

# Class 11: Structural Bioinformatics pt2

: visual

## Background

We saw last day that the PDB has 209,886 entries (Oct/Nov 2025). UniProtKB (i.e. protein sequence database) has 199,579,901 entries.

```
209886/199579901 * 100
```

```
[1] 0.1051639
```

So the PDB has only 0.1% coverage of the main sequence database.

Enter AlphaFold data base (AFDB) < <https://alphafold.ebi.ac.uk> > that attempts to provide computed models for all sequences in UniProt.

"AlphaFold DB provides open access to over 200 million protein structure predictions to accelerate scientific research."

## AlphaFold

AlphaFold has 3 main outputs

- the predicted coordinates (PDB files)
- a local quality score called pLDDT (predicted Local Distance Difference Test)
- a predicted aligned error (PAE) matrix

We can run AlphaFold ourselves if we not happy with AFDB (i.e. no coverage or poor model).

## Interpreting/analyzing AF results in R

```
results_dir <- "HIVPR_dimer_23119/"
pdb_files <- list.files(path=results_dir,
                        pattern="*.pdb",
                        full.names = TRUE)

# Print our PDB file names
basename(pdb_files)
```

```
[1] "HIVPR_dimer_23119_unrelaxed_rank_001_alphaFold2_multimer_v3_model_4_seed_000.pdb"
[2] "HIVPR_dimer_23119_unrelaxed_rank_002_alphaFold2_multimer_v3_model_1_seed_000.pdb"
[3] "HIVPR_dimer_23119_unrelaxed_rank_003_alphaFold2_multimer_v3_model_5_seed_000.pdb"
```

```
[4] "HIVPR_dimer_23119_unrelaxed_rank_004_alphaFold2_multimer_v3_model_2_seed_000.pdb"
[5] "HIVPR_dimer_23119_unrelaxed_rank_005_alphaFold2_multimer_v3_model_3_seed_000.pdb"
```

```
library(bio3d)

# Read all data from Models
# and superpose/fit coords
pdbs <- pdbaln(pdb_files, fit=TRUE, exefile="msa")
```

Reading PDB files:

```
HIVPR_dimer_23119//HIVPR_dimer_23119_unrelaxed_rank_001_alphaFold2_multimer_v3_model_4_se
ed_000.pdb
HIVPR_dimer_23119//HIVPR_dimer_23119_unrelaxed_rank_002_alphaFold2_multimer_v3_model_1_se
ed_000.pdb
HIVPR_dimer_23119//HIVPR_dimer_23119_unrelaxed_rank_003_alphaFold2_multimer_v3_model_5_se
ed_000.pdb
HIVPR_dimer_23119//HIVPR_dimer_23119_unrelaxed_rank_004_alphaFold2_multimer_v3_model_2_se
ed_000.pdb
HIVPR_dimer_23119//HIVPR_dimer_23119_unrelaxed_rank_005_alphaFold2_multimer_v3_model_3_se
ed_000.pdb
```

....

Extracting sequences

```
pdb/seq: 1 name:
HIVPR_dimer_23119//HIVPR_dimer_23119_unrelaxed_rank_001_alphaFold2_multimer_v3_model_4_se
ed_000.pdb
pdb/seq: 2 name:
HIVPR_dimer_23119//HIVPR_dimer_23119_unrelaxed_rank_002_alphaFold2_multimer_v3_model_1_se
ed_000.pdb
pdb/seq: 3 name:
HIVPR_dimer_23119//HIVPR_dimer_23119_unrelaxed_rank_003_alphaFold2_multimer_v3_model_5_se
ed_000.pdb
pdb/seq: 4 name:
HIVPR_dimer_23119//HIVPR_dimer_23119_unrelaxed_rank_004_alphaFold2_multimer_v3_model_2_se
ed_000.pdb
pdb/seq: 5 name:
HIVPR_dimer_23119//HIVPR_dimer_23119_unrelaxed_rank_005_alphaFold2_multimer_v3_model_3_se
ed_000.pdb
```

