Algorithms in Comparative Genomics

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Dr. Marília D. V. Braga · Leonard Bohnenkämper
https://gi.cebitec.uni-bielefeld.de/teaching/2020winter/cg

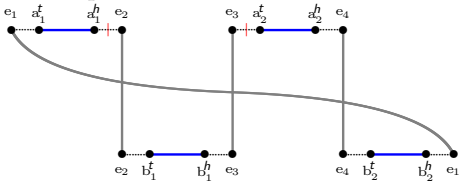
Exercise sheet 11, 21.1.2021

Exercise 1 (Singular DCJ-indel - indel-potential) (6 pts)

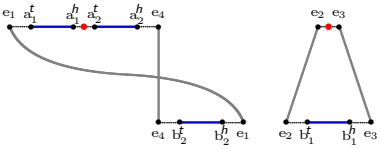
For each of the following cycles C_i:

1. Give the number of runs $\Lambda(C_i)$ and compute the indel-potential $\lambda(C_i)$.
2. Let x_i be the length of a sequence of **internal gaining DCJ operations** transforming C_i into a set of shorter cycles C_i^1, C_i^2, ..., $C_i^{x_i+1}$, such that, $\lambda(C_i) = \sum \lambda(C_i^k)$ and for each C_i^k, we have $\Lambda(C_i^k) = \lambda(C_i^k) \in \{1, 2\}$.
   (a) What is the minimum possible value of x_i, denoted by $x_i^* = \min\{x_i\}$?
   (b) Design a sequence with a minimum x_i^* DCJ operations for each C_i, always cutting on the top genome, resulting in shorter cycles C_i^1, C_i^2, ..., $C_i^{x_i^*+1}$ as described above. (For each DCJ operation, draw the cuts and the resulting cycles with the joins).

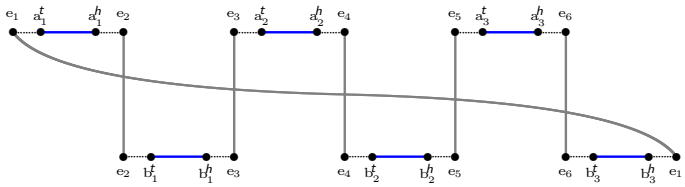
C_1: Example



1. $\Lambda(C_1) = 4$, $\lambda(C_1) = \frac{4}{2} + 1 = 3$
2. (a) $x_1^* = 1$
   (b)

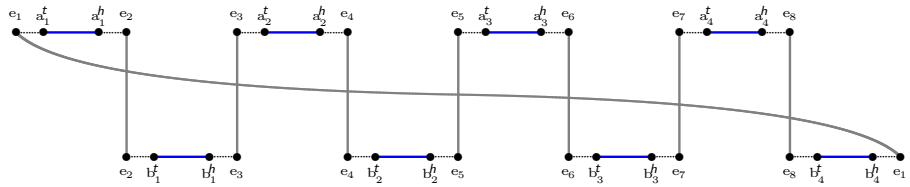


C_2:

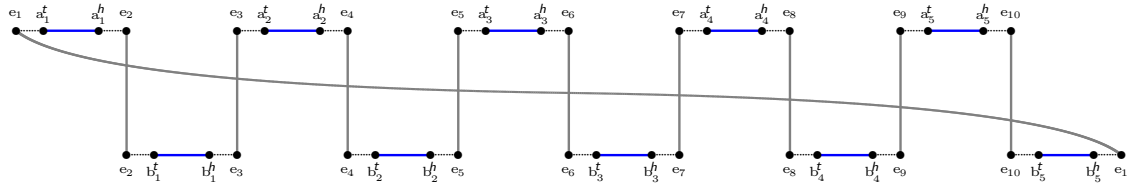


Hint: Here we have $\Lambda(C_2) = 6$. If the 1st DCJ splits the runs into 5+1, we still need a 2nd DCJ to split the cycle that receives the 5 runs. However, we can achieve our goal with only one DCJ, i.e., $x_2^* = 1$.

