The effects of plant genome instability on breeding

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Credits

- Mitotic recombination in potato

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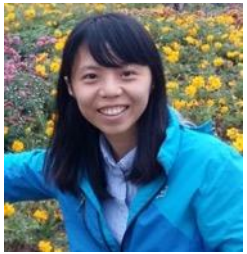

Isabelle Henry

Michelle Fossi

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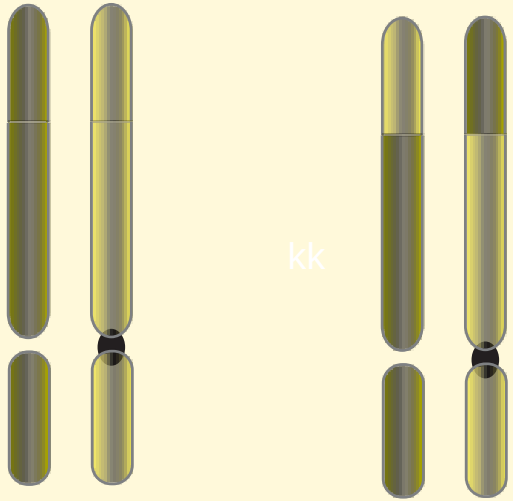
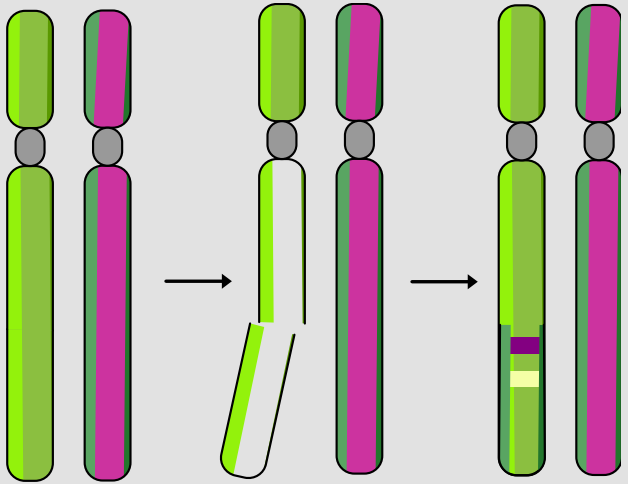
Desirable mitotic recombination events

