# The benefits of molecular cytogenetics in comparative genomics of crops
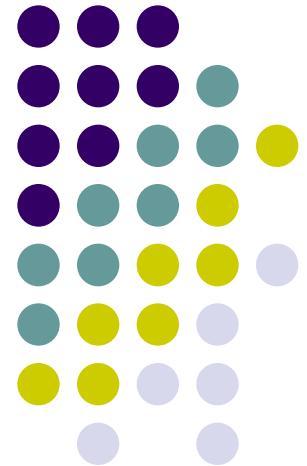
**Hans de Jong**

**Elio Schijlen and Sander Peters**

Wageningen University & Research (WUR)
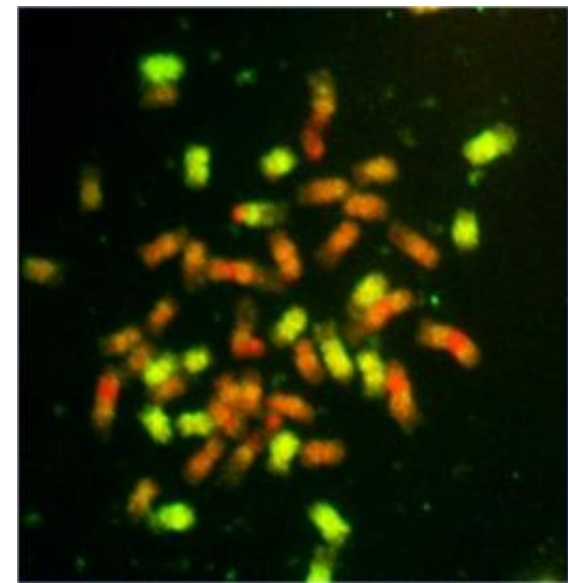
**6th Plant Genomics & Gene Editing Congress: Europe**
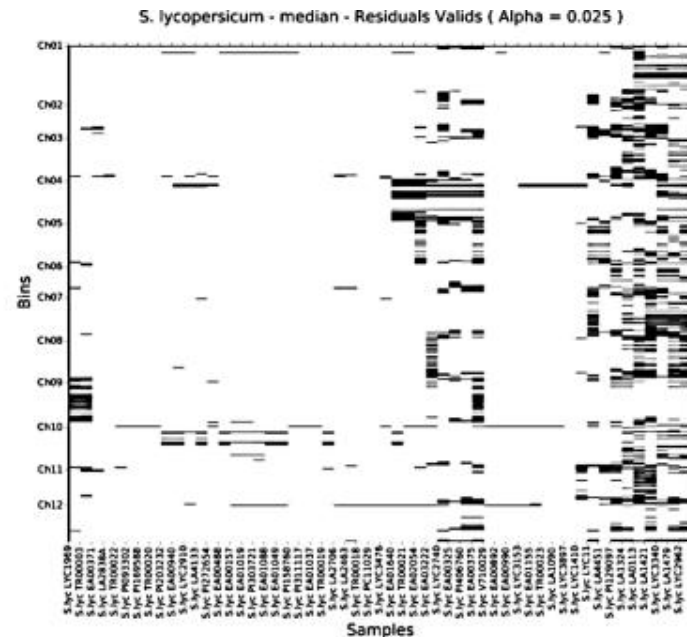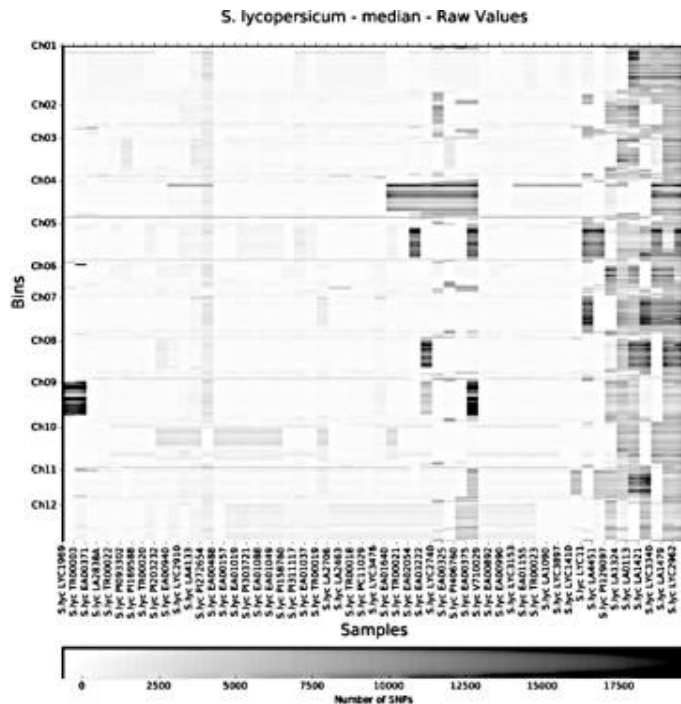
Rotterdam, 14-15 May 2018

# Cytogenetics – comparative genomics

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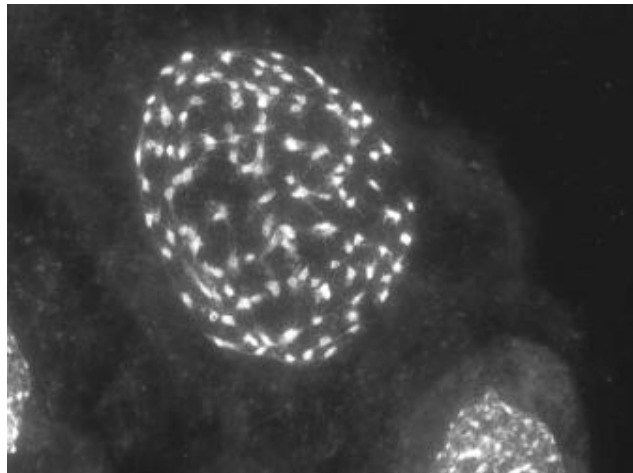  - Meiotic disturbances
  - Comparative genomics