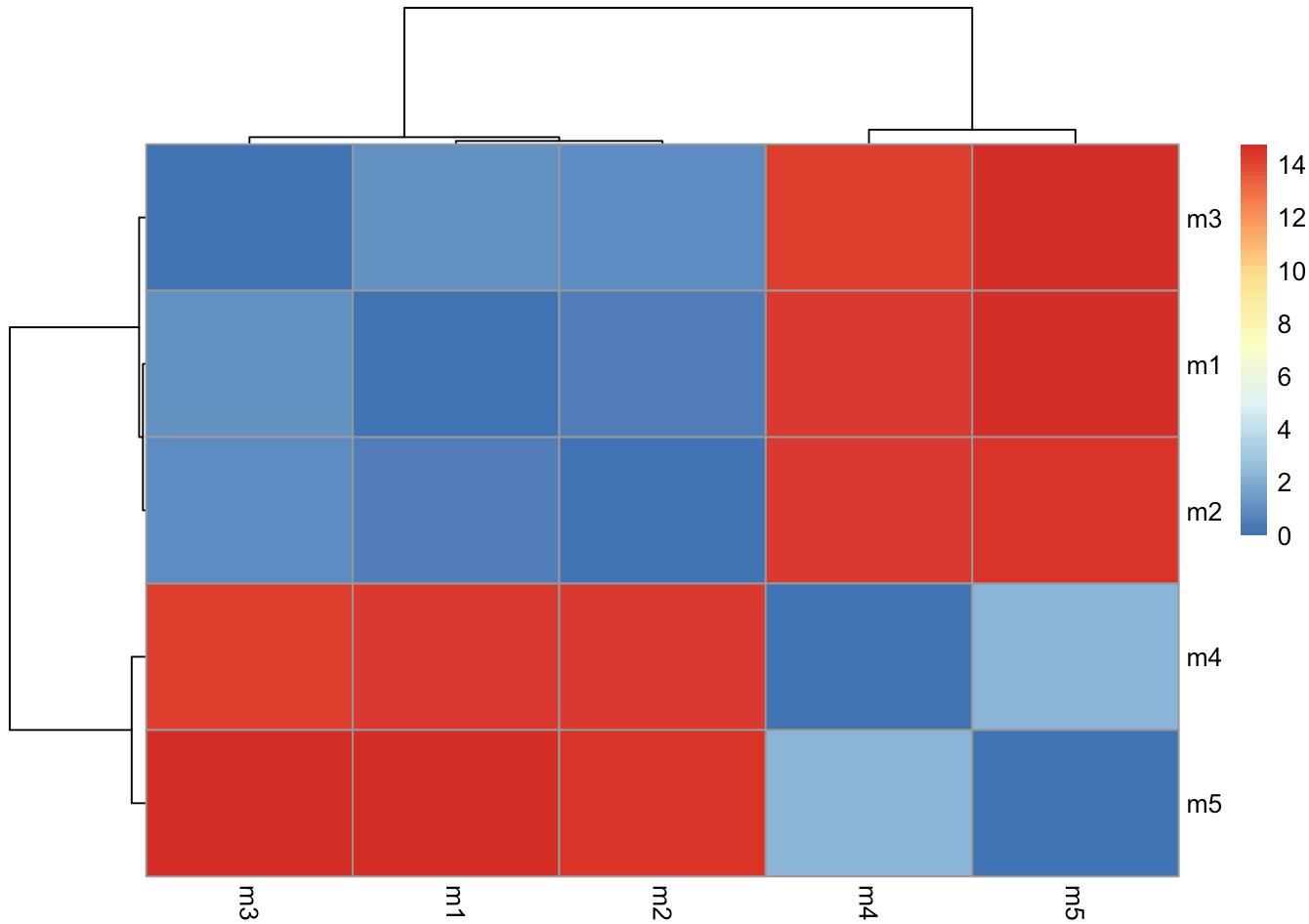
```
rd <- rmsd(pdbs, fit=T)
```

Warning in rmsd(pdbs, fit = T): No indices provided, using the 198 non NA positions

```
range(rd)
```

```
[1] 0.000 14.754
```

