

# The benefits of molecular cytogenetics in comparative genomics of crops

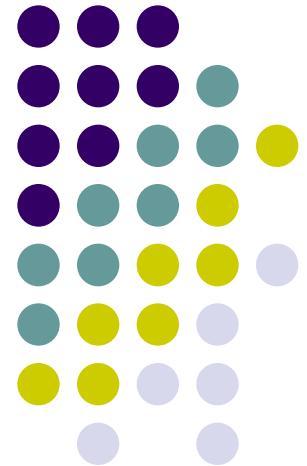
**Hans de Jong**

**Elio Schijlen and Sander Peters**

Wageningen University & Research (WUR)

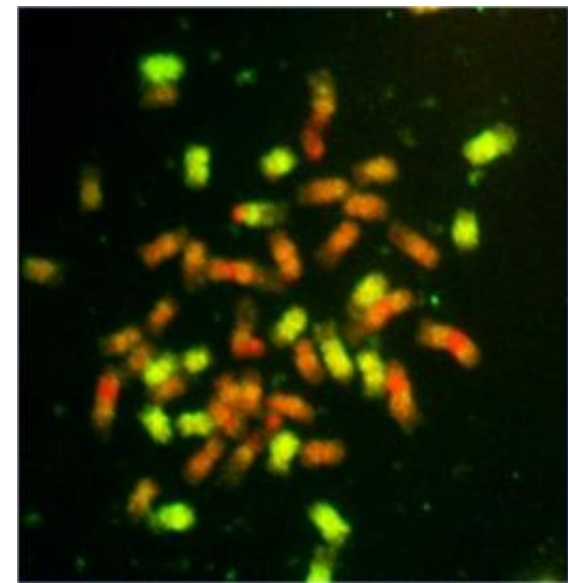
**6<sup>th</sup> Plant Genomics & Gene Editing Congress: Europe**

Rotterdam, 14-15 May 2018

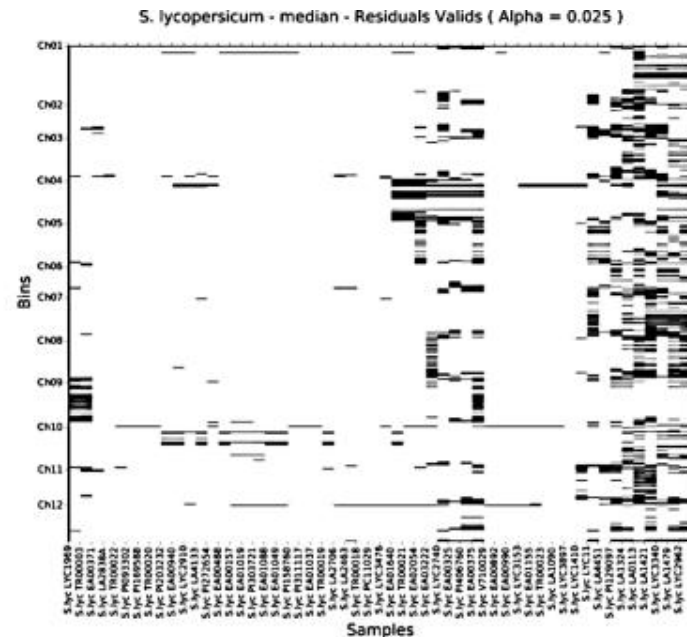
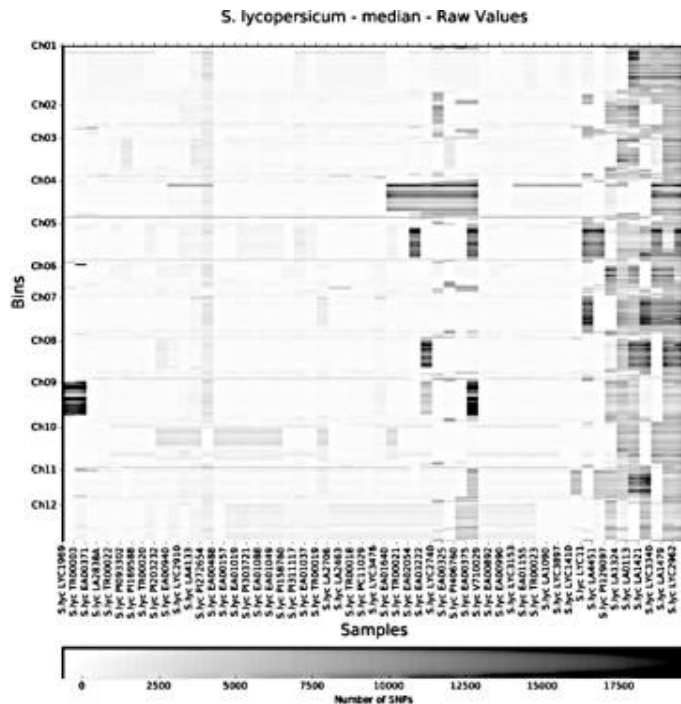


# Cytogenetics – comparative genomics

- Focus
  - Introgressive hybridization
  - Plant breeding, crossing barriers
  - Meiotic disturbances
  - Comparative genomics



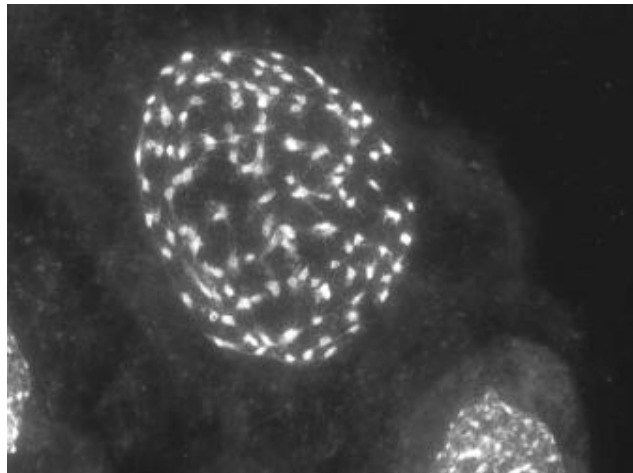
Genome painting  
Solanum hybrids



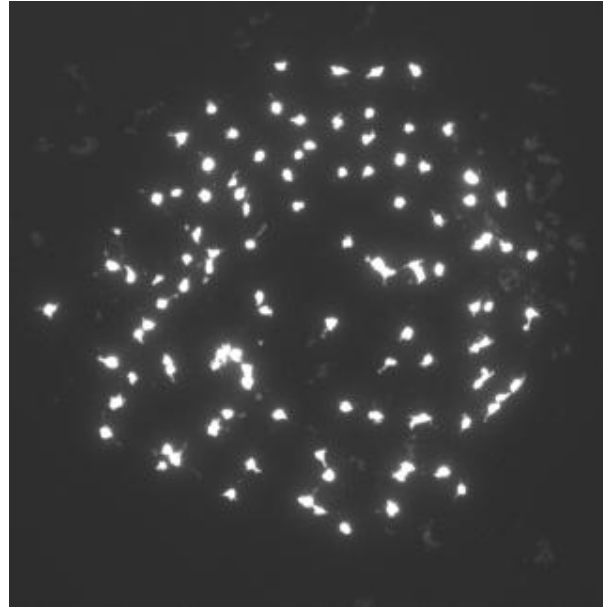
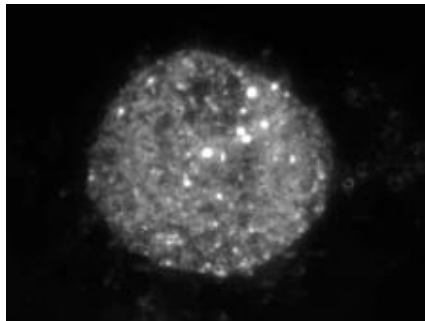
*iBrowser* for introgression hybrids)

Karin Horsman, Heleen Bastiaanssen, Saulo Aflitos, Sander Peters, Dick de Ridder, Gabino Sanchez

