs17221435-rs12268008"
[652] "M3-rs11598936-rs11253495-rs7077992"
[653] "M3-rs11598936-rs11253495-rs10904578"
[654] "M3-rs11598936-rs11253495-rs11253516"
[655] "M3-rs11598936-rs11253495-rs12268008"
[656] "M3-rs11598936-rs7077992-rs10904578"
[657] "M3-rs11598936-rs7077992-rs11253516"
[658] "M3-rs11598936-rs7077992-rs12268008"
[659] "M3-rs11598936-rs10904578-rs11253516"
[660] "M3-rs11598936-rs10904578-rs12268008"
[661] "M3-rs11598936-rs11253516-rs12268008"
[662] "M3-rs10904576-rs17221435-rs11253495"
[663] "M3-rs10904576-rs17221435-rs7077992"
[664] "M3-rs10904576-rs17221435-rs10904578"
[665] "M3-rs10904576-rs17221435-rs11253516"
[666] "M3-rs10904576-rs17221435-rs12268008"
[667] "M3-rs10904576-rs11253495-rs7077992"
[668] "M3-rs10904576-rs11253495-rs10904578"
[669] "M3-rs10904576-rs11253495-rs11253516"
[670] "M3-rs10904576-rs11253495-rs12268008"
[671] "M3-rs10904576-rs7077992-rs10904578"
[672] "M3-rs10904576-rs7077992-rs11253516"
[673] "M3-rs10904576-rs7077992-rs12268008"
[674] "M3-rs10904576-rs10904578-rs11253516"
[675] "M3-rs10904576-rs10904578-rs12268008"
[676] "M3-rs10904576-rs11253516-rs12268008"
[677] "M3-rs17221435-rs11253495-rs7077992"
[678] "M3-rs17221435-rs11253495-rs10904578"
[679] "M3-rs17221435-rs11253495-rs11253516"
```

```
[680] "M3-rs17221435-rs11253495-rs12268008"
[681] "M3-rs17221435-rs7077992-rs10904578"
[682] "M3-rs17221435-rs7077992-rs11253516"
[683] "M3-rs17221435-rs7077992-rs12268008"
[684] "M3-rs17221435-rs10904578-rs11253516"
[685] "M3-rs17221435-rs10904578-rs12268008"
[686] "M3-rs17221435-rs11253516-rs12268008"
[687] "M3-rs11253495-rs7077992-rs10904578"
[688] "M3-rs11253495-rs7077992-rs11253516"
[689] "M3-rs11253495-rs7077992-rs12268008"
[690] "M3-rs11253495-rs10904578-rs11253516"
[691] "M3-rs11253495-rs10904578-rs12268008"
[692] "M3-rs11253495-rs11253516-rs12268008"
[693] "M3-rs7077992-rs10904578-rs11253516"
[694] "M3-rs7077992-rs10904578-rs12268008"
[695] "M3-rs7077992-rs11253516-rs12268008"
[696] "M3-rs10904578-rs11253516-rs12268008"

[[9]][[3]]$generation
  [1] "M1" "M1" "M1" "M1" "M1" "M1" "M1" "M1" "M1" "M1" "M1" "M1" "M1" "M1" "M1"
 [16] "M1" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2"
 [31] "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2"
 [46] "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2"
 [61] "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2"
 [76] "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2"
 [91] "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2"
[106] "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2"
[121] "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2" "M2"
[136] "M2" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[151] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[166] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[181] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[196] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[211] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[226] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[241] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[256] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[271] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[286] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[301] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[316] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[331] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[346] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[361] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[376] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
```

```
[391] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[406] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[421] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[436] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[451] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[466] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[481] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[496] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[511] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[526] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[541] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[556] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[571] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[586] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[601] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[616] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[631] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[646] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[661] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[676] "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3" "M3"
[691] "M3" "M3" "M3" "M3" "M3" "M3"

[[9]][[3]]$BF
  [1]  96.2878167   2.2011067  93.0279079 188.7171021 164.0866396  -5.2741585
  [7] 179.2633424  -0.6880818  -5.5347943  50.4627055  61.8852310   5.1712236
 [13] 164.9887938 148.2375020   1.5115831   7.7280330 115.4597793 112.2709805
 [19] 185.7283166 157.0976384 100.8534173 195.5404917  91.8316552  88.7527009
 [25] 115.3124053 129.5622803 117.3178136 176.2334895 179.4081887 108.3274817
 [31]  88.8121659 119.5988123 183.5739932 191.3513250  -3.2958615 173.8635016
 [37]   1.5426530  -4.5399738  46.3992703  57.6538007  -1.7183056 195.4022592
 [43] 140.0997226   2.9297055  18.4458537 185.1647324 156.7709139 112.6078785
 [49] 207.7317633  84.9870774 116.3932254 133.0068873 119.0998578 112.0237602
 [55] 172.9531839 190.8178129 116.9077885  85.4971914 194.1403359 214.4915127
 [61] 213.5592669 180.7235915 180.5935751 188.3424648 199.6742644 184.3423882
 [67] 237.9051177 218.4075804 209.7965949 180.5947345 183.0526080 215.9272245
 [73] 156.0944036 155.9577148 170.3436645 183.1610251 184.8446932 196.1608429
 [79] 214.1268337 180.0409487 158.5768793 193.4291667  -4.6388917 -11.3762386
 [85]  42.7188494  53.9558796   0.2123088 171.4984839 145.3604092  -4.1110245
 [91]  10.4126921 172.2015275 173.7276336 174.8028050 176.1567241 172.3289595
 [97] 198.7093473 187.2715450 179.0391066 187.1524584  -5.8867099  46.7362687
[103]  56.7972540   4.8751532 157.7018004 140.6650315   3.0453158   5.6710806
[109]  43.3591168  60.5379781  -1.5635979 157.5256628 140.5184056  -4.9558677
[115]   1.2376345 137.5490109  49.1290040 159.6896361 141.1011668  44.6759545
[121]  45.2082209  58.8965007 165.1569613 141.5795872  55.4248838 115.1512454
[127] 184.2445631 140.3451436   6.8226631  18.0170101 176.6741432 162.5353879
```

```
[133] 159.3386654 141.7509946 158.6368129  25.7683795 141.9866271 178.4113807
[139] 184.9404856 120.5038081 187.7293765 110.7366706 107.2842206 124.7535684
[145] 137.8067723 112.9862506 212.4804802 175.5321844 126.7365145 110.9284551
[151] 179.8706532 149.7919365 130.4408693 203.7970773 104.7301838 119.2235484
[157] 137.3508373 135.5282804 136.8724739 173.2287102 190.3539543 135.2611707
[163] 104.2086728 186.8178672 211.8043383 210.1329618 177.6390650 177.6035293
[169] 184.7690634 196.1753125 178.7936783 230.2460142 214.1628176 207.9446076
[175] 177.7932068 175.9427124 208.8191145 149.0640231 148.9677346 163.1842243
[181] 176.0488754 178.8983076 188.9619926 206.8176602 173.4096249 151.6154227
[187] 195.7772721  98.1319012  92.7906024 114.0269761 124.3518986 124.1322423
[193] 172.5491796 171.5031534 101.1337601  96.7923082 188.1802088 189.6919496
[199] 189.6337797 192.2949490 188.1593720 203.2647489 200.7947107 188.7661003
[205] 193.4221072  84.4407477 109.6788830 122.9768031 112.9929169 168.8261937
[211] 171.6033343 106.0005906  84.2302245 108.1066542 124.2633163 109.1438967
[217] 168.3957616 171.8538826 100.2261884  81.2067271 168.5487963 127.3899592
[223] 170.4660448 172.7009454 117.9400322 107.5650607 138.6617996 176.7972304
[229] 172.8796920 130.1792872 141.7166852 201.9487842 176.7799202 130.7698821
[235] 111.0656547 188.0376114 168.7835767 168.3317626 171.7089807 176.5124220
[241] 107.5316093 177.8933072 184.8303604 143.4766489 200.5684915 111.4573176
[247] 139.5687252 146.9441352 132.6687791 113.5301124 213.2378988 189.3421817
[253] 144.7658543 114.9504043 190.0621863 212.5953035 212.7655244 175.7303209
[259] 175.4028955 183.5998753 195.3886590 177.2390011 233.5651573 215.6617035
[265] 206.9315975 176.0511410 212.3160470 211.9890581 183.6692820 183.6981635
[271] 189.2965103 199.6372586 185.7157428 233.5880820 216.8764209 206.4705532
[277] 183.6150026 191.0987800  -2.6765337 -10.4265189  38.6588233  49.6919928
[283]  -6.8050375 208.3710189 137.2358365  -2.8371847  23.2883767 166.6459150
[289] 168.0253633 169.4630211 170.6489574 166.5984824 197.0812536 182.0190616
[295] 174.9290510 179.5130891  -4.9475312  42.8049988  52.7083984  -2.0852980
[301] 187.8090685 132.5331744   4.4057377  16.0631019  39.7115549  54.9255002
[307]  -8.5527804 187.2326645 132.3992861  -4.4249096  10.6400847 129.4702287
[313]  41.8202428 187.6202981 132.9629493  40.5674667  44.4224068  51.7324996
[319] 188.8412886 133.4421610  51.1542551 120.5741509 188.6635525 133.2894247
[325]  -0.3020984  13.4593123 188.9933177 198.1355708 196.2428549 133.6147786
[331] 151.8764294  39.5018227 186.8350723 217.8102595 214.5938284 177.5054742
[337] 178.4585888 187.5635673 194.2706299 178.4308376 230.4021349 217.2564901
[343] 211.4981458 177.2362467 176.9710711 211.1393061 148.7870268 149.3271129
[349] 164.1687093 176.3373387 177.6991121 188.9220208 207.7762668 173.8450737
[355] 151.2607442 203.0103645 104.7895860 135.9944351 142.0436399 121.9506373
[361] 136.2269817 167.9748047 183.7927890 111.5656179 109.5432889 199.6461132
[367] 201.7164663 205.2300699 201.5316125 200.2194485 209.0961745 213.7639501
[373] 199.9718191 203.8764293 108.2498369 124.8849647 110.9564108 103.9322998
[379] 164.8294394 183.2234363 109.2140034  77.4626642 135.0823746 143.7711543
[385] 131.5002464 173.7704405 189.6222687 138.8856962 108.6354966 178.4248368
[391] 142.5440846 171.5516472 183.2270522 142.0930911 127.0767064 127.1686628
[397] 171.7275176 183.0904221 127.6052777 131.2376852 197.1171320 187.4767349
```

