The Floor is Lava: Halving Natural Genomes with Viaducts, Piers and Pontoons

RECOMB-CG 2023

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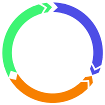
Bielefeld University

April, 2023

The Genome Halving Problem



Natural

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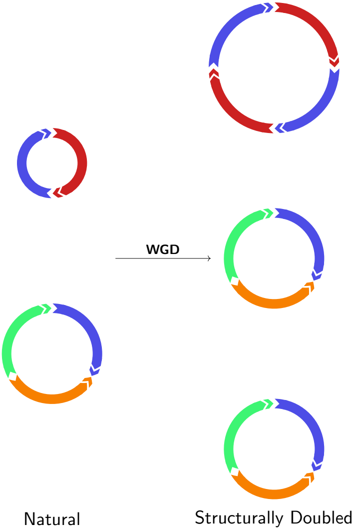

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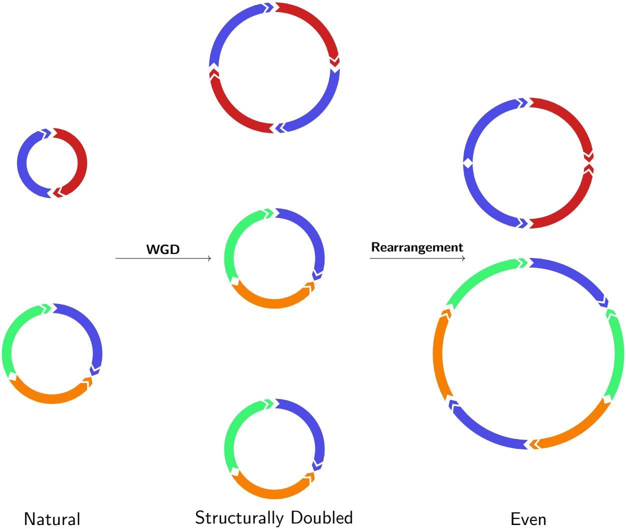

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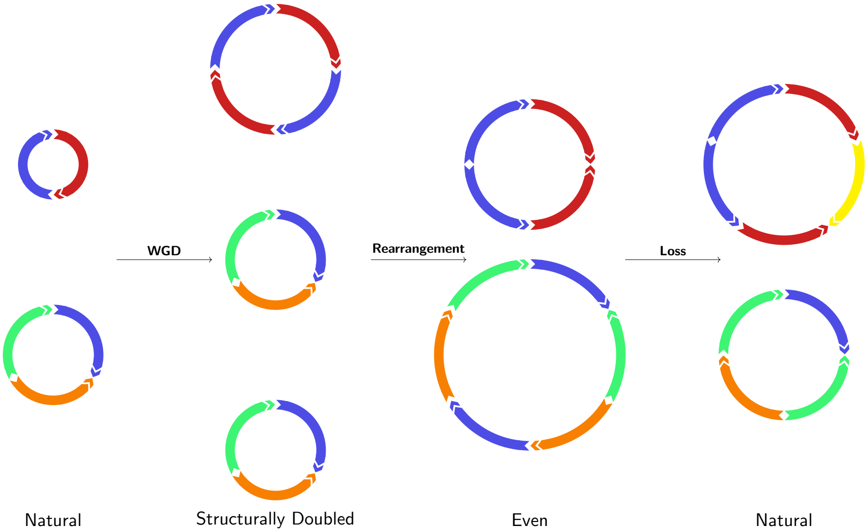

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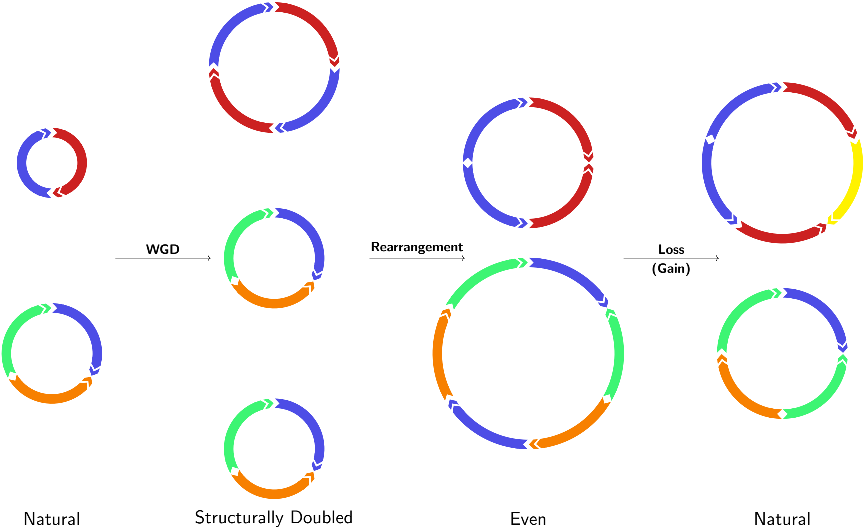

