A Fatgraph Model of Protein Structure

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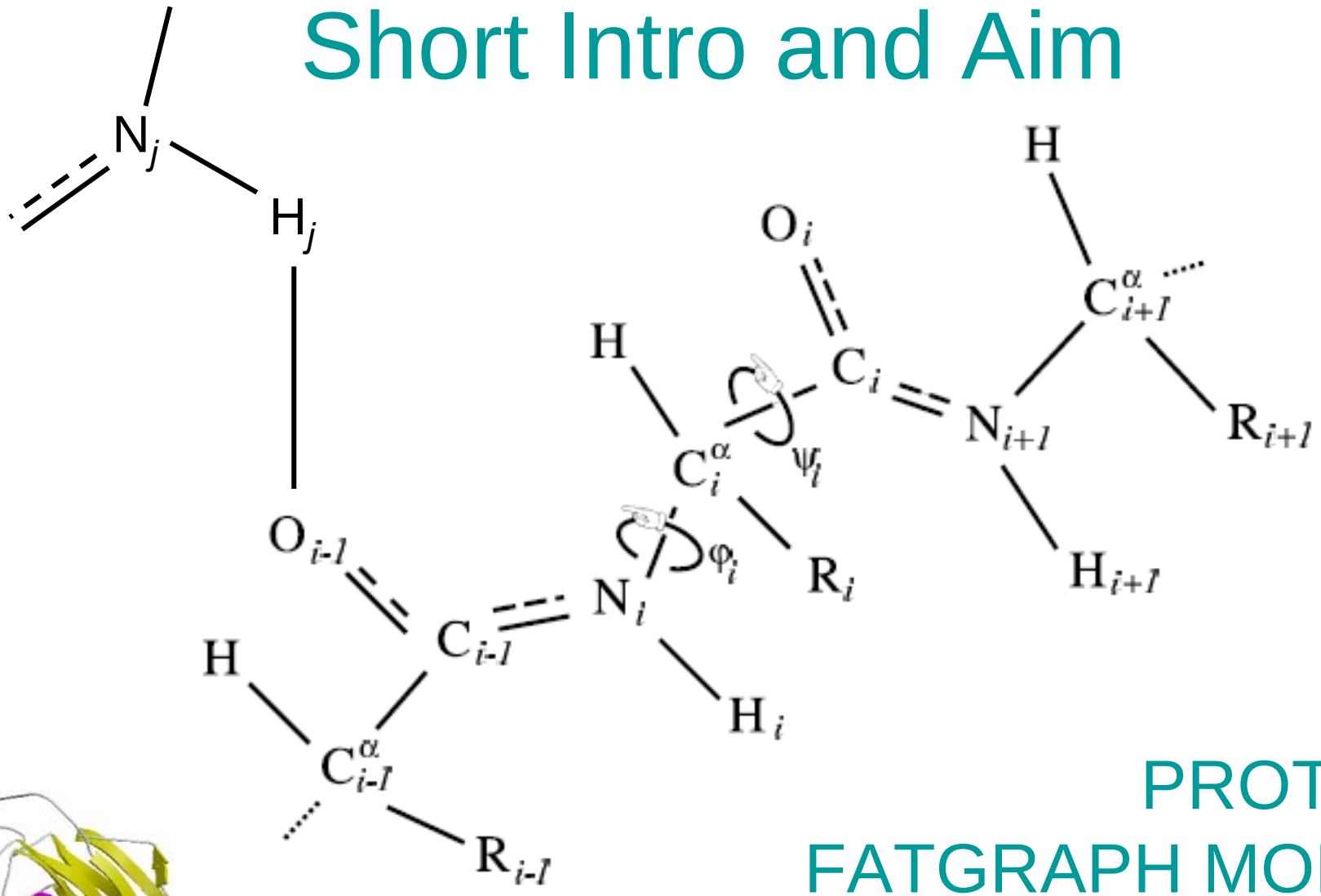
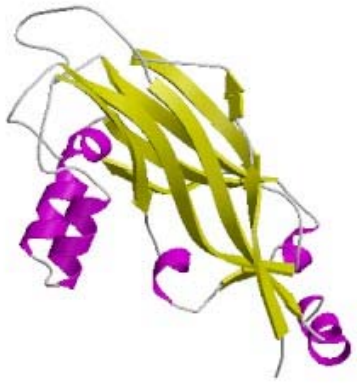
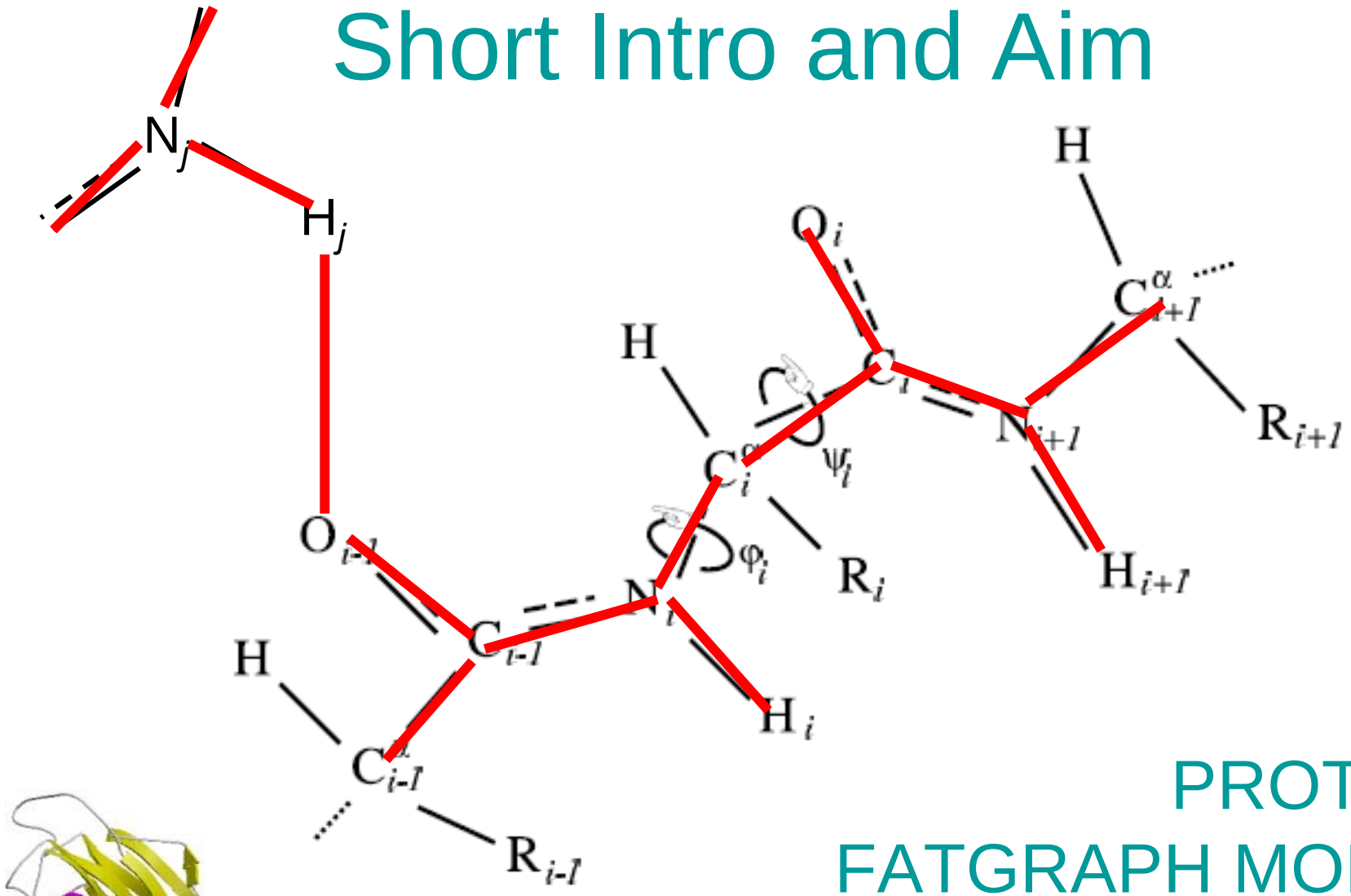
Short Intro and Aim

