RNA 3D structure prediction
GeneSilico group (128) in CASP15

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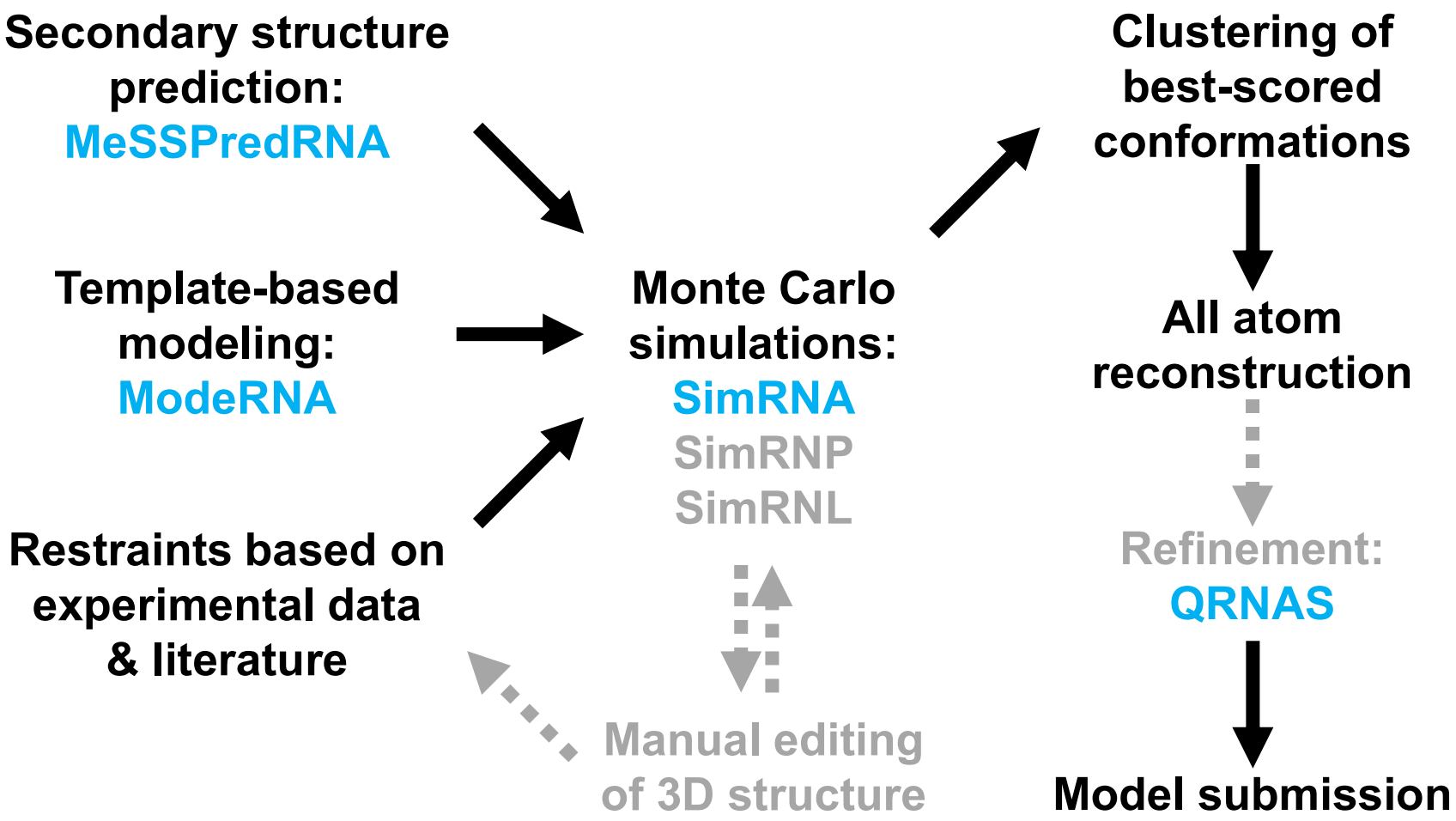