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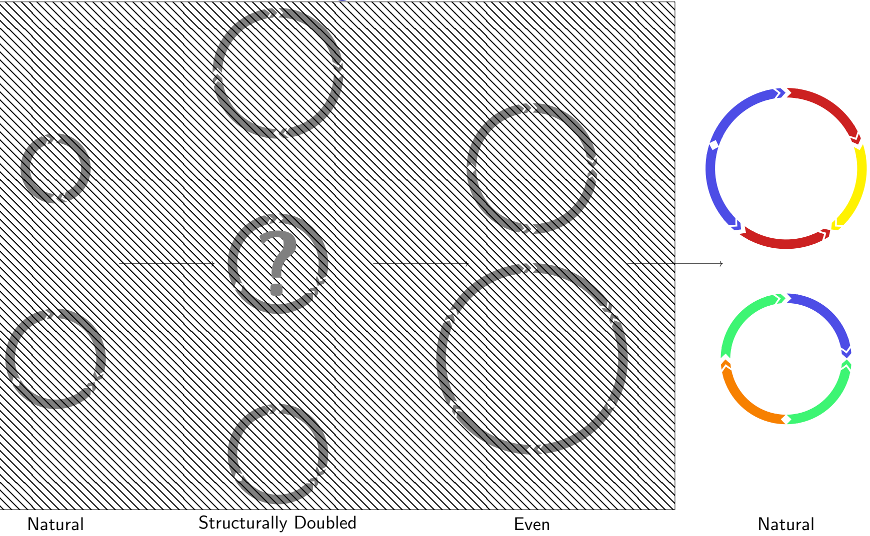

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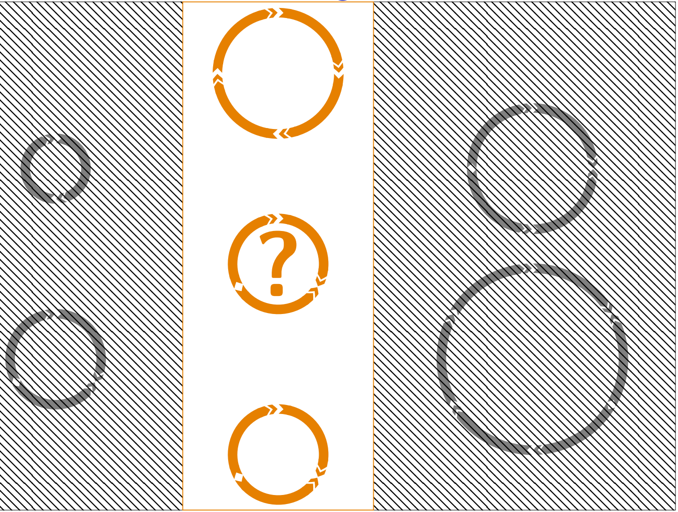
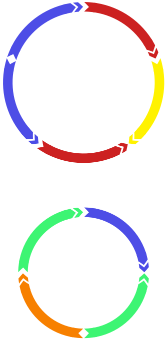


Structurally Doubled



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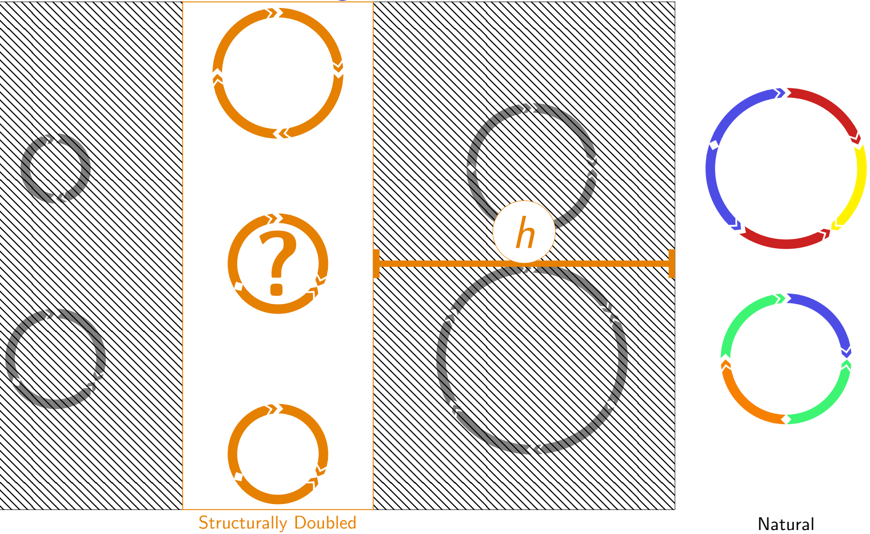
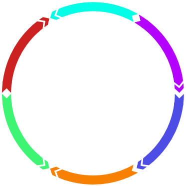


Operations: Double-Cut-And-Join



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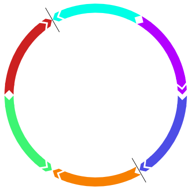

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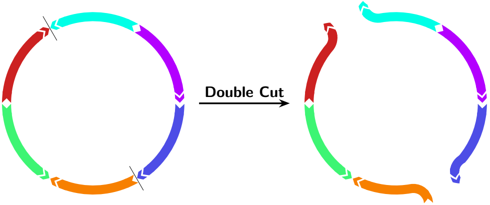

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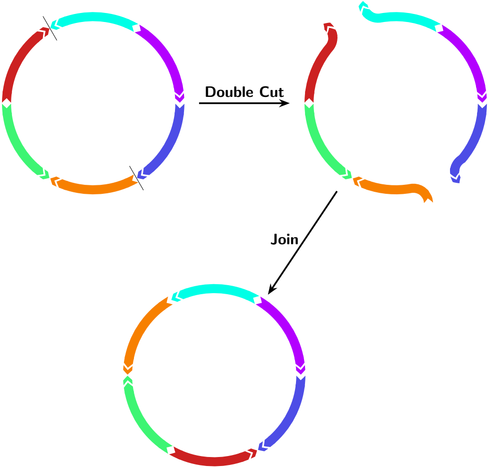