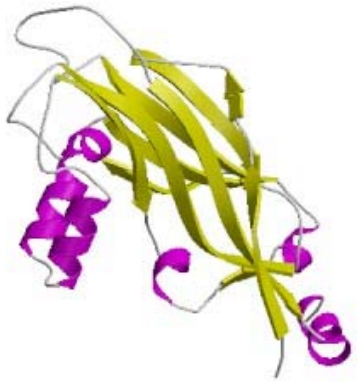




PROTEIN
FATGRAPH MODEL
DESCRIPTORS/ INVARIANTS
CLASSIFICATION

Short Intro and Aim





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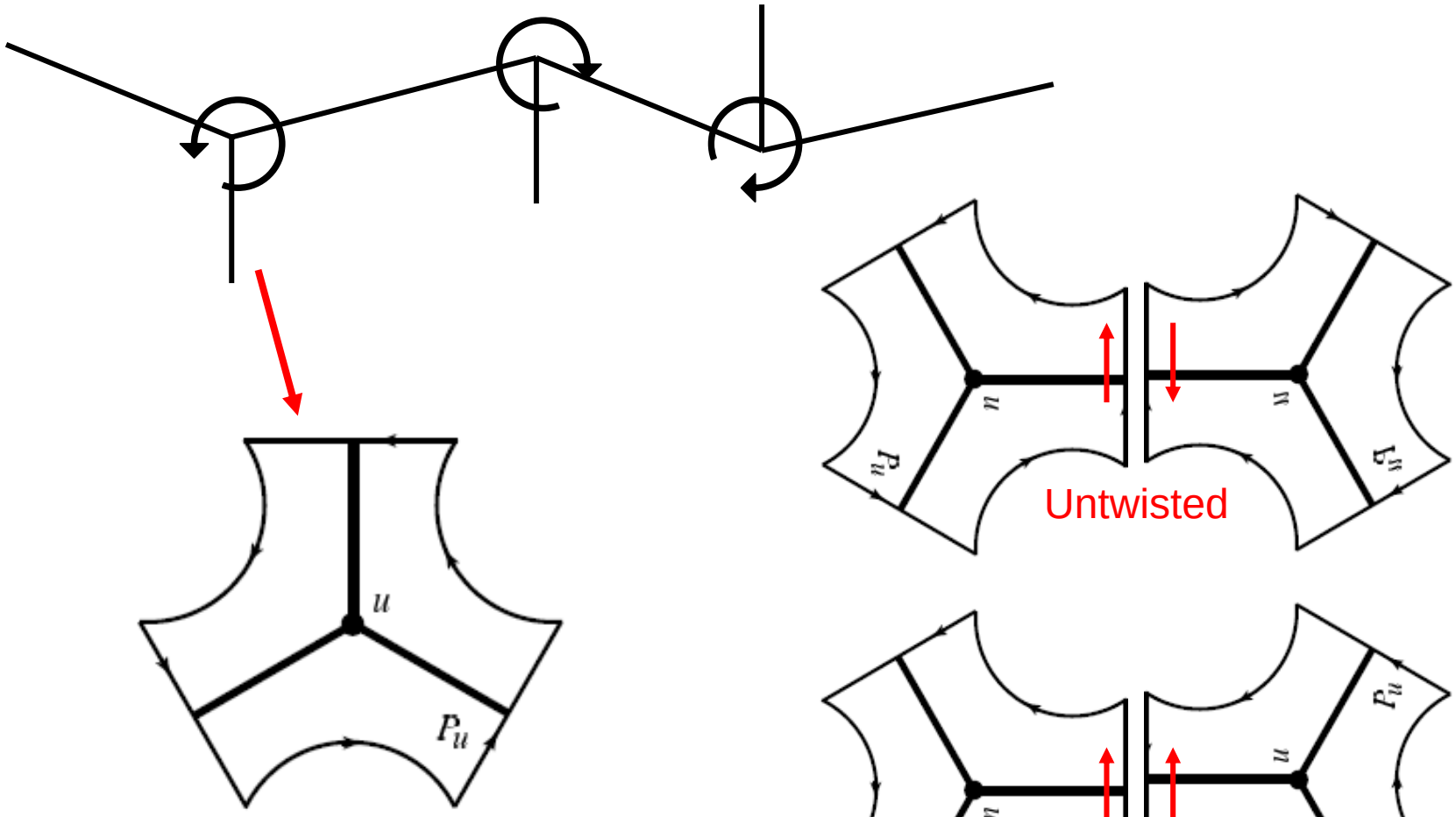
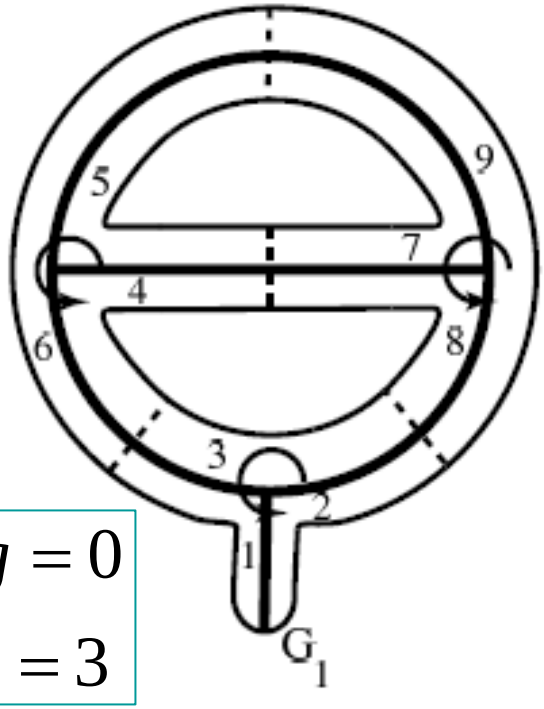
Fatgraphs and Surfaces

(in math, originally due to Bob Penner)

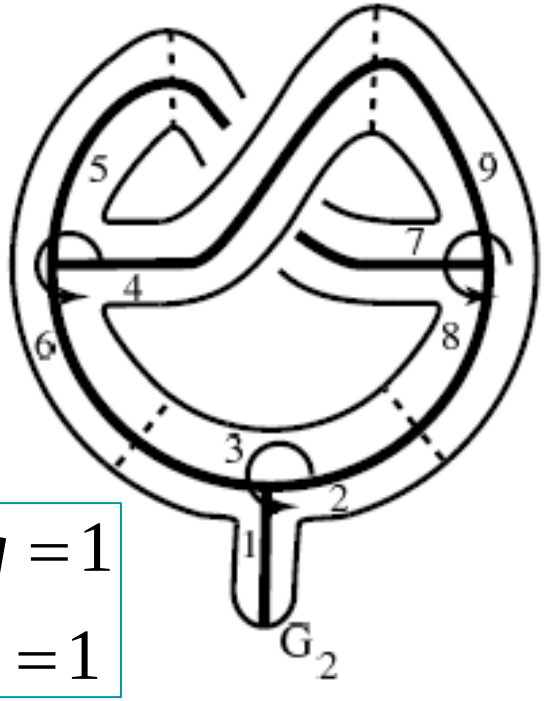


Examples of Associated Surfaces



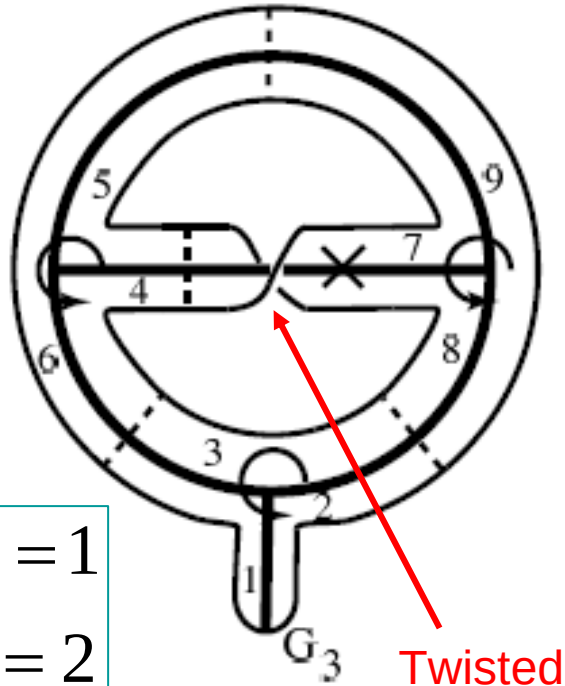
$g = 0$

$r = 3$



$g = 1$

$r = 1$



$g = 1$

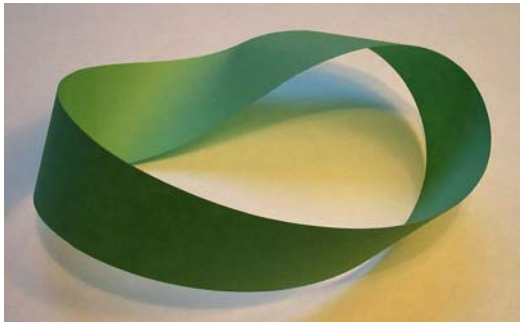
$r = 2$

Euler characteristic

$$\chi(F) = v(G) - e(G)$$

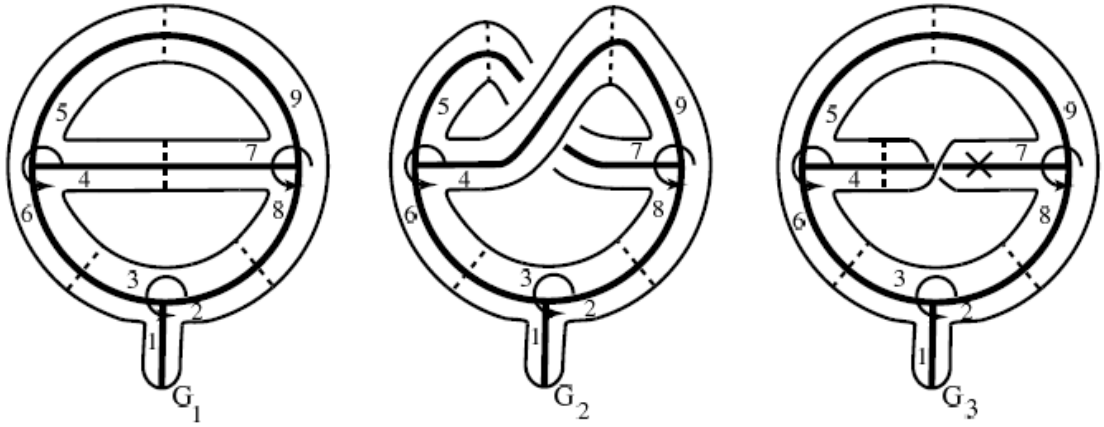
$$\chi(F) = 2 - 2g - r \quad F \text{ orientable}$$