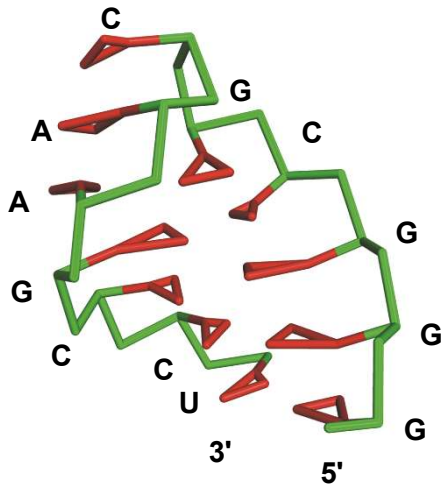
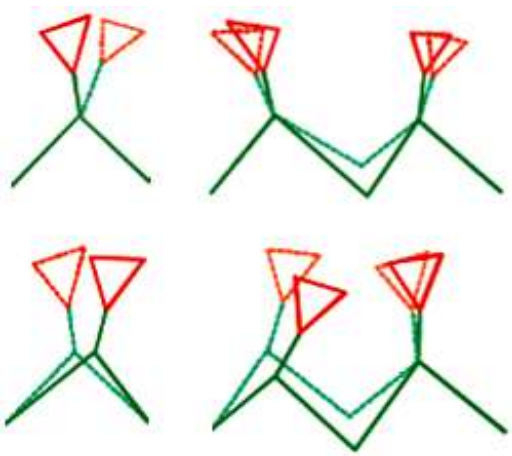
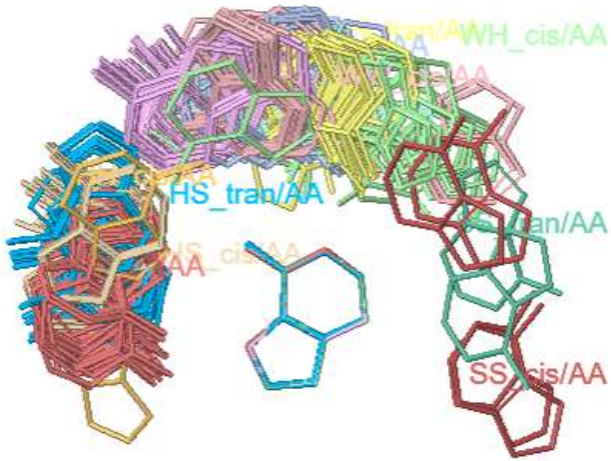
Overall methodological workflow