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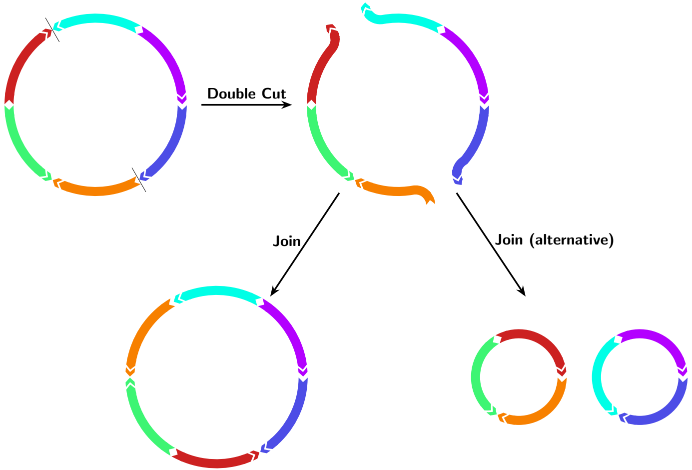
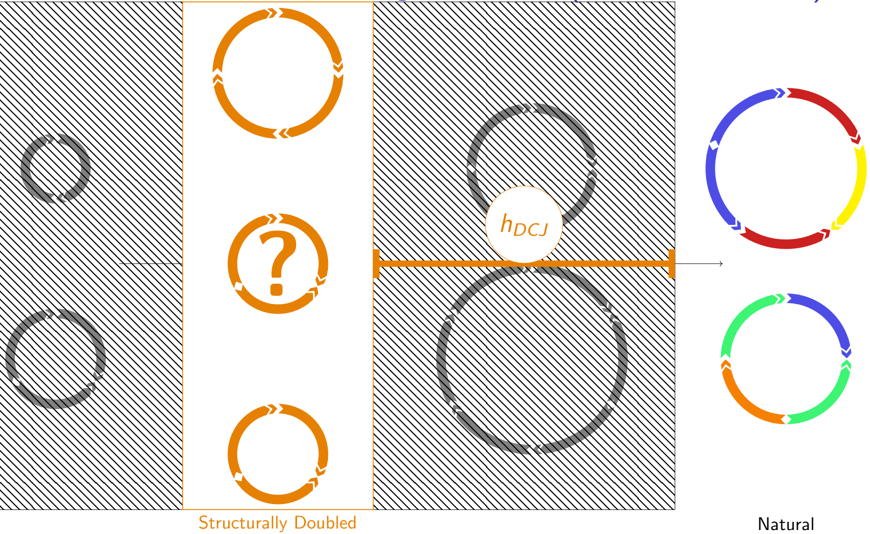


The Classic DCJ Halving Problem (Mixtacki, 2008)



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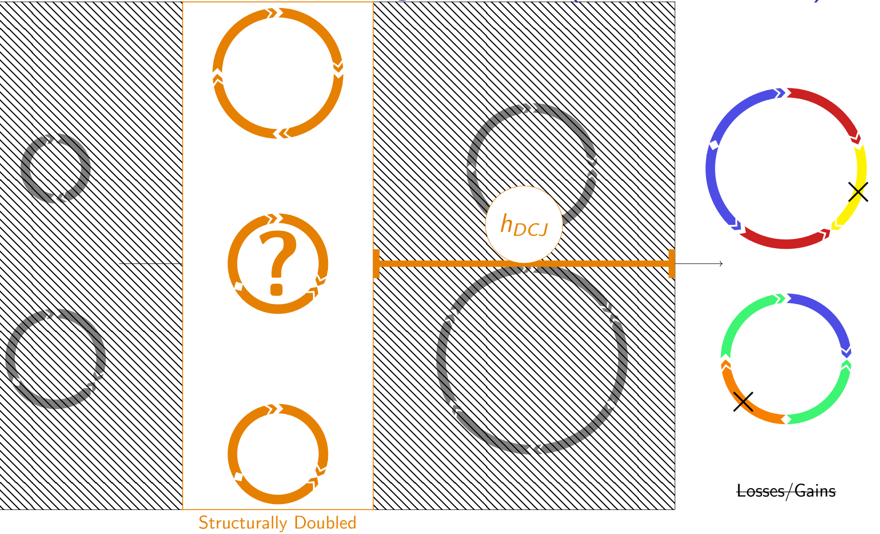