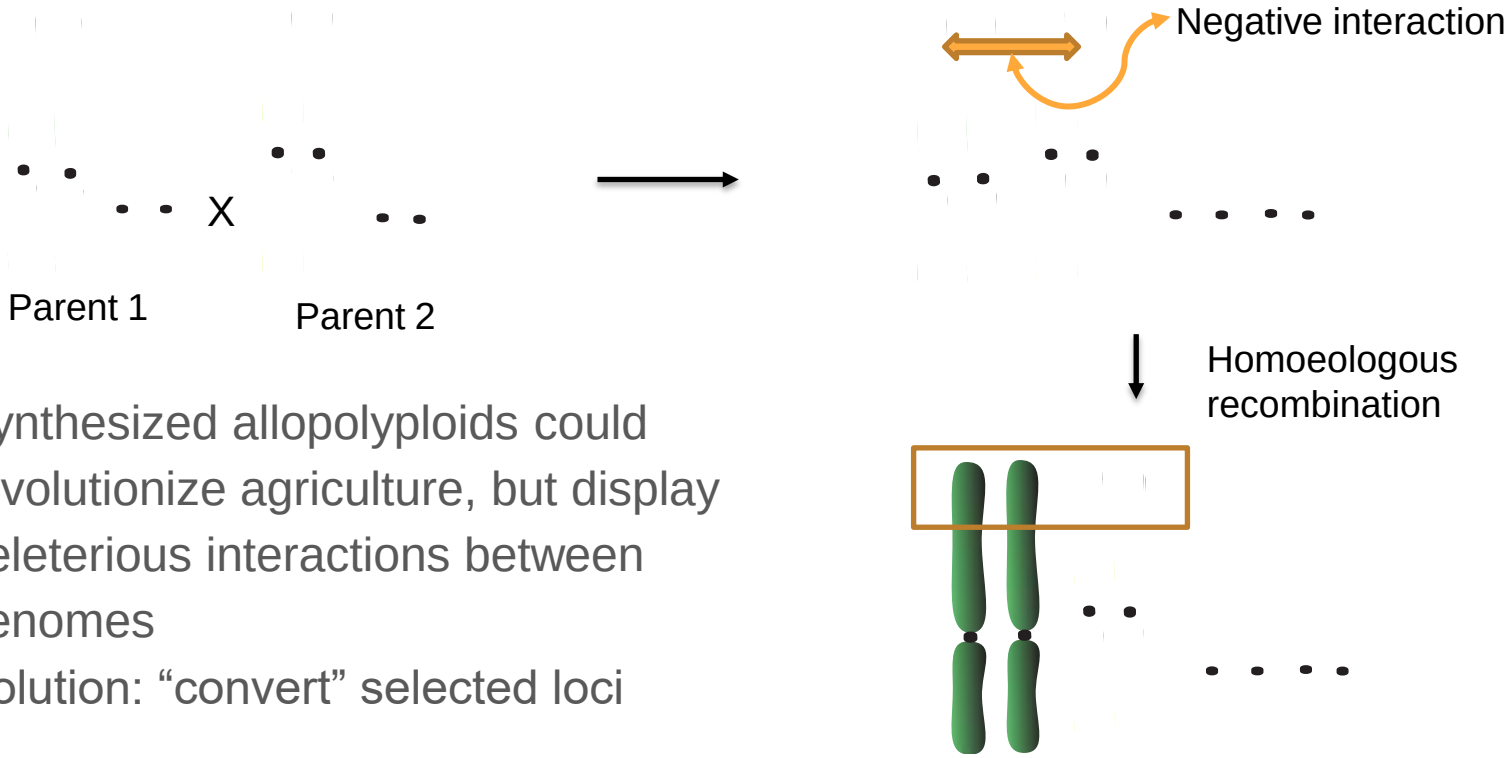


Homologous translocation
(mimics meiotic recombination)



Large-scale conversion

Example of utility: homoeologous recombination



- Synthesized allopolyploids could revolutionize agriculture, but display deleterious interactions between genomes
- Solution: “convert” selected loci

Potato (*Solanum tuberosum*)

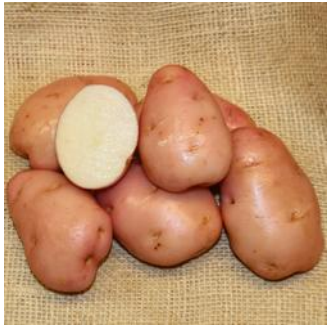
Bred sexually, propagated clonally