Central methodology:
RNA 3D structure modeling with SimRNA







Representation:
coarse-grained

3 atoms per base
2 atoms for backbone
3D grids

Move set:
random conformational changes

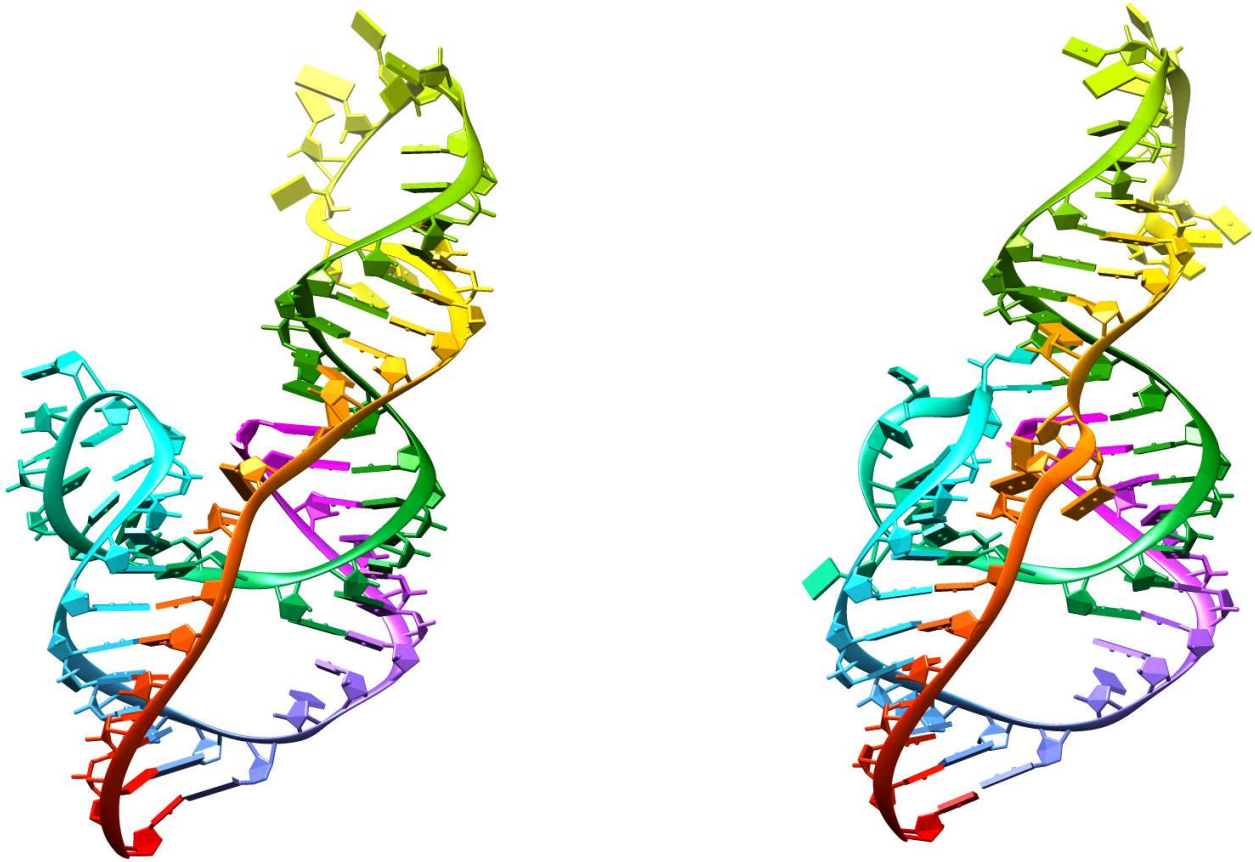
Monte Carlo approach
moves accepted or rejected
depending on energy and temperature

Scoring:
statistical potential

calculated from
experimentally determined
RNA 3D structures

Boniecki MJ, Lach G, Dawson WK, Tomala K, Lukasz P, Soltysinski T, Rother KM, Bujnicki JM
SimRNA: a coarse-grained method for RNA folding simulations and 3D structure prediction
Nucleic Acids Res. 2016 Apr 20;44(7):e63.

