Maximizing future gain

Exploiting variance of descendants for optimized selection decisions

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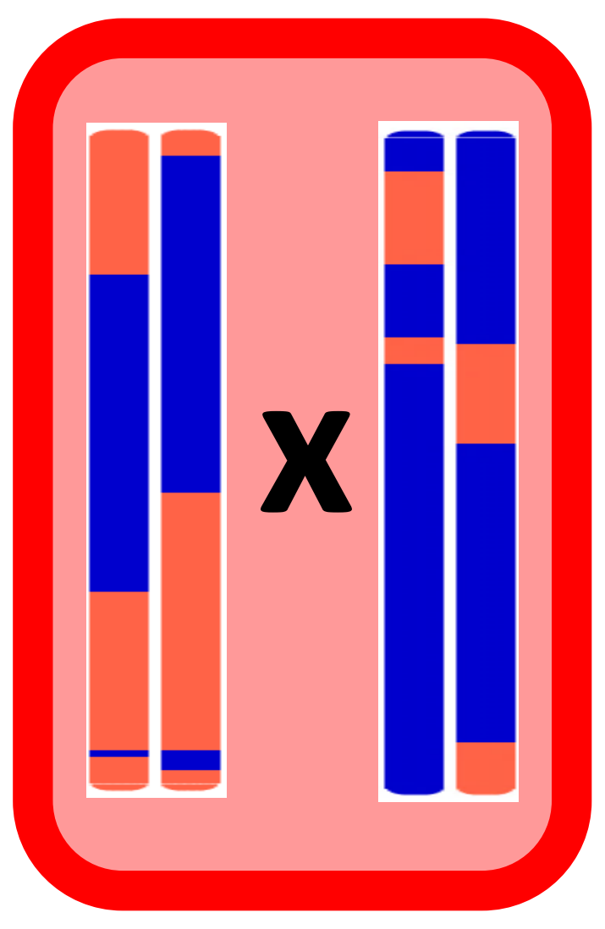
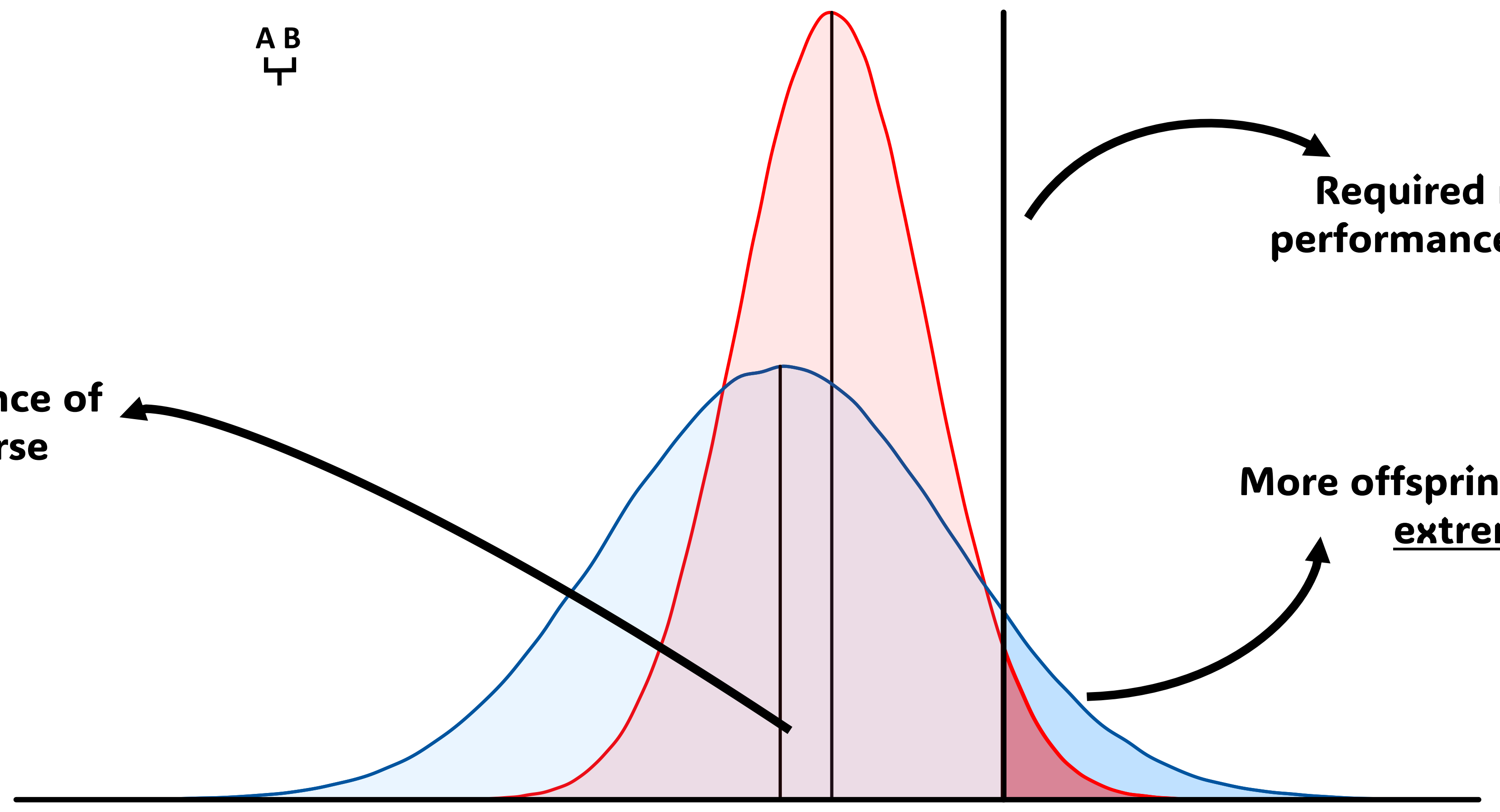
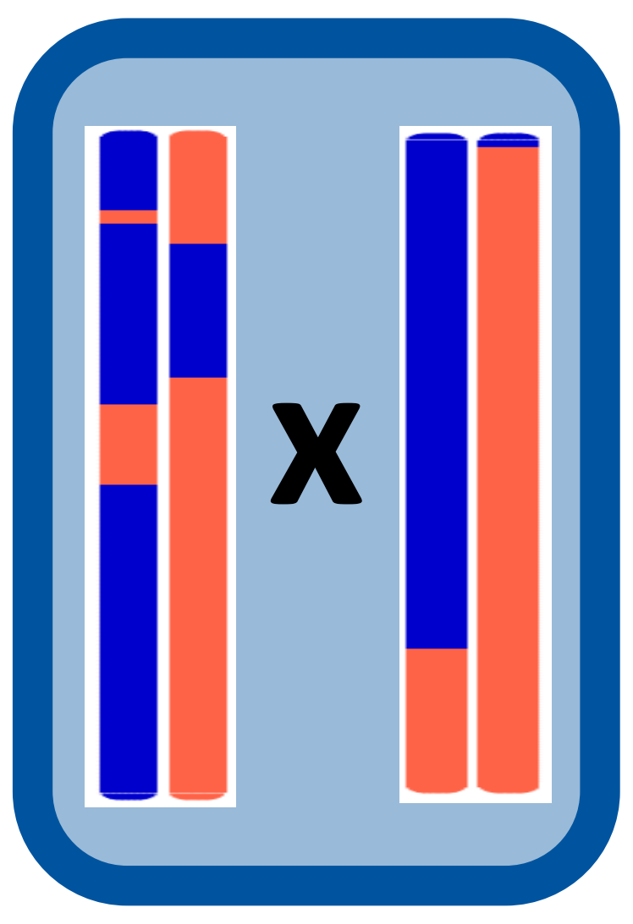
Looking 1 generation ahead