$$\chi(F) = 2 - g - r \quad F \text{ non-orientable}$$



Moebius strip: Non-orientable

How to determine *g* and *r* ?
Permutations *σ* and *τ* on stubs



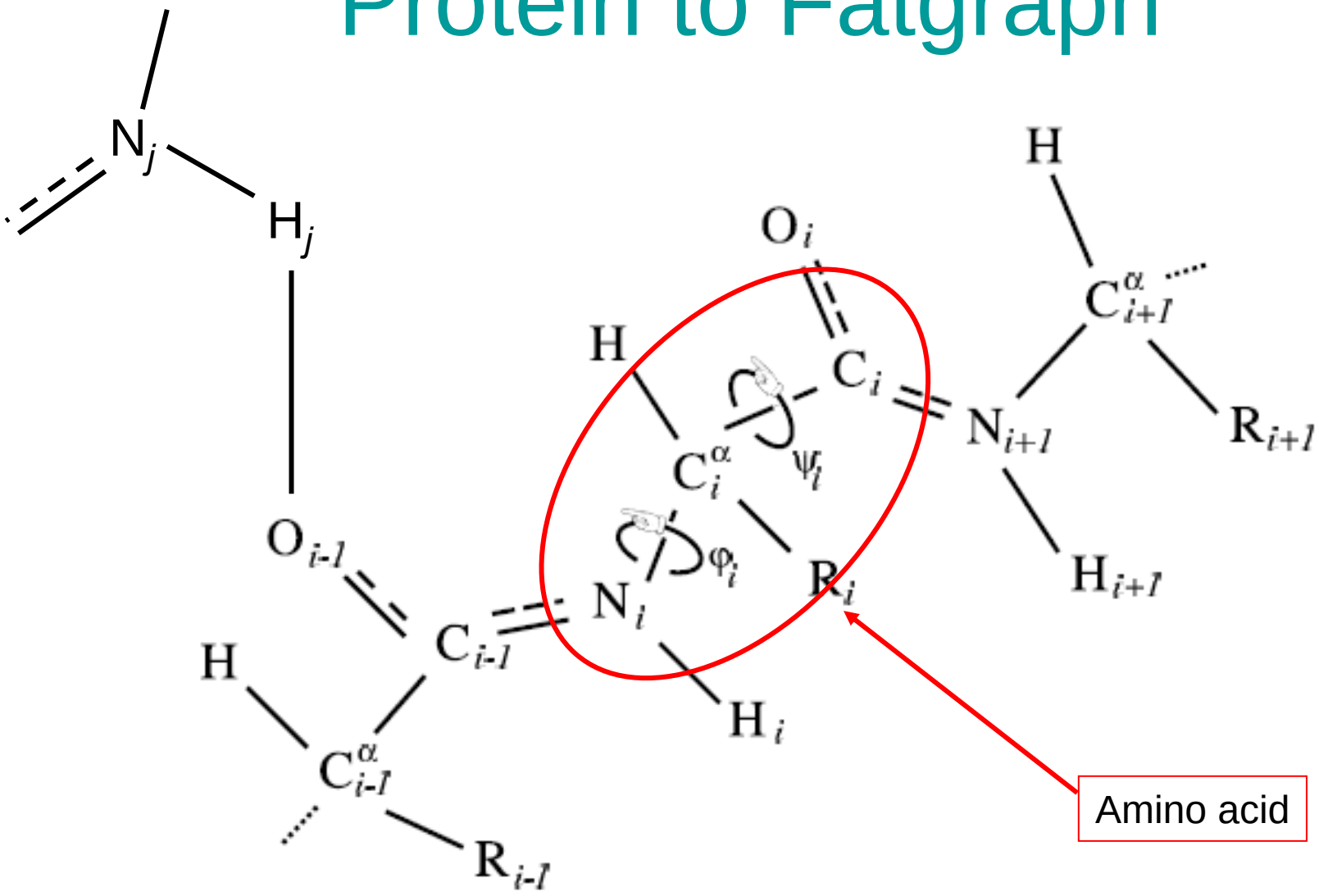
$$\sigma(G_1) = \sigma(G_2) = \sigma(G_3) = (1,2,3)(4,5,6)(7,8,9),$$

$$\tau_u(G_1) = (2,8)(3,6)(4,7)(5,9), \tau_t(G_1) = 1s,$$

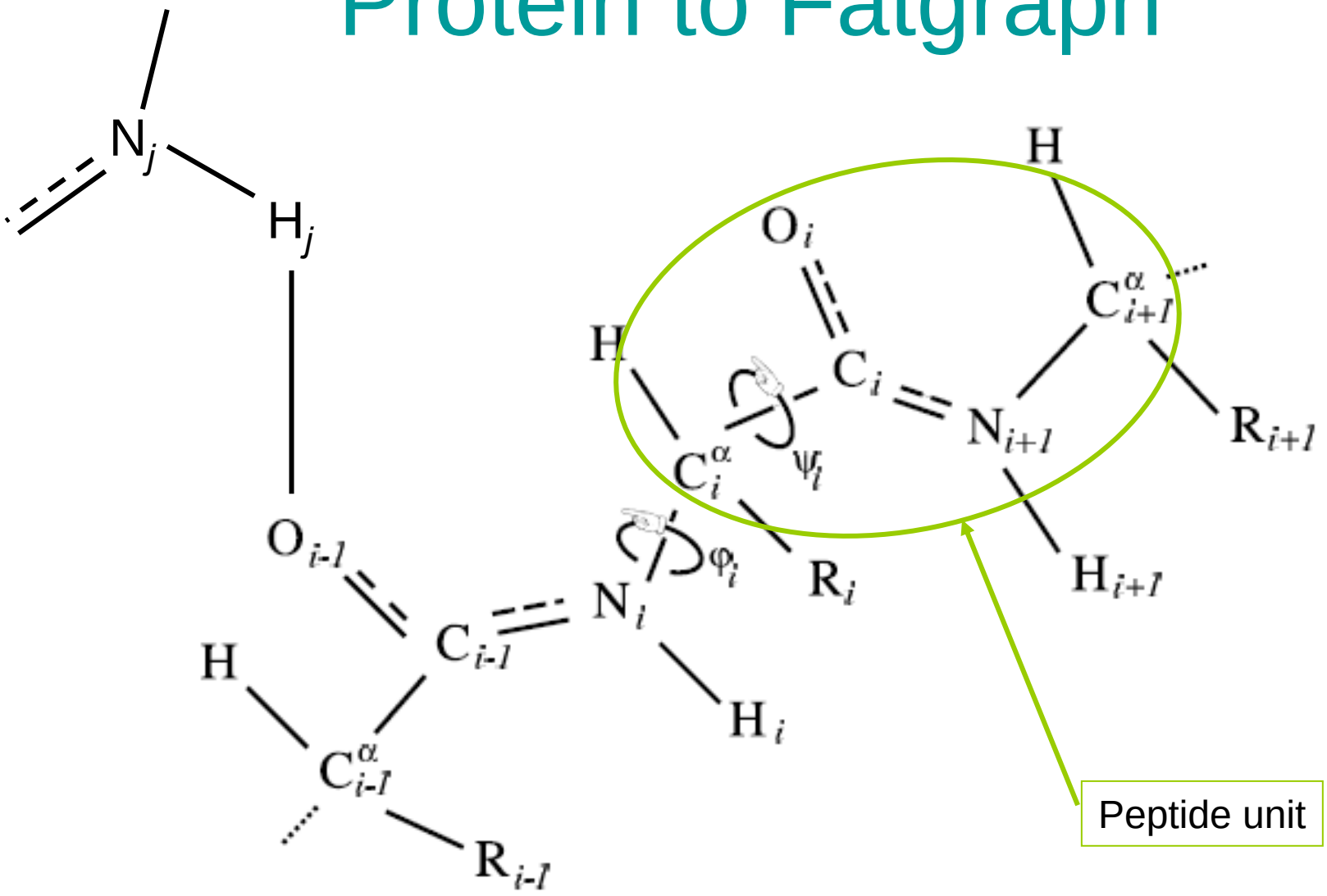
$$\tau_u(G_2) = (2,8)(3,6)(4,9)(5,7), \tau_t(G_2) = 1s,$$