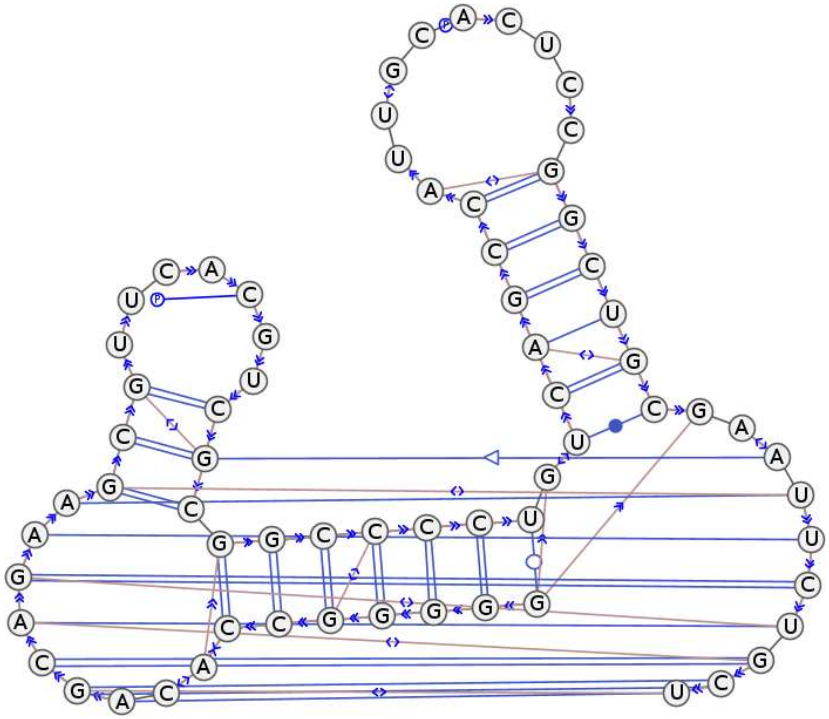
R1108 – model 3, ranked 1st

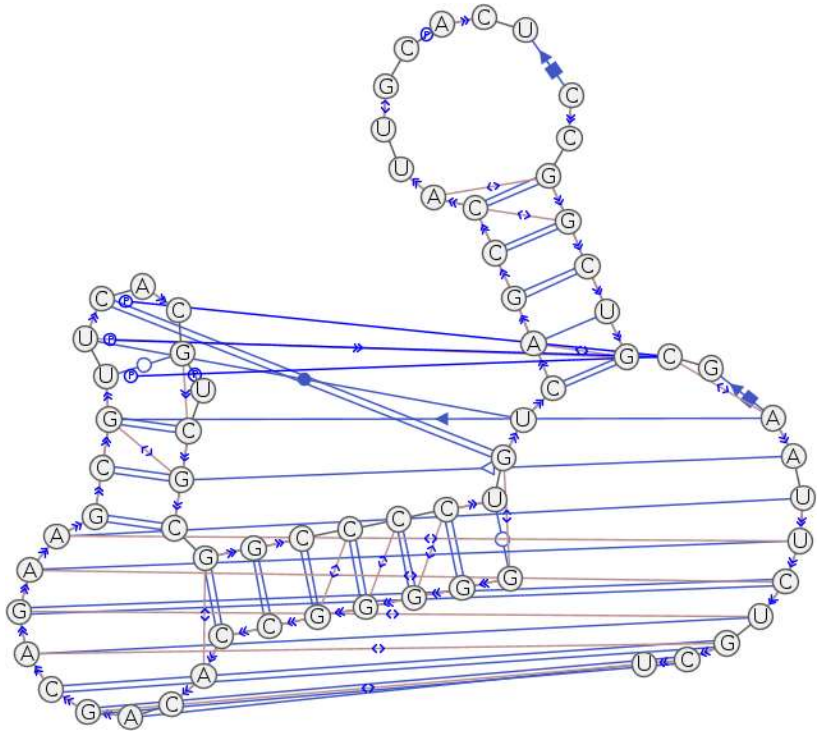


reference **model**

RMSD 5.48, LDDT 0.742, TMscore 0.544, GDT_TS 64.86