Generate 100 offspring of red or blue cross. Which cross do you chose?







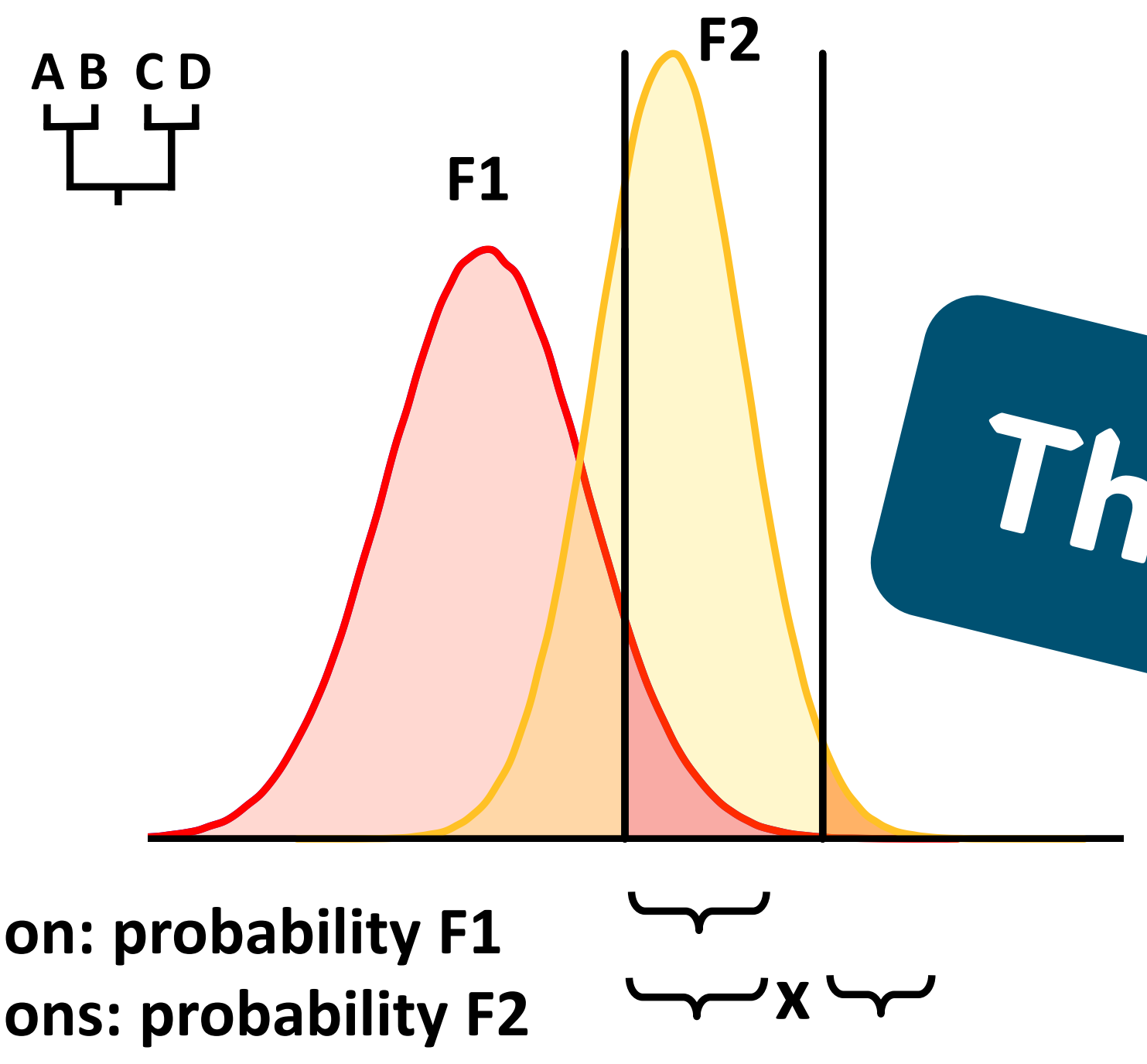
Required minimum performance for variety

Average performance of blue cross is worse

More offspring of blue cross are extremely good

This problem is addressed by the Usefulness criterion (Schnell & Utz, 1975)