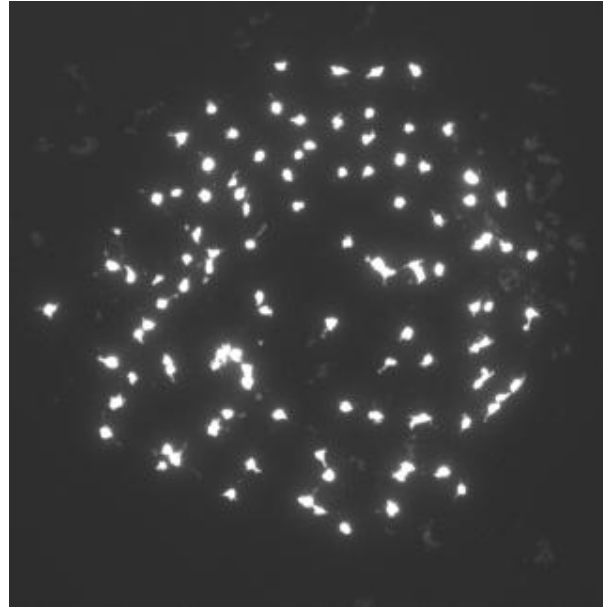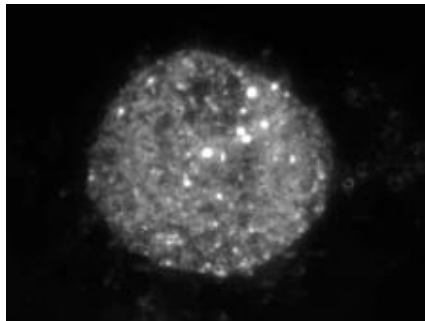

**Genome painting Solanum hybrids**



S. lycopersicum - median - Raw Values



S. lycopersicum - median - Residuals Valids ( Alpha = 0.025 )

*iBrowser* **for introgression hybrids)**

# Cytogenetics – comparative genomics



Thai sugar cane cultivar, 2n=112
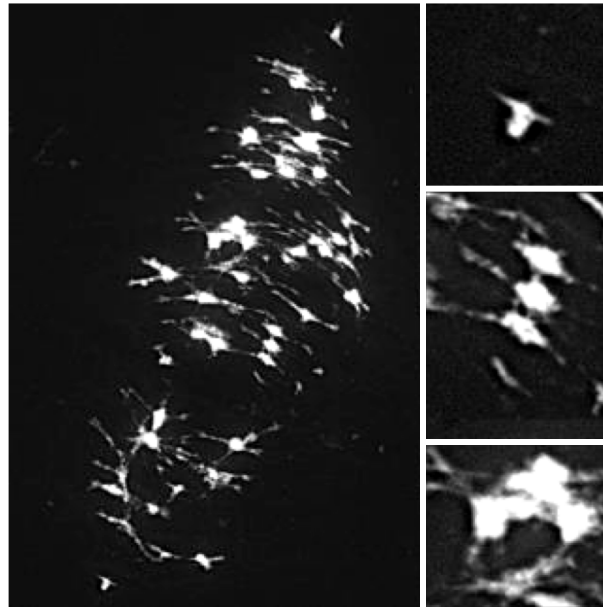
Meiosis diploid like: only bivalents, regular pollen