```
[403] 138.5580654 105.6718351 192.3304823 165.3230396 165.1231332 184.7428271
[409] 186.6743590 117.2561065 222.7796875 216.6915096 186.6096913 186.0191937
[415] 192.8476375 204.0444488 187.9152937 230.9025354 221.7325575 215.8957971
[421] 187.5059698 209.8395164 206.3412913 207.7827991 208.1255048 212.1720051
[427] 212.5528059 232.5107156 219.1970003 209.0154585 209.6478598 205.4379408
[433] 207.3696535 207.1028648 211.2835728 212.2701343 233.5199046 218.2962087
[439] 209.7269973 208.2385079 172.6198250 180.3540349 191.9388515 176.5996128
[445] 230.2452623 210.7620177 201.6496559 172.6013895 181.6322820 191.7343988
[451] 176.1724734 229.7699570 211.4229655 202.5482315 172.4745300 210.3514657
[457] 183.9590458 229.9872575 211.8037777 203.3938772 180.6728826 196.3937512
[463] 233.0804071 212.1016655 210.4665192 198.9350860 230.7455674 215.8434228
[469] 206.8067906 176.6023631 233.5228136 232.5433253 229.9914411 217.7249926
[475] 212.1446923 206.6166869 208.6785649 174.9120284 175.1476806 181.9890099
[481] 188.3647700 207.3343006 189.4684006 209.3795090 177.5094618 175.1431879
[487] 207.8785621 209.7843491 209.5775032 213.0650201 211.1559408 215.7348912
[493] 220.9742011 208.3621078 208.6416906 147.9574526 162.3829311 175.5344266
[499] 176.9065350 188.0954618 206.7558542 171.9008278 150.6335266 163.2746479
[505] 176.0655484 176.8879913 188.0652254 206.8172456 171.9741883 150.4906761
[511] 203.7756075 184.7409534 190.5355318 207.6245923 178.6230694 168.3467887
[517] 194.2382828 197.6329349 207.5917514 188.4431957 178.0578325 220.3413632
[523] 214.6789663 202.0758186 177.8779847 210.4076713 189.9451450 188.9898852
[529] 208.9777045 206.2643248 172.2560294 185.2980962 187.6570934 187.9380315
[535] 191.8424889 189.6905581 221.5620607 201.5214932 187.4808768 191.1493896
[541] -10.5446989  39.4854304  48.7171493   1.3487279 163.3962880 137.3510556
[547]  -2.9402955  10.2717776  35.7280663  53.1682206  -6.9676192 164.8709318
[553] 137.4735215 -10.3881245   2.8953406 134.3848341  41.5562146 165.4987549
[559] 138.5851815  38.2839827  39.4228573  50.8508834 174.1066433 139.2120585
[565]  53.8656682 110.1576261 191.7528502 137.2919182   0.9190729  23.2027238
[571] 184.5857653 164.9465418 163.6032757 138.7941045 151.3331845  19.4828658
[577] 166.4556892 167.6166822 168.8027130 165.1313669 190.9951123 179.5408672
[583] 171.1972580 179.5926899 171.5570631 169.2376969 166.6524730 191.3595962
[589] 182.0647060 173.4209492 182.8847498 179.1311907 167.8241498 191.0523127
[595] 179.7338162 174.9821924 179.5554441 169.2728483 192.3605541 179.8266258
[601] 176.3544732 198.7092818 194.3388767 180.4904318 173.4645139 179.2931013
[607] 194.5805827 205.0051935 198.2954459 188.9241967 196.3056478 180.7130645
[613]  39.3768499  55.6631099  -1.6178990 150.3165507 132.8847162  -3.2168309
[619]  -0.5332710 130.0245610  45.7587361 152.3406170 133.4996676  41.9933305
[625]  41.1842683  54.1448860 157.5572030 133.9605704  51.1413925 107.6166920
[631] 176.9887838 132.8281011   8.8241129  16.1596937 168.8245715 154.6510031
[637] 151.9296003 133.9169734 150.6813955  26.4649777 129.5957698  42.4854057
[643] 151.7131383 133.2541504  37.6929551  38.0270924  56.0935279 158.7403292
[649] 133.6443681  53.3192766 112.1968260 176.0959478 132.6874161  -0.5874077
[655]  10.3835189 168.5143901 155.4948451 151.6965670 133.9609790 151.6020958
[661]  17.8889718 129.9174241 168.8422351 136.3743430 130.6253187 160.2822653
[667] 176.5684463 133.1846232  43.6507906  46.2183325 169.5616358 157.4381907
```

```
[673] 153.0443267 134.6546537 159.4774682  44.8162628 178.9092374 133.6670047
[679]  52.7200410 116.0347428 169.8426898 163.4610139 170.7018806 135.1413956
[685] 162.9935117 125.2192915 181.3441604 182.9787876 181.3253818 133.7583202
[691] 151.8262035  39.4302337 176.2305982 175.7259410 154.8559286 151.0541474