Looking 2 generations ahead

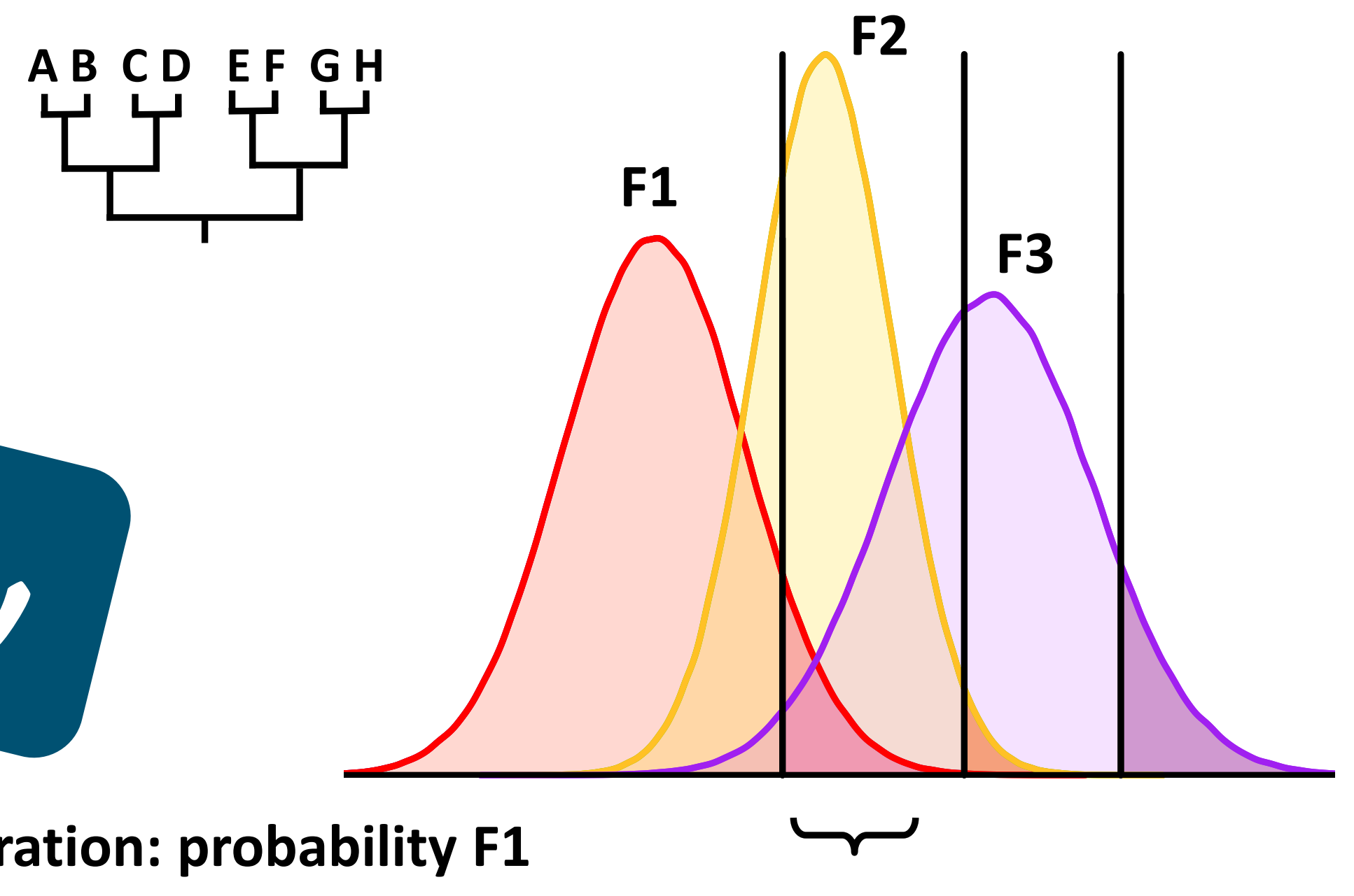


1 generation: probability F1
2 generations: probability F2

$\text{Prob}_{F2} = \text{Prob}_{F1} \times \text{Prob}(F2|\text{selected } F1)$