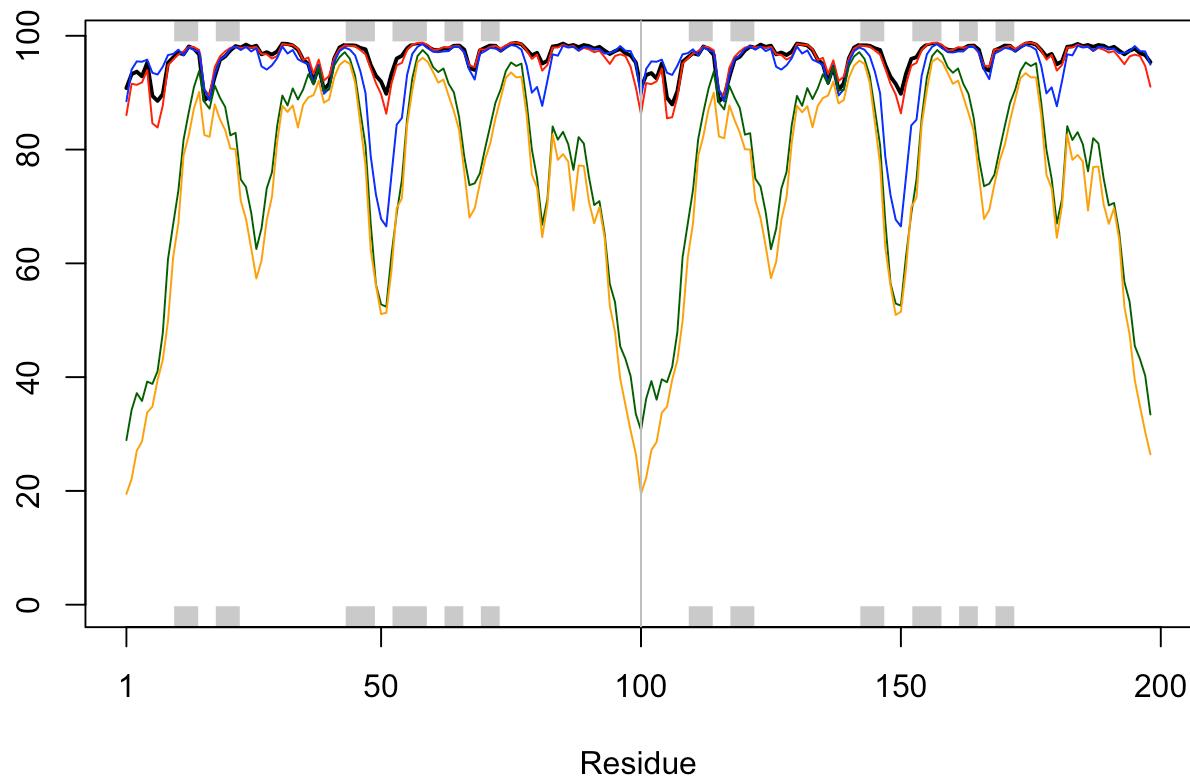
```
library(pheatmap)
colnames(rd) <- paste0("m", 1:5)
rownames(rd) <- paste0("m", 1:5)
pheatmap(rd)
```



```
# Read a reference PDB structure
pdb <- read.pdb("1hsg")
```

Note: Accessing on-line PDB file

```
plotb3(pdbs$b[1], typ="l", lwd=2, sse=pdb)
points(pdbs$b[2], typ="l", col="red")
points(pdbs$b[3], typ="l", col="blue")
points(pdbs$b[4], typ="l", col="darkgreen")
points(pdbs$b[5], typ="l", col="orange")
abline(v=100, col="gray")
```



```
core <- core.find(pdbs)
```

```
core size 197 of 198  vol = 9886.027
core size 196 of 198  vol = 6910.101
core size 195 of 198  vol = 1339.391
core size 194 of 198  vol = 1040.703
core size 193 of 198  vol = 951.872
core size 192 of 198  vol = 899.097
core size 191 of 198  vol = 834.744
core size 190 of 198  vol = 771.349
core size 189 of 198  vol = 733.076
core size 188 of 198  vol = 697.291
core size 187 of 198  vol = 659.753
core size 186 of 198  vol = 625.285
core size 185 of 198  vol = 589.553
core size 184 of 198  vol = 568.266
core size 183 of 198  vol = 545.027
core size 182 of 198  vol = 512.902
core size 181 of 198  vol = 490.736
core size 180 of 198  vol = 470.28
core size 179 of 198  vol = 450.744
core size 178 of 198  vol = 434.749
core size 177 of 198  vol = 420.351
```

