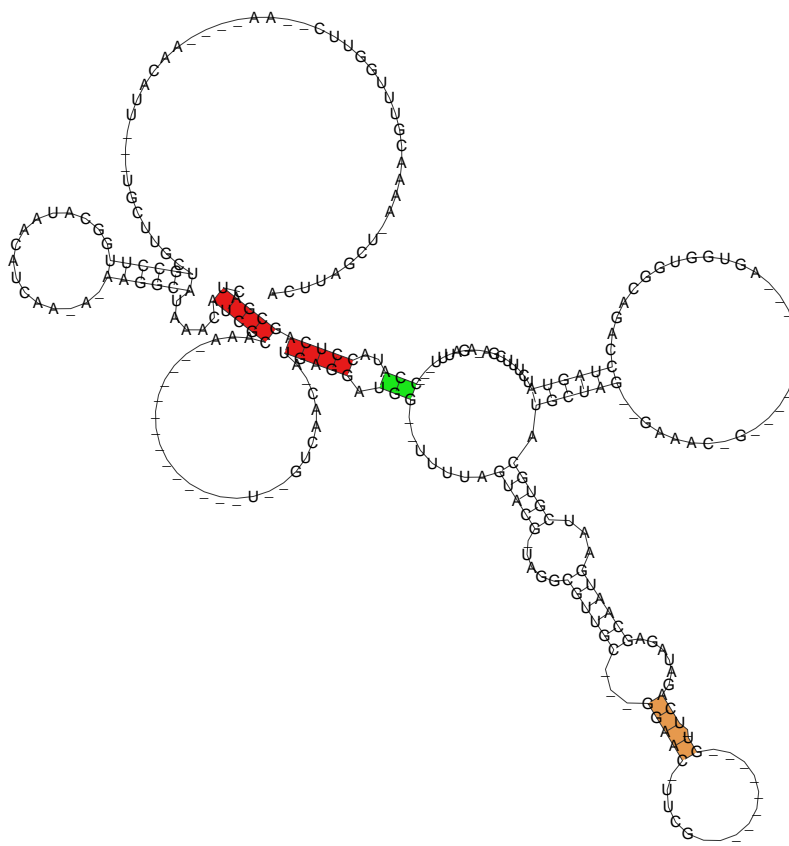


R2 retro element



Reference secondary structure (Rfam)

While the RIBOSUM `RNAalifold` variant correctly predicts all base pairs, the colored stems can not be predicted using the original `RNAalifold` implementation.

Using the more sophisticated gap treatment, is sufficient to predict the orange and red stems. In the orange stem, the single bulge that is actually only there in one sequence, would destabilize the short stem (see alignment below). For the red stem, the size of the interior loop is much smaller in most sequences than what the old `RNAalifold` implementation uses in the energy evaluations. As the destabilizing effect of interior loops rises with their length, this leads to neglecting this stem loop.

The green stem is a good example for the superiority of the RIBOSUM scoring over the old ad-hoc scoring. Only some (20%) of the structures can not realize it, and there are some compensatory mutations: there are 3 different stems of length three, which are distributed very unevenly: one only occurs once, one twice. That will lead to quite small covariance score when using ad-hoc scoring. RIBOSUM scoring also uses small bonuses for keeping a sequence, so the