$$\tau_u(G_3) = (2,8)(3,6)(5,9), \tau_t(G_3) = (4,7).$$

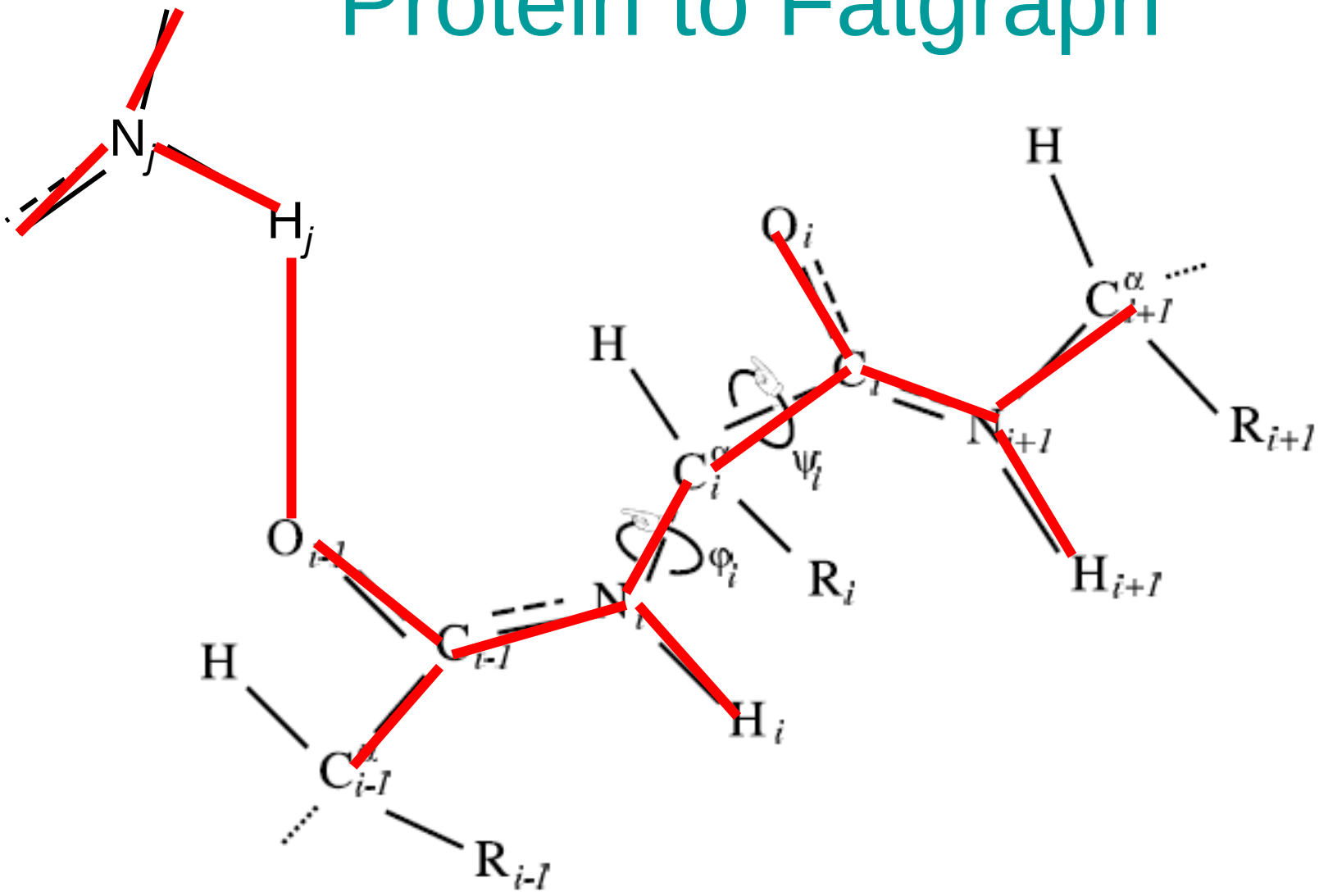
Protein to Fatgraph



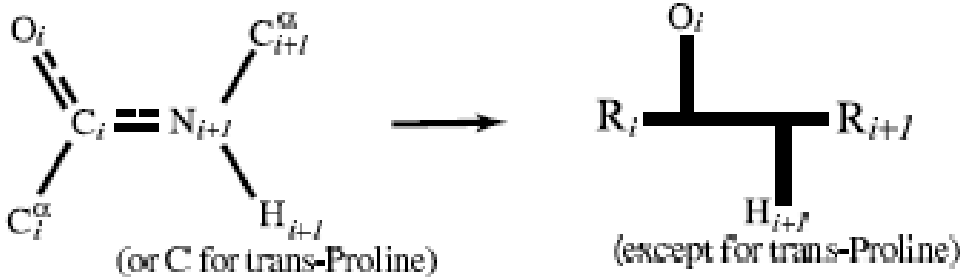
Protein to Fatgraph

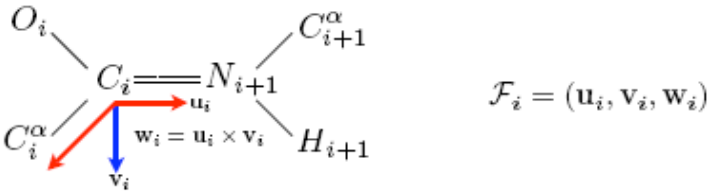


Protein to Fatgraph

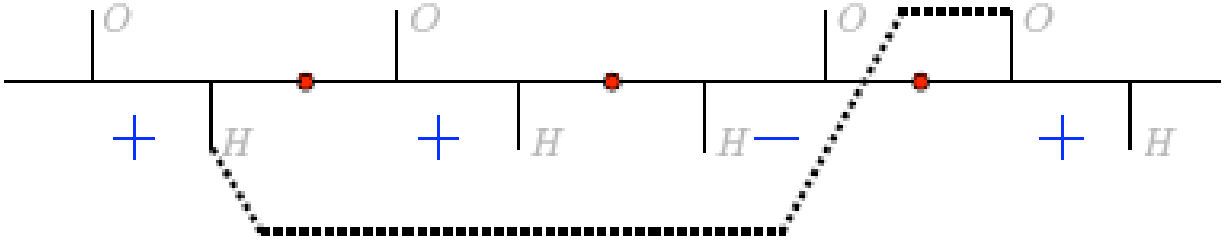


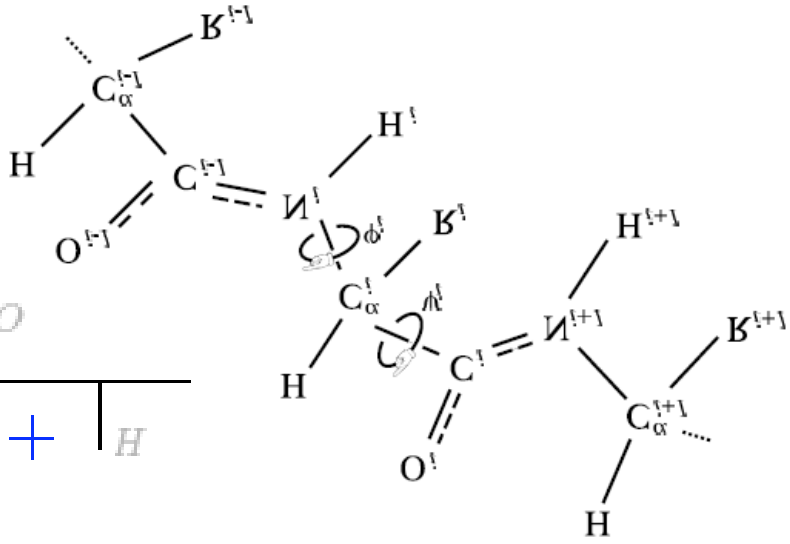
Building the Fatgraph





Twist vs Non-twist determined from the backbone

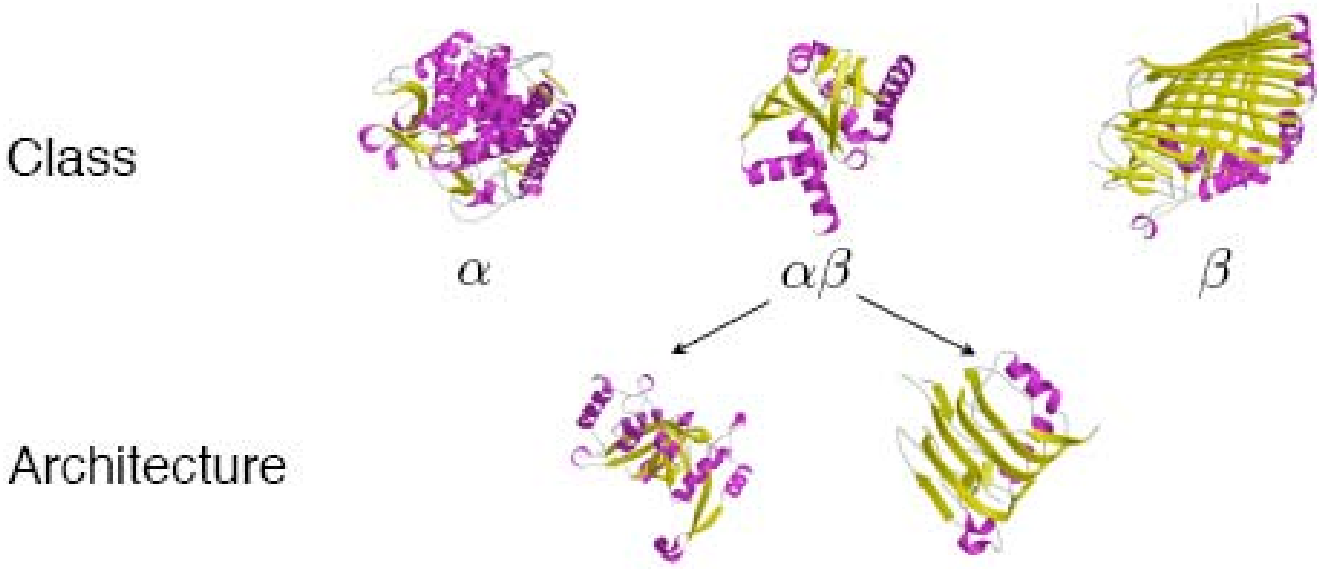




Protein Classification

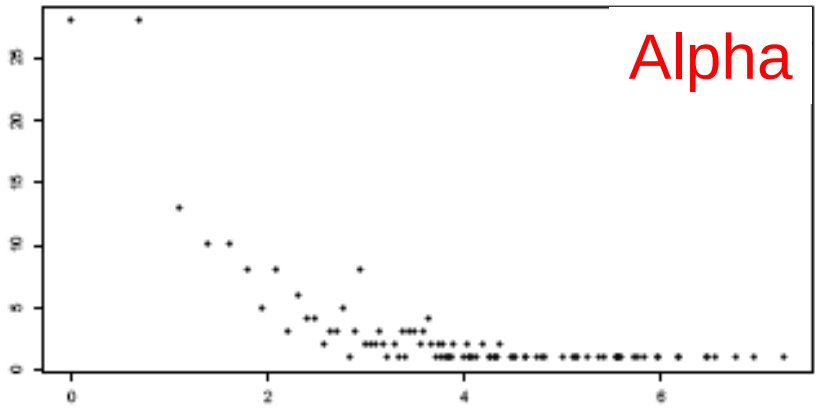
- More than 50,000 known protein structures and 200,000 domains stored in PDB
- Protein Classification
  - CATH and SCOP; largely manual
  - Assisted by secondary structure knowledge
- Automated classification
  - Rogen and co-workers; geometric classification