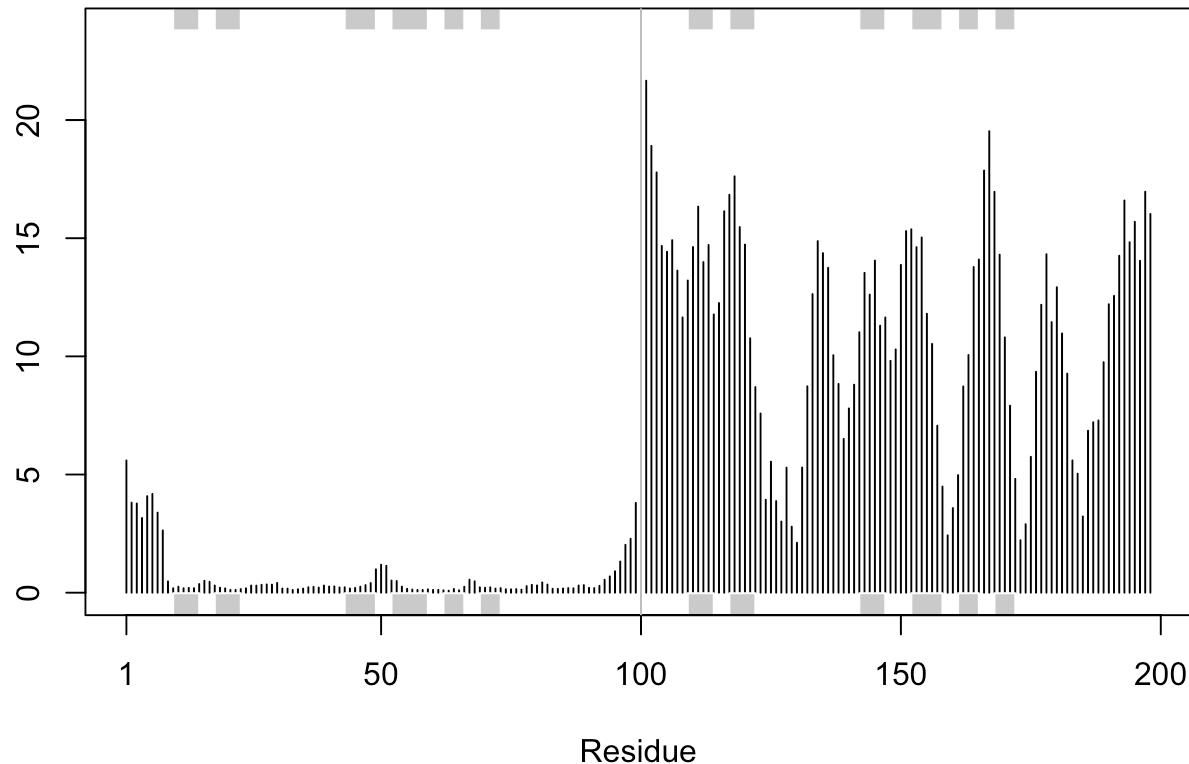
core size 176 of 198 vol = 406.672  
core size 175 of 198 vol = 393.347  
core size 174 of 198 vol = 382.408  
core size 173 of 198 vol = 372.872  
core size 172 of 198 vol = 357.007  
core size 171 of 198 vol = 346.581  
core size 170 of 198 vol = 337.46  
core size 169 of 198 vol = 326.673  
core size 168 of 198 vol = 314.965  
core size 167 of 198 vol = 304.142  
core size 166 of 198 vol = 294.567  
core size 165 of 198 vol = 285.663  
core size 164 of 198 vol = 278.9  
core size 163 of 198 vol = 266.78  
core size 162 of 198 vol = 259.01  
core size 161 of 198 vol = 247.737  
core size 160 of 198 vol = 239.855  
core size 159 of 198 vol = 234.978  
core size 158 of 198 vol = 230.077  
core size 157 of 198 vol = 222  
core size 156 of 198 vol = 215.636  
core size 155 of 198 vol = 206.808  
core size 154 of 198 vol = 196.999  
core size 153 of 198 vol = 188.554  
core size 152 of 198 vol = 182.276  
core size 151 of 198 vol = 176.967  
core size 150 of 198 vol = 170.725  
core size 149 of 198 vol = 166.134  
core size 148 of 198 vol = 159.81  
core size 147 of 198 vol = 153.78  
core size 146 of 198 vol = 149.107  
core size 145 of 198 vol = 143.672  
core size 144 of 198 vol = 137.152  
core size 143 of 198 vol = 132.531  
core size 142 of 198 vol = 127.244  
core size 141 of 198 vol = 121.587  
core size 140 of 198 vol = 116.787  
core size 139 of 198 vol = 112.583  
core size 138 of 198 vol = 108.182  
core size 137 of 198 vol = 105.145  
core size 136 of 198 vol = 101.261  
core size 135 of 198 vol = 97.387  
core size 134 of 198 vol = 92.986  
core size 133 of 198 vol = 88.195  
core size 132 of 198 vol = 84.039  
core size 131 of 198 vol = 81.908  
core size 130 of 198 vol = 78.029  
core size 129 of 198 vol = 75.282  
core size 128 of 198 vol = 73.063  
core size 127 of 198 vol = 70.706  
core size 126 of 198 vol = 68.984

```
core size 125 of 198 vol = 66.715
core size 124 of 198 vol = 64.384
core size 123 of 198 vol = 61.153
core size 122 of 198 vol = 59.037
core size 121 of 198 vol = 56.633