covariance term is bigger and sufficient for a correct prediction.

```
U13032.1/1423-1651 ACUUAAGCU-AAAACGUTUUGGUUC--AA----AACAUU--UGCUUGUCUGUCUGGCAUAACAUCAAUA--AAGGCAUAAACUUGCGAAUAUU
U81815-1/525-734 AUGUACUA-ACCUCUAGCUUUUCUUAU--ACCUUU--UGCCUGCUACCUUGGCAUUAACAUCUAAA--AAGGUACAACUCUGCAUU----
U13031-1/1423-1644 ACUUAAGCU-AAAACGUTUUGGUUC--AA----AACAUU--UGCUUGUCUGUCUGGCAUAACAUCAAUA--AAGGCAUAAACUCGCAAAUAUU
U13033-1/1423-1658 ACUUAAGCU-AAAACGUTUUGGUUC--AA----AACAUU--UGCUUGUCUGUCUGGCAUAACAUCAAUA--AAGGCAUAAACUCGCAAAUAUU
U81811-1/530-751 ACUGUAGCUGAGCGUUGUUAUAU--GU----GAUAAA--UGCCUGUCUGCCUGGCAUAACAUCAAUA--AAGGCAUAAACUCGCAAAUAUU
U81813-1/515-708 ACUUAAGCC-UAUACACUAUUGUUGG--AG----AGAGAC--GCUUGUCUACCUAGGCAUAUAUGUGAA--U--UAGGUUAUAAACUCUGGUGU----
U81985-1/508-709 ACCUAGCC-GAAACACUAUUGUUGG--AA----AGAAGA--CGUUGUCUACCUAGGCAUAUAUGUAAA--UAGGUUAUAAACUCUGGAGU----
X51967-1/3549-3585 ACUUAAGCU-AAAACGUTUUGGUUC--AA----AACAUU--UGCUUGUCUGUCUGGCAUAACAUCAAUA--AAGGCAUAAACUCGCAAAUAUU
U81814-1/504-719 CGUUAAGU-UCUGUAUUGUUGUCU--AUUUUGAACAUU--UGCCUGCUACCUUGGCAUAACAUCAAUA--U--AAGGUUAUAAACUCGCAAAUAUU
U81812-1/515-708 ACUUAAGCC-UAUACACUAUUGUUGG--AG----AGAGAC--GCUUGUCUACCUAGGCAUAUAUGUGAA--U--UAGGUUAUAAACUCUGGUGU----
U81809-1/517-738 ACUUAUAC-A-UGCACCACGAAC--AU----AUUGAUGAAAGCUUGCCUGGCAUAACAUCAAUA--AAGGCAUAAACUCGCAAAUAUU
U13035-1/1423-1647 ACGUAGCUUAAAACGUTUUGGUUCA--CA----UACAUC--UGCCUGUCUGCCUGGCAUAACAUCAAUA--A--AAGGCAUAAACUCGCAAAUAUU
U81810-1/484-703 ACUUAUAC-A-UGCACCACGAAC--AU----AUUAAA--AGCUUGCCUGGCAUAACAUCAAUA--AAGGCAUAAACUCGCAAAUAUU
U13034-1/1423-1648 ACGUAGCU-UAAAACGUTUUGGUUCA--CA----UACAUC--UGCCUGUCUGCCUGGCAUAACAUCAAUA--A--AAGGCAUAAACUCGCAAAUAUU
AF015819-1/3308-3490 AAAUCGCA-U-UGGGAUAGGAUG--AU----ACGC-----CACCUGGCAUCGUCUCUC-U-CAGCUCUCA-CUUGGUCUUC--
structure .....(((((((.....)))))).....).....(((.....)))).....

U13032.1/1423-1651 GGUAAUAUA-UAAAUUGGCUAUUAGGAGUGG--UUUUAGUACG-UAGGCGUUGC--GGAAC-UUCG-----GU-UCAGAUAGAGCAA
U81815-1/525-734 -----GUCAUA-AAAGAG-UGG--UUUUAGUACG-UAGGCGUUGC--GGAAC-UUCA-----UUUU-CCCGUGUAGCGAG
U13031-1/1423-1644 GGUAAUAUA-UAAAUGGCU-AUAGGAGUGG--UUUUAGUACG-UAGGCGUUGC--GGAAC-UUCG-----GU-UCG-----GCAA
U13033-1/1423-1658 UGGUUAUAUAUAAAUGGCU-AUAGGAGUGG--UUUUAGUACG-UAGGCGUUGC--GGAAC-UUCG-----GU-UCAGAUAGAGCAA
U81811-1/530-751 -----UAGCA-ACA-AAGGAGAGUGU-UUUUAGUACG-UAGGCAUUGC--GGAACCCUCAACGUGAAGAA--GU-UCAGAUAGAGCAA
U81813-1/515-708 -----U-GUAAAC-UGGAG-UGGCG--UUUUAGUACGUAUGGCGU--AUUAC-UUC-----GU-AAU-----CA
U81985-1/508-709 -----U-GUAAAC-UGGAG-UGGCG--UUUUAGUACG-UAGGCGUUGU--GADGA-CUUG-----UU-GAAG-UAAAACCA