[[9]][[3]]$pp
  [1] 2.189129e+21 8.120858e+00 4.289347e+20 2.576533e+41 1.155045e+36
  [6] 1.933609e-01 2.281276e+39 1.915237e+00 1.697354e-01 2.451743e+11
 [11] 7.410454e+13 3.585540e+01 1.813423e+36 4.178325e+32 5.752727e+00
 [16] 1.287534e+02 3.364273e+25 6.830499e+24 6.102535e+40 3.702009e+34
 [21] 2.265479e+22 8.245121e+42 2.489484e+20 5.339774e+19 3.125284e+25
 [26] 3.883385e+28 8.518406e+25 5.293401e+38 2.588880e+39 9.508950e+23
 [31] 5.500923e+19 2.664838e+26 2.078284e+40 1.015152e+42 5.488220e-01
 [36] 1.618447e+38 6.167393e+00 2.946293e-01 3.393066e+10 9.429366e+12
 [41] 1.207796e+00 7.694497e+42 7.540272e+30 1.233946e+01 2.887919e+04
 [46] 4.603939e+40 3.144055e+34 8.083676e+24 3.660143e+45 8.125089e+18
 [51] 5.365208e+25 2.173689e+29 2.076463e+26 6.036278e+24 1.026657e+38
 [56] 7.774641e+41 6.939409e+25 1.048571e+19 4.094087e+42 1.074877e+47
 [61] 6.744106e+46 4.997445e+39 4.682905e+39 2.255098e+41 6.513799e+43
 [66] 3.051826e+40 1.304844e+52 7.615918e+47 1.027710e+46 4.685620e+39
 [71] 1.601355e+40 2.203534e+47 2.241753e+34 2.093660e+34 2.784682e+37
 [76] 1.690558e+40 3.923141e+40 1.124358e+43 8.957151e+46 3.552336e+39
 [81] 7.756228e+34 2.868987e+42 2.804118e-01 9.656060e-03 5.387646e+09
 [86] 1.484189e+12 3.171181e+00 4.960682e+37 1.046479e+32 3.651078e-01
 [91] 5.202429e+02 7.050264e+37 1.512151e+38 2.588604e+38 5.094076e+38
 [96] 7.514098e+37 4.020733e+43 1.320134e+41 2.152617e+39 1.243823e+41
[101] 1.502574e-01 4.015786e+10 6.144489e+12 3.263960e+01 5.007600e+34
[106] 1.000328e+31 1.307377e+01 4.859351e+01 7.420469e+09 3.988170e+13
[111] 1.304932e+00 4.585449e+34 9.296144e+30 2.393127e-01 5.295021e+00
[116] 2.106236e+30 1.328454e+11 1.352953e+35 1.244079e+31 1.433438e+10
[121] 1.870506e+10 1.755219e+13 2.082079e+36 1.580285e+31 3.093708e+12
[126] 2.883328e+25 2.906145e+40 8.524708e+30 8.642537e+01 2.330573e+04
[131] 6.598140e+38 5.613449e+35 1.135195e+35 1.721695e+31 7.992175e+34
[136] 1.123702e+06 1.291314e+31 1.048496e+39 2.743745e+40 2.793167e+26
[141] 1.106480e+41 2.114414e+24 3.762704e+23 2.338410e+27 1.597305e+30
[146] 6.511486e+24 2.621667e+46 2.485175e+38 6.302487e+27 2.327209e+24
[151] 2.174921e+39 6.396365e+32 4.017005e+28 3.411933e+44 1.049296e+23
[156] 1.472625e+26 1.271695e+30 5.112339e+29 1.001169e+30 7.855322e+37
[161] 4.110205e+41 4.473192e+29 8.084502e+22 7.014746e+40 1.869628e+46
[166] 8.106258e+45 7.126238e+38 7.000739e+38 2.518372e+40 7.550146e+42
[171] 1.269350e+39 1.889358e+50 6.079844e+46 2.714097e+45 7.697183e+38
[176] 3.051421e+38 4.202639e+45 4.444970e+32 4.236040e+32 5.176445e+35
[181] 3.217771e+38 1.337523e+39 2.049287e+41 1.544941e+45 8.599023e+37
[186] 1.591836e+33 6.187596e+42 3.873460e+21 2.680716e+20 1.095647e+25
[191] 1.912931e+27 1.713963e+27 5.592497e+37 3.314852e+37 1.737579e+22
```

```
[196] 1.982486e+21 1.386247e+41 2.951964e+41 2.867342e+41 1.084789e+42
[201] 1.371880e+41 2.614610e+44 7.604050e+43 1.858084e+41 1.905919e+42
[206] 4.121952e+18 1.245932e+24 9.618360e+26 6.533226e+24 8.693000e+36
[211] 3.485123e+37 1.980447e+23 3.710123e+18 5.676612e+23 1.830054e+27
[216] 9.535062e+23 7.009750e+36 3.950244e+37 1.103743e+22 8.181713e+17
[221] 7.567172e+36 8.737872e+27 1.973599e+37 6.033389e+37 7.751399e+25
[226] 4.329958e+23 2.449372e+30 4.677979e+38 6.597443e+37 3.524525e+28
[231] 1.128274e+31 1.354094e+44 4.637666e+38 4.735290e+28 2.492459e+24
[236] 1.290851e+41 8.509725e+36 6.788992e+36 3.674167e+37 4.057074e+38
[241] 4.258139e+23 8.092233e+38 2.596751e+40 2.720107e+31 6.790818e+43
[246] 3.031632e+24 3.854705e+30 1.540072e+32 1.223734e+29 8.546301e+24
[251] 3.828678e+46 2.478334e+41 5.182429e+31 1.738564e+25 3.552277e+41
[256] 2.776586e+46 3.023250e+46 2.743986e+38 2.329605e+38 1.403569e+40
[261] 5.094901e+42 5.834284e+38 9.932464e+50 1.286386e+47 1.635509e+45
[266] 3.221418e+38 2.414745e+46 2.050532e+46 1.453133e+40 1.474270e+40
[271] 2.422381e+41 4.262922e+43 4.042860e+40 1.004697e+51 2.361261e+47
[276] 1.298789e+45 1.414226e+40 5.964861e+41 4.986842e-01 1.034994e-02
[281] 4.717201e+08 1.173564e+11 6.328961e-02 3.359072e+45 1.200634e+30
[286] 4.601937e-01 2.167875e+05 2.922323e+36 5.824673e+36 1.195240e+37
[291] 2.162608e+37 2.853831e+36 1.187621e+43 6.367435e+39 1.838181e+38
[296] 1.818861e+39 1.602082e-01 3.749859e+09 5.302868e+11 6.702098e-01
[301] 1.151459e+41 1.143512e+29 1.720764e+01 5.849056e+03 7.985132e+08
[306] 1.606750e+12 2.641282e-02 8.631455e+40 1.069467e+29 2.080514e-01
[311] 3.885908e+02 2.472467e+28 2.291806e+09 1.047750e+41 1.417637e+29
[316] 1.225014e+09 8.418420e+09 3.255345e+11 1.929267e+41 1.801460e+29
[321] 2.437995e+11 2.893155e+26 1.765214e+41 1.669008e+29 1.634661e+00
[326] 1.591036e+03 2.081637e+41 2.011963e+43 7.809478e+42 1.963849e+29
[331] 1.813740e+33 7.190173e+08 7.075351e+40 3.766382e+47 7.541978e+46
[336] 6.665788e+38 1.073539e+39 1.018448e+41 2.913123e+42 1.058746e+39
[341] 2.042751e+50 2.855452e+47 1.604229e+46 5.826255e+38 5.102786e+38
[346] 1.340742e+46 3.870079e+32 5.069885e+32 8.468564e+35 3.717013e+38
[351] 7.343438e+38 2.008737e+41 2.495000e+45 1.069069e+38 1.333155e+33
[356] 2.302333e+44 1.080929e+23 6.454222e+29 1.328654e+31 5.758004e+26
[361] 7.250045e+29 5.679275e+36 1.545698e+40 3.200322e+24 1.164261e+24
[366] 4.281837e+43 1.205596e+44 6.985073e+44 1.099161e+44 5.703328e+43
[371] 4.827085e+45 4.980575e+46 5.039138e+43 3.550027e+44 6.097909e+23
[376] 2.497198e+27 2.359967e+24 7.041086e+22 1.178380e+36 1.162763e+40
[381] 9.875225e+23 1.258437e+17 4.090651e+29 3.151643e+31 6.822495e+28
[386] 1.029910e+38 2.850887e+41 2.739512e+30 7.394790e+23 1.055574e+39
[391] 1.706405e+31 3.396209e+37 1.164867e+40 1.361916e+31 7.471085e+27
[396] 7.822612e+27 3.708379e+37 1.087946e+40 9.731090e+27 5.983134e+28
[401] 1.209119e+43 9.751765e+40 2.325568e+30 1.680254e+23 1.104234e+42
[406] 1.508236e+36 1.364773e+36 2.485551e+40 6.529043e+40 5.506397e+25
[411] 4.518788e+48 2.152737e+47 6.321310e+40 4.705244e+40 1.430079e+42
[416] 3.861149e+44 1.214269e+41 2.623469e+50 2.676952e+48 1.446120e+47
```