core size 120 of 198 vol = 54.022
core size 119 of 198 vol = 51.805
core size 118 of 198 vol = 49.652
core size 117 of 198 vol = 48.193
core size 116 of 198 vol = 46.648
core size 115 of 198 vol = 44.752
core size 114 of 198 vol = 43.292
core size 113 of 198 vol = 41.093
core size 112 of 198 vol = 39.147
core size 111 of 198 vol = 36.472
core size 110 of 198 vol = 34.117
core size 109 of 198 vol = 31.47
core size 108 of 198 vol = 29.448
core size 107 of 198 vol = 27.325
core size 106 of 198 vol = 25.822
core size 105 of 198 vol = 24.15
core size 104 of 198 vol = 22.648
core size 103 of 198 vol = 21.069
core size 102 of 198 vol = 19.953
core size 101 of 198 vol = 18.3
core size 100 of 198 vol = 15.723
core size 99 of 198 vol = 14.841
core size 98 of 198 vol = 11.646
core size 97 of 198 vol = 9.434
core size 96 of 198 vol = 7.354
core size 95 of 198 vol = 6.179
core size 94 of 198 vol = 5.666
core size 93 of 198 vol = 4.705
core size 92 of 198 vol = 3.665
core size 91 of 198 vol = 2.77
core size 90 of 198 vol = 2.151
core size 89 of 198 vol = 1.715
core size 88 of 198 vol = 1.15
core size 87 of 198 vol = 0.874
core size 86 of 198 vol = 0.685
core size 85 of 198 vol = 0.528
core size 84 of 198 vol = 0.37
FINISHED: Min vol ( 0.5 ) reached
```

```
core.inds <- print(core, vol=0.5)
```

```
# 85 positions (cumulative volume <= 0.5 Angstrom^3)
  start end length
1      9   49     41
2     52   95     44
```

```
xyz <- pdbsfit(pdbs, core.ind, outpath="corefit_structures")
rf <- rmsf(xyz)
plotb3(rf, sse=pdb)
abline(v=100, col="gray", ylab="RMSF")
```



```
library(jsonlite)
# Listing of all PAE JSON files
pae_files <- list.files(path=results_dir,
pattern=".*model.*\\.json",
full.names = TRUE)

pae1 <- read_json(pae_files[1], simplifyVector = TRUE)
pae5 <- read_json(pae_files[5], simplifyVector = TRUE)
attributes(pae1)
```

```
$names
[1] "plddt"    "max_pae"   "pae"       "ptm"       "iptm"
```

```
# Per-residue pLDDT scores
# same as Bfactor of PDB..
head(pae1$plddt)
```

```
[1] 90.81 93.25 93.69 92.88 95.25 89.44
```