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

# Chromosome painting *Solanum*



seed BAC

extension BACs for contig with minimum tiling path

Xiaomin Tang

5S

5 hetero-chromatin

5L euchromatin

Potato chromosome 5

Tomato chromosome 6

centromere

Cy3.5 BA76f14

FITC BA151m8

Cy3 BA180d11
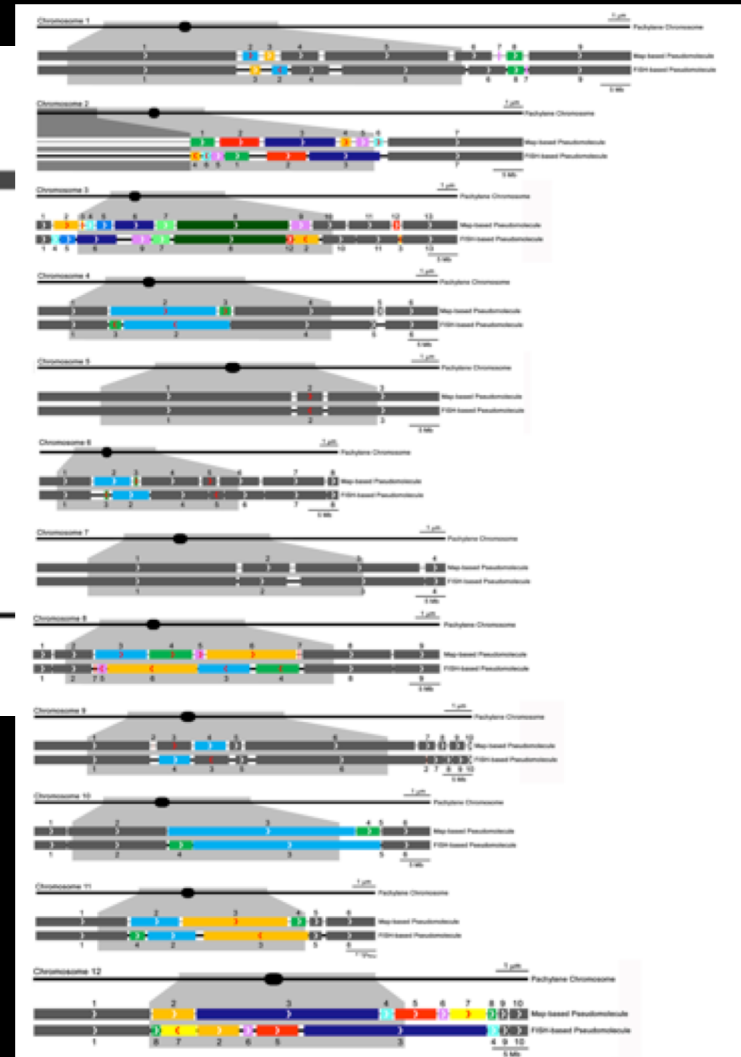
DEAC BA188f1