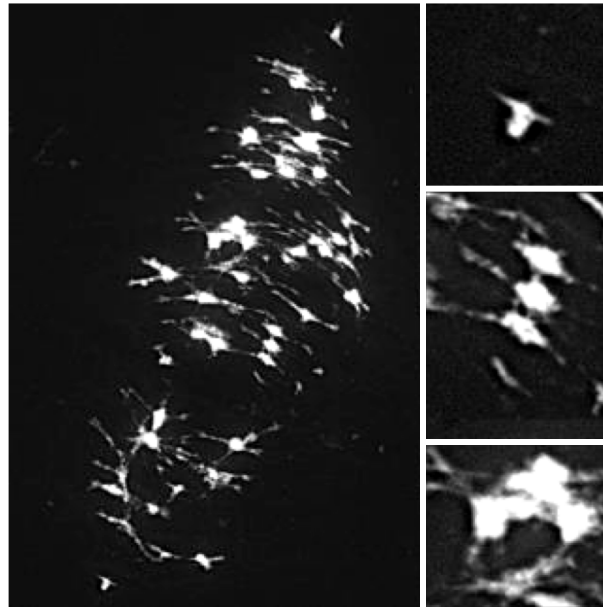
# Cytogenetics – comparative genomics



Okra,  $2n=130$   
10 dots in  
some  
interphases  
c. 10 genomes

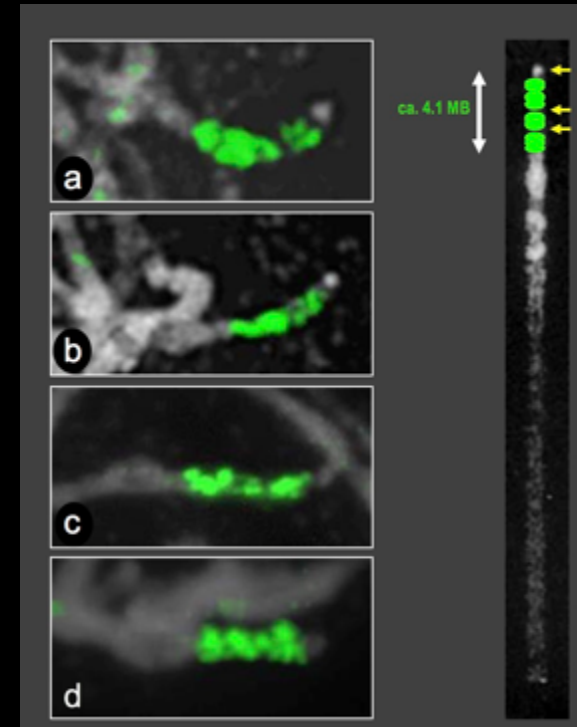
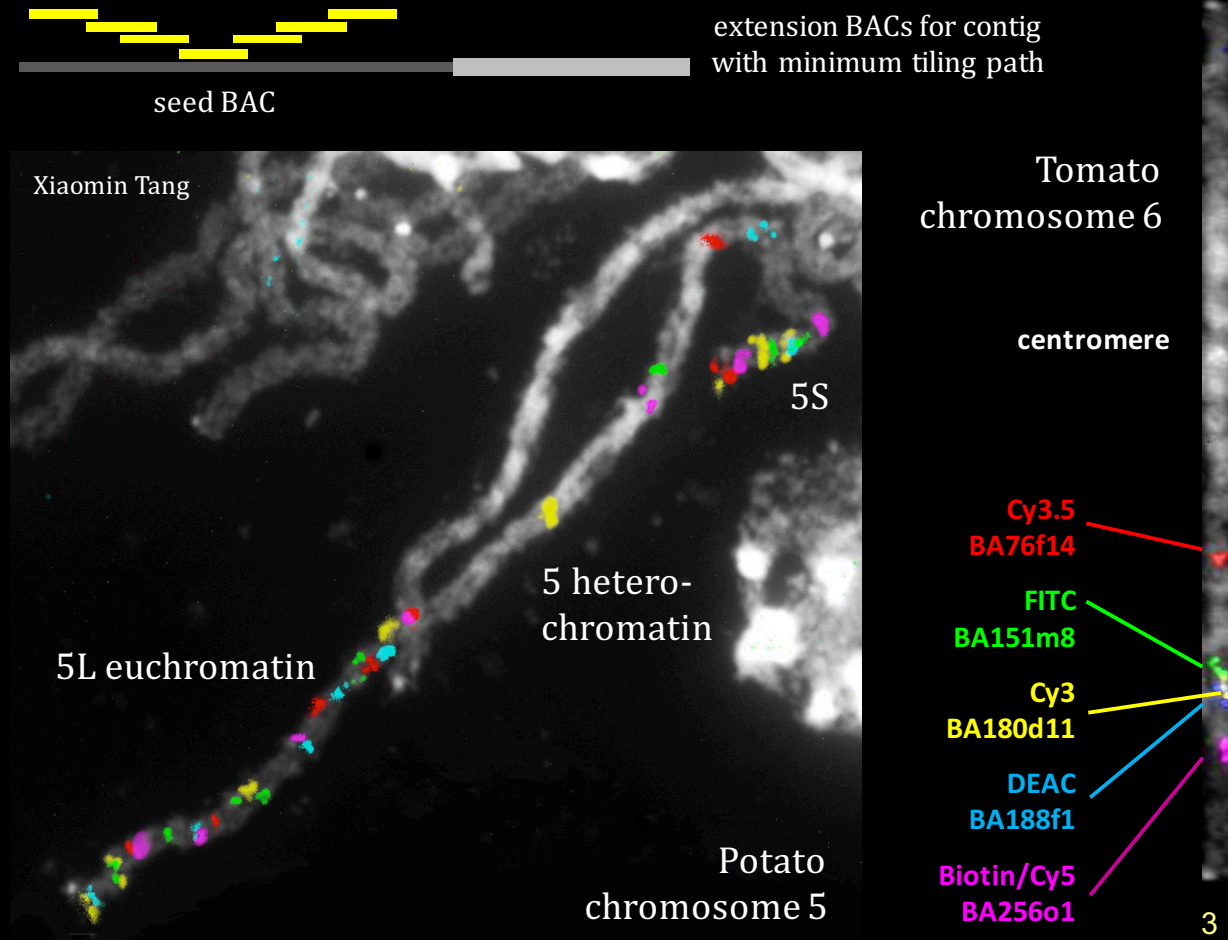