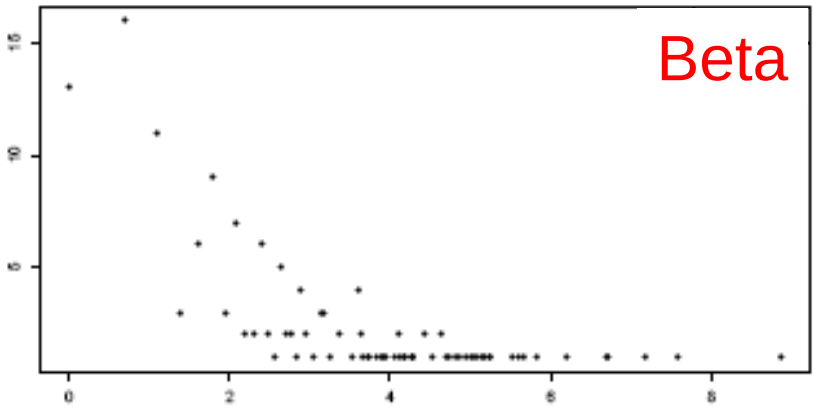
CATH

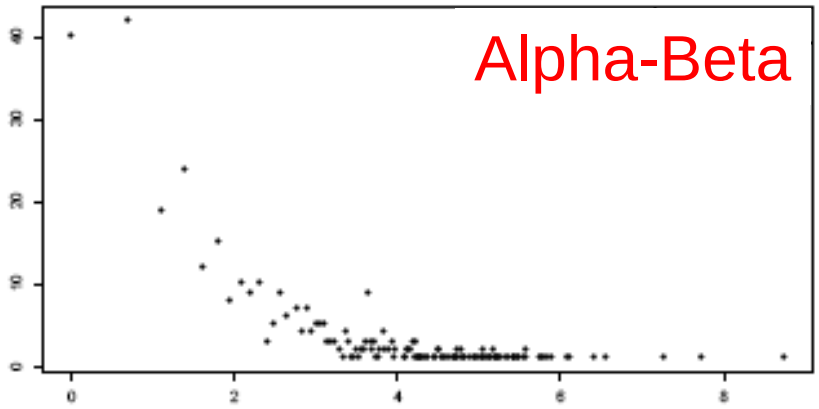


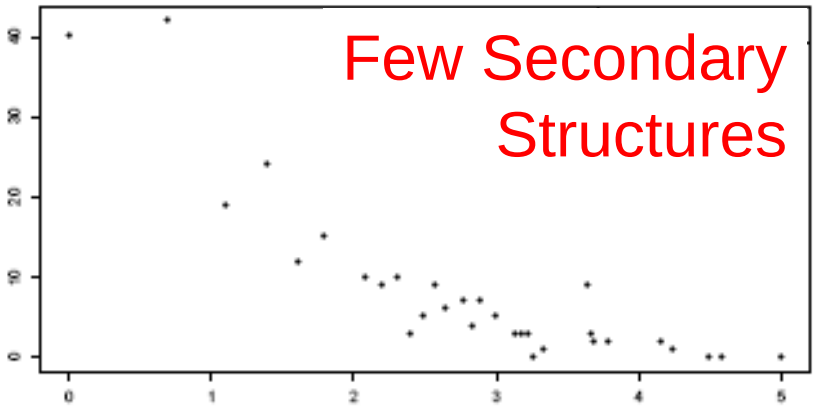
The classification is hierarchical with the four main levels called ***C**lass*, ***A**rchitecture*, ***T**opology*, and ***H**omology*, respectively.