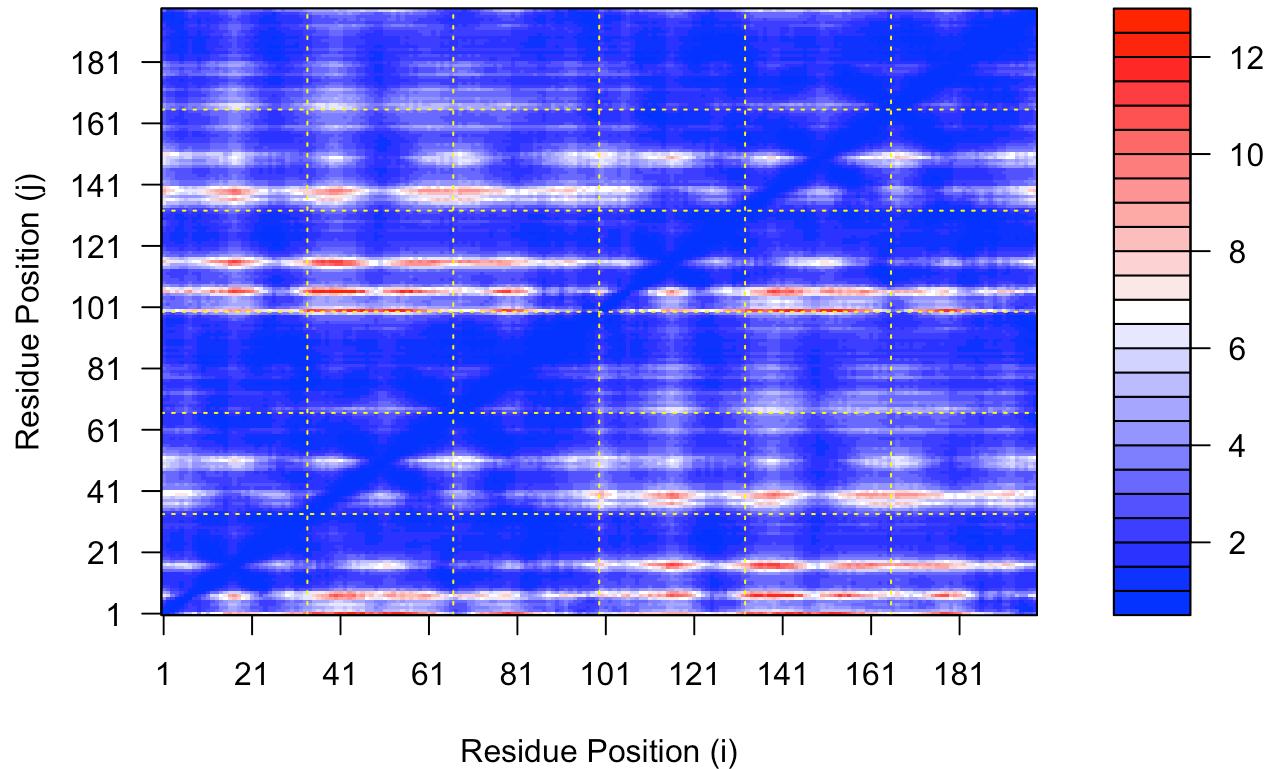
```
pae1$maxpae
```

NULL

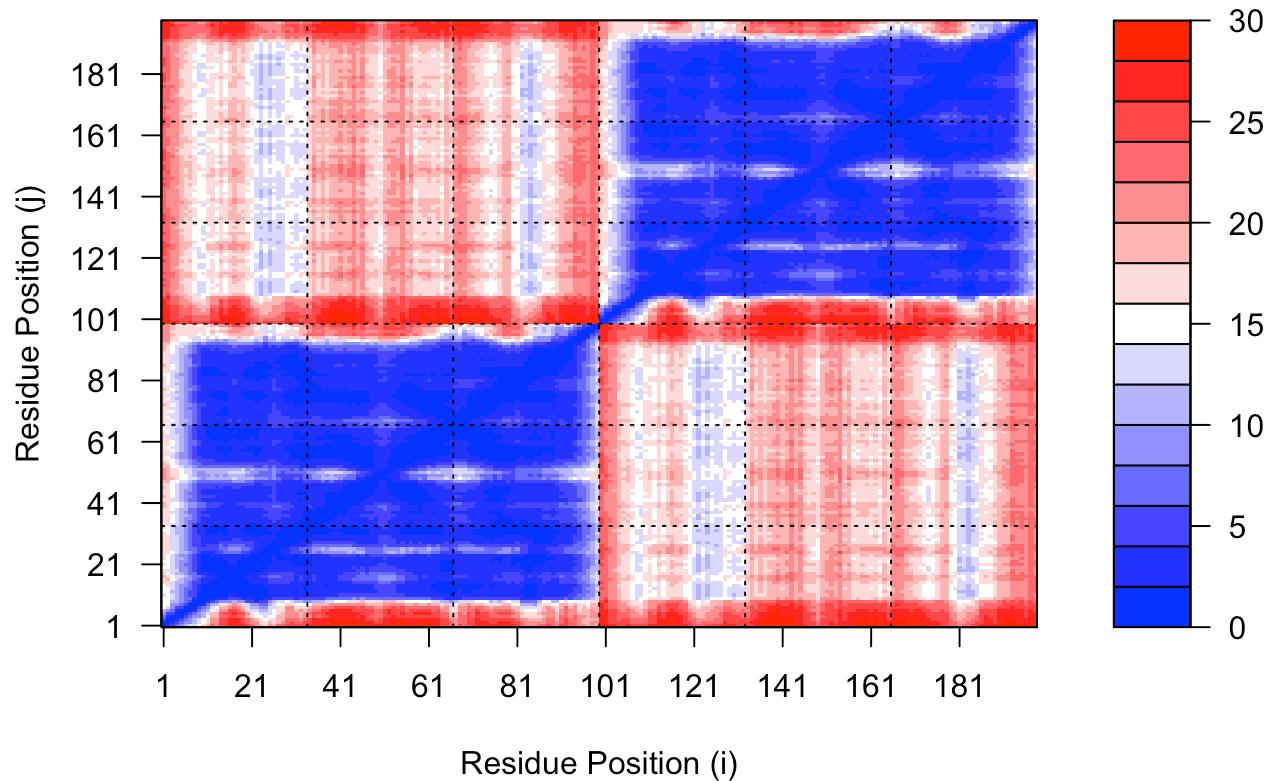
```
pae5$max_pae
```

```
[1] 29.59375
```