```
[421] 9.895358e+40 7.000024e+45 1.217502e+45 2.503163e+45 2.971027e+45
[426] 2.246948e+46 2.718209e+46 5.862568e+50 7.534446e+47 4.636152e+45
[431] 6.360362e+45 7.750140e+44 2.035990e+45 1.781735e+45 1.441028e+46
[436] 2.359943e+46 9.710252e+50 4.802274e+47 6.617079e+45 3.143728e+45
[441] 5.793570e+37 2.769546e+39 9.078614e+41 4.237856e+38 1.888648e+50
[446] 1.110243e+46 1.165988e+44 5.740412e+37 5.247790e+39 8.196401e+41
[451] 3.422899e+38 1.489154e+50 1.545045e+46 1.827331e+44 5.387606e+37
[456] 9.042071e+45 1.679681e+40 1.660068e+50 1.869104e+46 2.788989e+44
[461] 3.248220e+39 8.421486e+42 7.794618e+50 2.169297e+46 9.577485e+45
[466] 3.000769e+43 2.425442e+50 1.408741e+47 1.536567e+45 4.243688e+38
[471] 9.724386e+50 5.958940e+50 1.663544e+50 3.609183e+47 2.216471e+46
[476] 1.397240e+45 3.917438e+45 1.822602e+38 2.050516e+38 6.272474e+39
[481] 1.520259e+41 2.000317e+45 2.639781e+41 5.561734e+45 6.679091e+38
[486] 2.045915e+38 2.625933e+45 6.809577e+45 6.140505e+45 3.511630e+46
[491] 1.351940e+46 1.334332e+47 1.832169e+48 3.344139e+45 3.845873e+45
[496] 2.556113e+32 3.467632e+35 2.487963e+38 4.940757e+38 1.328734e+41
[501] 1.497928e+45 4.044064e+37 9.742765e+32 5.415852e+35 3.244708e+38
[506] 4.895159e+38 1.308797e+41 1.544620e+45 4.195155e+37 9.071155e+32
[511] 3.375503e+44 2.483224e+40 4.500829e+41 2.312783e+45 1.165559e+39
[516] 6.840191e+36 2.866386e+42 1.564855e+43 2.275116e+45 1.581057e+41
[521] 8.786068e+38 1.335201e+48 7.869964e+46 1.442893e+44 8.030473e+38
[526] 9.299783e+45 3.350362e+41 2.078068e+41 4.549456e+45 1.171538e+45
[531] 4.830021e+37 3.280937e+40 1.067204e+41 1.228153e+41 8.651565e+41
[536] 2.949910e+41 2.458203e+48 1.093613e+44 9.771982e+40 6.117727e+41
[541] 9.756077e-03 7.131482e+08 7.208121e+10 3.731643e+00 5.755468e+35
[546] 1.271834e+30 4.370695e-01 3.232330e+02 1.089629e+08 6.673596e+11
[551] 5.834830e-02 1.203083e+36 1.352145e+30 1.055055e-02 8.086168e+00
[556] 2.886180e+29 2.008375e+09 1.646742e+36 2.357313e+30 3.911008e+08
[561] 6.911817e+08 2.094867e+11 1.218442e+38 3.225091e+30 9.458205e+11
[566] 1.582895e+24 8.272369e+41 1.234778e+30 3.010244e+00 2.076993e+05
[571] 2.297826e+40 1.249436e+36 6.383038e+35 2.616883e+30 1.382328e+33
[576] 3.233539e+04 2.657181e+36 4.748184e+36 8.591538e+36 1.370403e+36
[581] 5.663556e+41 1.844300e+39 2.844721e+37 1.892712e+39 3.405418e+37
[586] 1.067890e+37 2.931921e+36 6.795726e+41 6.514425e+39 8.647850e+37
[591] 9.816267e+39 1.502697e+39 5.267185e+36 5.827873e+41 2.031093e+39
[596] 1.887677e+38 1.857791e+39 1.086825e+37 1.120963e+42 2.127567e+39
[601] 3.748994e+38 2.680401e+43 3.014244e+42 2.965014e+39 8.838287e+37
[606] 1.629408e+39 3.401451e+42 6.242228e+44 2.179398e+43 2.010924e+41
[611] 8.058558e+42 3.314140e+39 6.754634e+08 2.323369e+12 8.466525e-01
[616] 8.314799e+32 1.363255e+29 3.806287e-01 1.456227e+00 3.262137e+28
[621] 1.642142e+10 2.287558e+33 1.854010e+29 2.498983e+09 1.667546e+09
[626] 1.087527e+12 3.105556e+34 2.334510e+29 2.422366e+11 4.443194e+23
[631] 5.148178e+38 1.325205e+29 1.567326e+02 6.138474e+03 8.685952e+36
[636] 7.262166e+33 1.862606e+33 2.284172e+29 9.978765e+32 1.061266e+06
[641] 2.632639e+28 3.196069e+09 1.671541e+33 1.639829e+29 2.910373e+08
```

```
[646] 3.439582e+08 2.881259e+12 5.611152e+34 1.993119e+29 7.197163e+11
[651] 4.387920e+24 3.294403e+38 1.235190e+29 1.417338e+00 3.418062e+02
[656] 7.438106e+36 1.107399e+34 1.657748e+33 2.334987e+29 1.581264e+33
[661] 1.457365e+04 3.091987e+28 8.763004e+36 7.804406e+29 4.405093e+28
[666] 1.213051e+35 4.172328e+38 1.583802e+29 5.723692e+09 2.066383e+10
[671] 1.255651e+37 2.926148e+34 3.252227e+33 3.303042e+29 8.111846e+34
[676] 1.025074e+10 1.344853e+39 2.015806e+29 5.333827e+11 2.989866e+25
[681] 1.445104e+37 5.944779e+35 2.220598e+37 4.213167e+29 4.705642e+35
[686] 2.951557e+27 4.543721e+39 1.028884e+40 4.501258e+39 2.109977e+29
[691] 1.768759e+33 6.937356e+08 3.523836e+38 2.737983e+38 8.045724e+33
[696] 1.202317e+33

[[9]][[3]]$color
  [1] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
  [7] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [13] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [19] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [25] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [31] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [37] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [43] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [49] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [55] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [61] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [67] "#FFFFE6FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [73] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [79] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [85] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [91] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
 [97] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[103] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[109] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[115] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[121] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[127] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[133] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[139] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[145] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[151] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[157] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[163] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[169] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[175] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[181] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[187] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
```

```
[193] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[199] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[205] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[211] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[217] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[223] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[229] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[235] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[241] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[247] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[253] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[259] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF1200FF" "#FF0000FF"
[265] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[271] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF1200FF" "#FF0000FF" "#FF0000FF"
[277] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[283] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[289] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[295] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[301] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[307] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[313] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[319] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[325] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[331] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[337] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[343] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[349] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[355] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[361] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[367] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[373] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[379] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[385] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[391] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[397] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[403] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[409] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[415] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[421] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[427] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[433] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF1200FF" "#FF0000FF"
[439] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[445] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[451] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[457] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
```

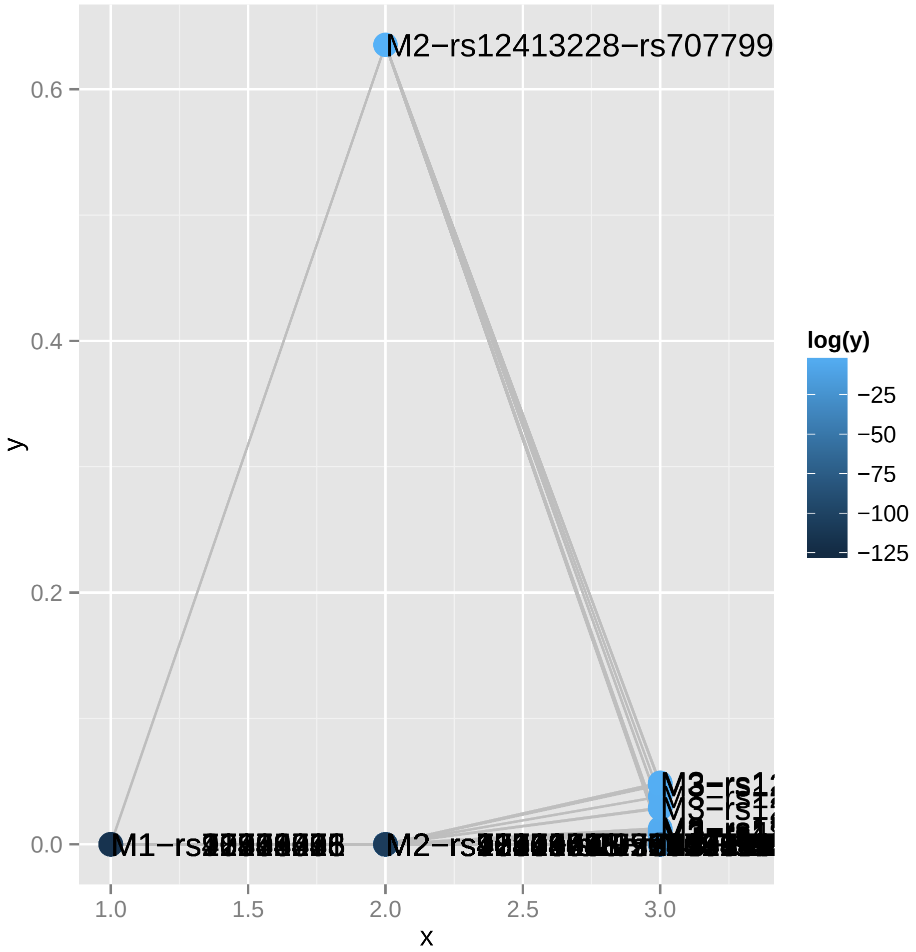
```
[463] "#FF1200FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[469] "#FF0000FF" "#FF0000FF" "#FF1200FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[475] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[481] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[487] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[493] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[499] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[505] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[511] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[517] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[523] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[529] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[535] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[541] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[547] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[553] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[559] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[565] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[571] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[577] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[583] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[589] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[595] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[601] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[607] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[613] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[619] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[625] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[631] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[637] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[643] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[649] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[655] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[661] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[667] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[673] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[679] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[685] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"
[691] "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF" "#FF0000FF"