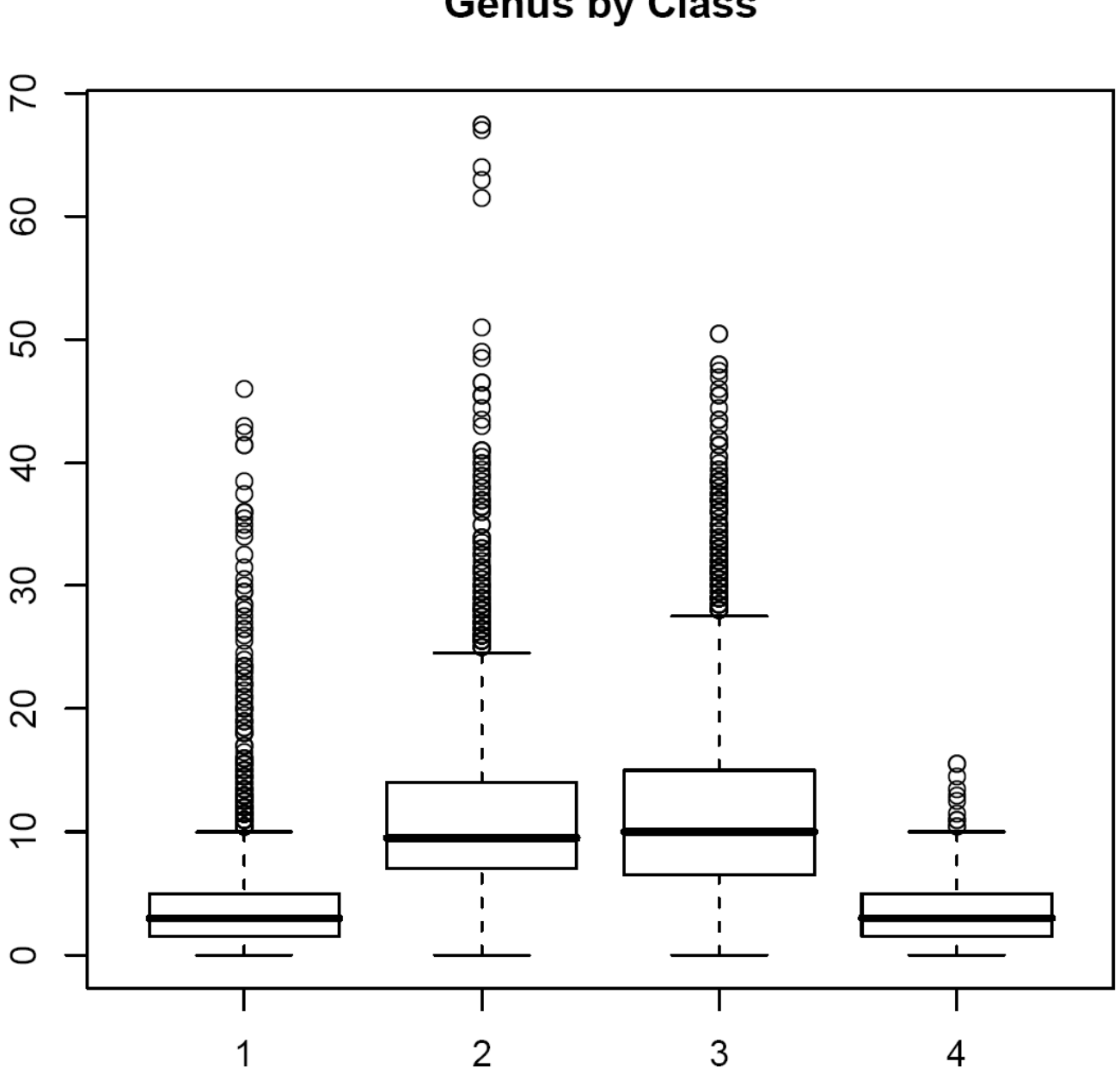
CATH
Size of topology class in CATH

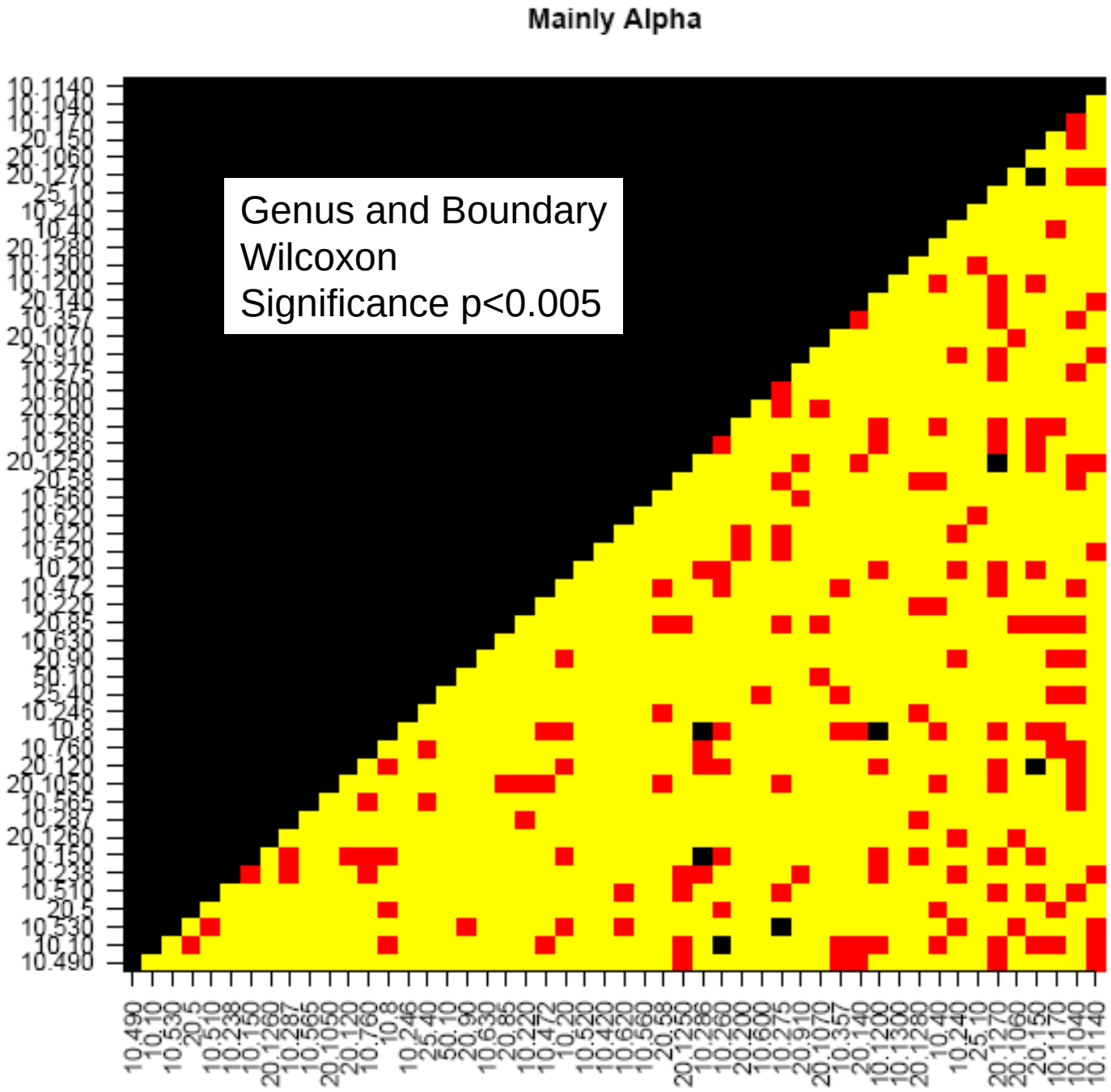




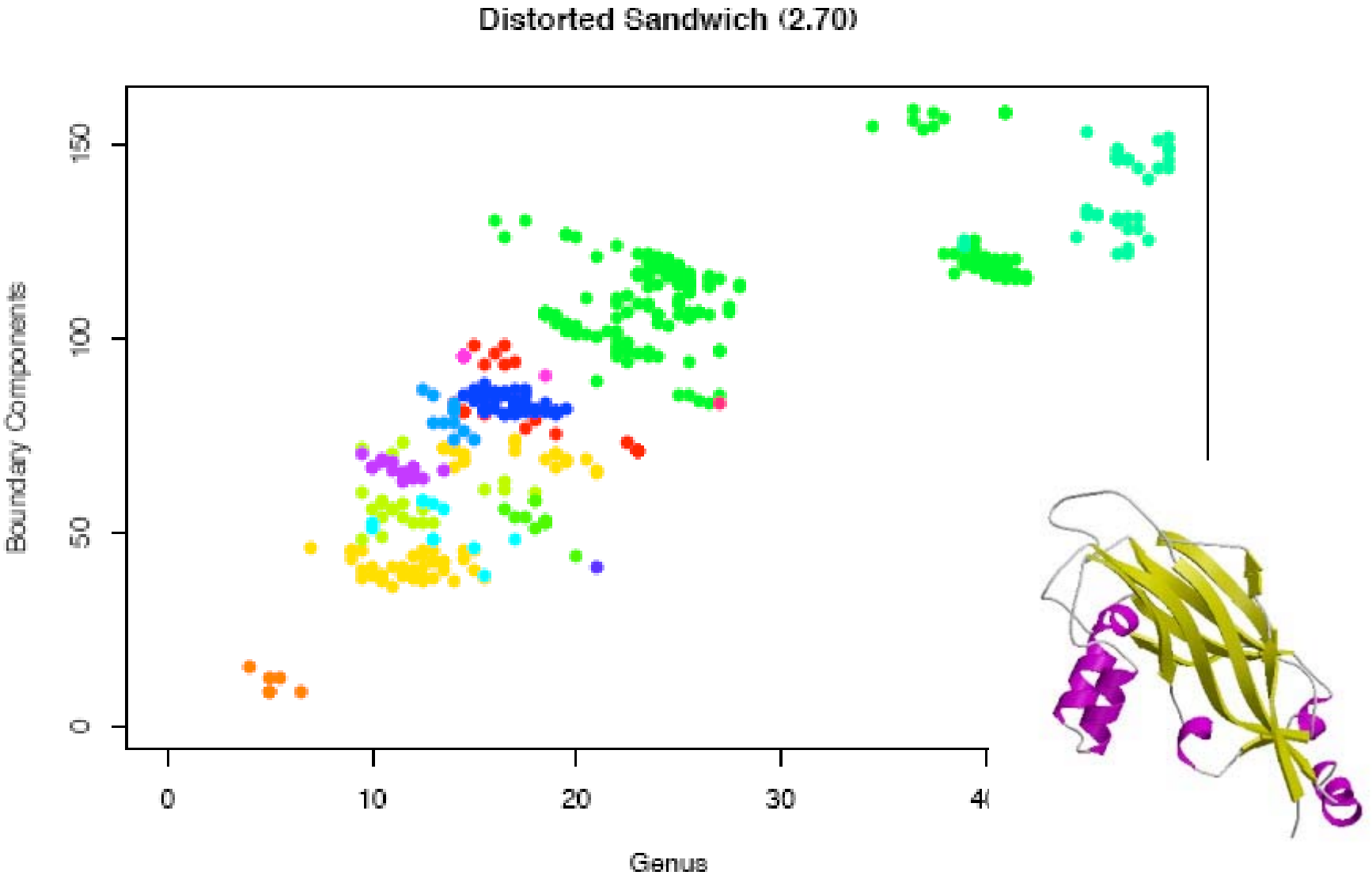





Genus by Class
0
10
20
30
40
50
60
70
1
2
3
4

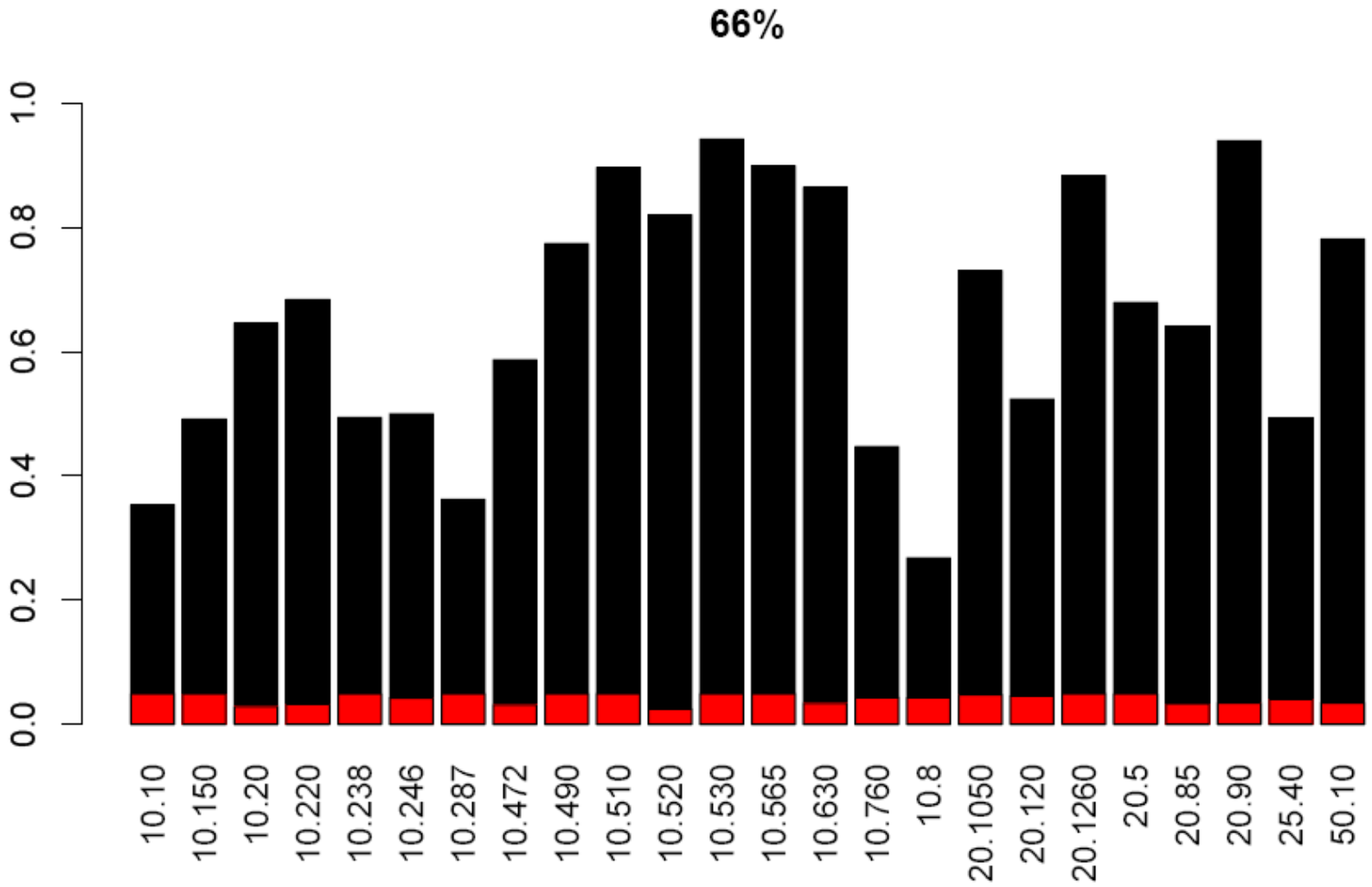

Mainly Alpha
Genus and Boundary
Wilcoxon
Significance p<0.005

Distorted Sandwich - 13 topologies (in “mainly beta”)