Biotin/Cy5 BA256o1

ca. 4.1 MB

a

b

c

d

3
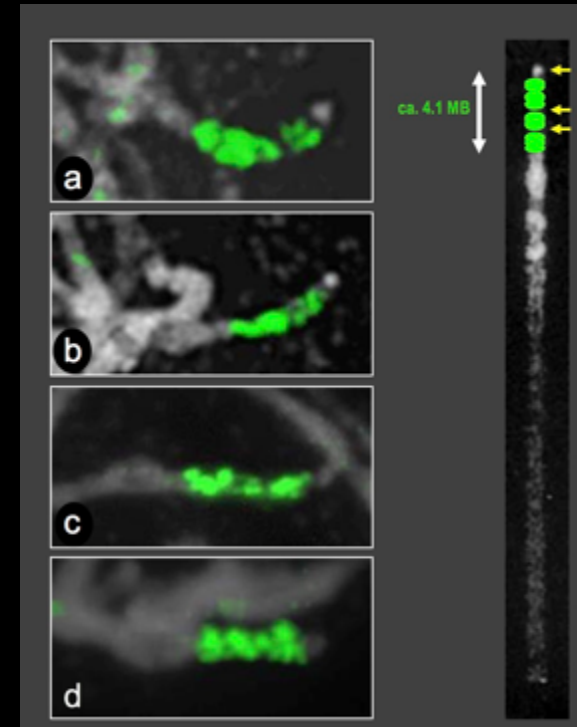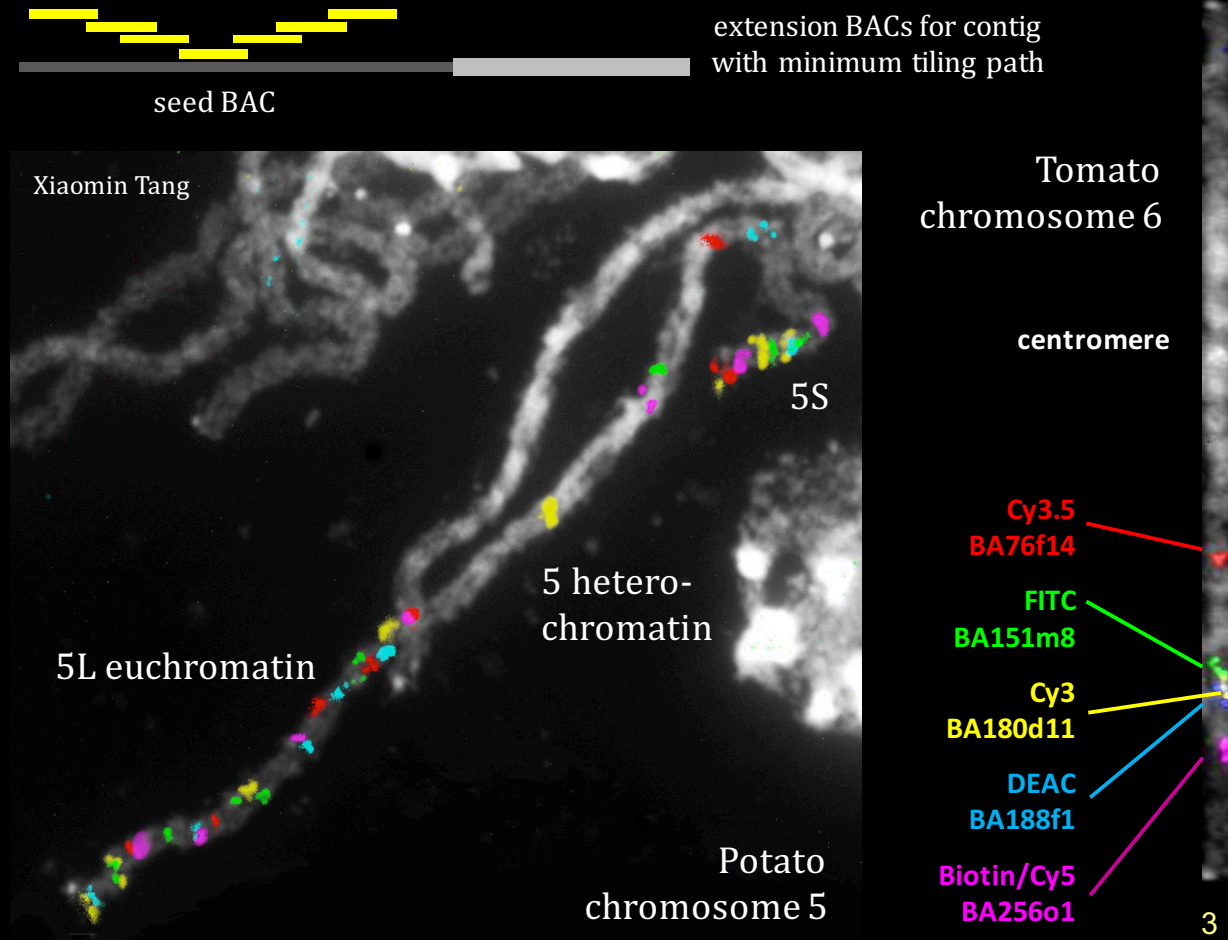
Xiaobo Zhong, Song-Bin Chang, Chunting Lang, Xiaomin Tang Dóra Szinay, José van der Belt
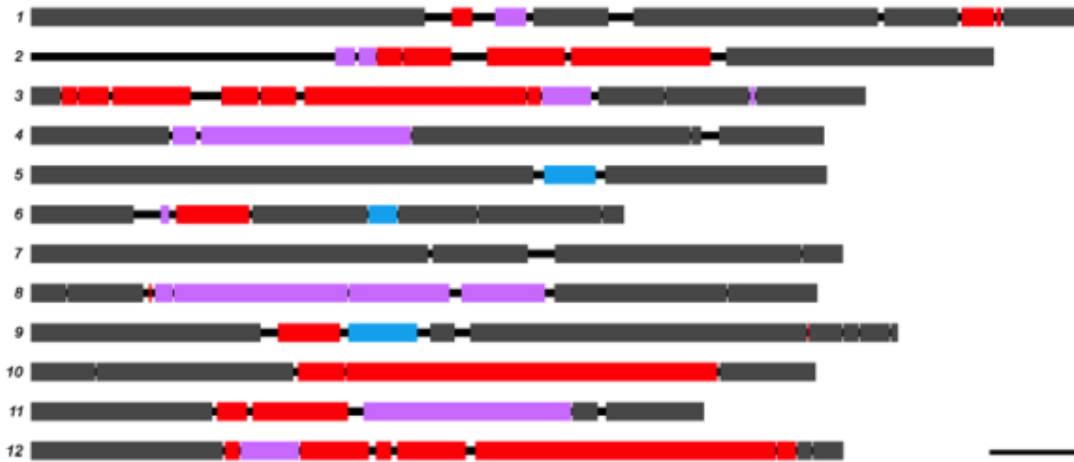
changed in order
changed in orientation
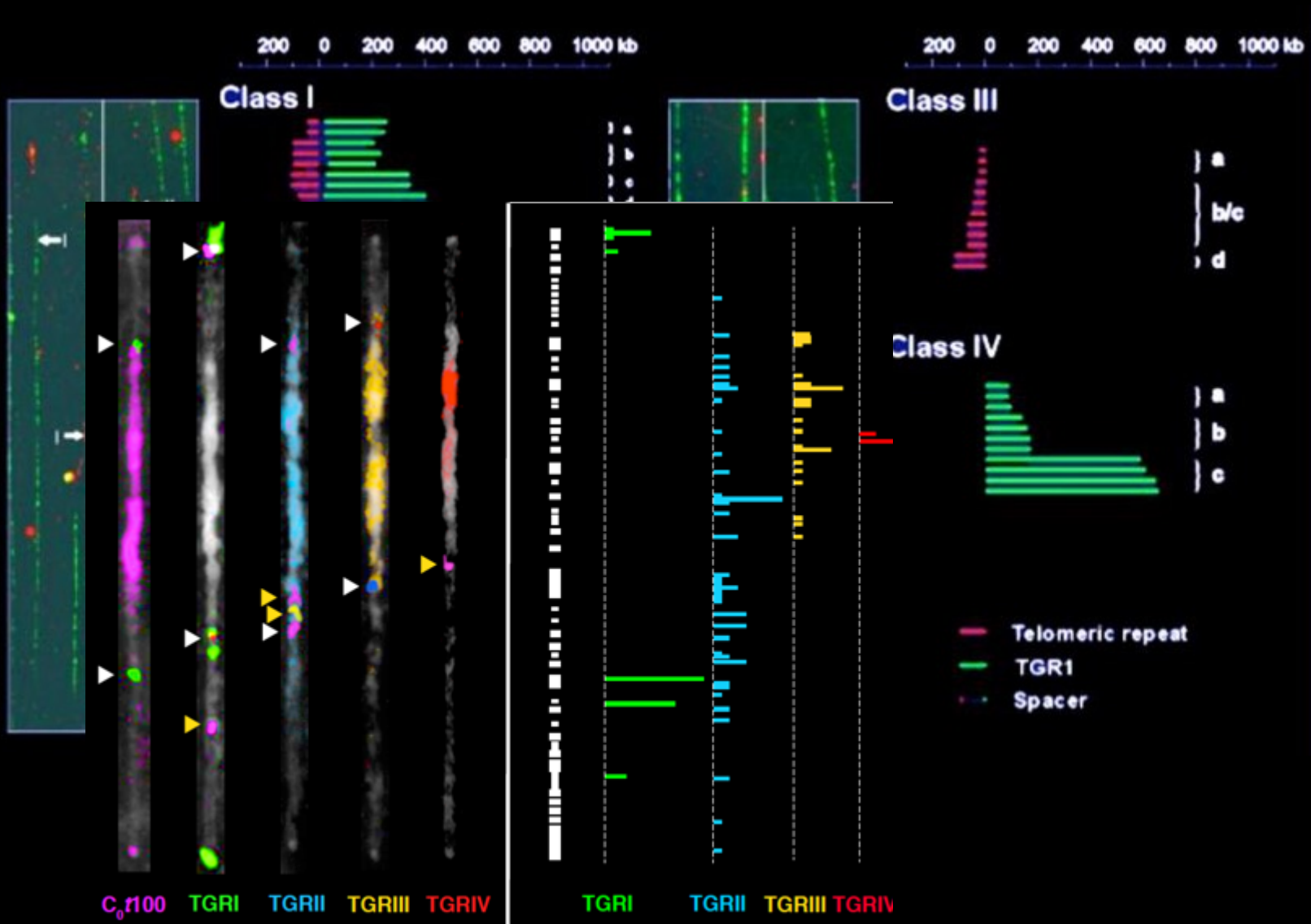changed in order and orientation