Thai sugar cane  
cultivar,  $2n=112$

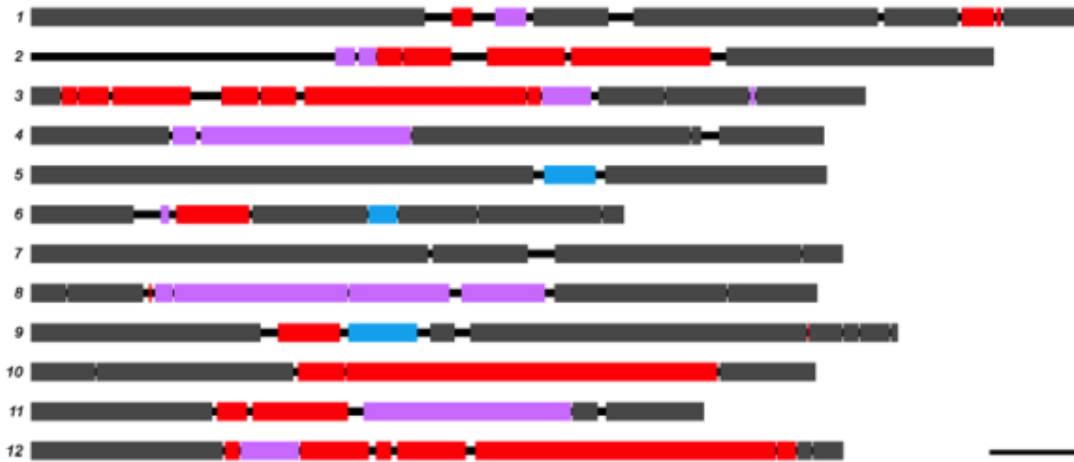


Meiosis diploid  
like: only  
bivalents,  
regular pollen

# Chromosome painting *Solanum*



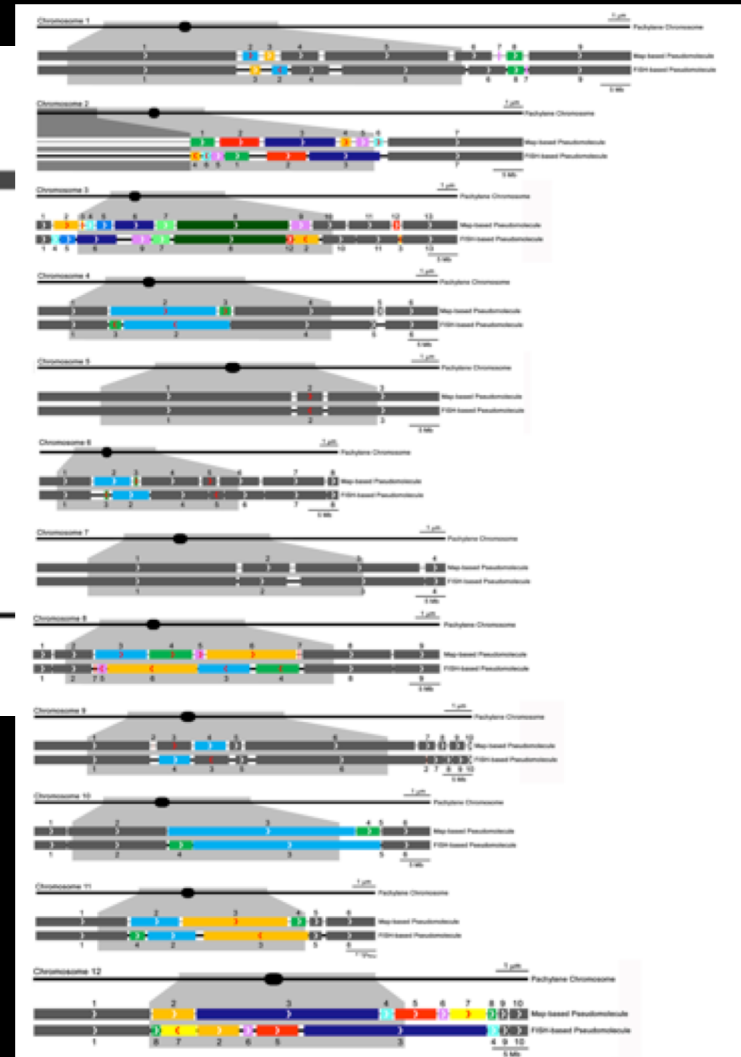
Xiaobo Zhong, Song-Bin Chang,  
Chunting Lang, Xiaomin Tang  
Dóra Szinay, José van der Belt



- changed in order
- changed in orientation
- changed in order and orientation

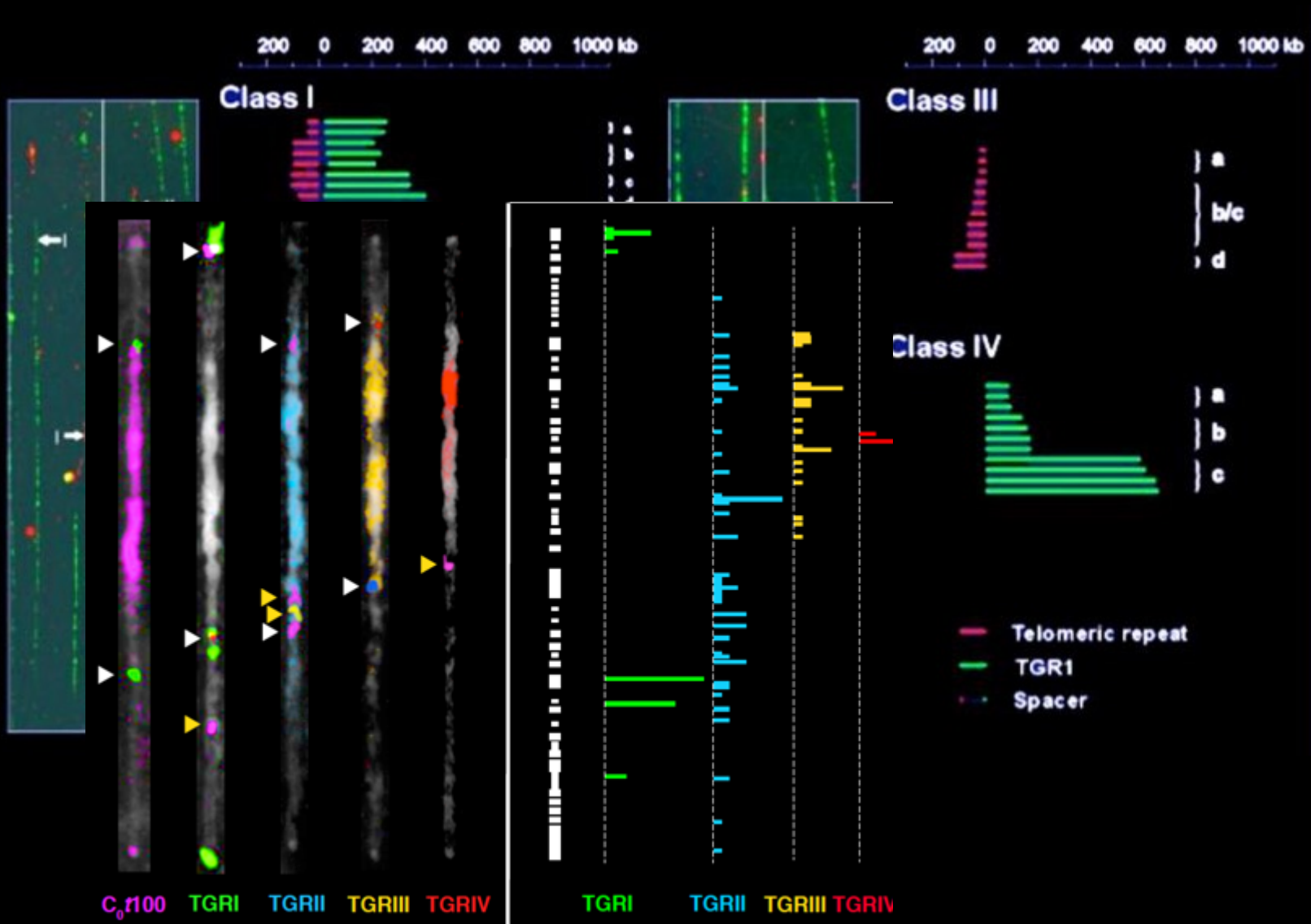
**Chromosome painting of BACs anchoring 91 contigs tomato.**  
**1/3 of all assembled contigs in wrong position or orientation!!**

**Supported by optical mapping, and the internal consistency of FISH results.**



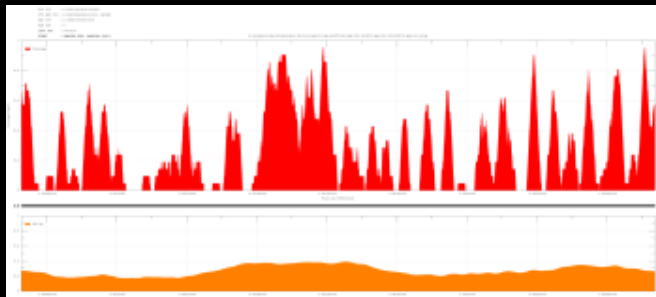
Shearer et al. 2014,  
 Steve Stack lab, Co, USA  
 De Jong lab, WUR



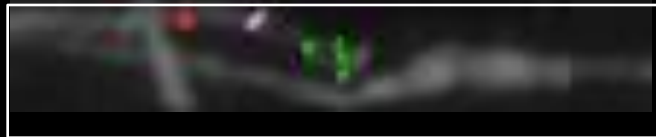
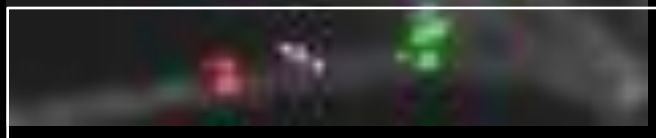
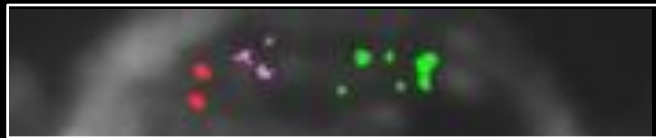


Xiaobo Zhong, Song-Bin Chang, Xiaomin Tang, Dóra Szinay, José van der Belt, Murielle Phillipot