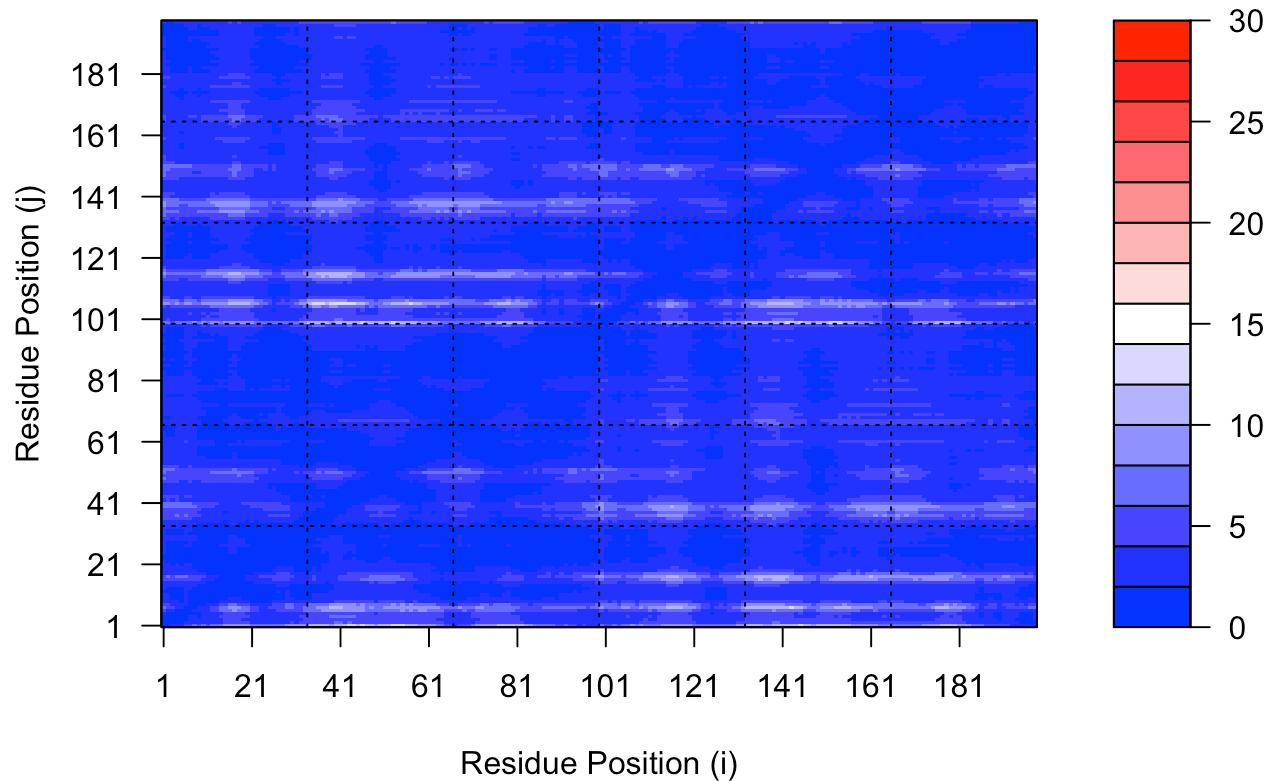
```
plot.dmat(pae1$pae,  
xlab="Residue Position (i)",  
ylab="Residue Position (j)")
```



```
plot.dmat(pae5$pae,  
xlab="Residue Position (i)",  
ylab="Residue Position (j)",  
grid.col = "black",  
zlim=c(0,30))
```