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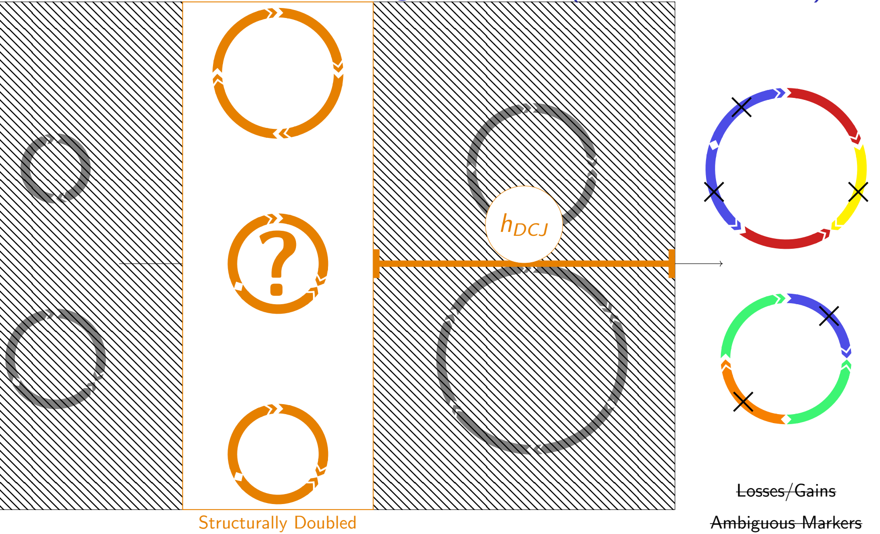

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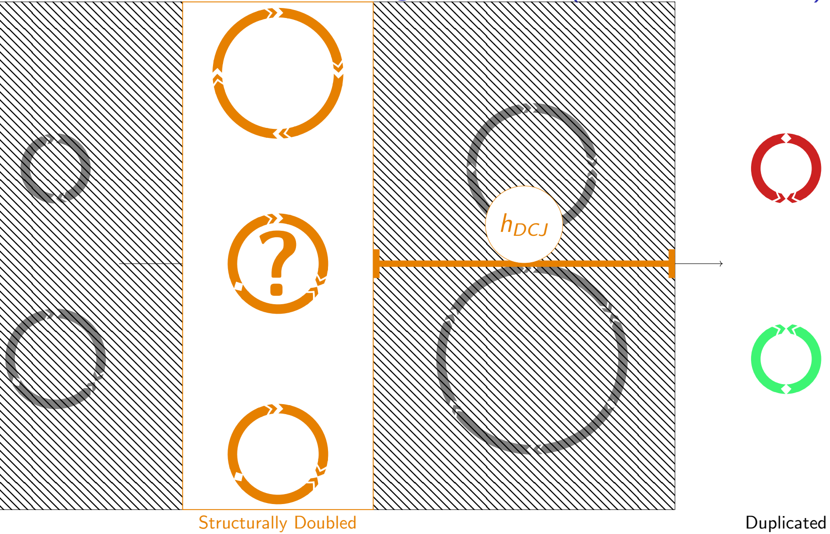

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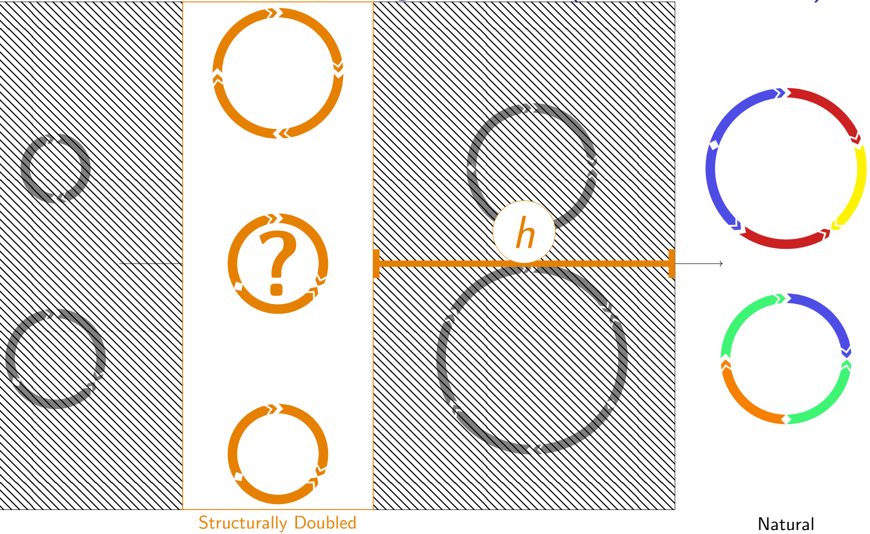

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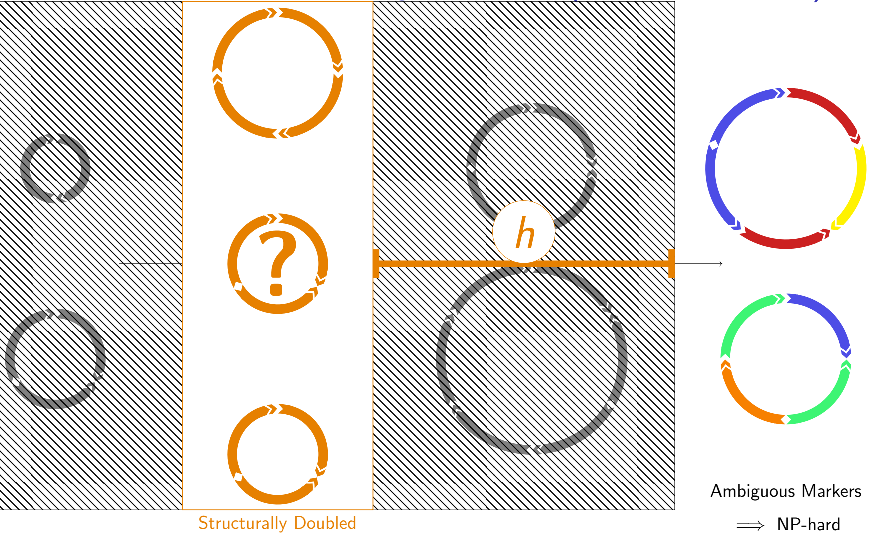