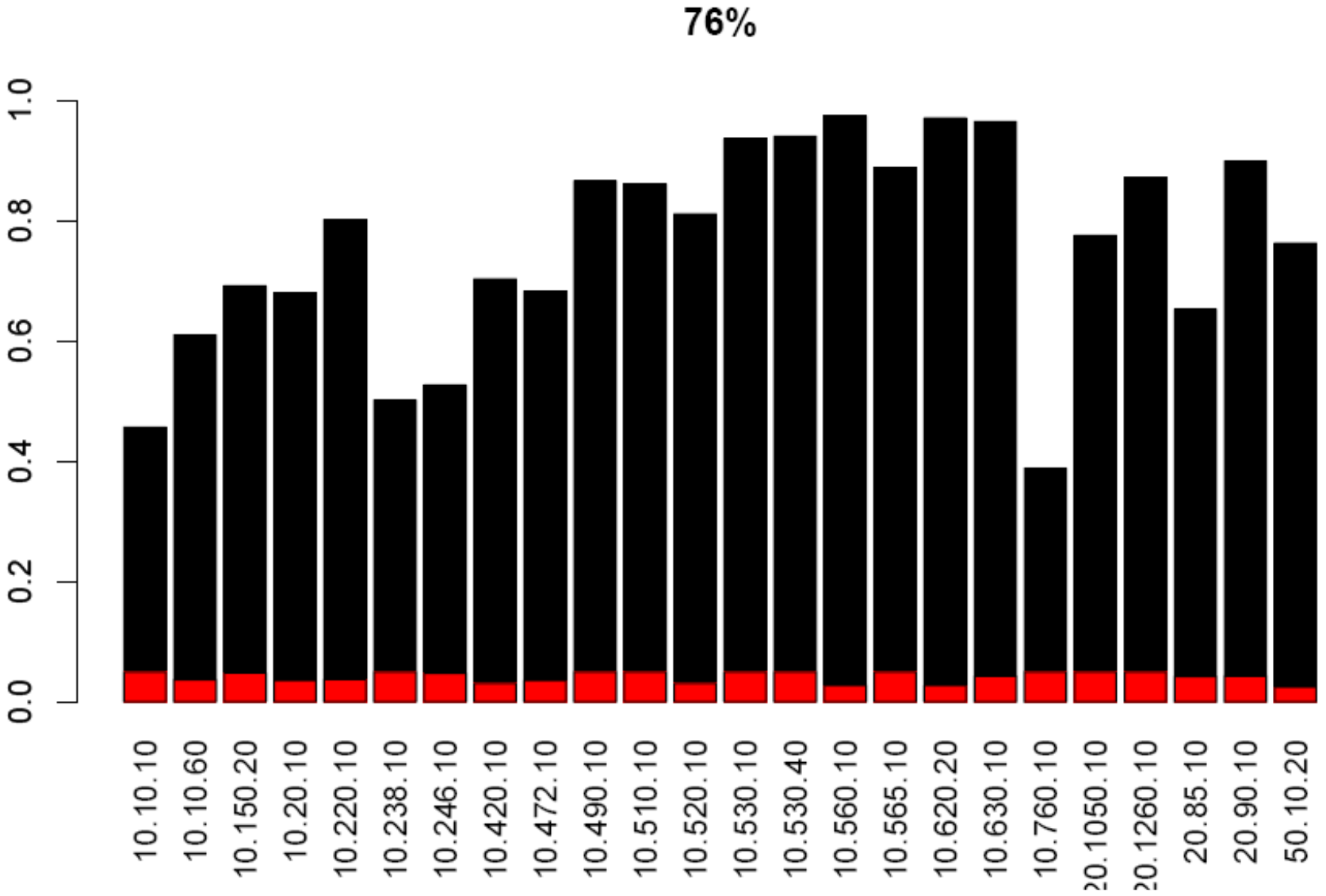
Mainly Alpha – 24 largest topologies

(Nearest Neighbour with 25)



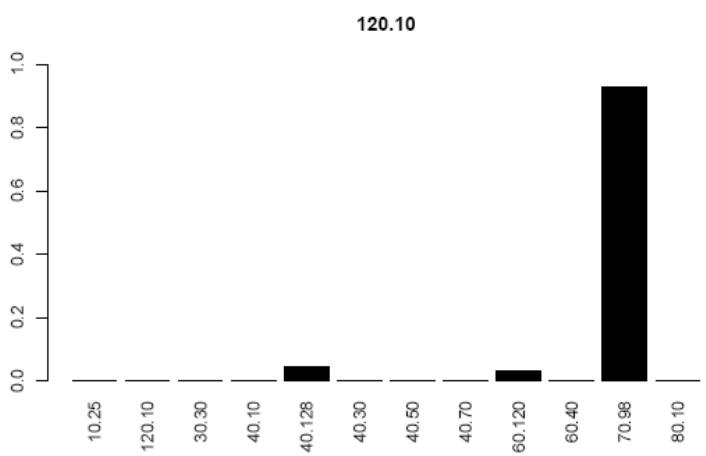
Mainly Alpha – 24 largest homologies

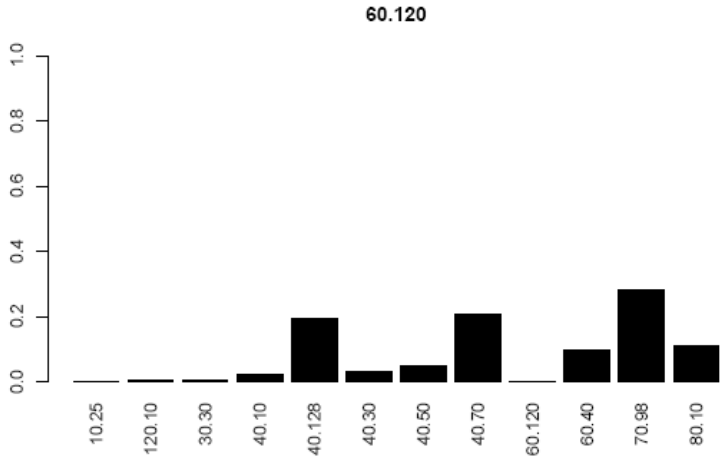
(Nearest Neighbour with 25)

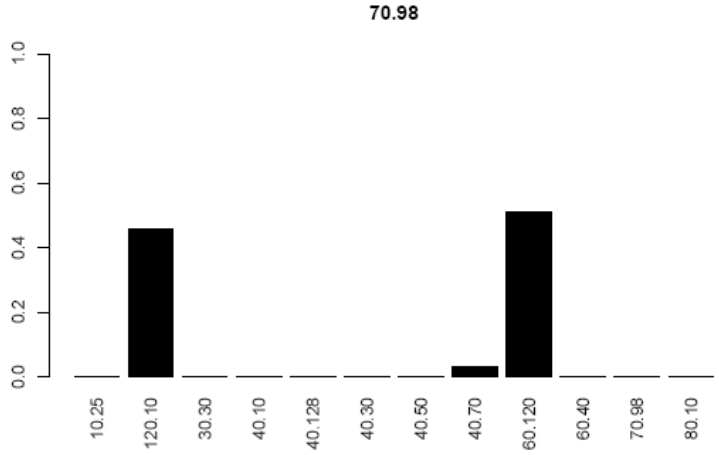


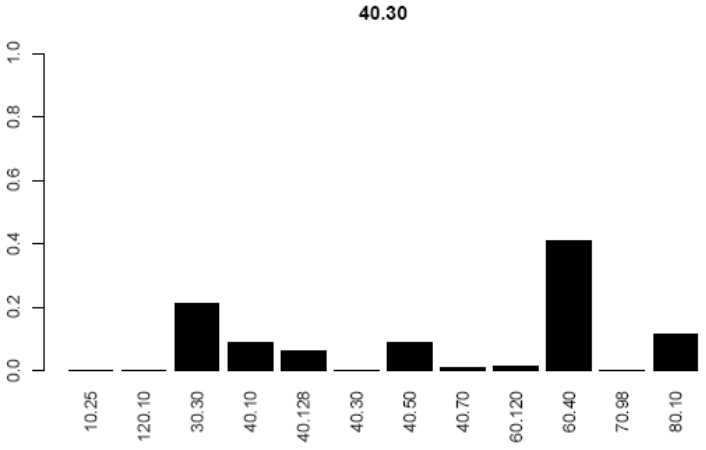
Classify “Unknown” Topology

(“Mainly beta”; 12 largest topologies)