Clonal variants (sports) common (10^{-4})

Autotetraploid and diploid

Outbreeding and heterozygous

Haploid inducers available



Early Rose

Sexual breeding

1867 - Selfing or unknown cross-pollinator

Burbank (no russeting)

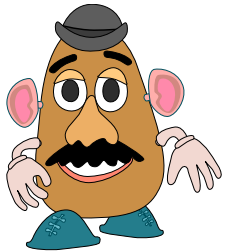
Clonal breeding

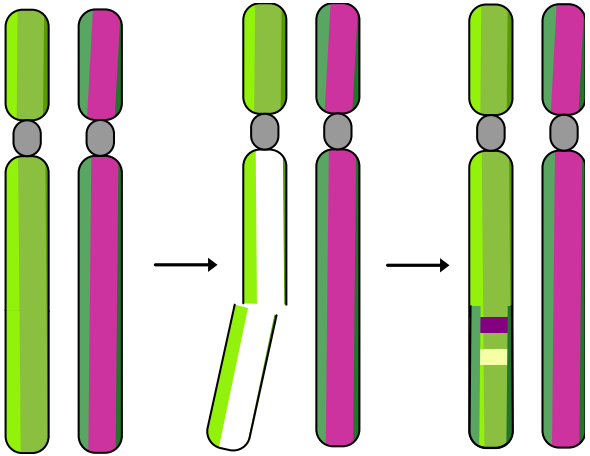
1876 - Clonal variant in garden

Russet Burbank

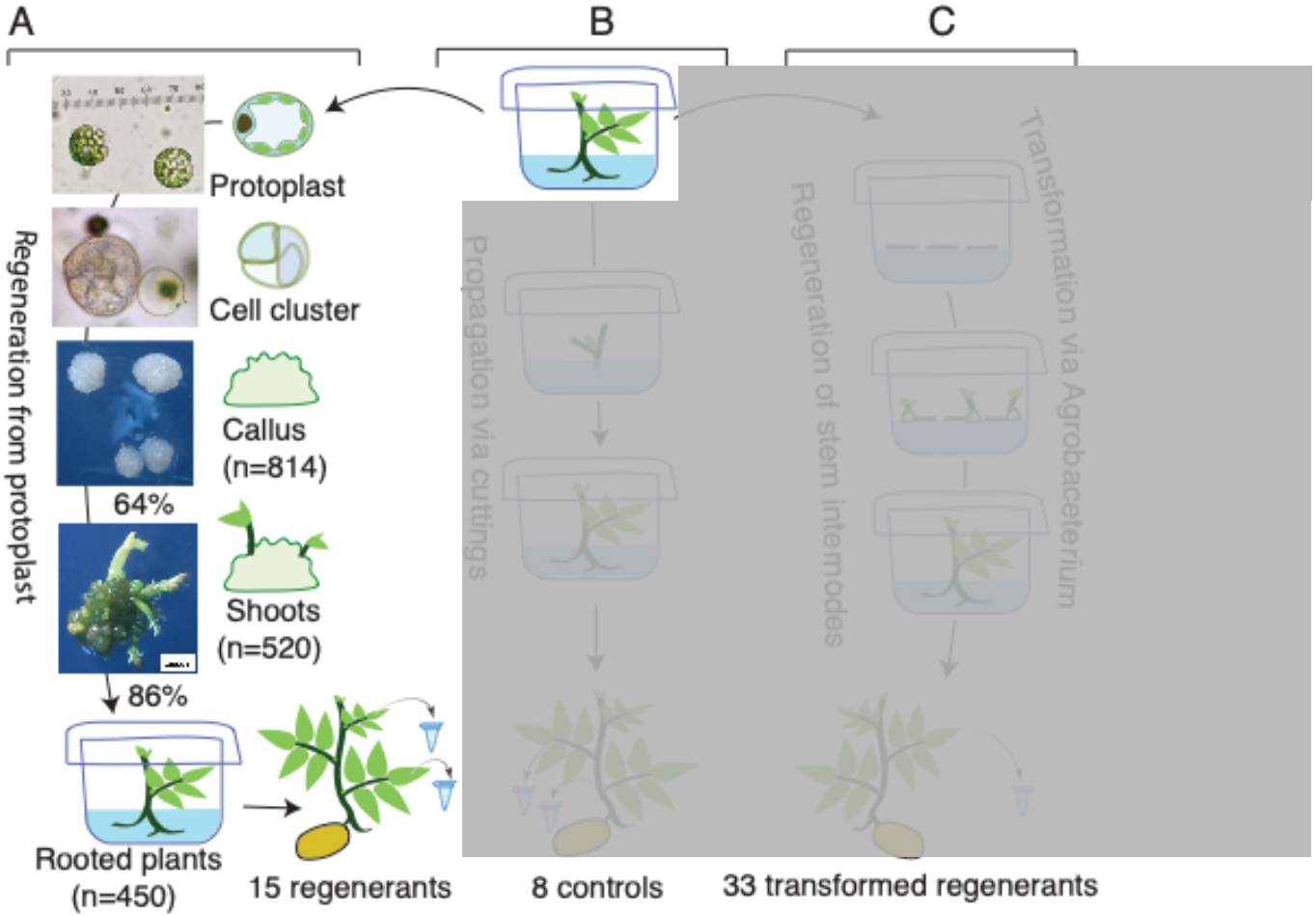
Large scale chromosome conversion in potato