[[9]][[3]]$x
  [1] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
 [38] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
 [75] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
[112] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3
```

```
[149] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[186] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[223] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[260] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[297] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[334] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[371] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[408] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[445] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[482] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[519] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[556] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[593] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[630] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
[667] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3

[[9]][[3]]$y
  [1] 2.189129e+21 8.120858e+00 4.289347e+20 2.576533e+41 1.155045e+36
  [6] 1.933609e-01 2.281276e+39 1.915237e+00 1.697354e-01 2.451743e+11
 [11] 7.410454e+13 3.585540e+01 1.813423e+36 4.178325e+32 5.752727e+00
 [16] 1.287534e+02 3.364273e+25 6.830499e+24 6.102535e+40 3.702009e+34
 [21] 2.265479e+22 8.245121e+42 2.489484e+20 5.339774e+19 3.125284e+25
 [26] 3.883385e+28 8.518406e+25 5.293401e+38 2.588880e+39 9.508950e+23
 [31] 5.500923e+19 2.664838e+26 2.078284e+40 1.015152e+42 5.488220e-01
 [36] 1.618447e+38 6.167393e+00 2.946293e-01 3.393066e+10 9.429366e+12
 [41] 1.207796e+00 7.694497e+42 7.540272e+30 1.233946e+01 2.887919e+04
 [46] 4.603939e+40 3.144055e+34 8.083676e+24 3.660143e+45 8.125089e+18
 [51] 5.365208e+25 2.173689e+29 2.076463e+26 6.036278e+24 1.026657e+38
 [56] 7.774641e+41 6.939409e+25 1.048571e+19 4.094087e+42 1.074877e+47
 [61] 6.744106e+46 4.997445e+39 4.682905e+39 2.255098e+41 6.513799e+43
 [66] 3.051826e+40 1.304844e+52 7.615918e+47 1.027710e+46 4.685620e+39
 [71] 1.601355e+40 2.203534e+47 2.241753e+34 2.093660e+34 2.784682e+37
 [76] 1.690558e+40 3.923141e+40 1.124358e+43 8.957151e+46 3.552336e+39
 [81] 7.756228e+34 2.868987e+42 2.804118e-01 9.656060e-03 5.387646e+09
 [86] 1.484189e+12 3.171181e+00 4.960682e+37 1.046479e+32 3.651078e-01
 [91] 5.202429e+02 7.050264e+37 1.512151e+38 2.588604e+38 5.094076e+38
 [96] 7.514098e+37 4.020733e+43 1.320134e+41 2.152617e+39 1.243823e+41
[101] 1.502574e-01 4.015786e+10 6.144489e+12 3.263960e+01 5.007600e+34
[106] 1.000328e+31 1.307377e+01 4.859351e+01 7.420469e+09 3.988170e+13
[111] 1.304932e+00 4.585449e+34 9.296144e+30 2.393127e-01 5.295021e+00
[116] 2.106236e+30 1.328454e+11 1.352953e+35 1.244079e+31 1.433438e+10
[121] 1.870506e+10 1.755219e+13 2.082079e+36 1.580285e+31 3.093708e+12
[126] 2.883328e+25 2.906145e+40 8.524708e+30 8.642537e+01 2.330573e+04
[131] 6.598140e+38 5.613449e+35 1.135195e+35 1.721695e+31 7.992175e+34
[136] 1.123702e+06 1.291314e+31 1.048496e+39 2.743745e+40 2.793167e+26
```

```
[141] 1.106480e+41 2.114414e+24 3.762704e+23 2.338410e+27 1.597305e+30
[146] 6.511486e+24 2.621667e+46 2.485175e+38 6.302487e+27 2.327209e+24
[151] 2.174921e+39 6.396365e+32 4.017005e+28 3.411933e+44 1.049296e+23
[156] 1.472625e+26 1.271695e+30 5.112339e+29 1.001169e+30 7.855322e+37
[161] 4.110205e+41 4.473192e+29 8.084502e+22 7.014746e+40 1.869628e+46
[166] 8.106258e+45 7.126238e+38 7.000739e+38 2.518372e+40 7.550146e+42
[171] 1.269350e+39 1.889358e+50 6.079844e+46 2.714097e+45 7.697183e+38
[176] 3.051421e+38 4.202639e+45 4.444970e+32 4.236040e+32 5.176445e+35
[181] 3.217771e+38 1.337523e+39 2.049287e+41 1.544941e+45 8.599023e+37
[186] 1.591836e+33 6.187596e+42 3.873460e+21 2.680716e+20 1.095647e+25
[191] 1.912931e+27 1.713963e+27 5.592497e+37 3.314852e+37 1.737579e+22
[196] 1.982486e+21 1.386247e+41 2.951964e+41 2.867342e+41 1.084789e+42
[201] 1.371880e+41 2.614610e+44 7.604050e+43 1.858084e+41 1.905919e+42
[206] 4.121952e+18 1.245932e+24 9.618360e+26 6.533226e+24 8.693000e+36
[211] 3.485123e+37 1.980447e+23 3.710123e+18 5.676612e+23 1.830054e+27
[216] 9.535062e+23 7.009750e+36 3.950244e+37 1.103743e+22 8.181713e+17
[221] 7.567172e+36 8.737872e+27 1.973599e+37 6.033389e+37 7.751399e+25
[226] 4.329958e+23 2.449372e+30 4.677979e+38 6.597443e+37 3.524525e+28
[231] 1.128274e+31 1.354094e+44 4.637666e+38 4.735290e+28 2.492459e+24
[236] 1.290851e+41 8.509725e+36 6.788992e+36 3.674167e+37 4.057074e+38
[241] 4.258139e+23 8.092233e+38 2.596751e+40 2.720107e+31 6.790818e+43
[246] 3.031632e+24 3.854705e+30 1.540072e+32 1.223734e+29 8.546301e+24
[251] 3.828678e+46 2.478334e+41 5.182429e+31 1.738564e+25 3.552277e+41
[256] 2.776586e+46 3.023250e+46 2.743986e+38 2.329605e+38 1.403569e+40
[261] 5.094901e+42 5.834284e+38 9.932464e+50 1.286386e+47 1.635509e+45
[266] 3.221418e+38 2.414745e+46 2.050532e+46 1.453133e+40 1.474270e+40
[271] 2.422381e+41 4.262922e+43 4.042860e+40 1.004697e+51 2.361261e+47
[276] 1.298789e+45 1.414226e+40 5.964861e+41 4.986842e-01 1.034994e-02
[281] 4.717201e+08 1.173564e+11 6.328961e-02 3.359072e+45 1.200634e+30
[286] 4.601937e-01 2.167875e+05 2.922323e+36 5.824673e+36 1.195240e+37
[291] 2.162608e+37 2.853831e+36 1.187621e+43 6.367435e+39 1.838181e+38
[296] 1.818861e+39 1.602082e-01 3.749859e+09 5.302868e+11 6.702098e-01
[301] 1.151459e+41 1.143512e+29 1.720764e+01 5.849056e+03 7.985132e+08
[306] 1.606750e+12 2.641282e-02 8.631455e+40 1.069467e+29 2.080514e-01
[311] 3.885908e+02 2.472467e+28 2.291806e+09 1.047750e+41 1.417637e+29
[316] 1.225014e+09 8.418420e+09 3.255345e+11 1.929267e+41 1.801460e+29
[321] 2.437995e+11 2.893155e+26 1.765214e+41 1.669008e+29 1.634661e+00
[326] 1.591036e+03 2.081637e+41 2.011963e+43 7.809478e+42 1.963849e+29
[331] 1.813740e+33 7.190173e+08 7.075351e+40 3.766382e+47 7.541978e+46
[336] 6.665788e+38 1.073539e+39 1.018448e+41 2.913123e+42 1.058746e+39
[341] 2.042751e+50 2.855452e+47 1.604229e+46 5.826255e+38 5.102786e+38
[346] 1.340742e+46 3.870079e+32 5.069885e+32 8.468564e+35 3.717013e+38
[351] 7.343438e+38 2.008737e+41 2.495000e+45 1.069069e+38 1.333155e+33
[356] 2.302333e+44 1.080929e+23 6.454222e+29 1.328654e+31 5.758004e+26
[361] 7.250045e+29 5.679275e+36 1.545698e+40 3.200322e+24 1.164261e+24
```