R1108 – model 3, ranked 1st





reference **model**

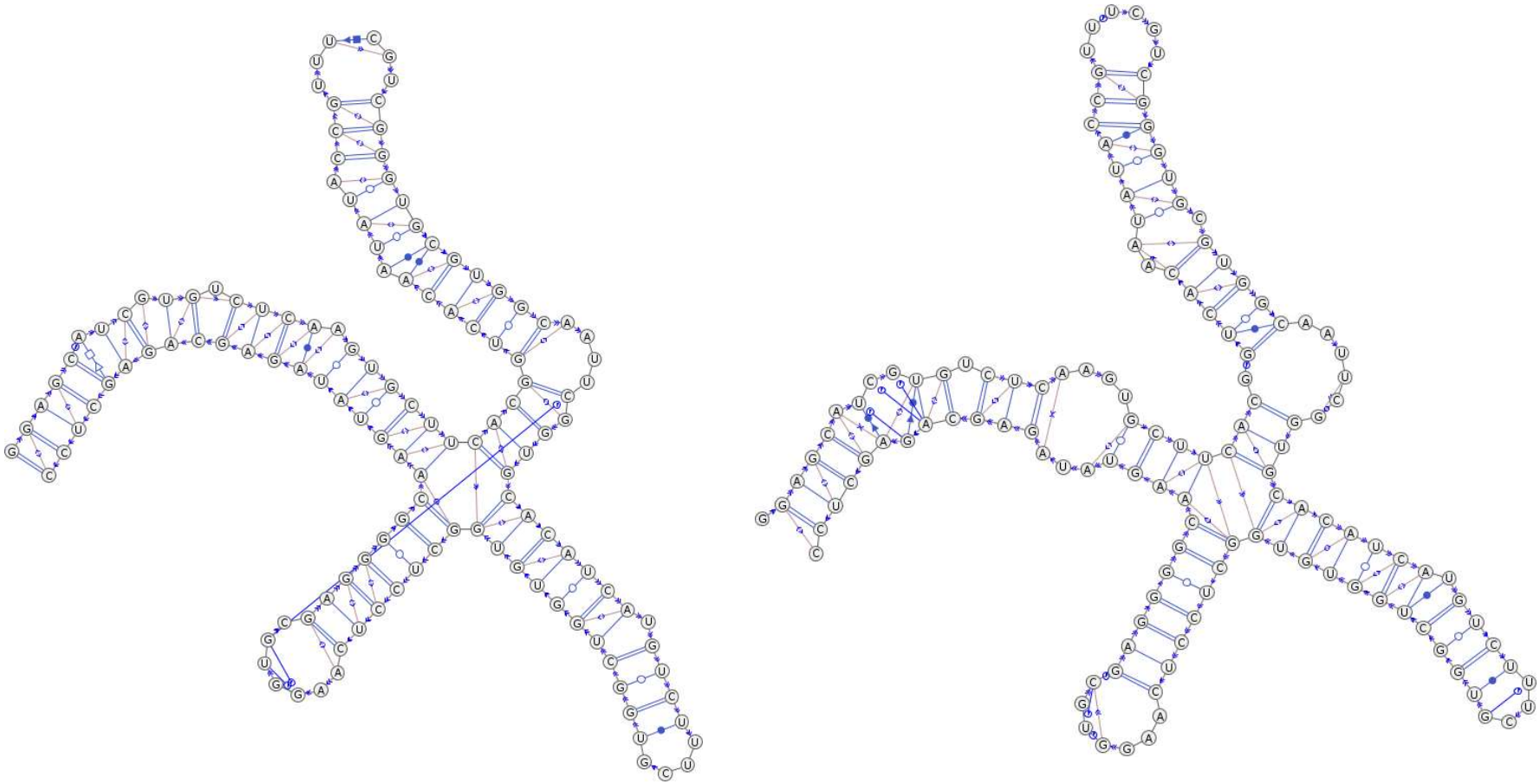
MCC: can 0.92, ncan 0.42, stack 0.74, all 0.70