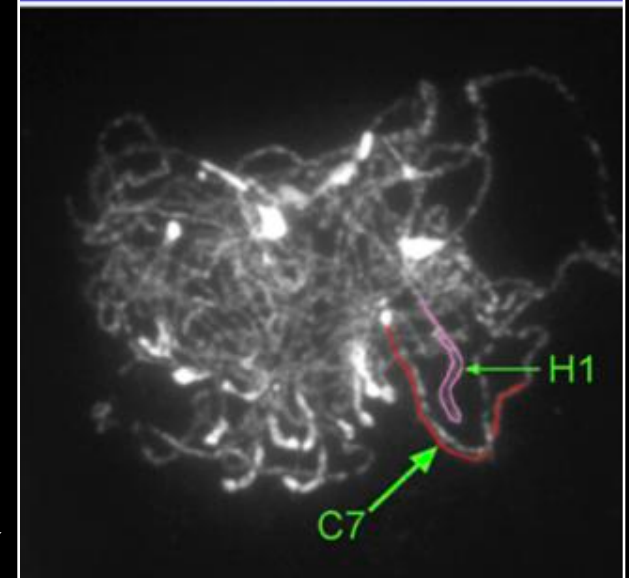
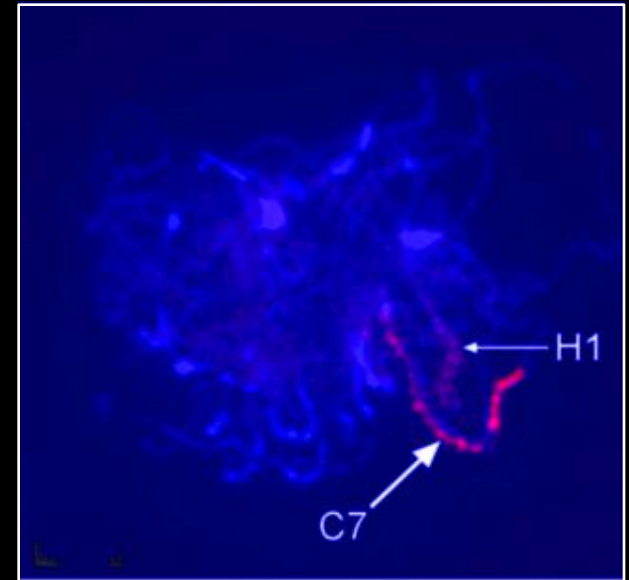
# Oligo painting based on sequence data



Tomato  
chromosome 10



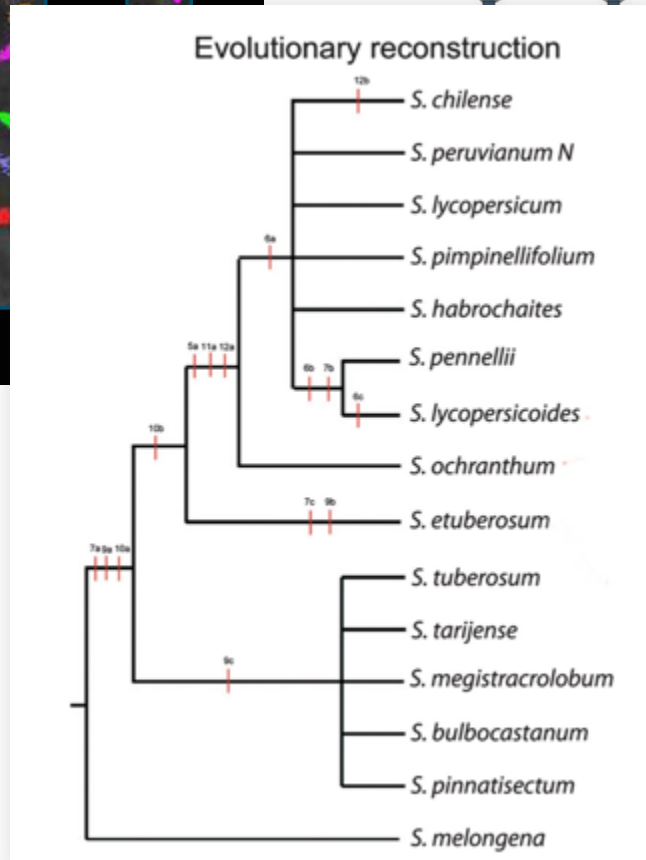
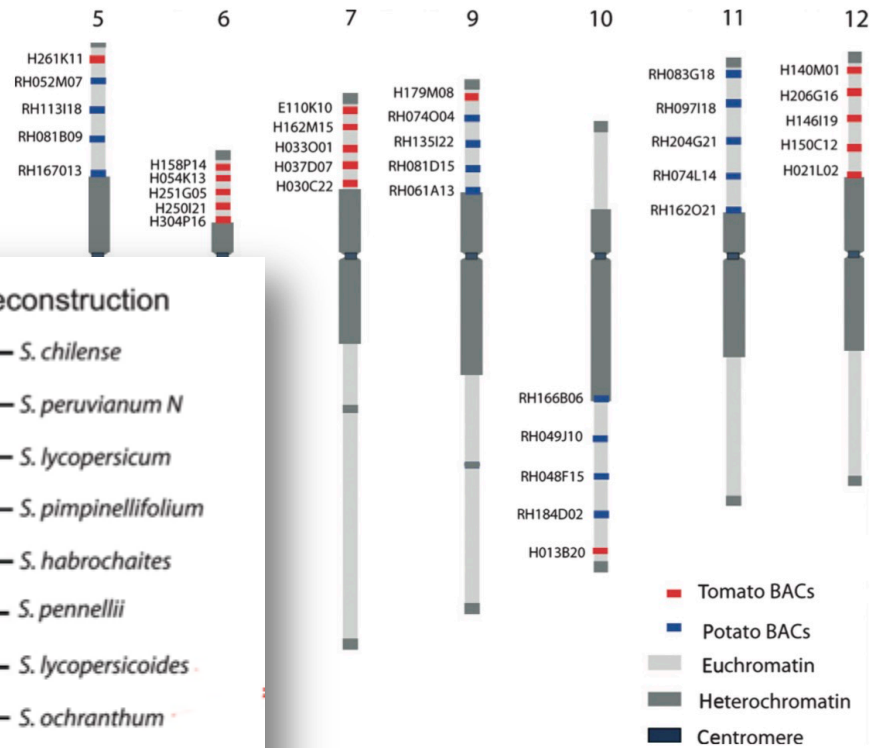
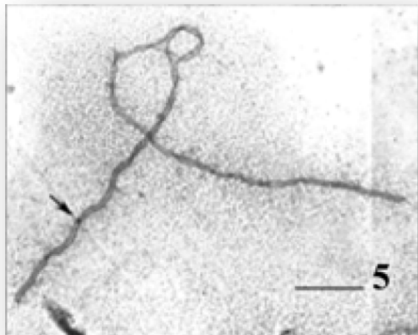
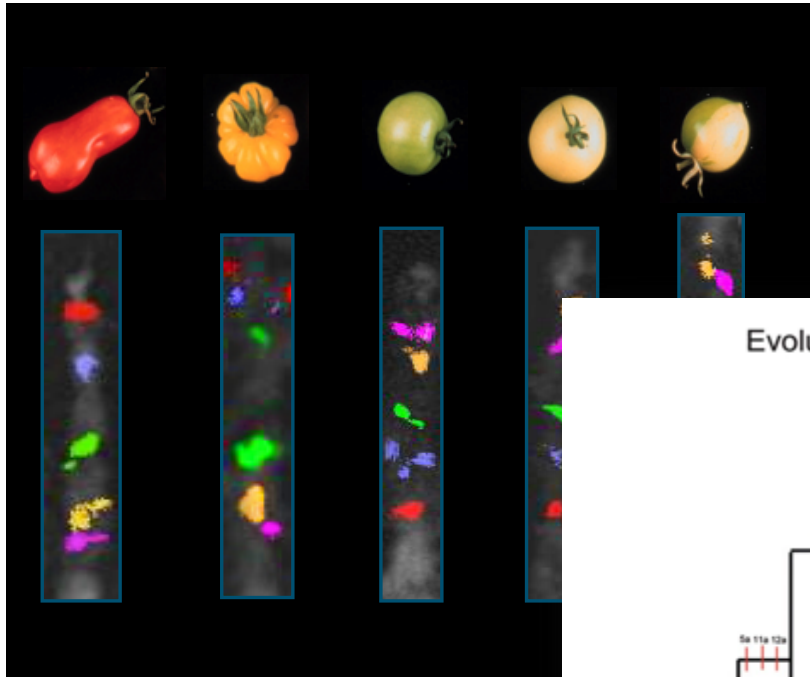
José van der Belt, Saulo Alves Aflitos  
Sander Peters, Dick de Ridder