```
[366] 4.281837e+43 1.205596e+44 6.985073e+44 1.099161e+44 5.703328e+43
[371] 4.827085e+45 4.980575e+46 5.039138e+43 3.550027e+44 6.097909e+23
[376] 2.497198e+27 2.359967e+24 7.041086e+22 1.178380e+36 1.162763e+40
[381] 9.875225e+23 1.258437e+17 4.090651e+29 3.151643e+31 6.822495e+28
[386] 1.029910e+38 2.850887e+41 2.739512e+30 7.394790e+23 1.055574e+39
[391] 1.706405e+31 3.396209e+37 1.164867e+40 1.361916e+31 7.471085e+27
[396] 7.822612e+27 3.708379e+37 1.087946e+40 9.731090e+27 5.983134e+28
[401] 1.209119e+43 9.751765e+40 2.325568e+30 1.680254e+23 1.104234e+42
[406] 1.508236e+36 1.364773e+36 2.485551e+40 6.529043e+40 5.506397e+25
[411] 4.518788e+48 2.152737e+47 6.321310e+40 4.705244e+40 1.430079e+42
[416] 3.861149e+44 1.214269e+41 2.623469e+50 2.676952e+48 1.446120e+47
[421] 9.895358e+40 7.000024e+45 1.217502e+45 2.503163e+45 2.971027e+45
[426] 2.246948e+46 2.718209e+46 5.862568e+50 7.534446e+47 4.636152e+45
[431] 6.360362e+45 7.750140e+44 2.035990e+45 1.781735e+45 1.441028e+46
[436] 2.359943e+46 9.710252e+50 4.802274e+47 6.617079e+45 3.143728e+45
[441] 5.793570e+37 2.769546e+39 9.078614e+41 4.237856e+38 1.888648e+50
[446] 1.110243e+46 1.165988e+44 5.740412e+37 5.247790e+39 8.196401e+41
[451] 3.422899e+38 1.489154e+50 1.545045e+46 1.827331e+44 5.387606e+37
[456] 9.042071e+45 1.679681e+40 1.660068e+50 1.869104e+46 2.788989e+44
[461] 3.248220e+39 8.421486e+42 7.794618e+50 2.169297e+46 9.577485e+45
[466] 3.000769e+43 2.425442e+50 1.408741e+47 1.536567e+45 4.243688e+38
[471] 9.724386e+50 5.958940e+50 1.663544e+50 3.609183e+47 2.216471e+46
[476] 1.397240e+45 3.917438e+45 1.822602e+38 2.050516e+38 6.272474e+39
[481] 1.520259e+41 2.000317e+45 2.639781e+41 5.561734e+45 6.679091e+38
[486] 2.045915e+38 2.625933e+45 6.809577e+45 6.140505e+45 3.511630e+46
[491] 1.351940e+46 1.334332e+47 1.832169e+48 3.344139e+45 3.845873e+45
[496] 2.556113e+32 3.467632e+35 2.487963e+38 4.940757e+38 1.328734e+41
[501] 1.497928e+45 4.044064e+37 9.742765e+32 5.415852e+35 3.244708e+38
[506] 4.895159e+38 1.308797e+41 1.544620e+45 4.195155e+37 9.071155e+32
[511] 3.375503e+44 2.483224e+40 4.500829e+41 2.312783e+45 1.165559e+39
[516] 6.840191e+36 2.866386e+42 1.564855e+43 2.275116e+45 1.581057e+41
[521] 8.786068e+38 1.335201e+48 7.869964e+46 1.442893e+44 8.030473e+38
[526] 9.299783e+45 3.350362e+41 2.078068e+41 4.549456e+45 1.171538e+45
[531] 4.830021e+37 3.280937e+40 1.067204e+41 1.228153e+41 8.651565e+41
[536] 2.949910e+41 2.458203e+48 1.093613e+44 9.771982e+40 6.117727e+41
[541] 9.756077e-03 7.131482e+08 7.208121e+10 3.731643e+00 5.755468e+35
[546] 1.271834e+30 4.370695e-01 3.232330e+02 1.089629e+08 6.673596e+11
[551] 5.834830e-02 1.203083e+36 1.352145e+30 1.055055e-02 8.086168e+00
[556] 2.886180e+29 2.008375e+09 1.646742e+36 2.357313e+30 3.911008e+08
[561] 6.911817e+08 2.094867e+11 1.218442e+38 3.225091e+30 9.458205e+11
[566] 1.582895e+24 8.272369e+41 1.234778e+30 3.010244e+00 2.076993e+05
[571] 2.297826e+40 1.249436e+36 6.383038e+35 2.616883e+30 1.382328e+33
[576] 3.233539e+04 2.657181e+36 4.748184e+36 8.591538e+36 1.370403e+36
[581] 5.663556e+41 1.844300e+39 2.844721e+37 1.892712e+39 3.405418e+37
[586] 1.067890e+37 2.931921e+36 6.795726e+41 6.514425e+39 8.647850e+37
```

```
[591] 9.816267e+39 1.502697e+39 5.267185e+36 5.827873e+41 2.031093e+39
[596] 1.887677e+38 1.857791e+39 1.086825e+37 1.120963e+42 2.127567e+39
[601] 3.748994e+38 2.680401e+43 3.014244e+42 2.965014e+39 8.838287e+37
[606] 1.629408e+39 3.401451e+42 6.242228e+44 2.179398e+43 2.010924e+41
[611] 8.058558e+42 3.314140e+39 6.754634e+08 2.323369e+12 8.466525e-01
[616] 8.314799e+32 1.363255e+29 3.806287e-01 1.456227e+00 3.262137e+28
[621] 1.642142e+10 2.287558e+33 1.854010e+29 2.498983e+09 1.667546e+09
[626] 1.087527e+12 3.105556e+34 2.334510e+29 2.422366e+11 4.443194e+23
[631] 5.148178e+38 1.325205e+29 1.567326e+02 6.138474e+03 8.685952e+36
[636] 7.262166e+33 1.862606e+33 2.284172e+29 9.978765e+32 1.061266e+06
[641] 2.632639e+28 3.196069e+09 1.671541e+33 1.639829e+29 2.910373e+08
[646] 3.439582e+08 2.881259e+12 5.611152e+34 1.993119e+29 7.197163e+11
[651] 4.387920e+24 3.294403e+38 1.235190e+29 1.417338e+00 3.418062e+02
[656] 7.438106e+36 1.107399e+34 1.657748e+33 2.334987e+29 1.581264e+33
[661] 1.457365e+04 3.091987e+28 8.763004e+36 7.804406e+29 4.405093e+28
[666] 1.213051e+35 4.172328e+38 1.583802e+29 5.723692e+09 2.066383e+10
[671] 1.255651e+37 2.926148e+34 3.252227e+33 3.303042e+29 8.111846e+34
[676] 1.025074e+10 1.344853e+39 2.015806e+29 5.333827e+11 2.989866e+25
[681] 1.445104e+37 5.944779e+35 2.220598e+37 4.213167e+29 4.705642e+35
[686] 2.951557e+27 4.543721e+39 1.028884e+40 4.501258e+39 2.109977e+29
[691] 1.768759e+33 6.937356e+08 3.523836e+38 2.737983e+38 8.045724e+33
[696] 1.202317e+33


[[9]][[4]]
list()


attr(,"class")
[1] "igraph"

> ## visualize
> graphView(g)
```



This shows the models according to posterior probabilities **across the model space visited**. One model stands out, with the tags of our causal SNPs. Similar information can be obtained from writing the top models to screen