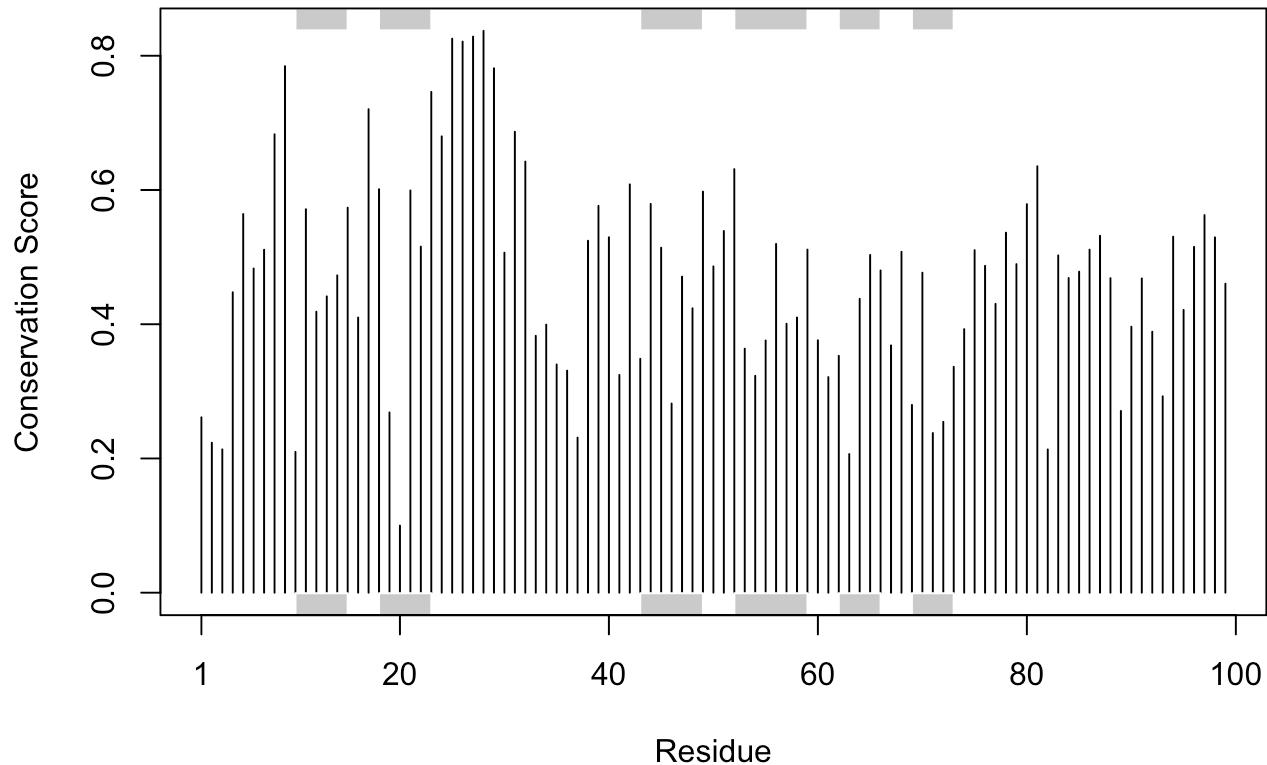
```
plot.dmat(pae1$pae,
xlab="Residue Position (i)",
ylab="Residue Position (j)",
grid.col = "black",
zlim=c(0,30))
```



```
aln_file <- list.files(path=results_dir,
pattern=".a3m$",
full.names = TRUE)
aln <- read.fasta(aln_file[1], to.upper = TRUE)
```

```
[1] " ** Duplicated sequence id's: 101 **"
[2] " ** Duplicated sequence id's: 101 **"
```

```
sim <- conserv(aln)
plotb3(sim[1:99], sse=trim.pdb(pdb, chain="A"),
ylab="Conservation Score")
```



```
con <- consensus(aln, cutoff = 0.9)
con$seq
```

```
[1] "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___"  
[19] "___" "___" "___" "___" "___" "D" "T" "G" "A" "___" "___" "___" "___" "___" "___" "___" "___"  
[37] "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___"  
[55] "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___"  
[73] "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___"  
[91] "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___"  
[109] "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___" "___"  
[127] "___" "___" "___" "___" "___" "___"
```

```
m1.pdb <- read.pdb(pdb_files[1])
occ <- vec2resno(c(sim[1:99], sim[1:99]), m1.pdb$atom$resno)
write.pdb(m1.pdb, o=occ, file="m1_conserv.pdb")
```