R1156 – model 5, ranked 1st

reference **model**

RMSD 5.37, LDDT 0.654, TMscore 0.664, GDT_TS 46.67

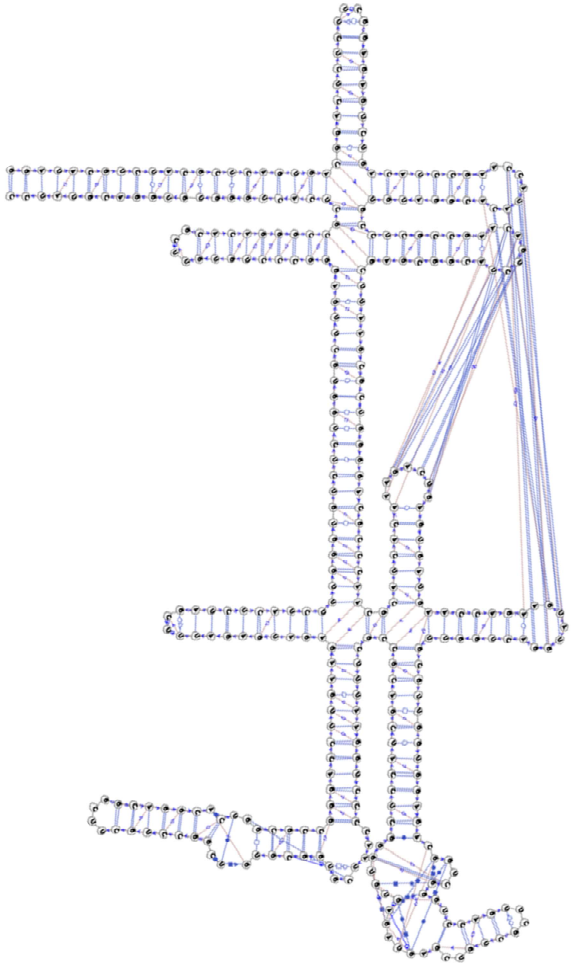
R1156 – model 5, ranked 1st

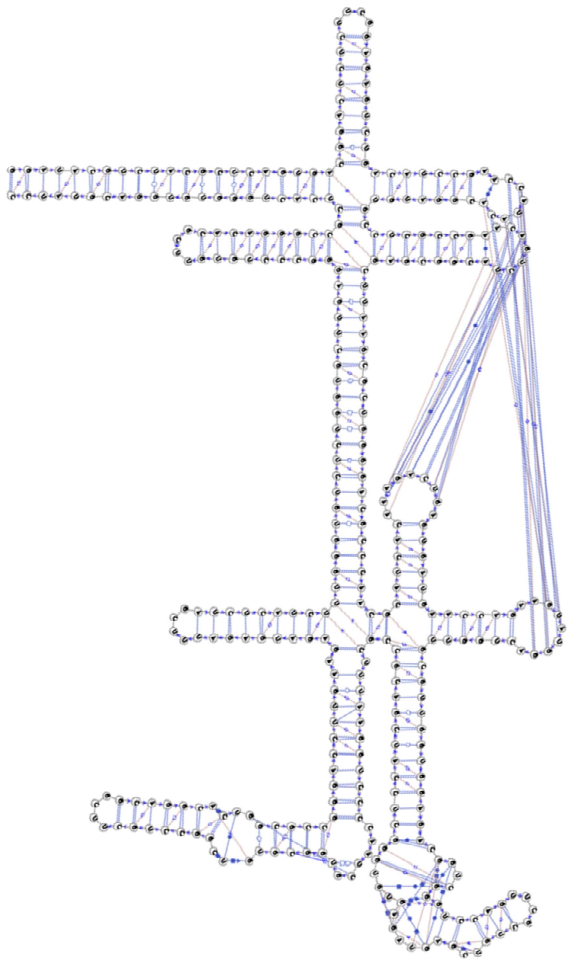


reference **model**

MCC: can 0.93, ncan 0.55, stack 0.71, all 0.64

R1136 – model 1, ranked ….