```
> top.models(results, priors=prior.odds, n=20)
```

```
                                PP_phi=phi.1 PP_phi=phi.2 PP_phi=phi.3
rs12413228-rs7077992            0.5135056451 6.353348e-01 8.407343e-01
rs11253446-rs9124-rs7077992     0.0646995686 4.891916e-02 2.145439e-02
rs11253446-rs12413228-rs7077992 0.0644578569 4.836163e-02 2.112522e-02
rs12413228-rs7077992-rs10904578 0.0635417270 4.734849e-02 2.060945e-02
rs12413228-rs10752021-rs7077992 0.0635466069 4.727967e-02 2.056324e-02
rs12413228-rs17221435-rs7077992 0.0507554806 3.795236e-02 1.654927e-02
rs12413228-rs7077992-rs11253516 0.0386474352 2.901436e-02 1.267804e-02
rs12413228-rs2296625-rs7077992  0.0379696617 2.854512e-02 1.248199e-02
rs12413228-rs9124-rs7077992     0.0169984688 1.277379e-02 5.584527e-03
rs12413228-rs11253495-rs7077992 0.0157549933 1.180959e-02 5.156128e-03
rs17159911-rs12413228-rs7077992 0.0132335905 9.946249e-03 4.348659e-03
```

```
rs4881529-rs12413228-rs7077992  0.0122595414 9.199372e-03 4.018763e-03
rs12413228-rs2275677-rs7077992  0.0122488867 9.195914e-03 4.018251e-03
rs12413228-rs7077992-rs12268008 0.0107909617 8.099875e-03 3.538988e-03
rs12413228-rs10904576-rs7077992 0.0107745721 8.082949e-03 3.530555e-03
rs12413228-rs11598936-rs7077992 0.0096657350 7.250762e-03 3.166975e-03
rs12413228-rs9124-rs2296625     0.0002915435 2.200219e-04 9.640133e-05
rs12413228-rs9124-rs10904578    0.0001760543 1.303420e-04 5.654432e-05
rs2296625-rs10752021-rs7077992  0.0001577420 1.196910e-04 5.258925e-05
rs9124-rs10752021-rs10904578    0.0001204382 8.920917e-05 3.870983e-05
```

and a character vector of the SNPs forming these models can be found by #BEGIN$_{\mathrm{SRC}}$ R :ravel label=top.snps top.snps(results, priors=prior.odds, n=16) # n refers to number of #+END$_{\mathrm{SRC}}$

## 4.2 Add back in the tagged SNPs

We used tagging to span the space quickly. Once we have found our favoured models, it makes sense to see how the tagged SNPs in LD with SNPs in those models change things. There are a couple of subtleties here to be aware of however:

1. the X matrix must be of full rank, which means a small amount of tagging may always be necessary, say at $r^2$=0.99
2. when two SNPs are in strong LD, fitting both in the model can make the model uninterpretable. With snpBMA you can group SNPs so that at most one of each group is included in any single model. The default grouping threshold is $r^2$=0.8, but the optimal value will depend on your data: with many subjects a higher threshold may be appropriate, as the SNPs become statistically distinguishable.

```
> ## First, tag at r2=0.99
> tags.99 <- tag(X, 0.99)
> ## group remaining snps at r2=0.8, using the first set of tags above as indices
> groups <- group.tags(tags, keep=tags.99)
> length(groups)

[1] 16

> data.99 <- make.data(X, Y, tags=tags.99, family="guassian")

Keeping 1000 of 1000 samples and 19 SNPs
```

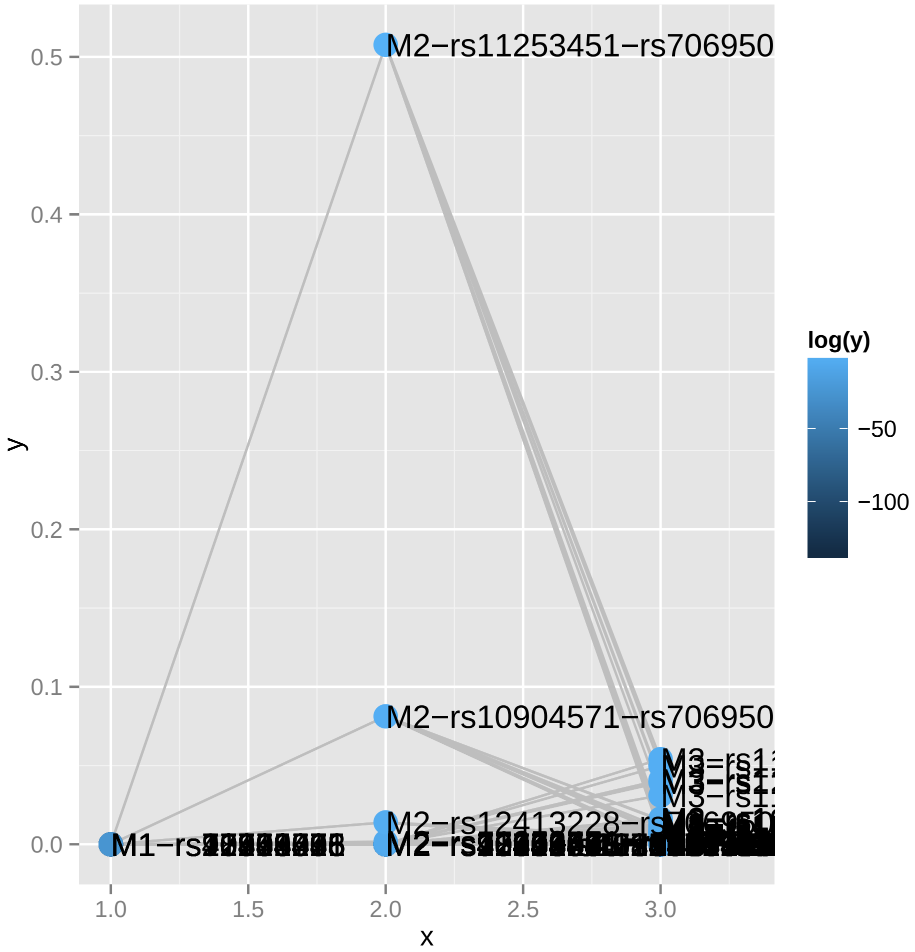
Now we decide which tag SNP groups we would like to ”expand”. Because we are keen not to miss the true causal variants, we choose any SNPs in the top 16 models, after which the posterior probabilities really do appear to tail off, and refit all models including these tagged SNPs in their groups:

```
> expand.snps <- top.snps(results, prior.odds, nmodels=17)
> bma.e1 <- bma.expand(data.99, bma.1, groups=groups[expand.snps])
```

```
Evaluating 19 models

> bma.e2 <- bma.expand(data.99, bma.2, groups=groups[expand.snps])

Evaluating 167 models

> bma.e3 <- bma.expand(data.99, bma.3, groups=groups[expand.snps])

Evaluating 903 models
```

You can see the model space grows much more quickly. But the end result is not dissimilar. The top model is now rs11253451-rs7069505. rs7069505 is one of the causal SNPs, and rs11253451 tags the other (rs1555897), at r2==1.

```
> ## create a graph of BMA results so far
> expand.results <- stack(bma.e1,bma.e2,bma.e3)
>  g.expand<-graphBMA(expand.results, prior.odds)
> ## visualize
> graphView(g.expand)
> top.models(expand.results, prior.odds)

                               PP_phi=phi.1 PP_phi=phi.2 PP_phi=phi.3
rs11253451-rs7069505             0.40376004   0.50769188   0.69064645
rs10904571-rs7069505             0.06464480   0.08127372   0.11055400
rs11253451-rs7069505-rs11253446  0.07090410   0.05410507   0.02430552
rs11253451-rs7069505-rs17221435  0.06549112   0.04976490   0.02230718
rs11253451-rs7069505-rs10752021  0.05400202   0.04084564   0.01826548
rs11253451-rs7069505-rs2296625   0.05150494   0.03935315   0.01769045
```



## 5 Speedup 2: excluding SNPs with low single SNP support

An additional, fairly brute force, way to prune the model space is to exclude all SNPs with very limited single SNP support. In this case, we drop SNPs that have a 2 log Bayes Factor (versus the null model with no SNPs) < 2.2, a threshold previously described as ”weak support” (TODO:REF).

```
> ## define the list of SNPs to drop
> max.bf <- apply(ss1,1,max)
> snps.drop <- rownames(ss1)[ max.bf < 0 ]
> snps.drop
```

```
[1] "rs2296625"  "rs11598936"
```

Then we can assess all two SNP models excluding those in snps.drop. We will also analyse the complete set of data, so the two approaches can be compared. To do this, we need to prune the snps included in the `bma.1` object and the `data` object.