This is new

Looking 3 generations ahead

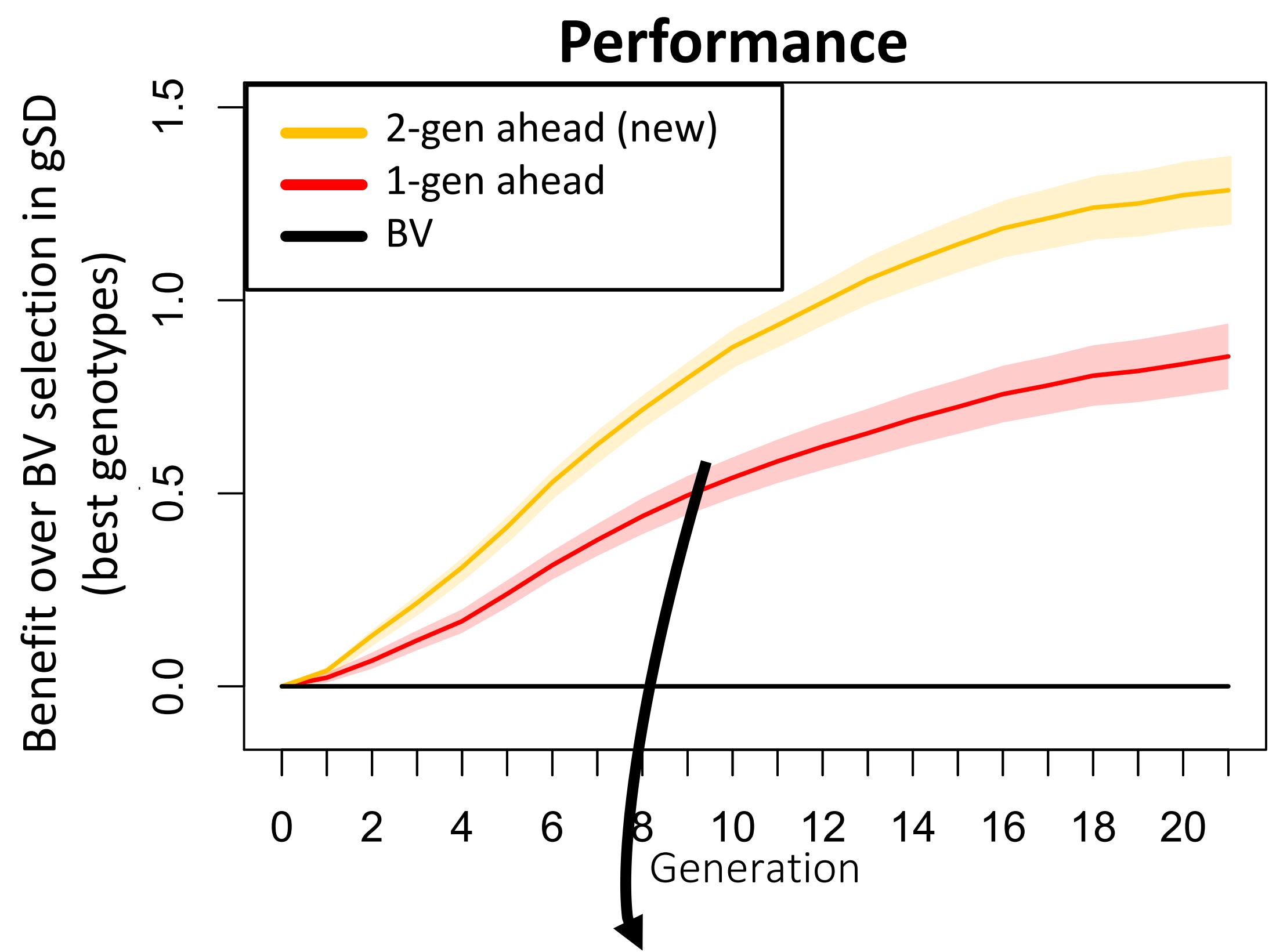


1 generation: probability F1
2 generations: probability F2
3 generations: probability F3