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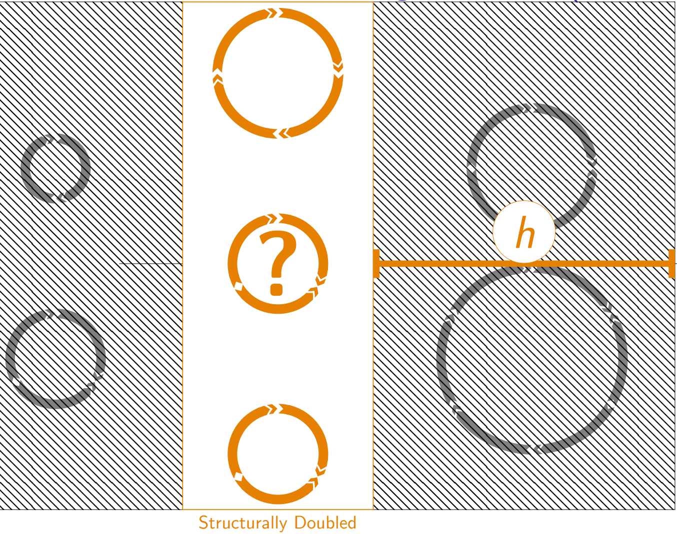
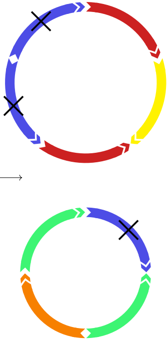
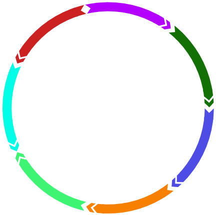




This talk:
~~Ambiguous Markers~~

Insertions and Deletions



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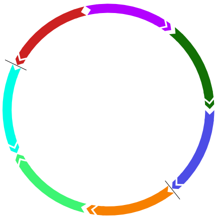

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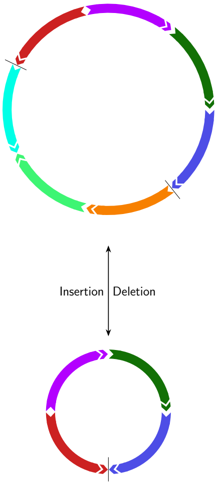
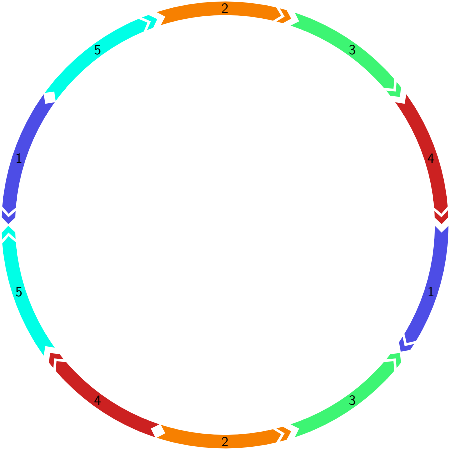


Supernatural Graph



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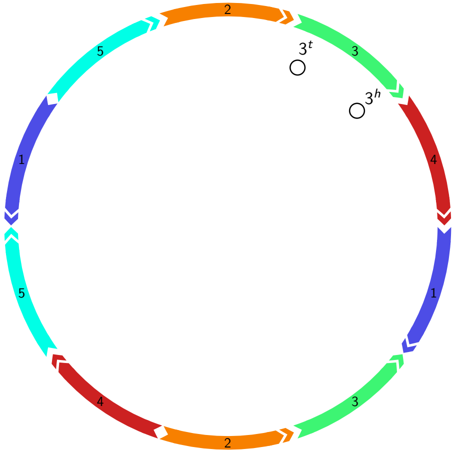

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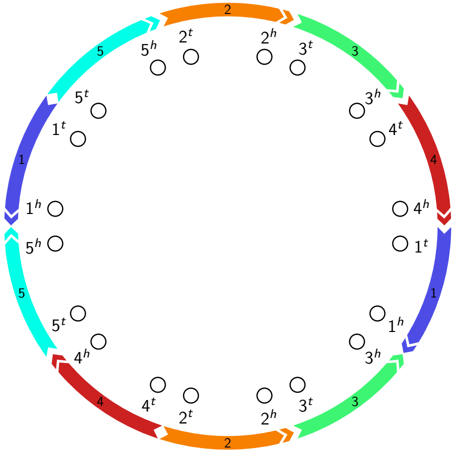

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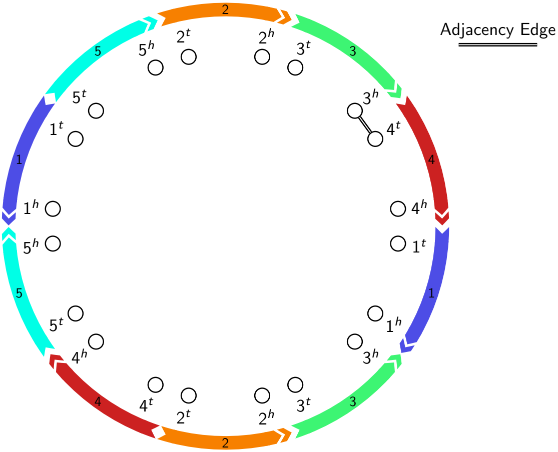