**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

Class I

Class III

Class IV

200  0  200  400  600  800  1000 kb

200  0  200  400  600  800  1000 kb

a
b/c
d

a
b
c

Telomeric repeat
TGR1
Spacer

C0r100   TGRI   TGRII   TGRIII   TGRIV

TGRI   TGRII   TGRIII  TGRIV

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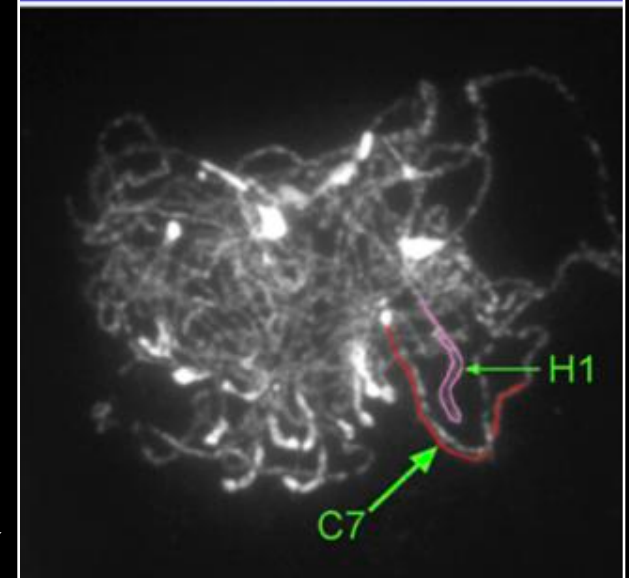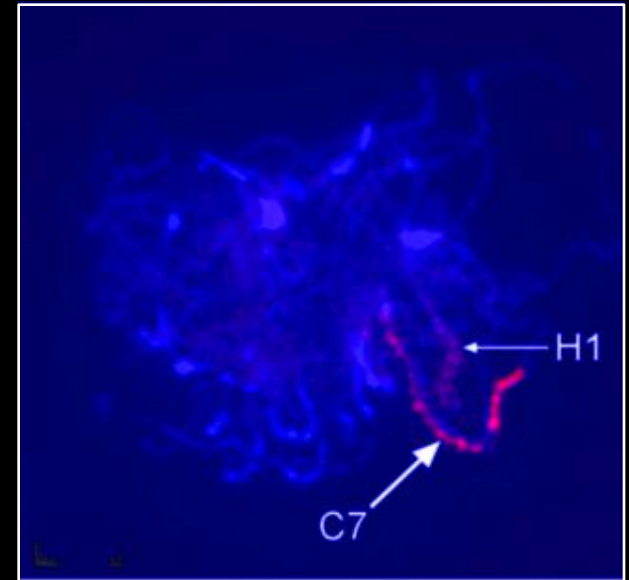Dóra Szinay, José van der Belt, Murielle Phillipot

# Oligo painting
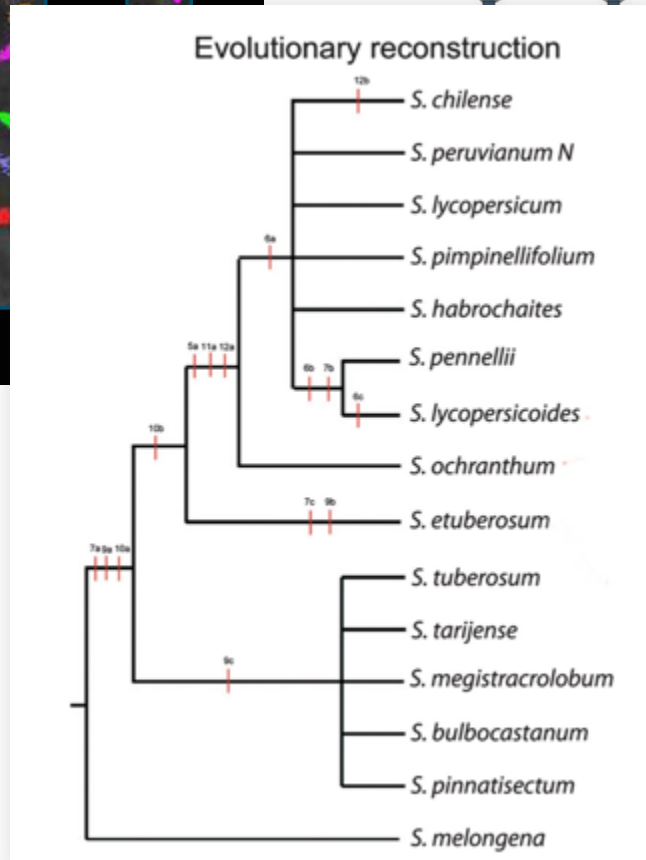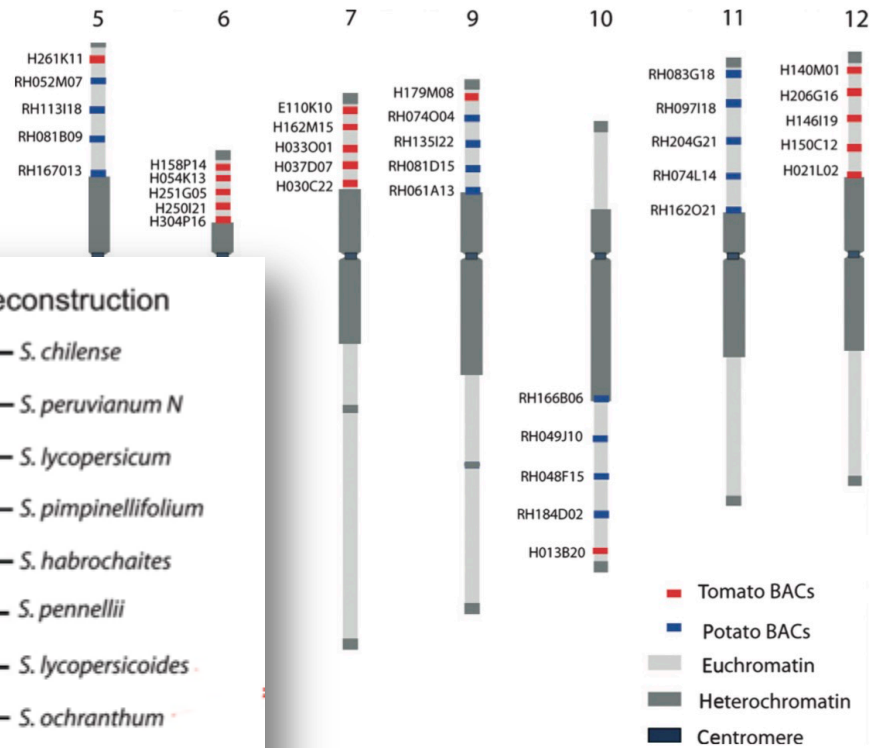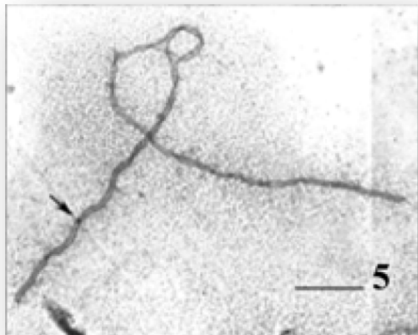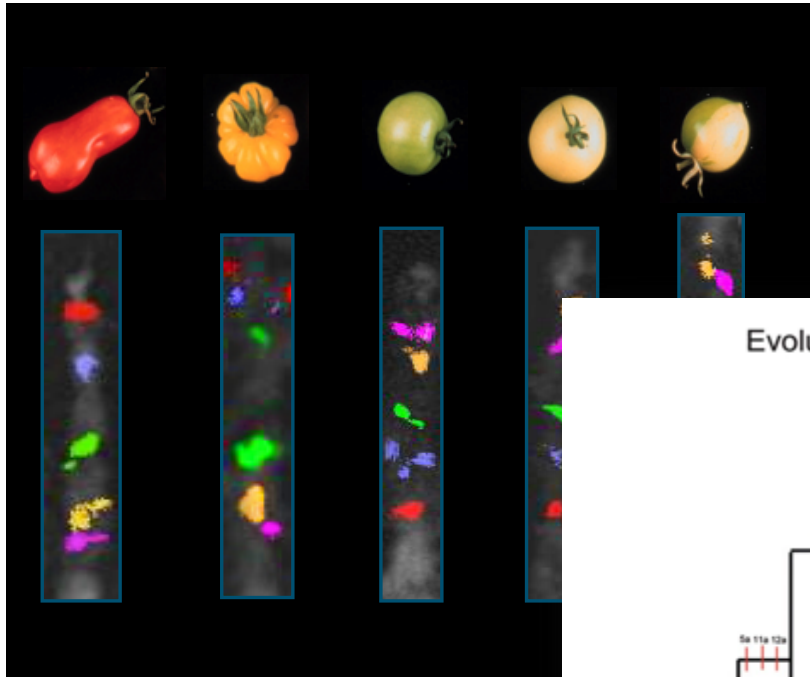# based on sequence data
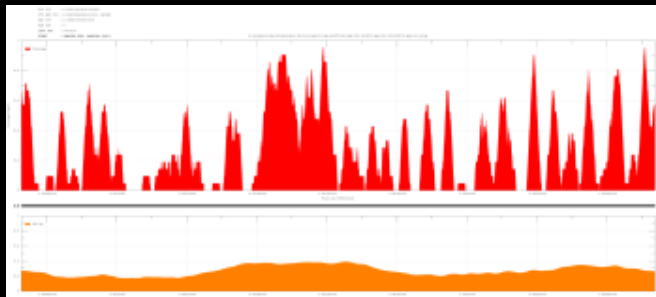