*Cucumis sativus*  
*x C. hystrix*

Yonghua Han, Tao Zhang, Paradee  
Thammapichai, Yiqun Weng, Jiming Jiang

# Chromosome evolution in *Solanum* traced by cross-species BAC-FISH



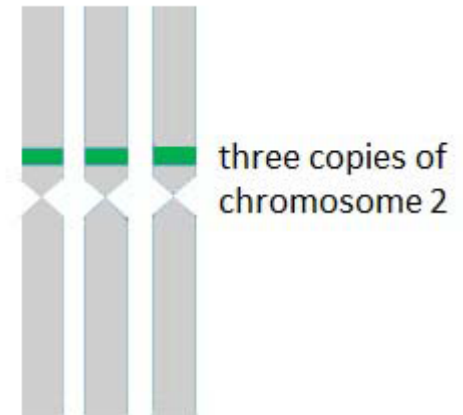
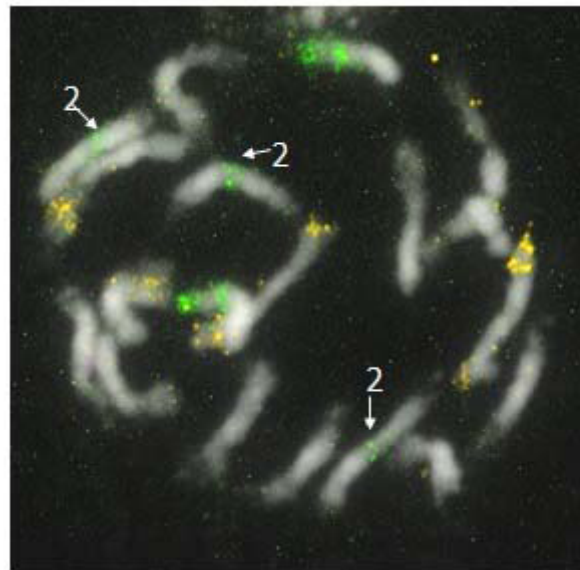
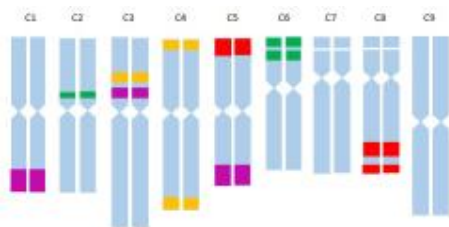
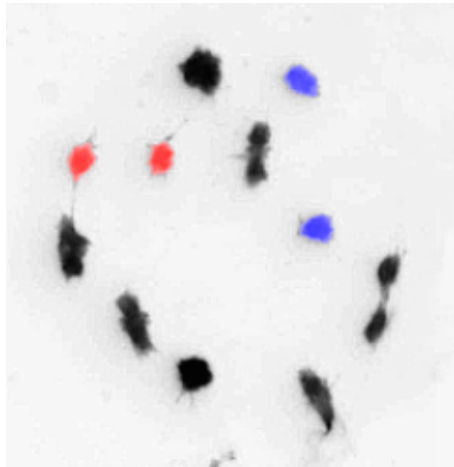
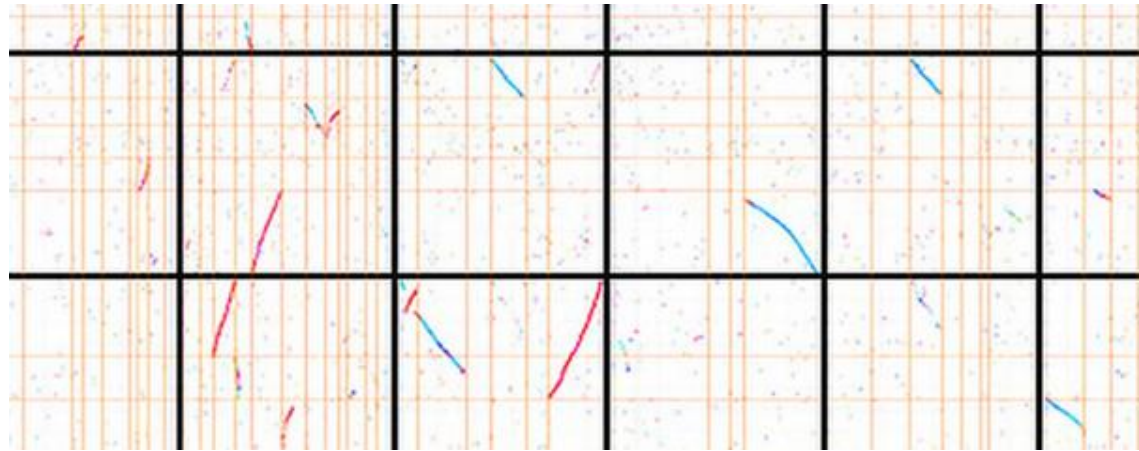
Szinay et al. 2012  
 Dóra Szinay, Erik Wijnker, Ronald van den Berg, Eric Schranz



# Disturbances meiosis II cauliflower: desynapsis



Mummerplot shows the genomic relation between Arabidopsis and cauliflower



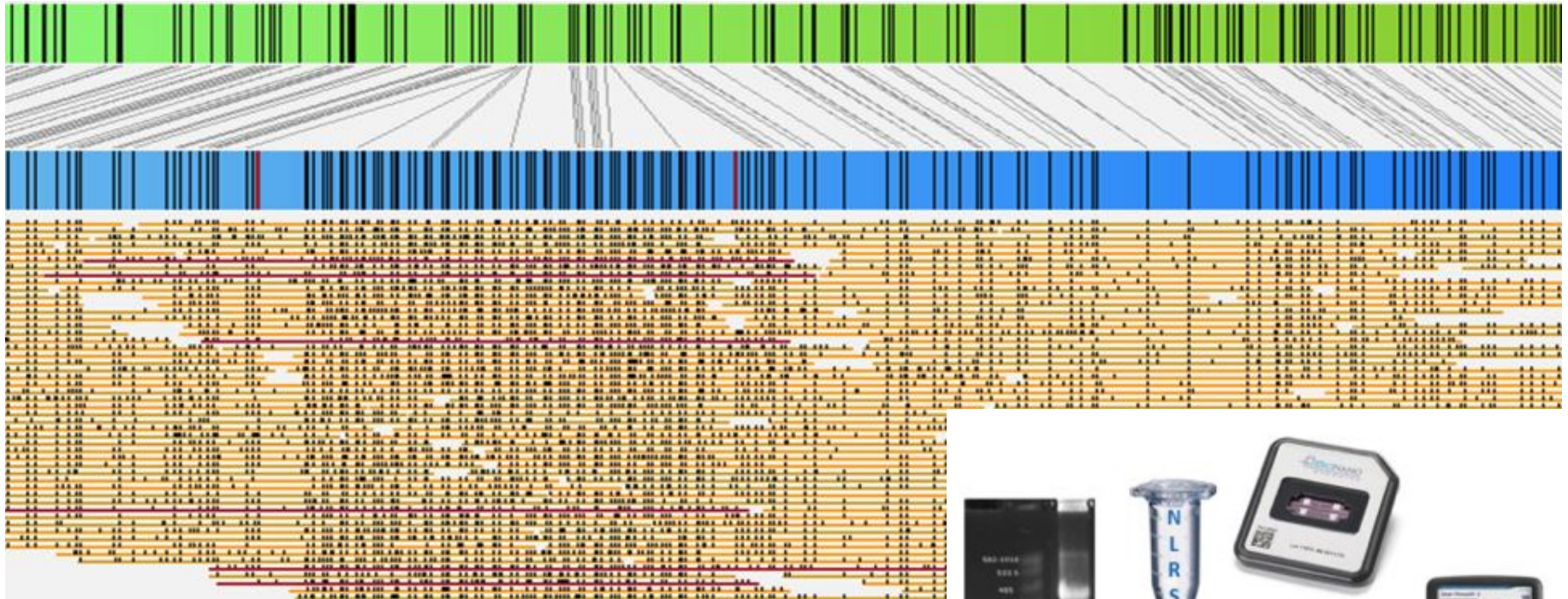
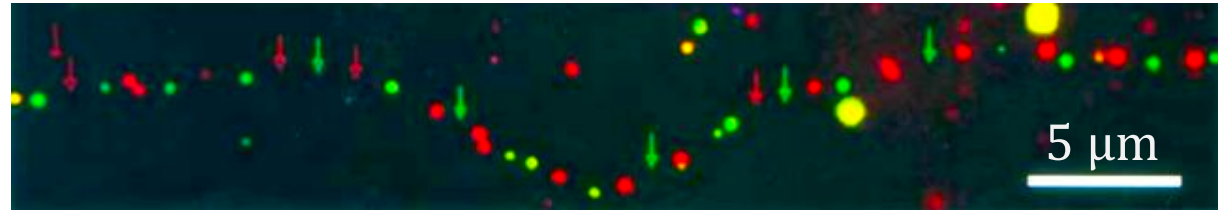
Rijk Zwaan Breeding Comp., Xianwen Ji, Leila Sharifzadeh, Cilia Lelivelt, Erik Wijnker