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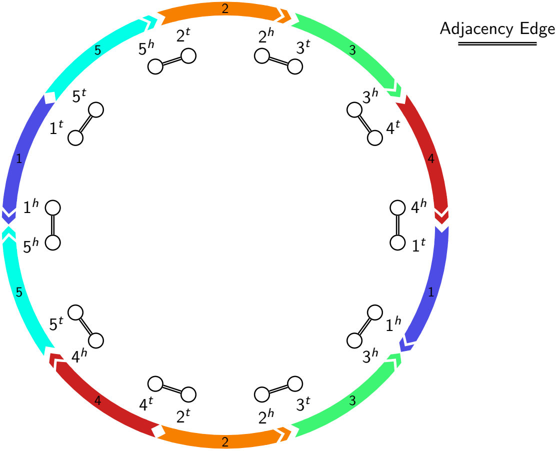

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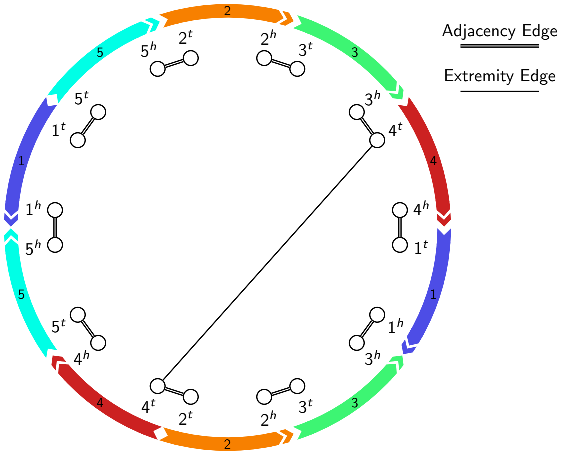

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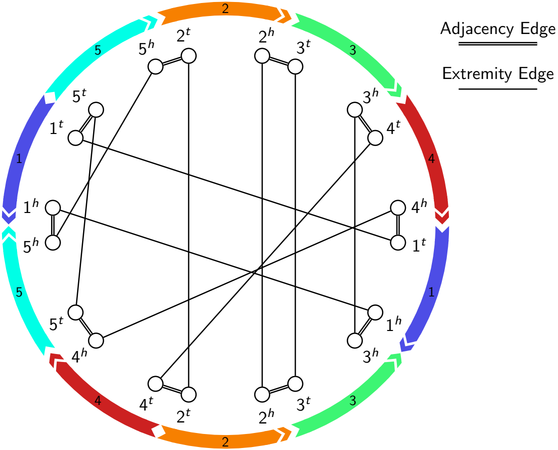
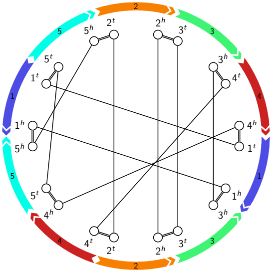
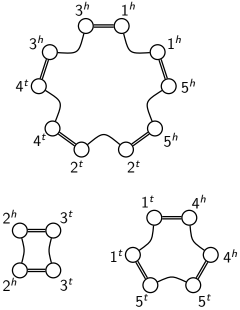
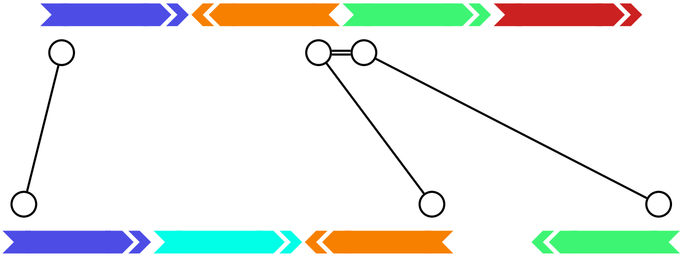


Supernatural Graph: Cycles





Supernatural Graph: Paths



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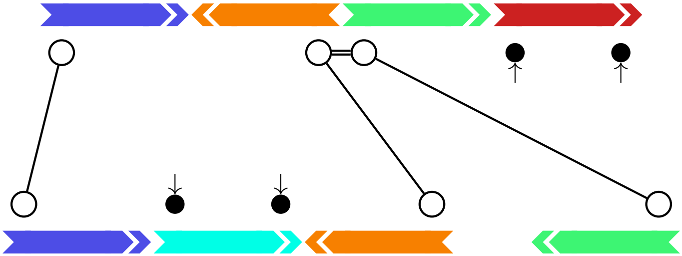
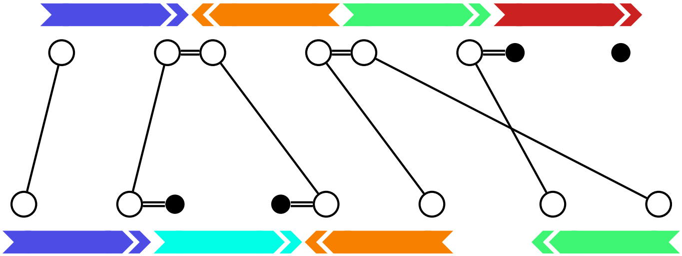
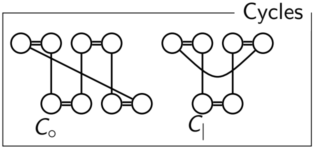