C_3:



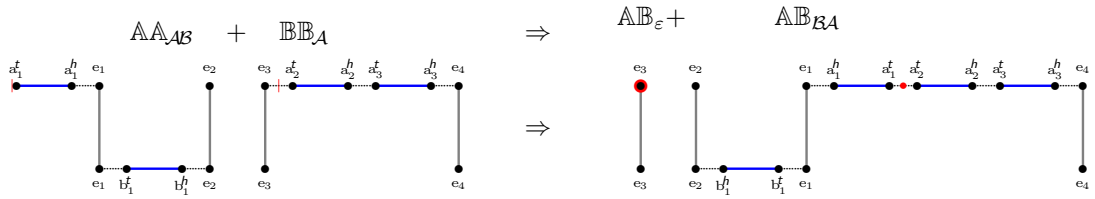
C_4:



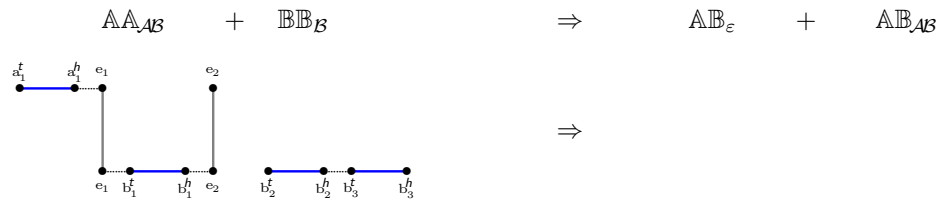
Exercise 2 (Singular DCJ-indel - deducting path recombinations) (6 pts)

For each of the following deducting path recombinations, draw the cuts and the resultants of the given types with the joins, so that the given $\Delta^{\lambda}_{\text{DCJ}}$ is achieved. (Recall that both cuts must be done in the same genome and each cut either breaks an adjacency or is next to a telomere.)

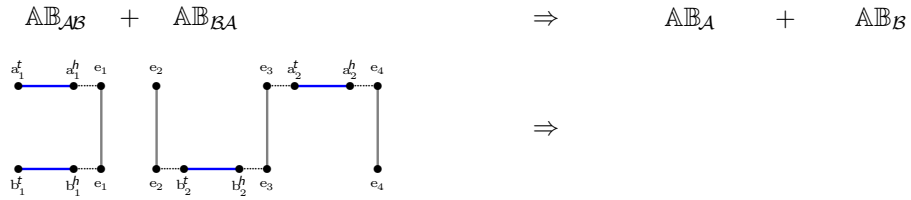
1. Example: $\Delta^{\lambda}_{\text{DCJ}} = -1$



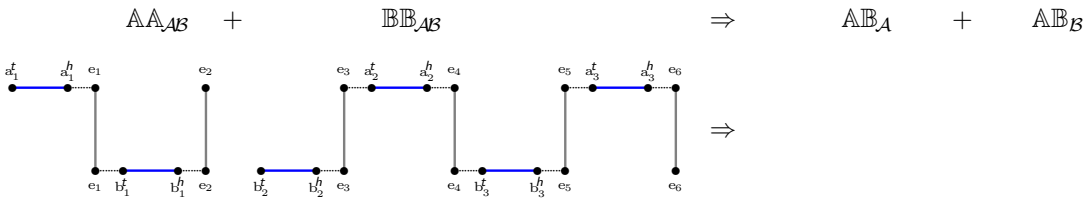
2. $\Delta^{\lambda}_{\text{DCJ}} = -1$



3. $\Delta^{\lambda}_{\text{DCJ}} = -1$

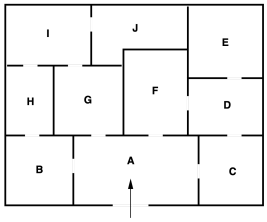


4. $\Delta^{\lambda}_{\text{DCJ}} = -2$



Exercise 3 (ILP formulation) (4 pts)

Example of a possible museum layout:



Formulate an ILP to find the minimum number of guards for taking care of a museum:

- Each guard stands at a door between rooms, taking care of two rooms at once.
- Each room must be taken care by at least one guard.