```
> ## generate a new set of tags and snpBMAdata object
> data2 <- snps.prune.data(data, snps.drop)

Keeping 1000 of 1000 samples and 14 SNPs

> bma.2 <- bma.nsnps(data, nsnps=2)

groups not needed, creating a model matrix of 120 x 16 .
Evaluating 120 models

> bma.2d <- bma.nsnps(data2, nsnps=2)

groups not needed, creating a model matrix of 91 x 14 .
Evaluating 91 models

> ## compare top models
> top.models(bma.2)

     rs12413228 rs9124 rs2296625 rs10752021 rs7077992 rs10904578 twologB10-phi1
[1,]          1      0         0          0         1          0       239.8248
[2,]          1      0         0          0         0          1       220.3352
[3,]          0      1         0          1         0          0       217.8585
[4,]          1      0         1          0         0          0       216.3604
[5,]          0      1         0          0         0          1       216.0529
[6,]          1      0         0          1         0          0       215.4962
     twologB10-phi2 twologB10-phi3
[1,]       237.9051       233.5136
[2,]       218.4076       214.0120
[3,]       215.9272       211.5297
[4,]       214.4915       210.1263
[5,]       214.1268       209.7321
[6,]       213.5593       209.1589

> top.models(bma.2d)

     rs12413228 rs9124 rs10752021 rs7077992 rs10904578 rs11253516
[1,]          1      0          0         1          0          0
[2,]          1      0          0         0          1          0
[3,]          0      1          1         0          0          0
[4,]          0      1          0         0          1          0
[5,]          1      0          1         0          0          0
[6,]          1      0          0         0          0          1
     twologB10-phi1 twologB10-phi2 twologB10-phi3
[1,]       239.8248       237.9051       233.5136
[2,]       220.3352       218.4076       214.0120
[3,]       217.8585       215.9272       211.5297
[4,]       216.0529       214.1268       209.7321
[5,]       215.4962       213.5593       209.1589
[6,]       211.6803       209.7966       205.4237
```

# 6 Speedup 3: excluding descendents of less likely model paths

Models with two or more SNPs can be thought of as children of many parent models. If a two SNP model contains SNPs A and B, then its parents are the single SNP models containing either A or B. Each parent model has many potential children. Thus the model space can be partitioned into generations, with each generation containing a fixed number of SNPs. Any two or more SNP model can be reached via multiple paths in this model space.

[?] proposed that where child models had a parent with greater support than the child, no further ”grandchild” models would be worth considering. This is quite a broad pruning. We choose to implement a variation where the future generation models are excluded if a child model has a parent model with $f$-fold greater support, and have set the default at $f = 10$.

Here, we compare the child and parent models in `bma.1` and `bma.2d` to determine the set of models we will not explore. One way to implement this would be to determine all the possible three SNP models, then delete those that are children of the dropped models. But a faster way is to drop these models from the `bma2` object, then use `bma.grow()` to automatically fit all the child models of those which remain.

```
> ## prune the bma.2d object
> bma.2dd <- models.prune(parents=bma.1, children=bma.2d,
+                          prior.parents=prior.odds[1],
+                          prior.children=prior.odds[2])

Identified 27 of 91 models with pp(parent) > 10 * pp(child)

> ## grow the BMA to a third generation
> bma.3dd <- bma.grow(data2, bma.2dd)

Evaluating 355 models

> ## for comparison, without pruning, we could use tagging only...
> bma.3 <- bma.nsnps(data, nsnps=3)

groups not needed, creating a model matrix of 560 x 16 .
Evaluating 560 models

> ## ... or tagging + excluding poorly supported single SNPs
> bma.3d <- bma.nsnps(data2, nsnps=3)

groups not needed, creating a model matrix of 364 x 14 .
Evaluating 364 models

> ## this should be the same as growing from the bma.2d object
> bma.3d2 <- bma.grow(data2, bma.2d)

Evaluating 364 models

> top.models(bma.3d)
```

```
     rs11253446 rs12413228 rs9124 rs10752021 rs17221435 rs7077992 rs10904578
[1,]          1          0      1          0          0         1          0
[2,]          1          1      0          0          0         1          0
[3,]          0          1      0          0          0         1          1
[4,]          0          1      0          1          0         1          0
[5,]          0          1      0          0          1         1          0
[6,]          0          1      0          0          0         1          0
     rs11253516 twologB10-phi1 twologB10-phi2 twologB10-phi3
[1,]          0       236.4928       233.5881       226.9879
[2,]          0       236.4853       233.5652       226.9569
[3,]          0       236.4566       233.5228       226.9075
[4,]          0       236.4568       233.5199       226.9030
[5,]          0       236.0073       233.0804       226.4687
[6,]          1       235.4622       232.5433       225.9357
```

```
> top.models(bma.3d2)
```

```
     rs11253446 rs12413228 rs9124 rs10752021 rs17221435 rs7077992 rs10904578
[1,]          1          0      1          0          0         1          0
[2,]          1          1      0          0          0         1          0
[3,]          0          1      0          0          0         1          1
[4,]          0          1      0          1          0         1          0
[5,]          0          1      0          0          1         1          0
[6,]          0          1      0          0          0         1          0
     rs11253516 twologB10-phi1 twologB10-phi2 twologB10-phi3
[1,]          0       236.4928       233.5881       226.9879
[2,]          0       236.4853       233.5652       226.9569
[3,]          0       236.4566       233.5228       226.9075
[4,]          0       236.4568       233.5199       226.9030
[5,]          0       236.0073       233.0804       226.4687
[6,]          1       235.4622       232.5433       225.9357
```

## 7 Automating the analysis

There are a lot of steps above. It's good to understand the detail of how we approach the problem, but once you understand it, it can be tedious to run each step. snpBMA **will** have a function, `bma.auto()`, that should automate much of this.

TODO!!!

```
\bibliographystyle{plain}
\bibliography{ProbePosition}
```

## 8 Stratified analysis

There is another data class, `snpBMAstrat`, which is used to store data for when a stratified analysis is needed. The stratification is based on the following factorization of the Bayes Factor

$$\frac{P(D|M_1)}{P(D|M_2)} = \frac{P(D_1|M_1) \times P(D_2|M_1)}{P(D_1|M_2) \times P(D_2|M_2)}$$

where $D$ represents the data, which can be stratified into two independent datasets $D_1$, $D_2$, and $M_1$, $M_2$ represent models under consideration. Strata may be, for example, batch in biological assays.

To define such data, we do

```
> sdata <- make.data(X,Y,tags=tags,family="gaussian",
+                    strata=rep(c(1,2),length=nrow(X)))
```

```
Keeping 1000 of 1000 samples and 16 SNPs
```

Analysis of the stratified and unstratified datasets here should produce similar results, as there is no intrinsic difference between the distribution of Y between strata.

```
> data <- make.data(X,Y,tags=tags,family="gaussian")
```

```
Keeping 1000 of 1000 samples and 16 SNPs
```

```
> bma.1 <- bma.nsnps(data, nsnps=1)
```

```
groups not needed, creating a model matrix of 16 x 16 .
Evaluating 16 models
```

```
> sbma.1 <- bma.nsnps(sdata, nsnps=1)
```

```
groups not needed, creating a model matrix of 16 x 16 .
Stratum 1        Evaluating 16 models
2        Evaluating 16 models
```

```
> top.models(bma.1)
```

```
     rs4881529 rs12413228 rs9124 rs10752021 rs7077992 rs10904578 twologB10-phi1
[1,]         0          1      0          0         0          0      189.62567
[2,]         0          0      0          1         0          0      180.17636
[3,]         0          0      0          0         1          0      165.90851
[4,]         0          0      1          0         0          0      165.00678
[5,]         0          0      0          0         0          1      149.16509
[6,]         1          0      0          0         0          0       97.23981
     twologB10-phi2 twologB10-phi3
[1,]      188.71710      186.54791
[2,]      179.26334      177.09185
[3,]      164.98879      162.81383
[4,]      164.08664      161.91146
[5,]      148.23750      146.05847
[6,]       96.28782       94.09615
```

```
> top.models(sbma.1)

     rs4881529 rs12413228 rs9124 rs10752021 rs7077992 rs10904578 twologB10-phi1
[1,]         0          1      0          0         0          0      185.80689
[2,]         0          0      0          1         0          0      174.95889
[3,]         0          0      0          0         1          0      160.44461
[4,]         0          0      1          0         0          0      160.05983
[5,]         0          0      0          0         0          1      143.90646
[6,]         1          0      0          0         0          0       93.60258
     twologB10-phi2 twologB10-phi3
[1,]      183.99282       179.6561
[2,]      173.13472       168.7928
[3,]      158.60694       154.2580
[4,]      158.22171       153.8725
[5,]      142.05305       137.6959
[6,]       91.70189        87.3203
```