# Extended fibre FISH and Optical mapping

1 kb 18S rDNA

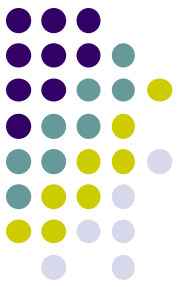


700 bl 25S rDNA



Paul Fransz, Hans de Jong  
Elio Schijlen, Henri van de Geest, Paul Mooijman, Saulo Aflitos, Gabino Sanchez-Perez, and Sander Peters



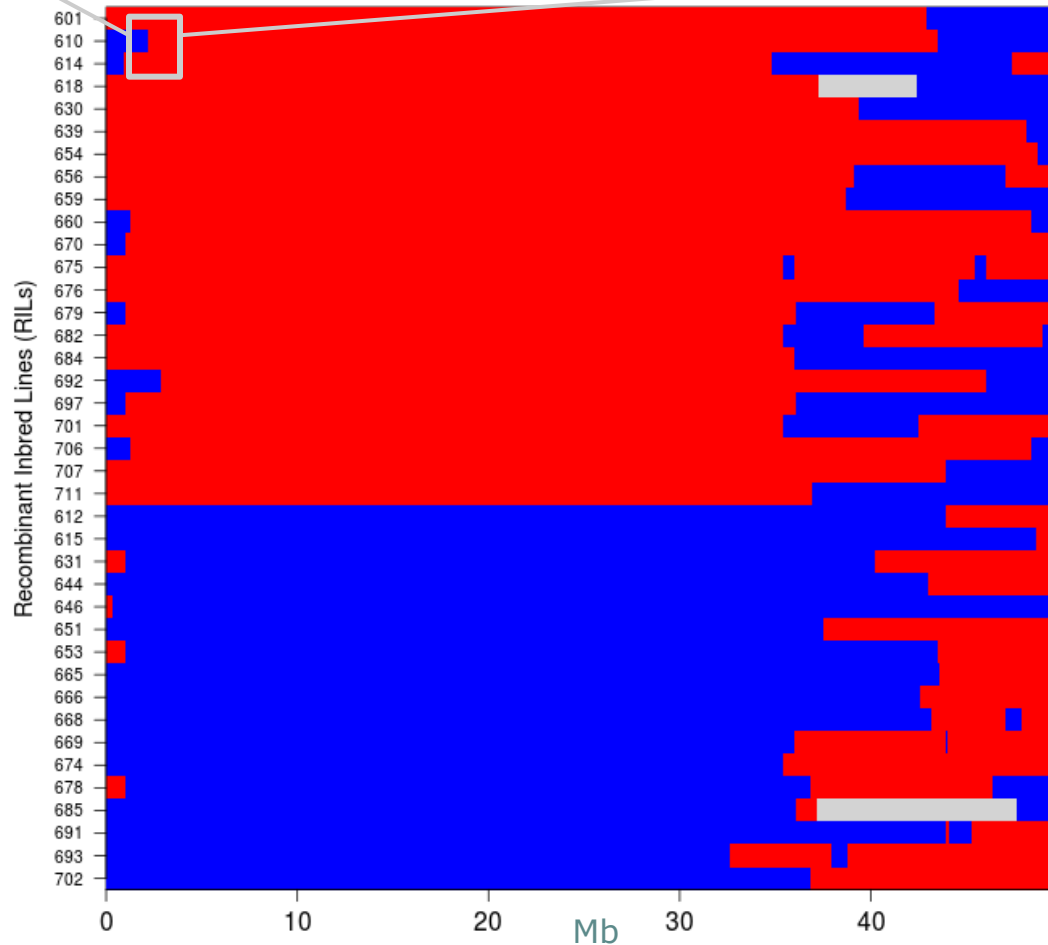


Genetics – cytogenetics – genomics – population studies

# **(WILD) RELATIVE TO CROP INTROGRESSIVE HYBRIDIZATIONS**

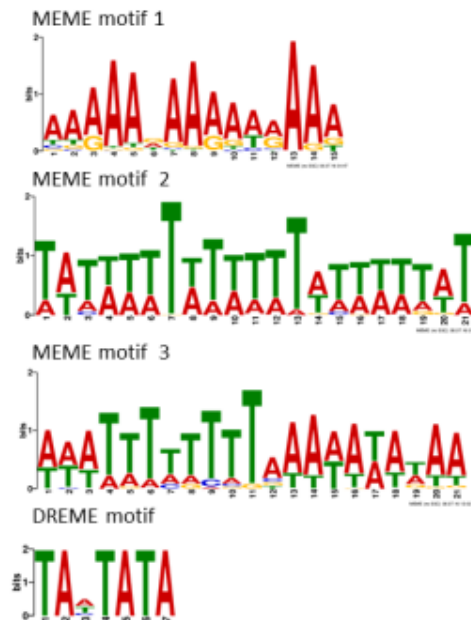
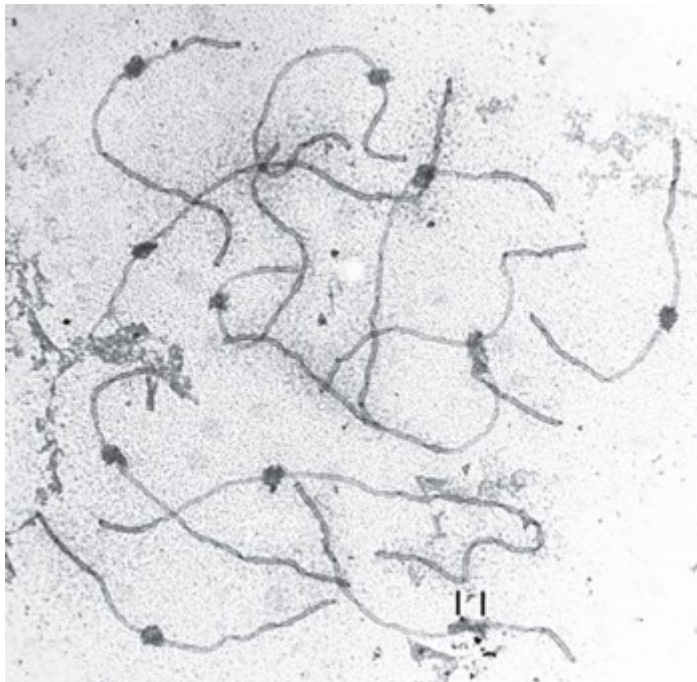
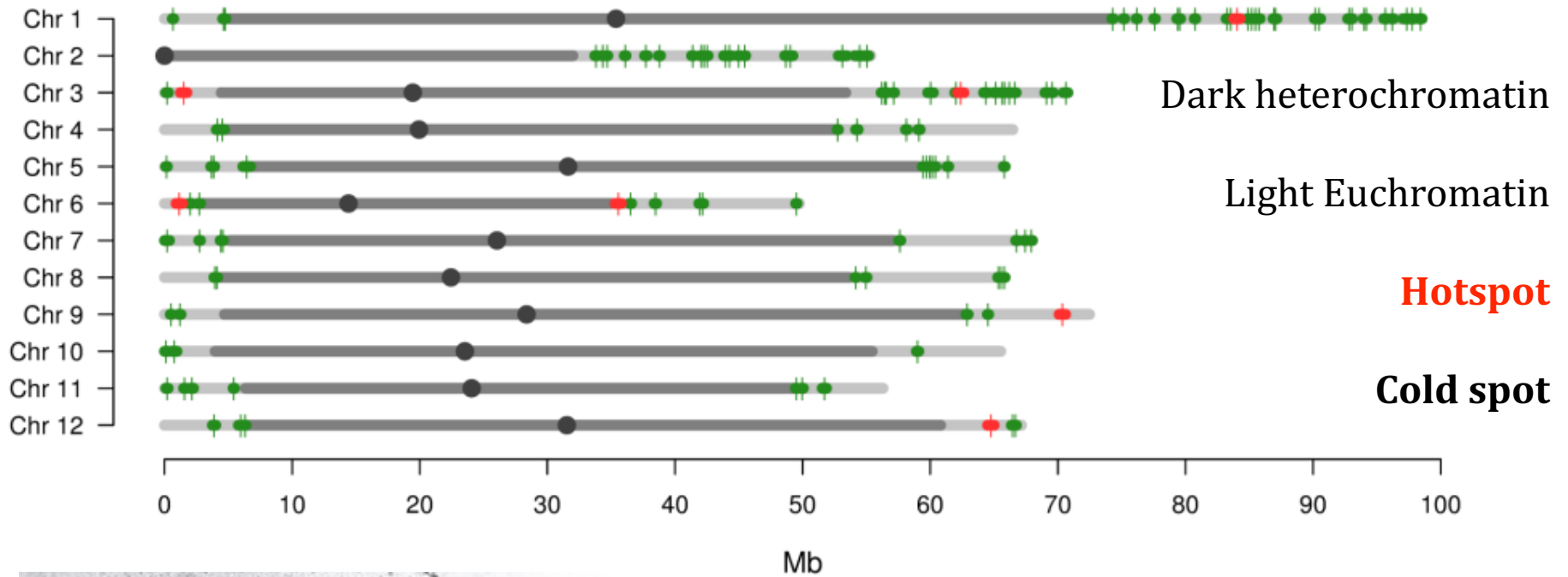
# *Solanum esculentum* X *S. pimpinellifolia* introgression lines