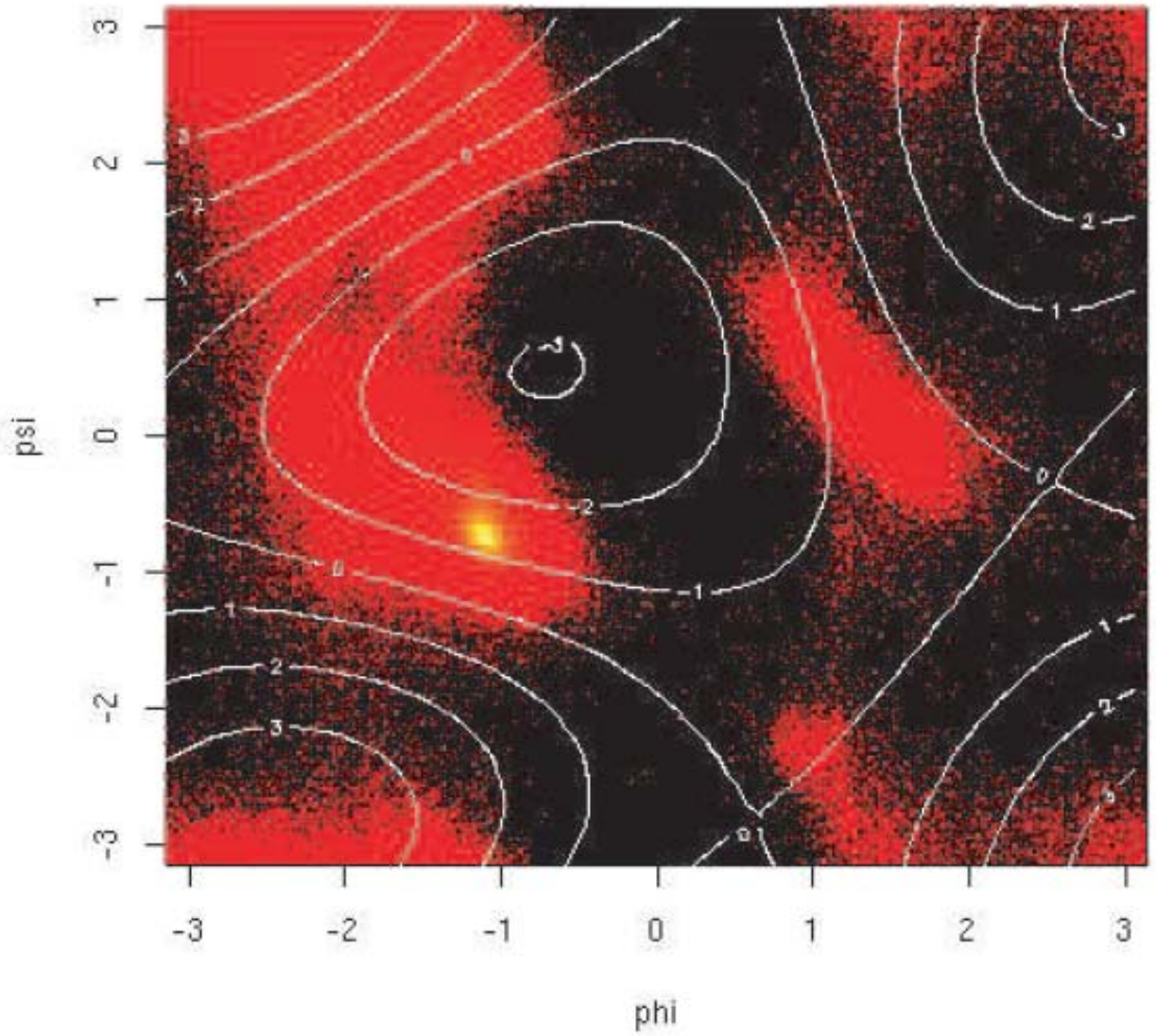


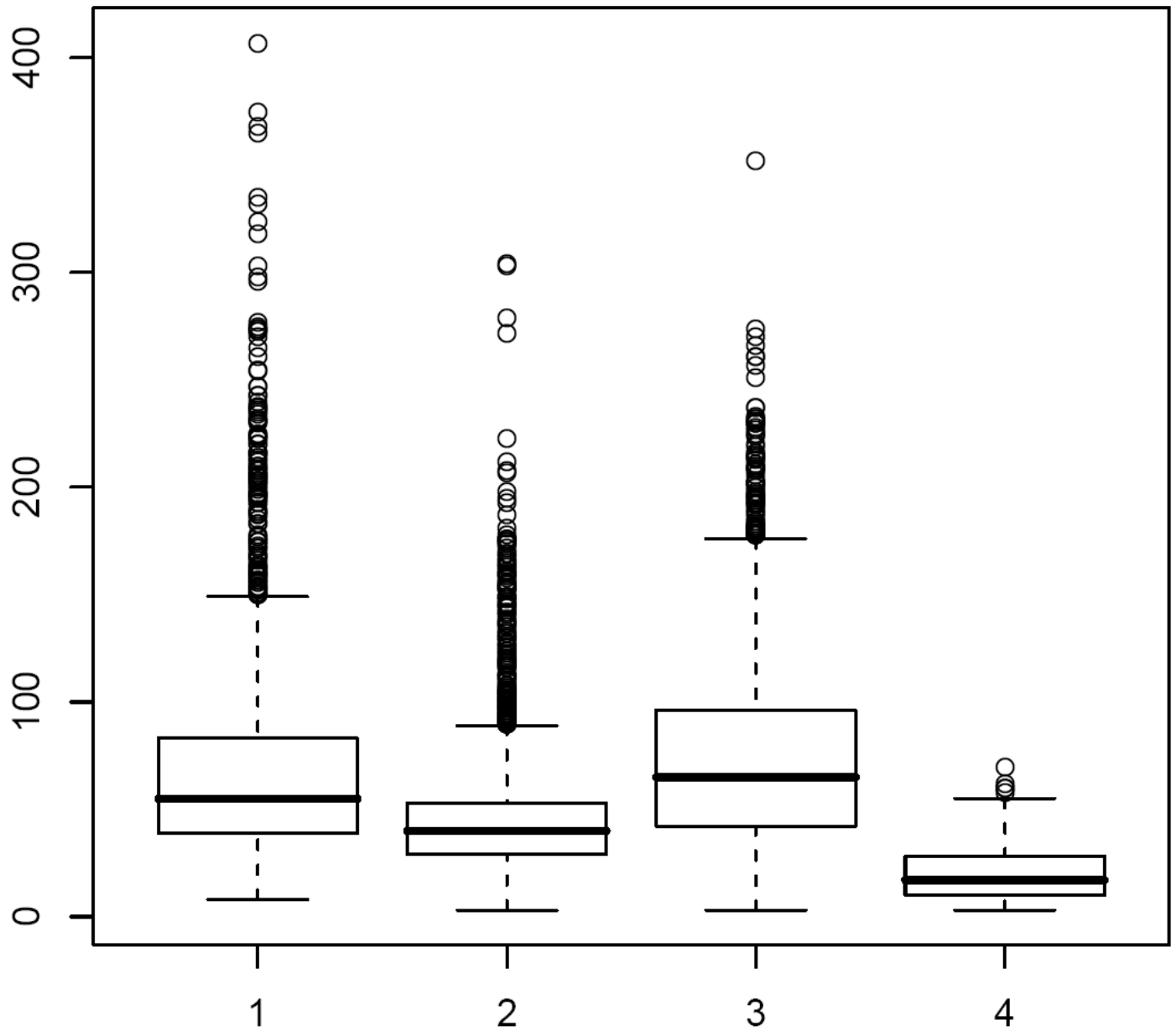
Acknowledgement

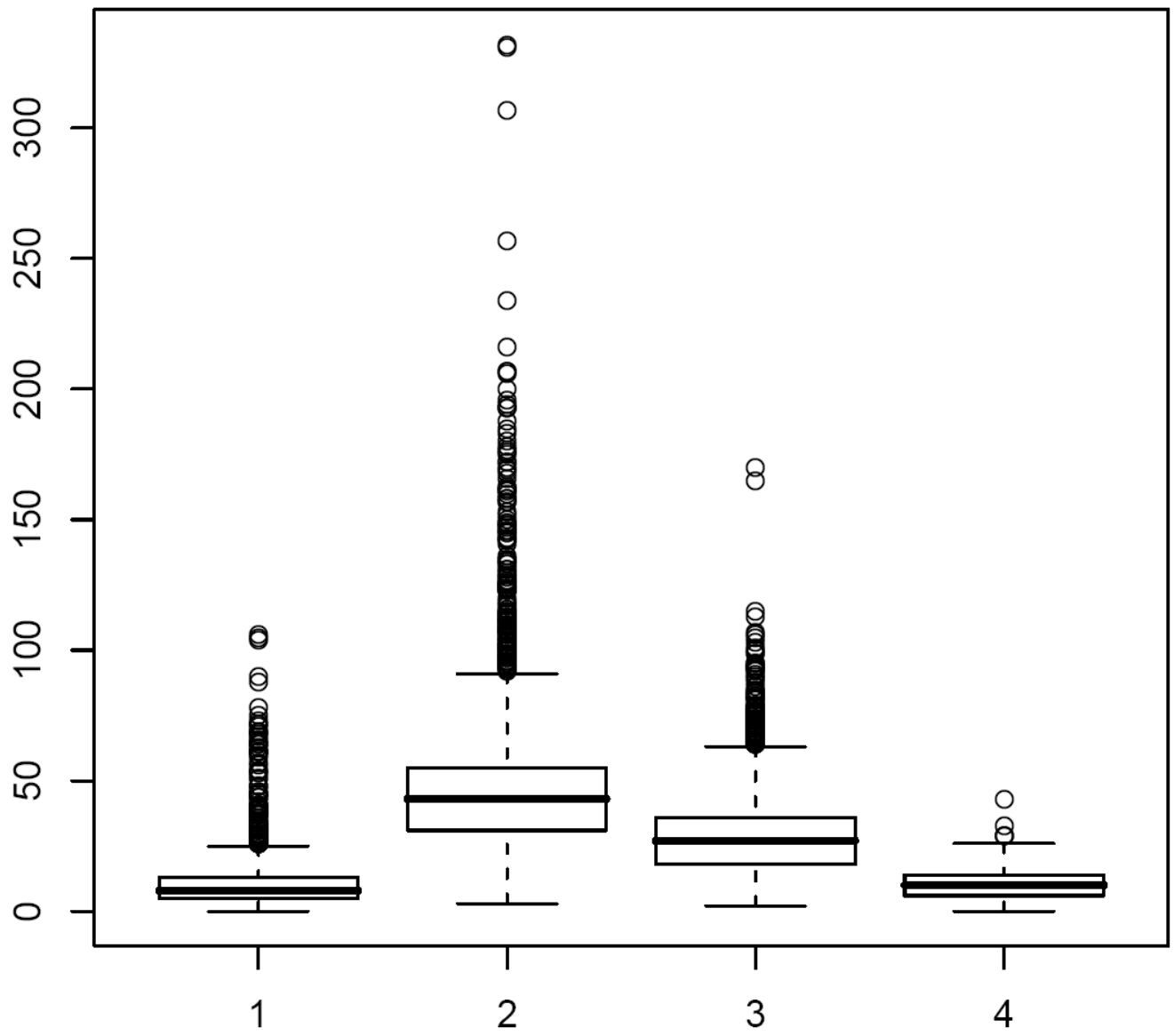
- Joint work with
  - Bob Penner
  - Jorgen Ellegaard Andersen
  - Michael Knudsen

END

Ramachandran Plot




Boundaries by Class
400
300
200
100
0
1
2
3
4


Twistedness by Class
0
50
100
150
200
250
300
1
2
3
4