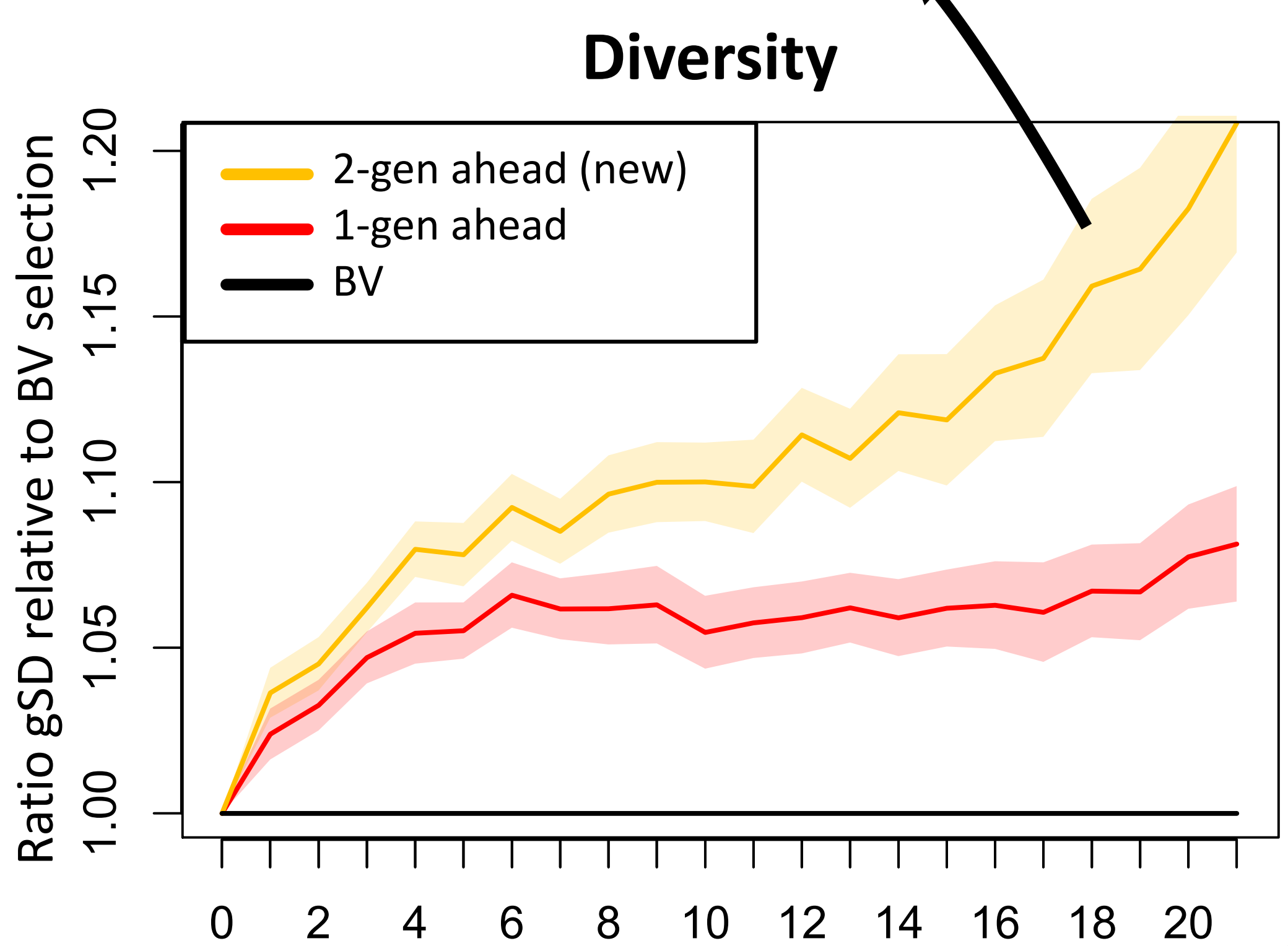
$\text{Prob}_{F3} = \text{Prob}_{F1} \times \text{Prob}_{F2} \times \text{Prob}(F3|\text{selected } F2)$

...extendable to any generation

Selection experiment (simulated)