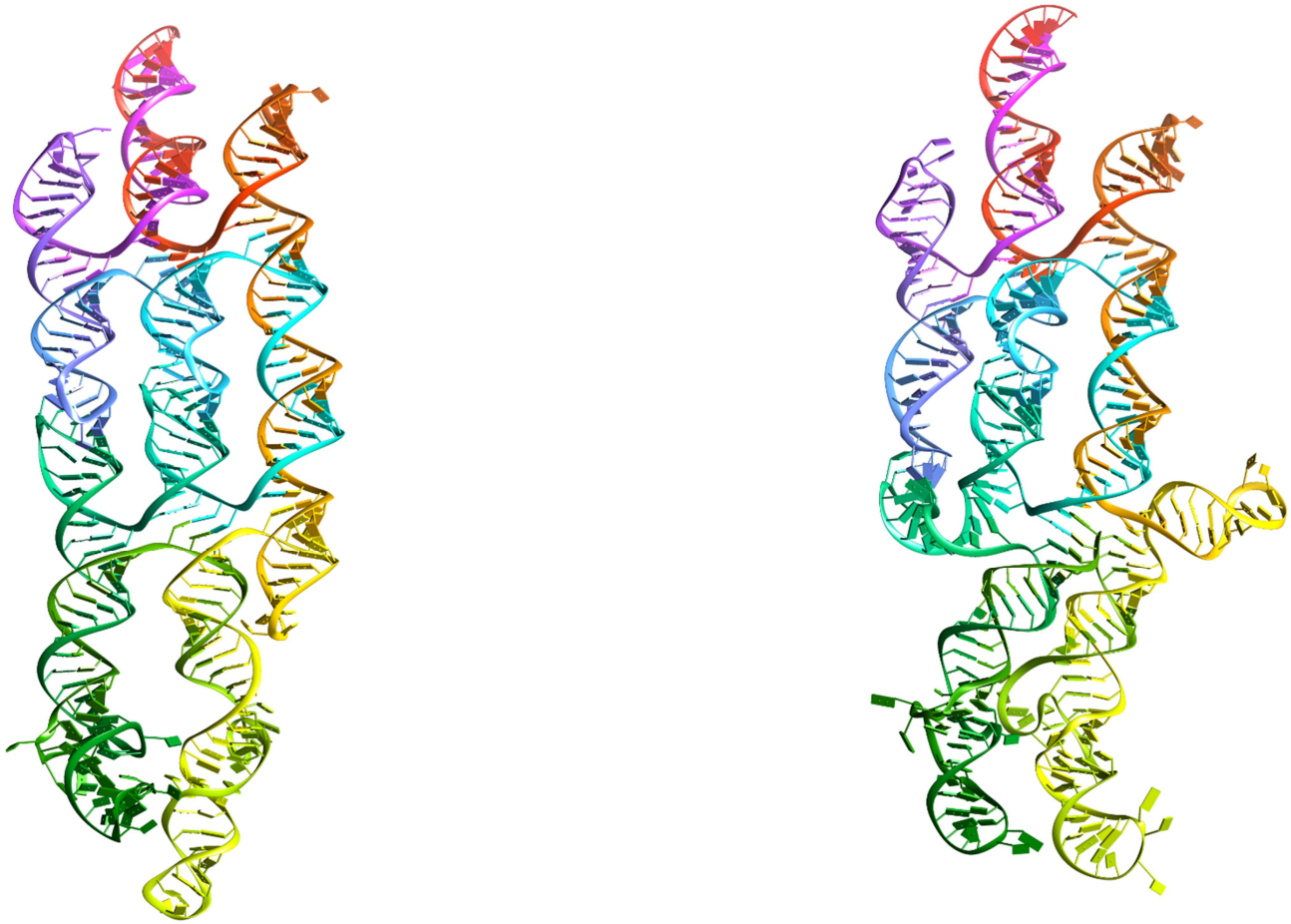




reference **model**

MCC: can 0.99, ncan 0.83, stack 0.88, all 0.86

R1136 – model 1, ranked 30th



reference model

RMSD 13.23, LDDT 0.701, TMscore 0.533, GDT_TS 20.99

What went right

Prediction of (nearly all) canonical and wobble pairs

- For all targets at least one model with $MCC_{canonical}$>0.9

- Always: Prediction of simple secondary structure elements

- Often: Prediction of pseudoknotted helices
  in particular kissing-loop interactions
  (important in artificially designed RNAs)

Prediction of stacking within helical segments

- For all targets at least one model with $MCC_{stacking}$>0.7

Sometimes:
- topology of 4-way junctions
- co-axial stacking of helices

What went wrong

Prediction of non-canonical pairs (who with whom and how)

- Long-range nc pairs are extremely hard to predict
- Average $MCC_{non\text{-}canonical}$ for our best models only 0.58
- Best prediction: $MCC_{non\text{-}canonical}$ 0.83 (R1136)
  but mostly based on short-range interactions within loops
- Successes are rare (e.g., R1117 model 1)

Prediction of stacking interactions outside of helices

- In helices and short loops it's easy, otherwise it's hard

Bending helices. In reality they break rather than bend.

Sometimes:
- topology of 4-way junctions
- co-axial stacking of helices

Acknowledgements

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our software: http://genesilico.pl