X51967-1/3549-3585 UGGUUAUAUAUAAAUGGCU-AUAGGAGUGG--UUUUAGUACG-UAGGCGUUGC--GGAAC-UUCG-----GU-UCAGAUAGAGCAA
U81814-1/504-719 -----AGUUAUC-AUAGAGUGGCG--UUUUAGUACG-UAGGCGUUGU--AGAAC-UUAA-----UUGU-UCUGAUAGAGCGG
U81812-1/515-708 -----U-GUAAAC-UGGAG-UGGCG--UUUUAGUACGUAUGGCGU--AUUAC-UUC-----GU-AAU-----CA
U81809-1/517-738 -----AAA-ACAGAGCGCGU--UUUUAGUACG-UAGGCAUCUUGGGGGGA--GGAU-----AU-CCACCCCAA-UGA
U13035-1/1423-1647 GGUUAU-----U-ACGGCUAUUAGGAGUGG--UUUUAGUACG-UAGGCGUUGC--GGAAC-UUCG-----GU-UCGAGAUAGAGCAA
U81810-1/484-703 -----AAA-ACAGAGCGCGU--UUUUAGUACG-UAGGCGUUGC--GGAAC-UUCG-----GU-UCGAGAUAGAGCAA
U13034-1/1423-1648 UGGU-----UAAUACGGCUAUUAGGAGUGG--UUUUAGUACG-UAGGCGUUGC--GGAAC-UUCG-----GU-UCGAGAUAGAGCAA
AF015819-1/3308-3490 -----UAAGUUAUAUACCCUUG--UUUUUUUAGUGGG-UAUUCUUUU-----ACGC-UUUC-----GUAG-----GAG
structure .....(((.....)).....).....(((((((.....)))))).....).....(((.....)))).....

U13032.1/1423-1651 UGAAUCGCGCAUGCUAG--GAAACUGA-----AGUGUUGACAGACCUAGUAUCUUUCGUAUAGAUUU--CCUAAUCUCGCGCAUC
U81815-1/525-734 UGAAUCGUGACUACGAGAUUGUCC-----AGUAGUUGGU--GCUCGUUAUUUAGA-AGAUUU--CCUU-CCUCGCGCAUC
U13031-1/1423-1644 UGAAUCGUGCAUGCUAG--GAAACUGA-----AGUGUUGACAGACCUAGUAUCUUUCGUAUAGAUUU--CCUAAUCUCGCGCAUC
U13033-1/1423-1658 UGAAUCGUGCAUGCUAG--GAAACUGA-----AGUGUUGACAGACCUAGUAUCUUUCGUAUAGAUUU--CCUAAUCUCGCGCAUC
U81811-1/530-751 UGAAUCGUGCAUGCUAG-AGUCAU-----UGGUUCGA--CCUAGUAUCUUUAGA-AGAUUU--CCUAAUCUCGCGCAUC
U81813-1/515-708 UGAAUCGUGCAUGCUAG-UGGGGU-----UUGGUCUCU--ACUAGUAUCUUU-AGAUUU--CCUAAUCUCGCGCAUC
U81985-1/508-709 CGAAUCGUGCUUGCUAU--UA-C-----GUUGGCCUUUA-AUAGUAUCUUA-AGAUUU--CCUU-CCUCGCGCAUC
X51967-1/3549-3585 UGAAUCGUGCAUGCUAG--GAAACUGA-----AGUGUUGGCGAGACCUAGUAUCUUUAGA-AGAUUU--CCUAAUCUCGCGCAUC
U81814-1/504-719 CGAAUCGUGCAUGCUAG-UCUUAAC-----AUUUUCUUGU-ACUAGUAUCUUUA-AGAUUU--CCUCUCUGGCGGUC
U81812-1/515-708 UGAAUCGUGCAUGCUAG-UGGGGU-----UUU-GCCUCCACUAGUAUCUUUA-AGAUUU--CCUAAUCUCGCGCAUC
U81809-1/517-738 UGAAUCGUGCAUGCACUCACUAAGGCGCAAAGAAGAAUACCGGCGGAGUGUUAUCUUUUA--AGAUUU--UAGGCAUCUUAAGCG-C
U13035-1/1423-1647 UGAAUCGUGCAUGCUAG--GAAACUGA-----AAAUAACGCAACCCUAGUAUCUUUAGA-AGAUUU--CCUAAUCUCGCGCAUC
U81810-1/484-703 UGAAUCGUGCAUGCACUCUCUUAUUGGCUAAAUAAC-AUCAUAAACGAGUGUGUAUCUUUUA-AGAUUUUUAAGAU--CCUAAUCUCGCGCAUC
U13034-1/1423-1648 UGAAUCGUGCAUGCUAG--GAAACUGA-----AAUUGGCGGCAACCUAGUAUCUUUUA-AGAUUU--CCUAAUCUCGCGCAUC
AF015819-1/3308-3490 CGAGUCCACACUCU-U--GAGC-----AAUCCGGG-----GUAGUCCUUA--A-CGCAUU--UCUU-CAAC-ATAAAA
structure ))...)))).(((((((.....)))))).....).....(((.....)))).....
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