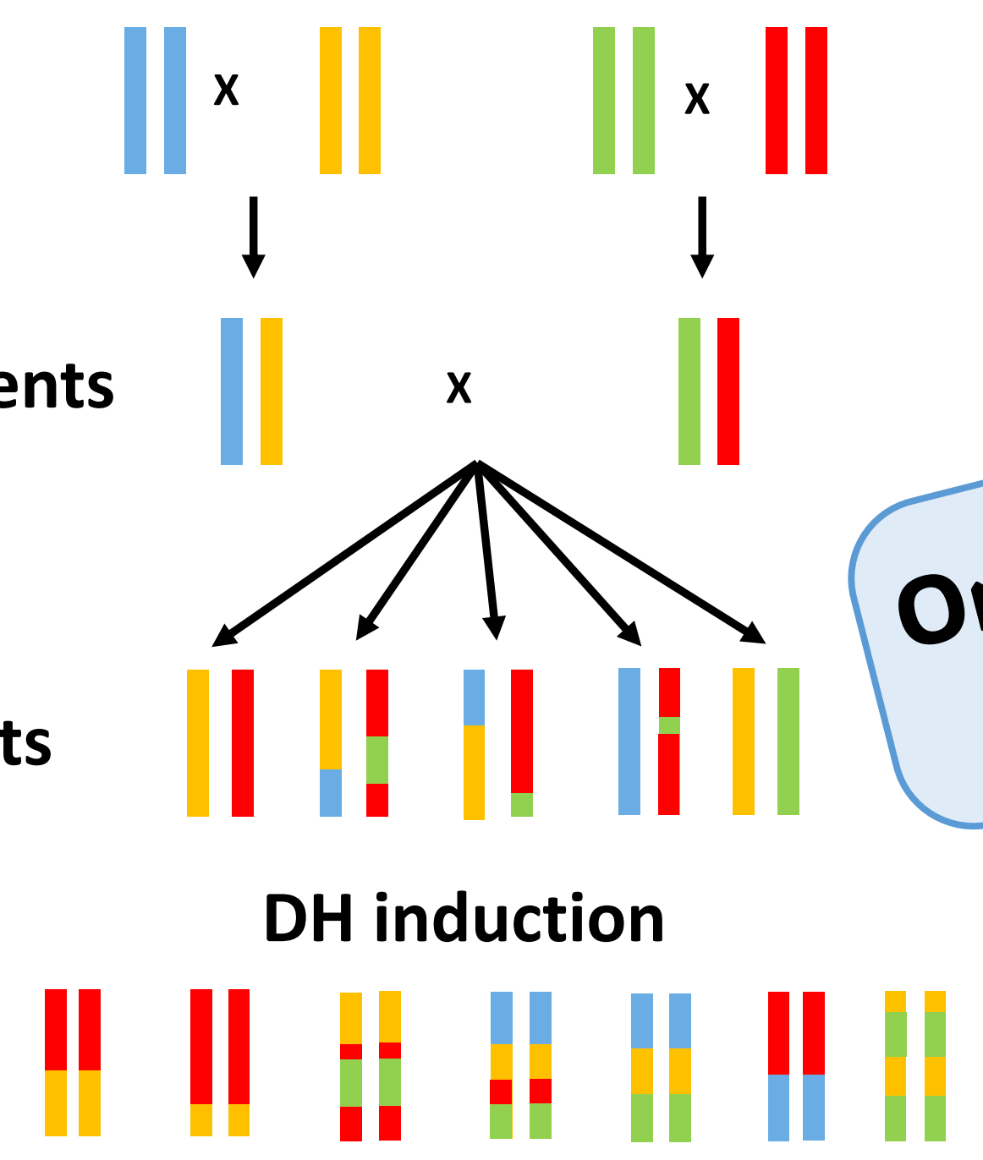


More gain + more variation



Works for all diploid species

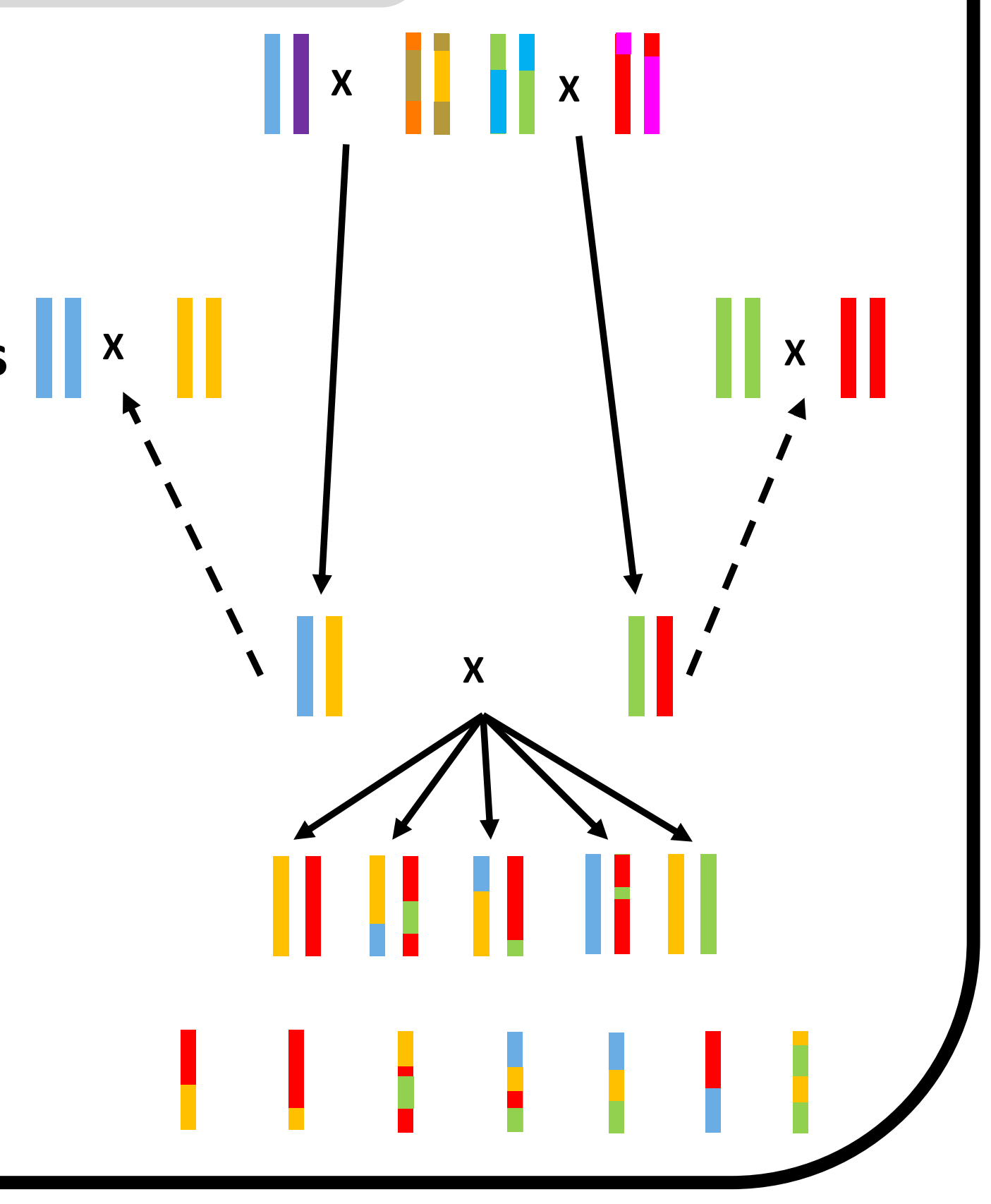
Line breeding
e.g. barley



4 inbred lines
2 2-way F1 parents
4-way F1 parents
DH induction
DH population

Only different in ploidy!

Outcross species
e.g. animals, apples



True grandparents
Pseudo grandparents
True parents
Fullsibs
Gametes of fullsibs

Prediction of progeny variances

n: number loci c: recombination frequency α: average effect j, l: locus j, locus l D: LD in haplotypes m: number of meiosis that reduce D of parents N: number haplotypes (2,4,8,16,...) i, k: haplotype i, haplotype k

- 2-way cross: Lehermeier et al. (2017), Osthushenrich et al. (2017)

$$V_{DH_{2-way}} = \sum_{j=1}^{n}\sum_{l=1}^{n} 4(1-2c_{jl})D_{jl}^{AB} * \alpha_j\alpha_l$$

- 4-way cross: Allier et al. (2019)

$$V_{DH_{4-way}} = \sum_{j=1}^{n}\sum_{l=1}^{n}\left((1-2c_{jl})^2\left(D_{jl}^{AB}+D_{jl}^{CD}\right)+(1-2c_{jl})\left(D_{jl}^{AC}+D_{jl}^{AD}+D_{jl}^{BC}+D_{jl}^{BD}\right)\right) * \alpha_j\alpha_l$$

- N-way cross: Niehoff et al. (new)

$$V_{DH_{N-way}} = \left(\frac{4}{N}\right)^2 \sum_{i=1}^{N}\sum_{k>i}^{N}\sum_{j=1}^{n}\sum_{l=1}^{n}(1-2c_{jl})^{m_{ik}} D_{jl}^{ik} * \alpha_j\alpha_l$$

DH variance can be partitioned into gametic Mendelian sampling variance of ancestors.