- Selective instability of chr.8 in Desiree
- Consistent with fragile site
- Homologous Recombination → chromosome conversion (BIR?)



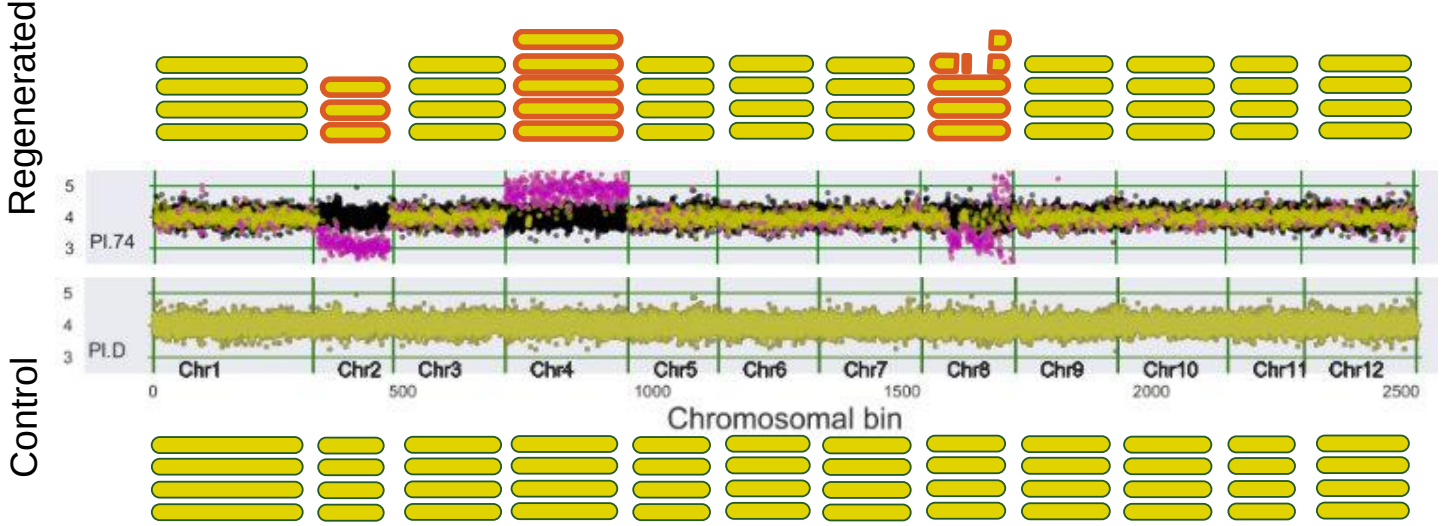


Potato genome display instability during regeneration



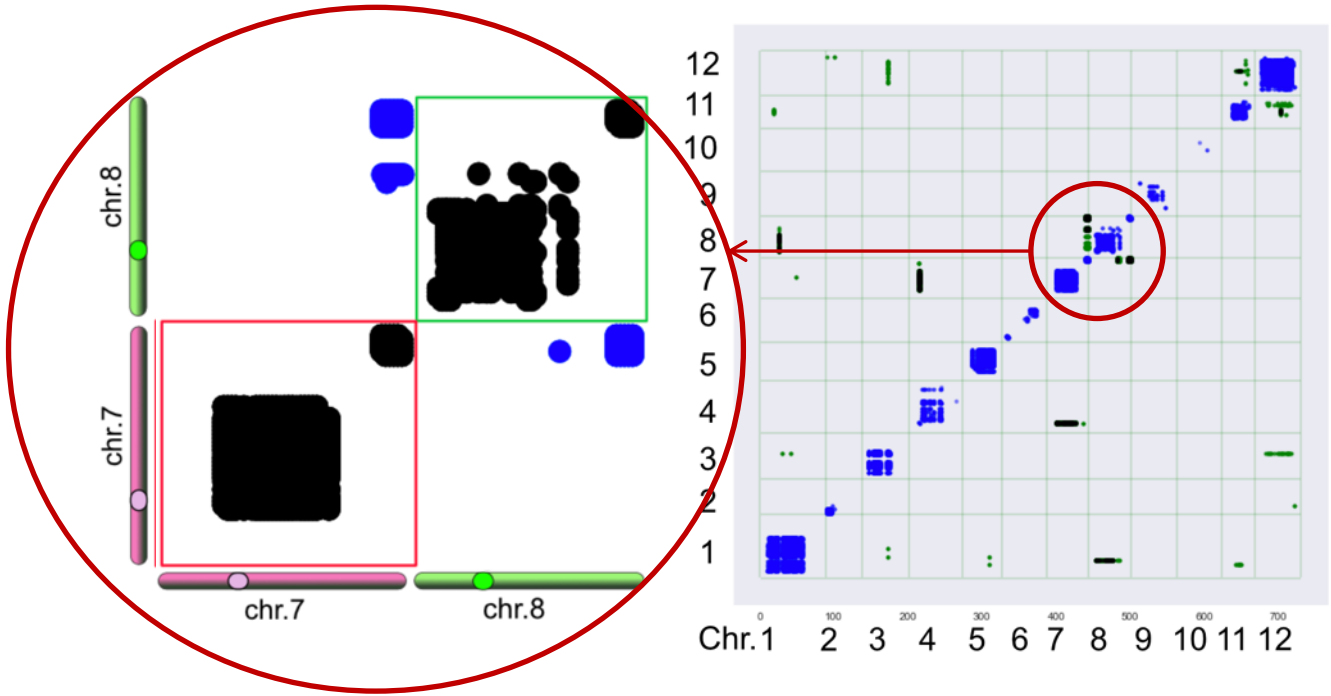
Fossi, Pl.Phys. 19

During regeneration from protoplasts, chromosomes can missegregate and break resulting in large indel and other aberrations



Fossi, Pl.Phys. 2019

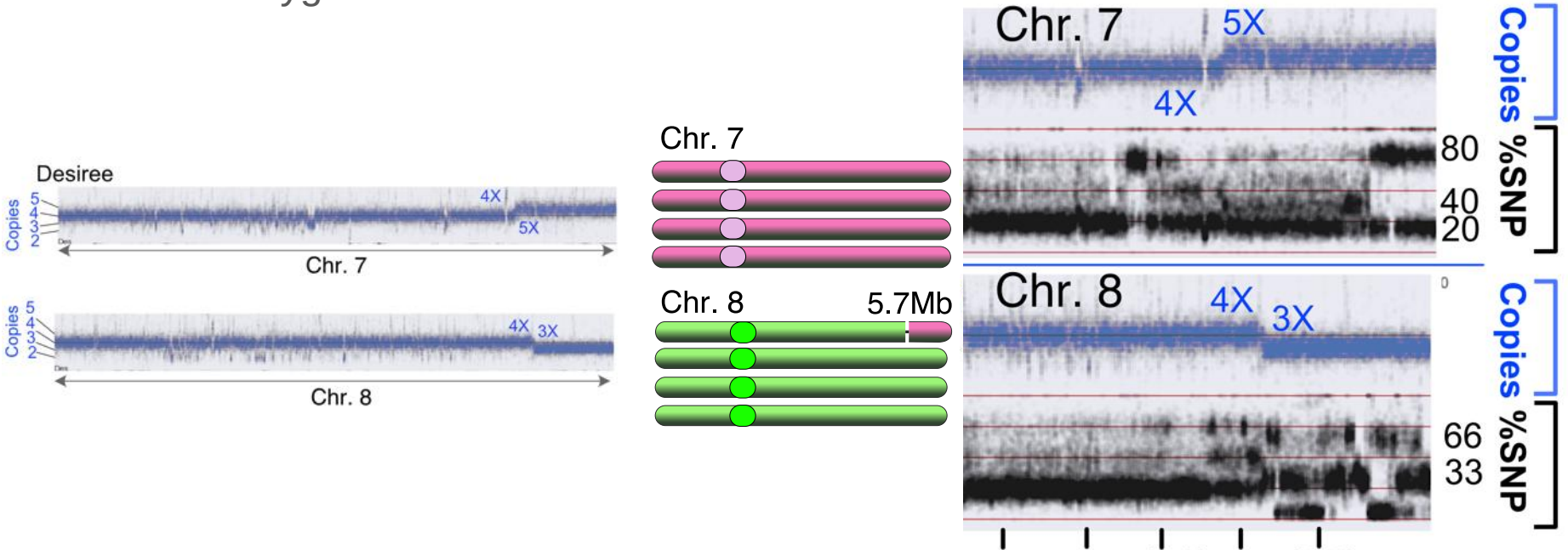
Var. Desiree: right tip of 7 is linked to the right tip of 8