Tomato
chromosome 10

*Cucumis sativus*
x *C. hystrix*
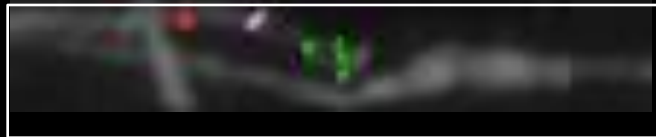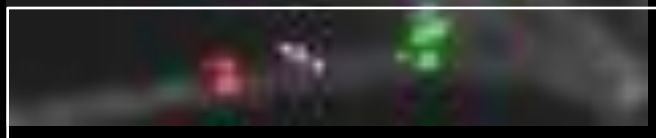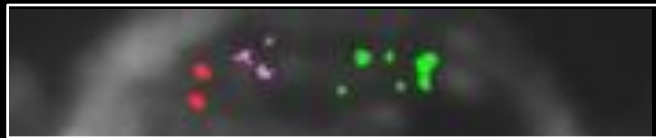
José van der Belt, Saulo Alves Aflitos
Sander Peters,m Dick de Ridder

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

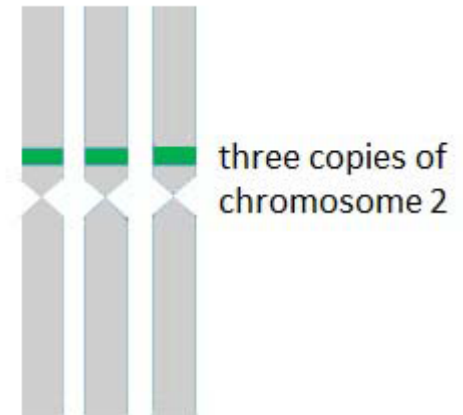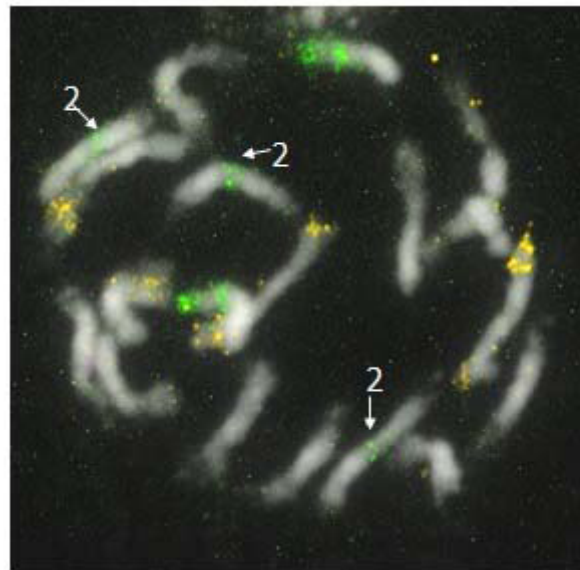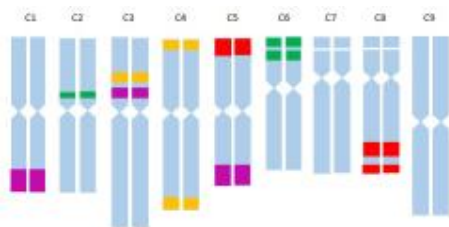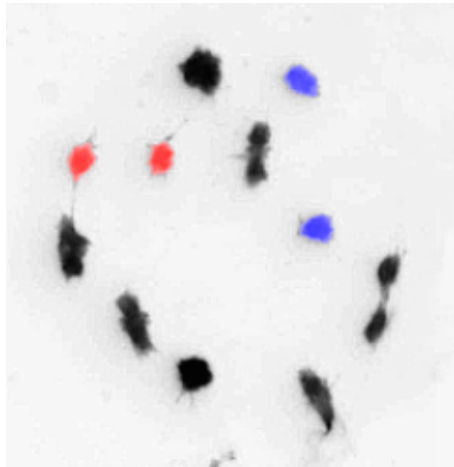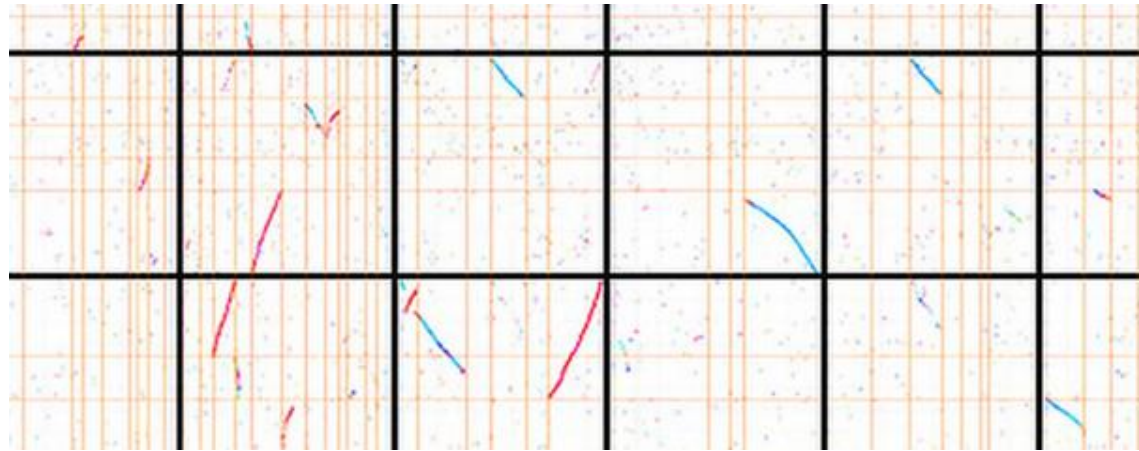# Chromosome evolution in *Solanum* traced by cross-species BAC-FISH