→ This gametic MSV can be used to derive variance of non-inbred offspring
→ Extension of Usefulness criterion (Schnell & Utz, 1975) to any generation

$$\sigma^2_{\text{gamMS 4-way F1}} = (\sigma^2_{\text{4-way DH}} - \sigma^2_{\text{4-way F1}}) * 0.25$$

Required input:

- ◆ Genetic map
- ◆ Phased genotypes
- ◆ Estimates of marker effects (e.g., rrBLUP)

Schnell, F. W., & **Utz**, H. F. (1975) F1-Leistung und Elternwahl in der Züchtung von Selbstbefruchtern, pp. 234-258 in Bericht über die Arbeitstagung 1975 der Arbeitsgemeinschaft der Saatzuchtleiter in Gumpenstein
Osthushenrich, T., Frisch, M., & Herzog, E. (2017). Genomic selection of crossing partners on basis of the expected mean and variance of their derived lines, PLOS ONE
Lehermeier, C., Teyssedre, S., & Schön, C. C. (2017). Genetic Gain Increases by Applying the Usefulness Criterion with Improved Variance Prediction in Selection of Crosses. Genetics
Allier, A., Moreau, L., Charcosset, A., Teyssedre, S., & Lehermeier, C. (2019). Usefulness Criterion and Post-selection Parental Contributions in Multi-parental Crosses: Application to Polygenic Trait Introgression. G3

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This work is part of the Breed4Food project and financially supported by:
Ministerie van Economische Zaken
Topigs Norsvin