  AACATTACCTTGAGTAACGTTT  CAGGAGTAAAATGAAAC   200 SNP window



Sevgin Demirci, Sander Peters,  
Dick de Ridder

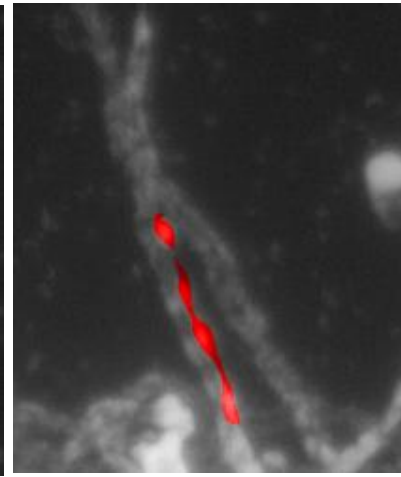
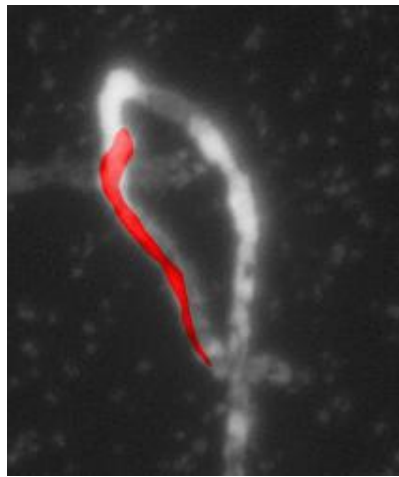
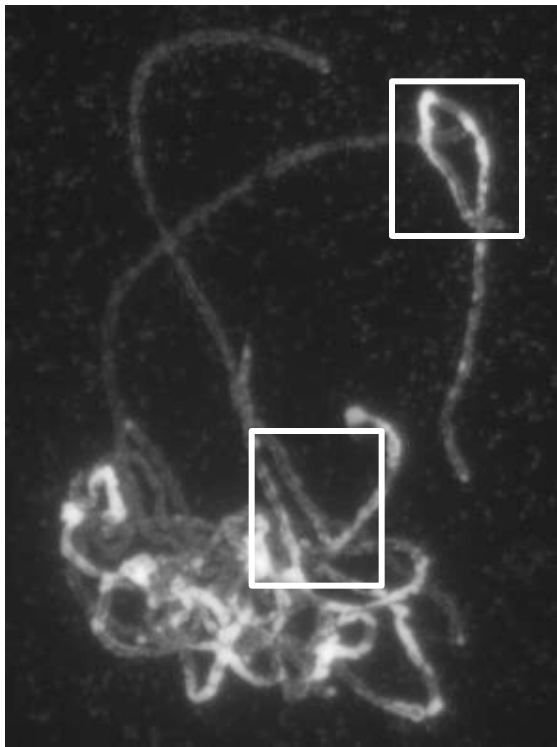




*Solanum esculentum* –  
*pimpinellifolia*

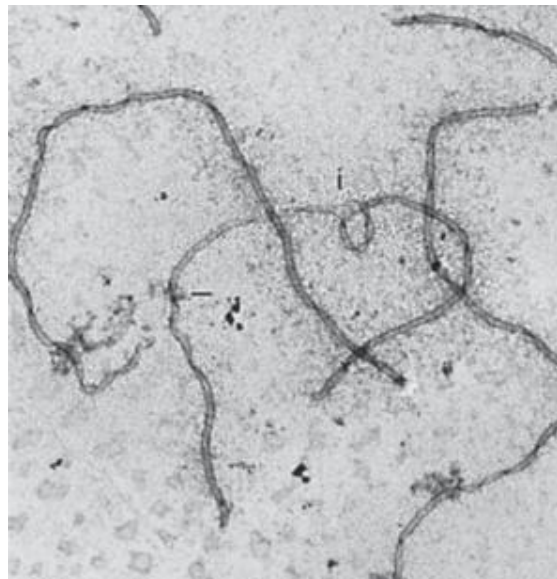
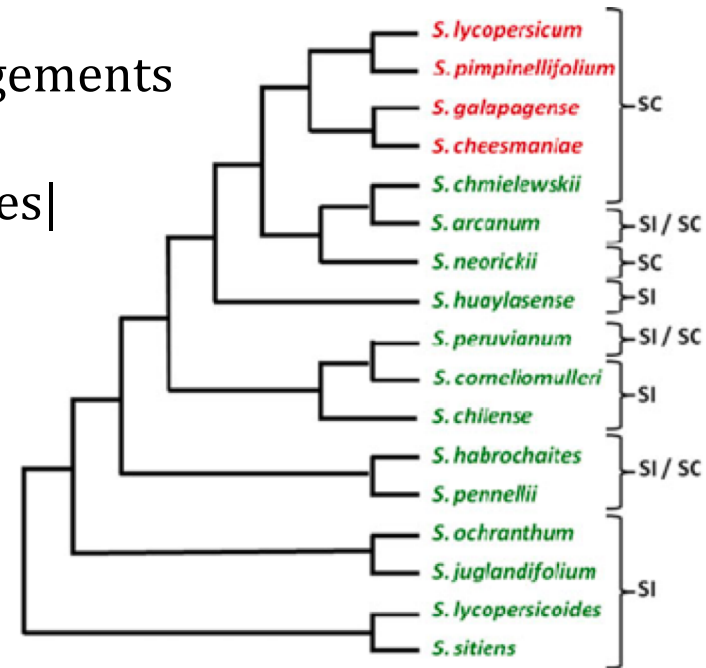
1. Normal pairing as homologues
2. No structural rearrangements
3. Same CO motifs
4. Like tomato heterozygotes