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

# Disturbances meiosis II cauliflower: desynapsis

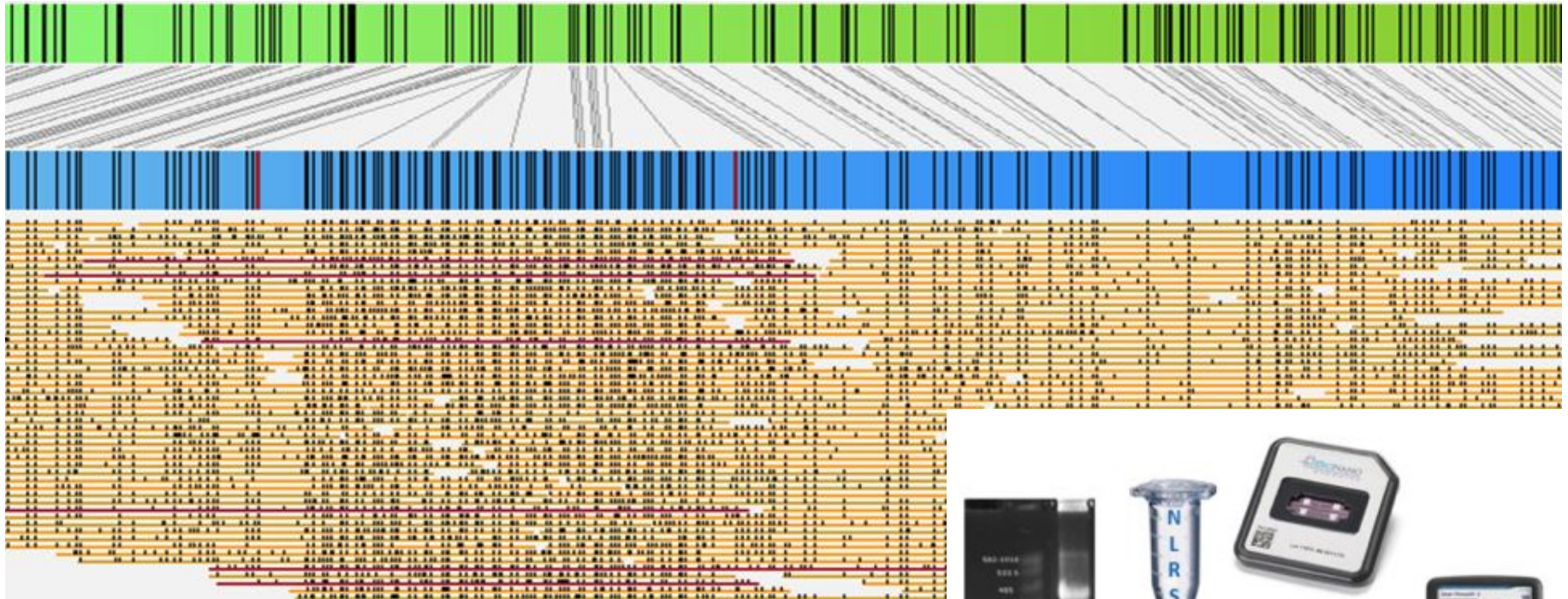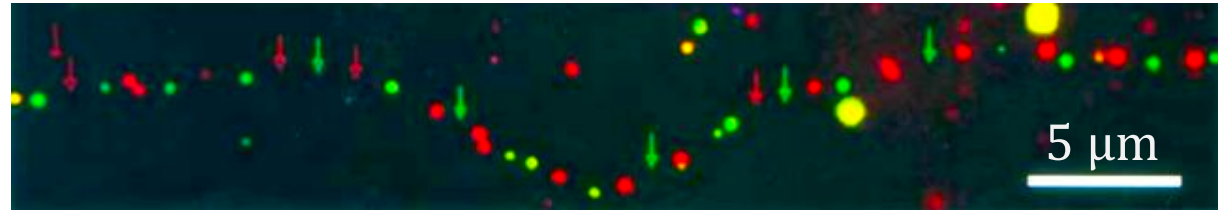Mummerplot shows the genomic relation between Arabidopsis and cauliflower



three copies of chromosome 2

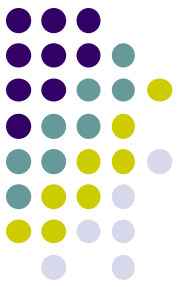# Extended fibre FISH and Optical mapping