Lava vertices

Supernatural Graph: Paths



Supernatural Graph: All Components



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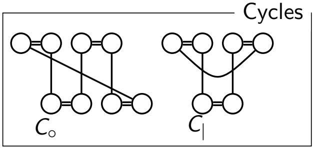

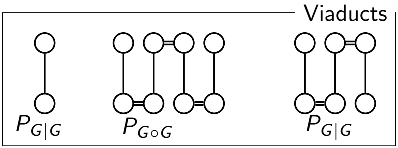

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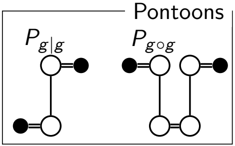

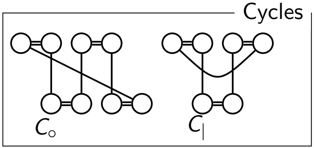

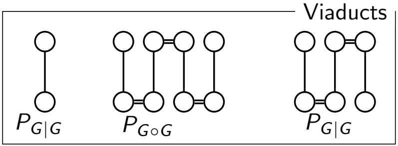

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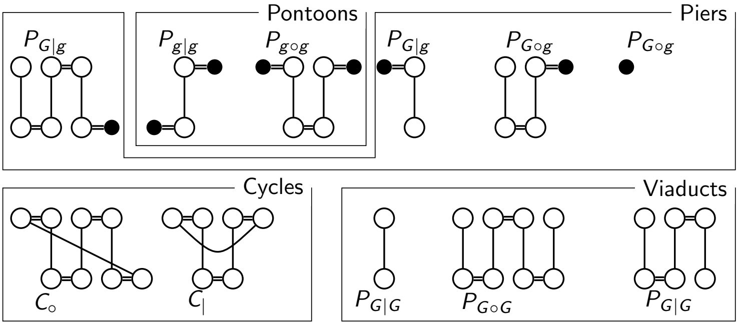

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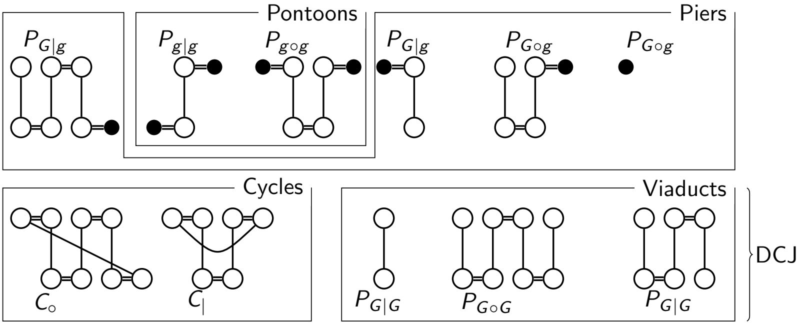

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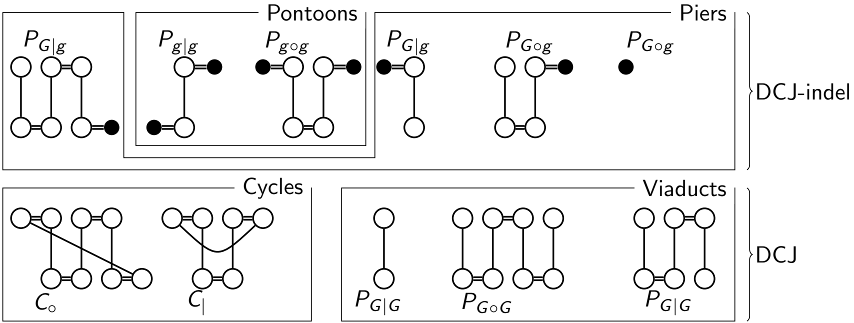
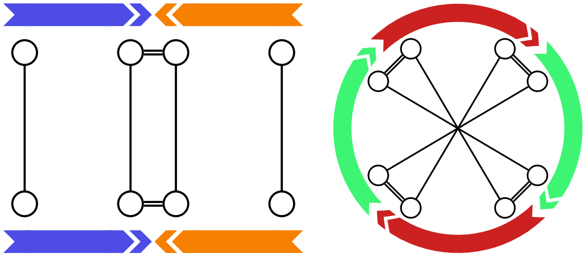


DCJ halving (Mixtacki 2008)

SNG for Structurally Doubled genomes



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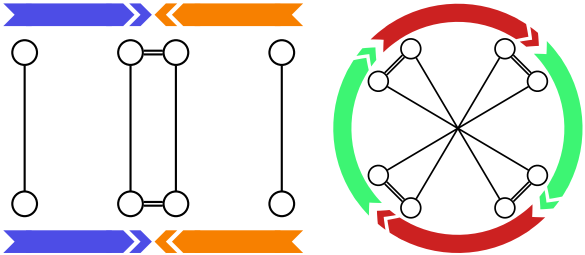
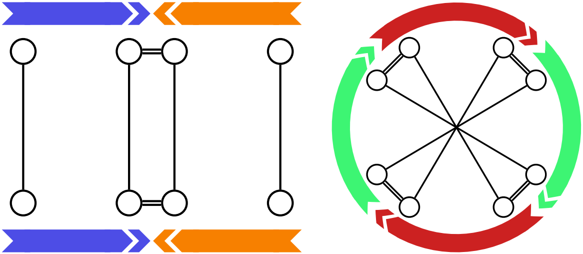


Only 2-cycles and 1-viaducts!