- Evidence: Linkage Disequilibrium between chr.7 and chr.8

DNA sequencing evidence for Tr8-7 translocation model

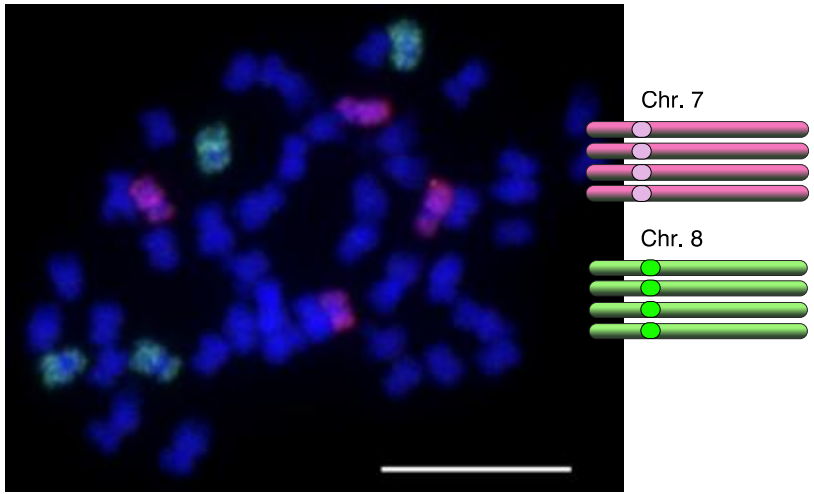
- DNA dosage -> **5 copies** of chr 7 tip, **3 copies** of 8 tip
- Heterozygous SNP ratio confirms it