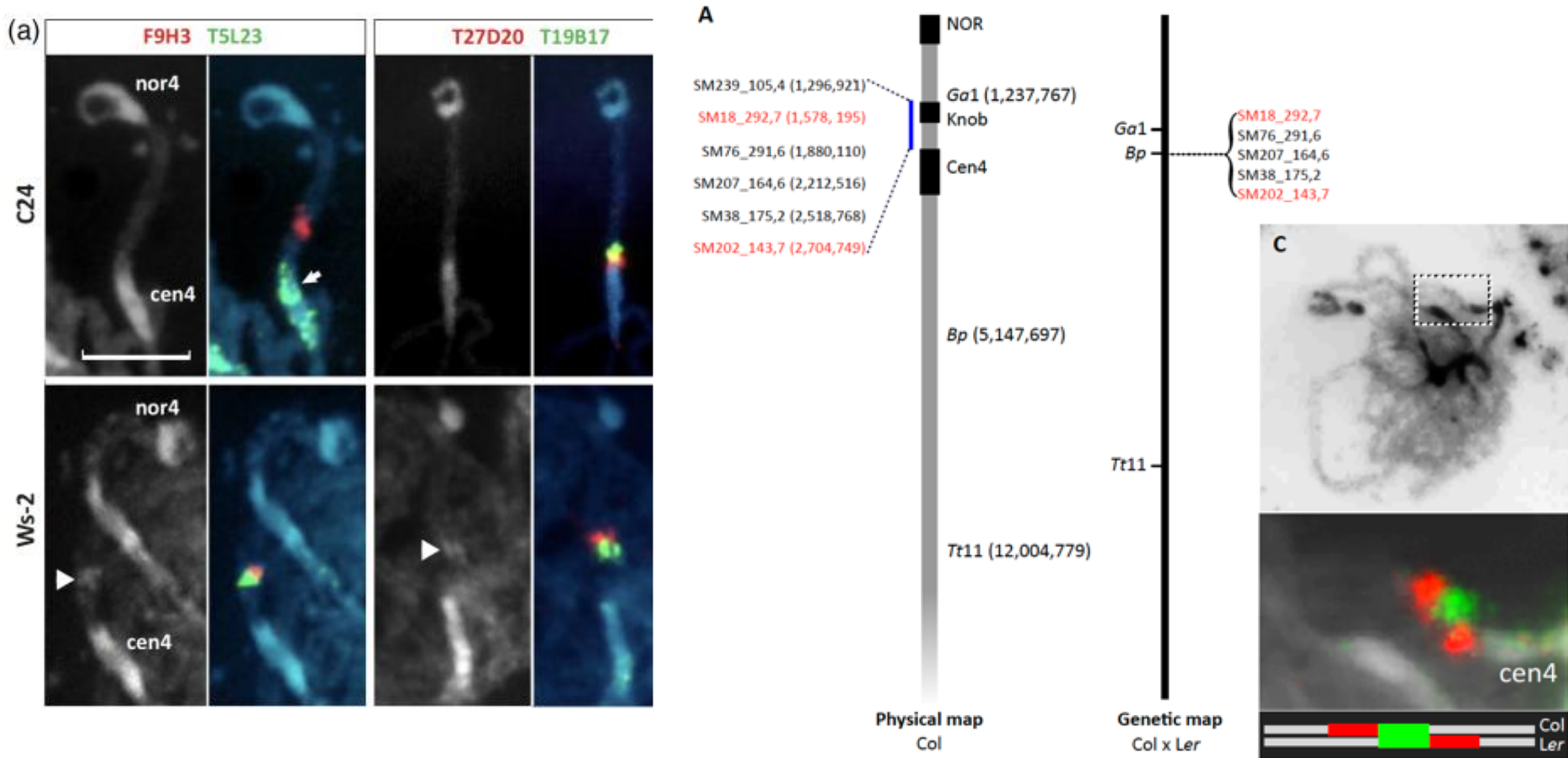


*Solanum lycopersicum* X *S. pennellii*

1. Structural rearrangements
2. Meiotic disturbances
3. Partial sterility
4. Linkage drag

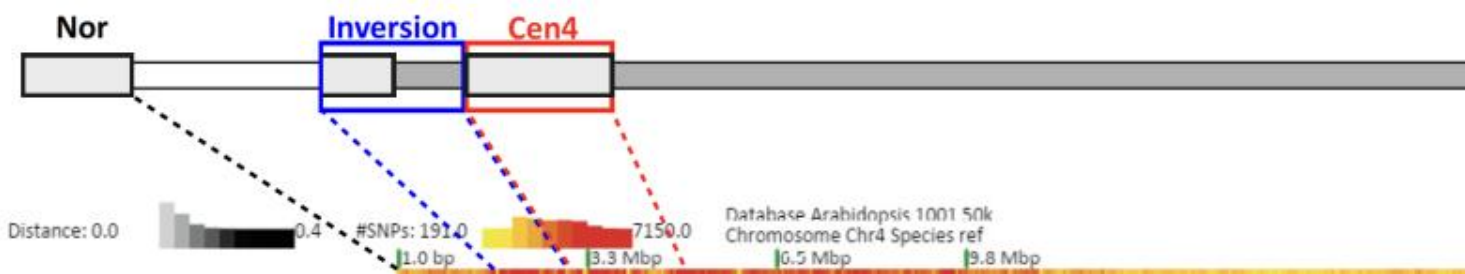


# Molecular, genetic and evolutionary analysis of a paracentric inversion in *Arabidopsis thaliana*



Paul Franz, Gabriella Linc, Cheng-Ruei Lee, Saulo Aflitos, Jesse Lasky, Christopher Toomajian, Hoda Ali, Janny Peters, Peter van Dam, Xianwen Ji, Mateusz Kuzak, Tom Gerats, Ingo Schubert, Korbinian Schneeberger, Vincent Colot, Rob Martienssen, Maarten Koornneef, Magnus Nordborg, Thomas Juenger, Hans de Jong and Michael E. Schranz

(a)



Col\_0\_CS28167\_CS28166\_CS76778  
ref  
UKSE06\_252\_CS78800  
H55\_CS28335\_CS76897  
UKNW06\_233\_CS78794  
Ca\_0\_CS28128\_CS76459  
Gu\_0\_CS28331\_CS76498  
Rag1\_I\_CS28667\_CS76583  
Ws\_2\_CS28828\_CS28827\_CS78920  
Ob\_0\_CS28579\_CS76566  
Ak\_1\_CS28011\_CS76431  
Uk\_3\_CS78789\_CS78777  
Mh\_0\_CS28492\_CS76550  
Cn\_2\_CS28234\_CS76481  
Star\_8\_CS76400  
Dr\_0\_CS28587\_CS76568  
MNF\_Pot\_15\_CS78979  
Map\_42\_CS77732  
627RMX\_1MN4\_CS79022  
627RMX\_1MN5\_CS79023  
Yo\_0\_CS28842\_CS76633  
KNO1\_37\_CS76972  
NC\_6\_CS77124  
Paw\_76\_CS77164  
Dem\_4\_CS76794  
MNF\_Pot\_75\_CS77100  
NOZ\_6\_CS77134  
Buckhorn\_Pass\_CS28123\_CS76733  
SLSP\_31\_CS77254  
Gre\_0\_CS28329\_CS76497  
DRR107\_CS78048  
Pna\_17\_CS28647\_CS76575  
PNA3\_10\_CS//183  
DIR\_9\_CS76796  
Tol\_0\_CS28761\_CS76614  
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RMX4\_118\_CS79029  
Mdn\_1\_CS77077  
MNF\_Che\_2\_CS77096  
MNF\_Pot\_2I\_CS77099  
RMX413\_85\_CS79034  
Nie1\_2\_CS76402  
TAL\_07\_CS77339  
Si\_0\_CS28739\_CS76601  
Nw\_0\_CS28573\_CS76564  
Ha\_0\_CS28336\_CS76500  
Ba\_1\_CS28053\_CS76441  
Gd\_1\_CS28275\_CS76491  
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T540\_CS77303  
Stenk\_4\_CS77276  
Ale Stenar\_64\_24\_CS76654  
Do\_0\_CS28210\_CS76474

Inversion accessions