DCJ halving formula (Mixtacki 2008)



$$h_{DCJ}(\mathbb{G}) = n - c_{\circ} - \left\lfloor \frac{p_{G|G}}{2} \right\rfloor$$

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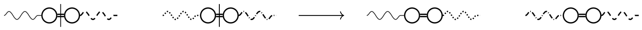

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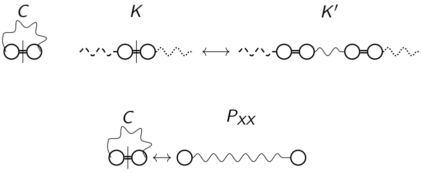

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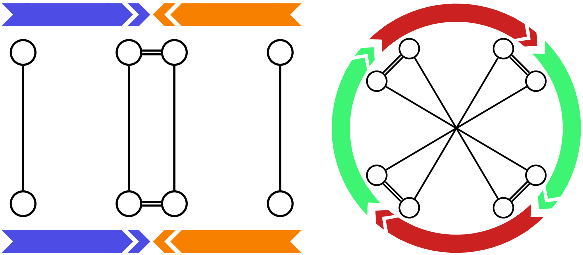
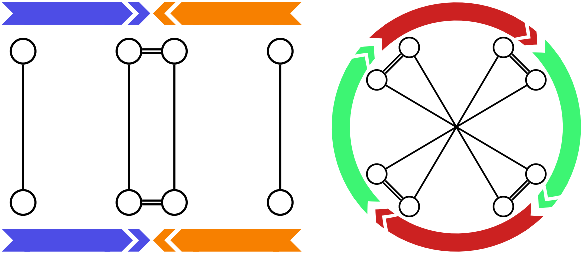
DCJ-indel halving formula



$$h^{id}_{DCJ}(\mathbb{G}) \geq n - c_\circ + \left\lceil \frac{p_{g|g} + \max(p_{G|g}, p_{G\circ g}) - p_{G|G}}{2} \right\rceil$$

DCJ-indel halving formula



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$$\overset{\mathbb{G}\ \text{SD}}{=} n - c_\circ - \left\lfloor \frac{p_{G|G}}{2} \right\rfloor$$

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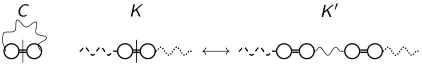

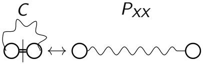

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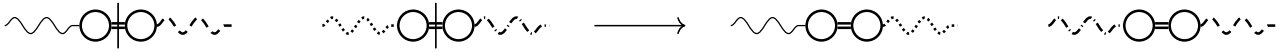

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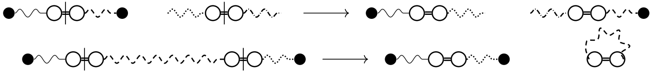

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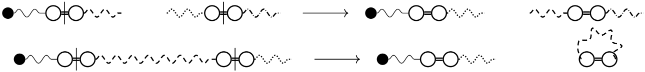

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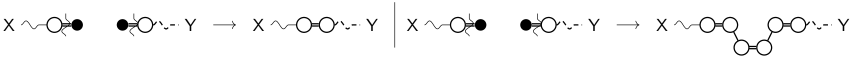

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DCJ-indel halving formula

$$h_{DCJ}^{id}(\mathbb{G}) = n - c_\circ + \left\lceil \frac{p_{g|g} + \max(p_{G|g}, p_{G\circ g}) - p_{G|G} + \delta}{2} \right\rceil$$

Conclusion and Future Work

- DCJ-indel halving can be solved in linear time without ambiguous markers.

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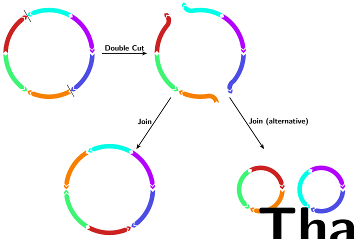
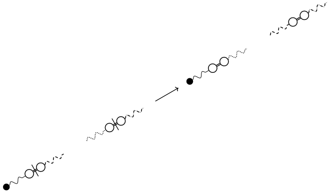
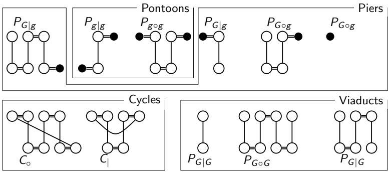
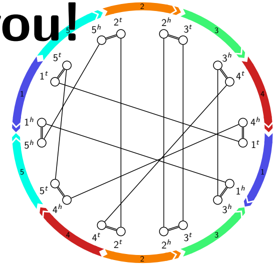
- Under other conditions it can be NP-hard.
- The view on the DCJ-indel model described here links the Braga-Willing-Stoye and Compeau conceptualizations!


Double Cut
Join
Join (alternative)



Thank you!


Pontoons
Piers
Cycles
Viaducts
$P_{G|g}$
$P_{g|g}$
$P_{g\circ g}$
$P_{G\circ g}$
$C_\circ$
$C_|$
$P_{G|G}$
$P_{G\circ G}$


1^t 1^h 2^t 2^h 3^t 3^h 4^t 4^h 5^t 5^h