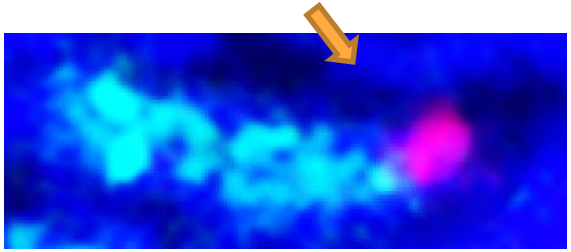
Chromosome painting

- Jiang lab (MSU) painted 7 and 8

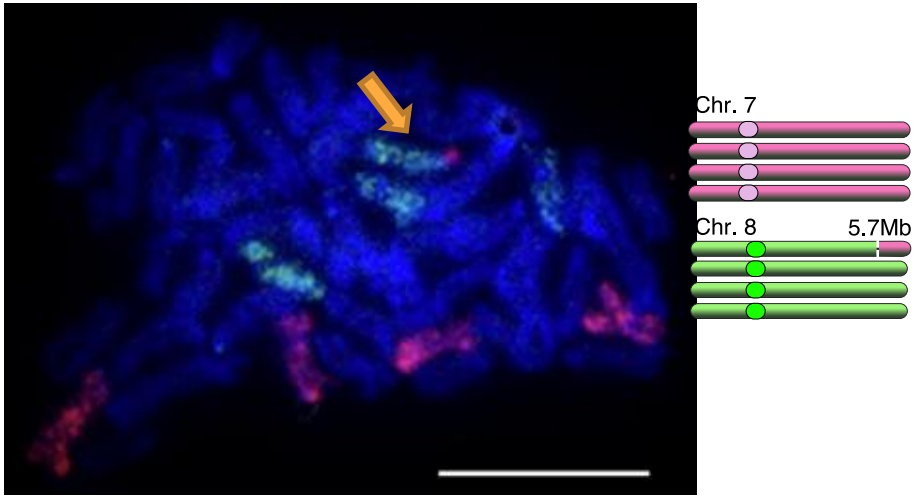
Normal karyotype



- Translocation evident

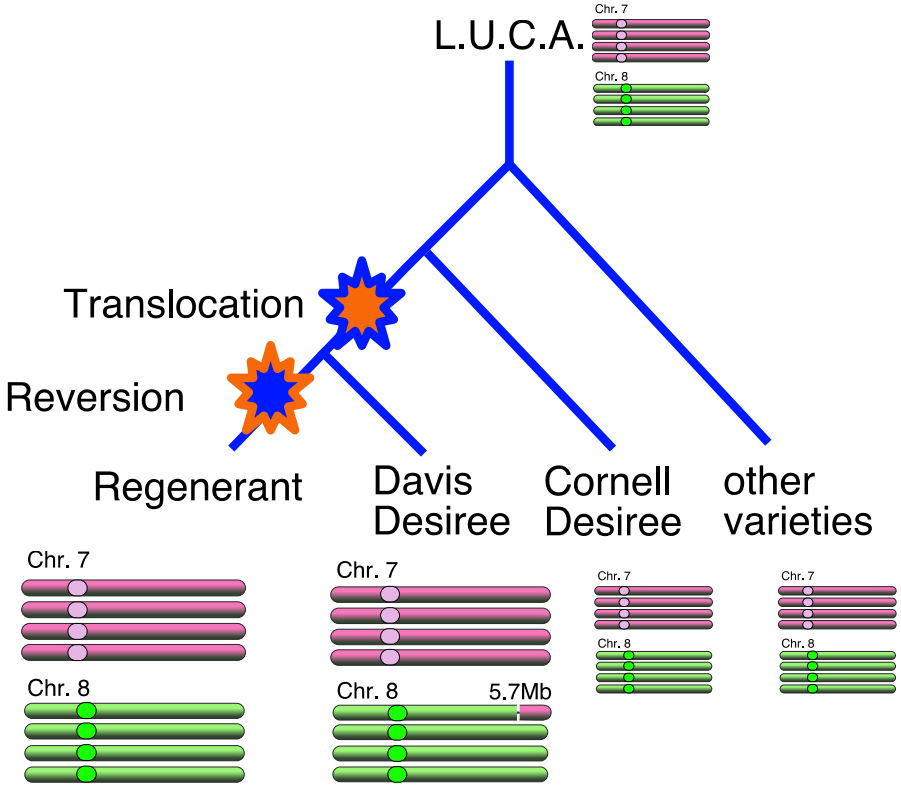


Desiree



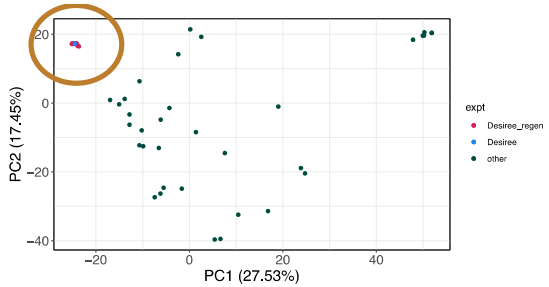
Cytology: X. Zhang, Painting: G.T. Braz, Jiang lab

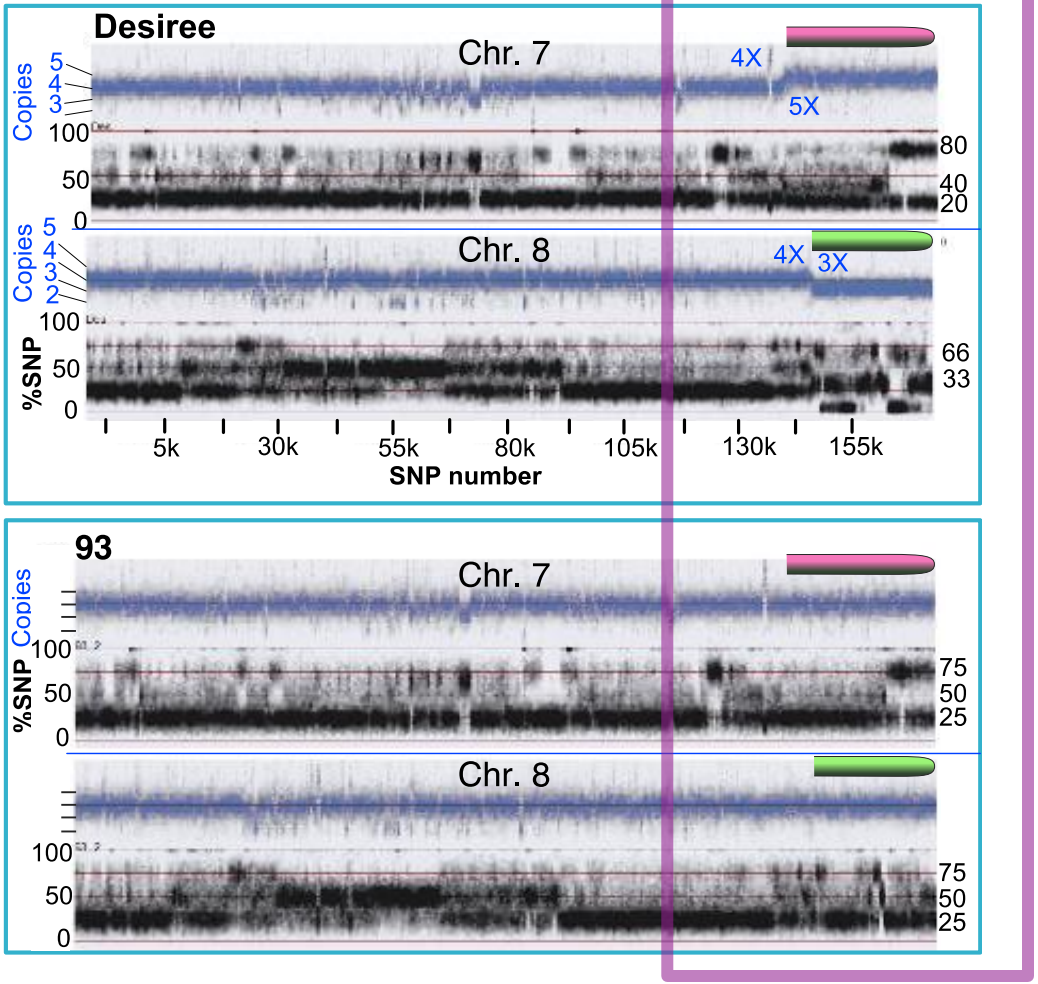
A short history of potato



Sequence evidence for reversion of Tr8-7 translocation

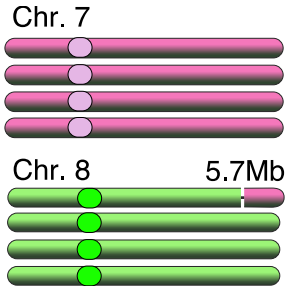
- Several protoplast regenerants display four normal copies of chr.7 and chr.8
- Evidence
  - Sequence dosage
  - Heterozygous SNP ratio
  - Identity confirmed by SNP fingerprinting



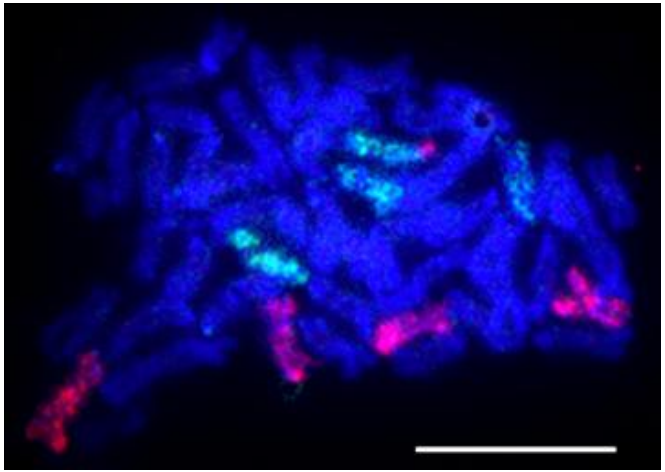


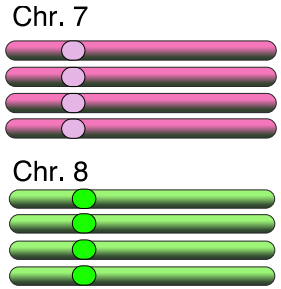
Reversion of the Tr8-7 translocation

- Chromosome painting
- Cytology: X. Zhang,
- Painting: G.T. Braz, J. Jiang lab

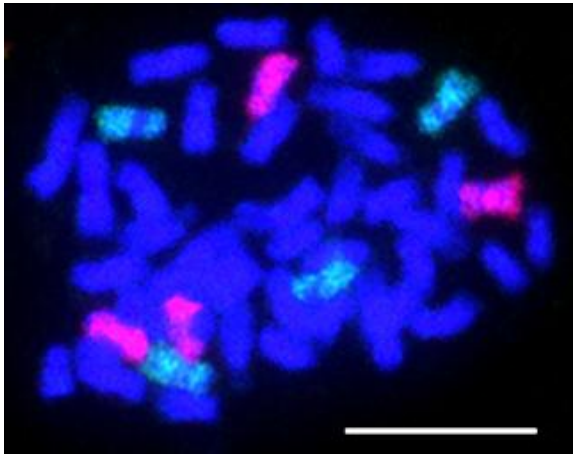


Desiree



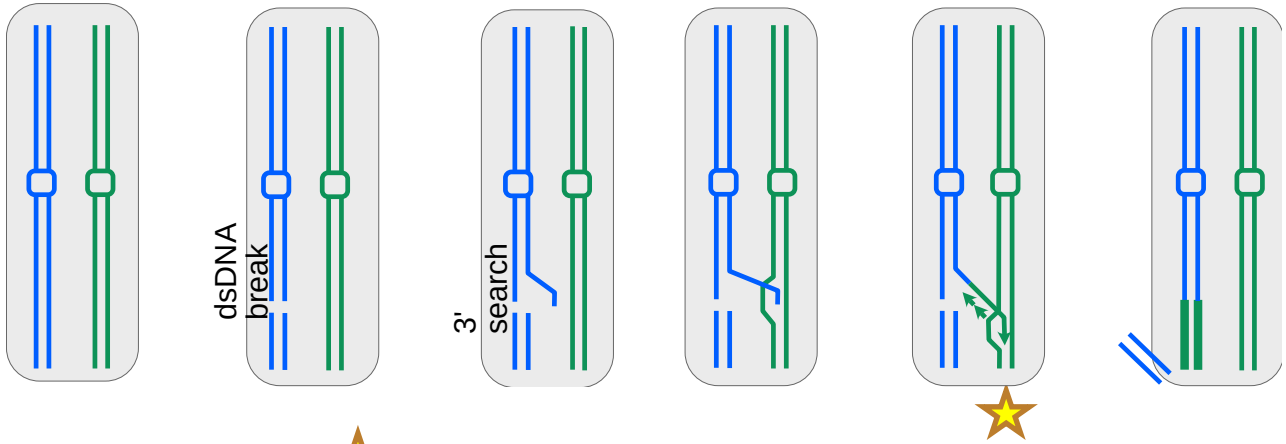


Regenerant 93



Candidate mechanisms for Tr8-7 reversion

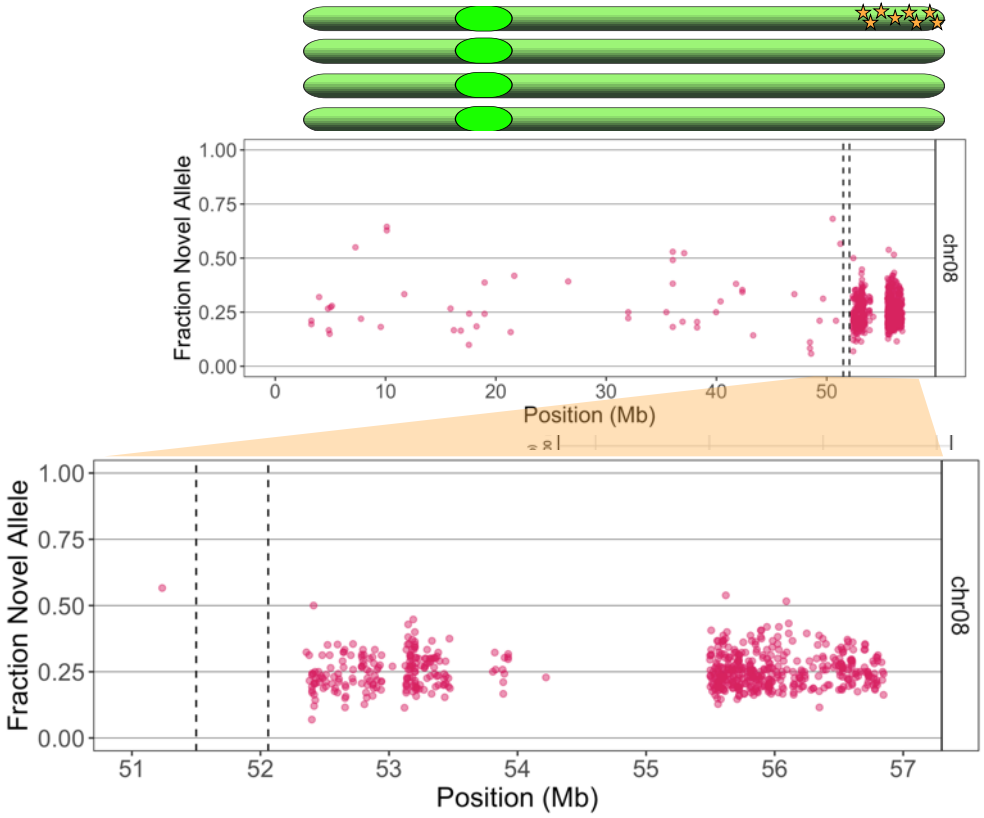
- **Loss and Replacement** involving missegregation + nondisjunction (LR)
- **Mitotic crossover** (MiXo)
- **Break Induced Replication** (BIR)



- Error prone replication
- Consequence: clustered, high-density mutation tracts (kataegis; Nik-Zainal, 2012)

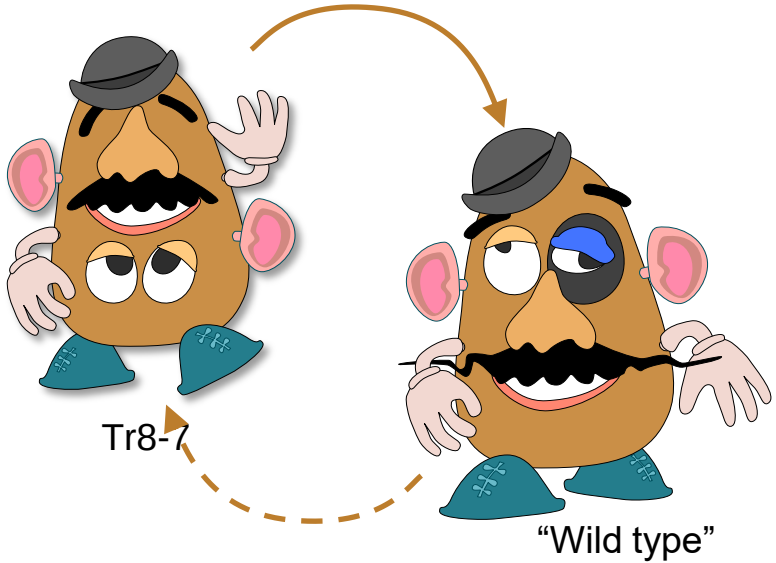
Test hypothesis: is there kataegis (a dense mutation tract)?

- Expect clusters of novel mutations on
  - One homolog (25% freq)
  - Conversion tract
  - Novel
- Conclusions
  - The observed mutation clusters are consistent with BIR (Nik-Zainal, 2012; Taylor, 2013)
  - BIR is the favorite explanation for reversion



Summary

- Chr.8 in Desiree is unstable
  - A translocation between chr.7 and chr.8 is present as single copy
  - The translocation is reverted by a homologous recombination event
  - A mechanism called BIR is a strong candidate



Perspective

- Change of Heterozygosity following dsDNA breaks could contribute to somatic variation
- Unwanted outcome from traditional use
- Useful for targeted genome remodeling
- May be triggered by CRISPR-induced cuts