1 kb 18S rDNA  🟢

700 bl 25S rDNA  🔴

5 μm

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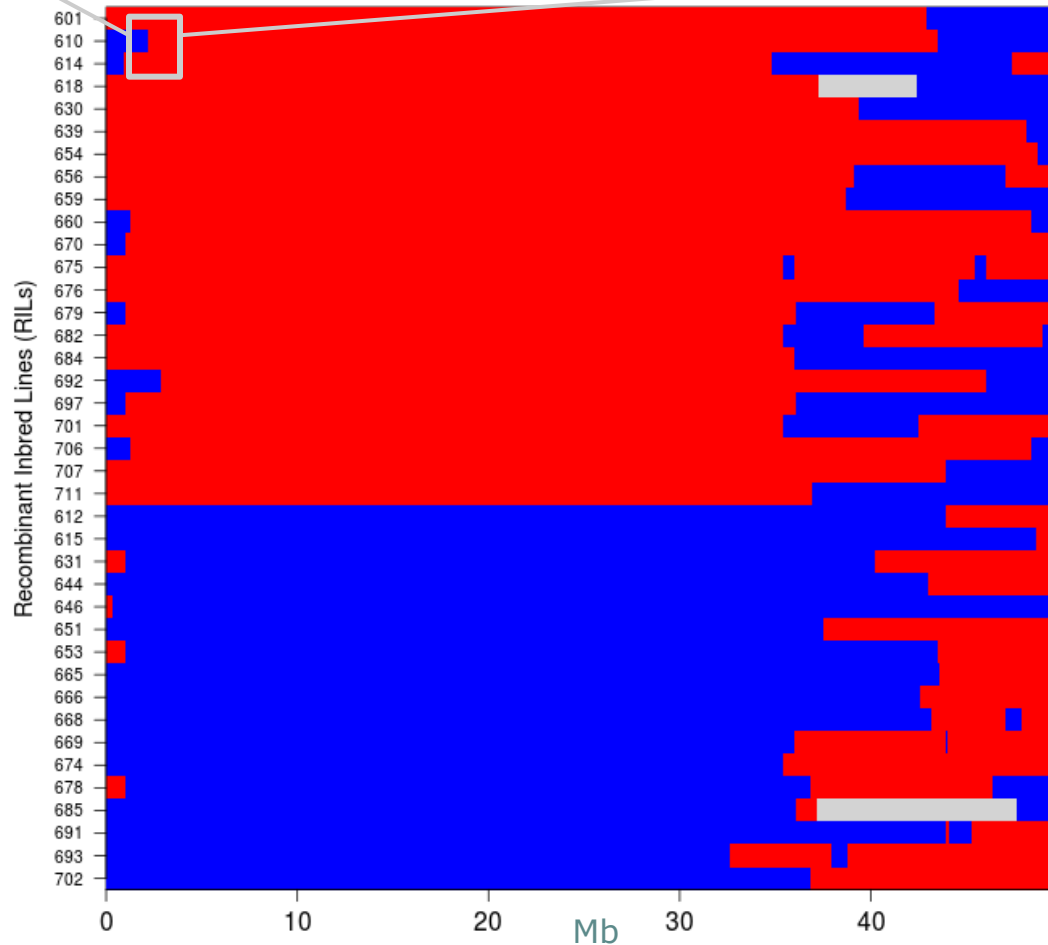Aflitos, Gabino Sanchez-Perez, and Sander Peters

Genetics – cytogenetics – genomics – population studies
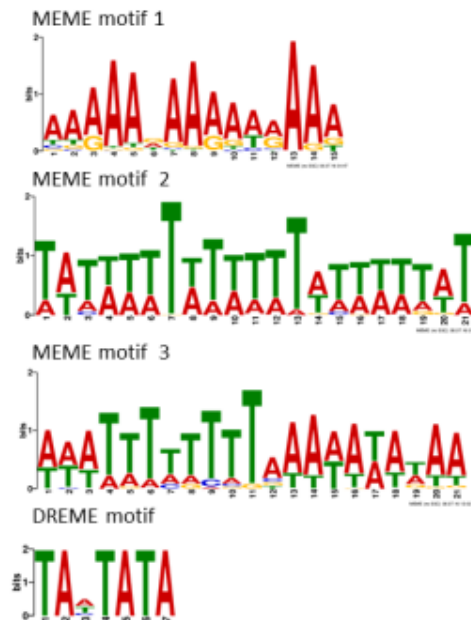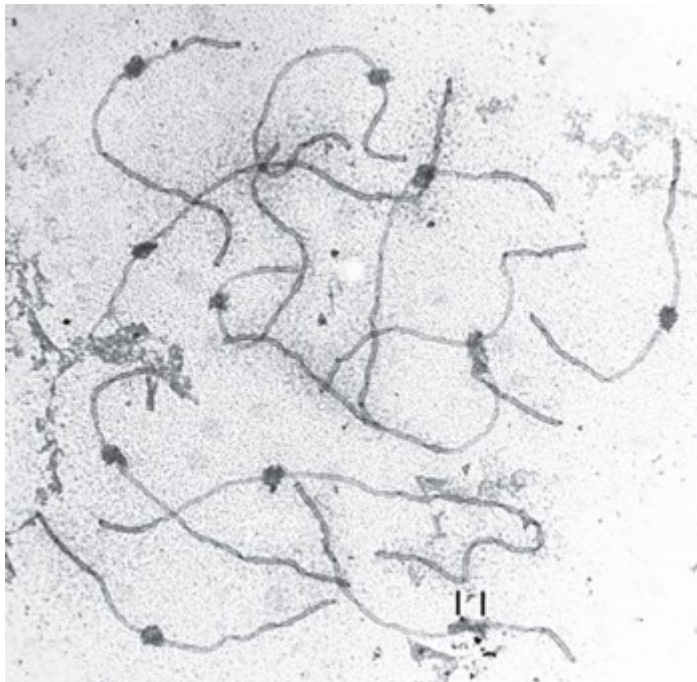
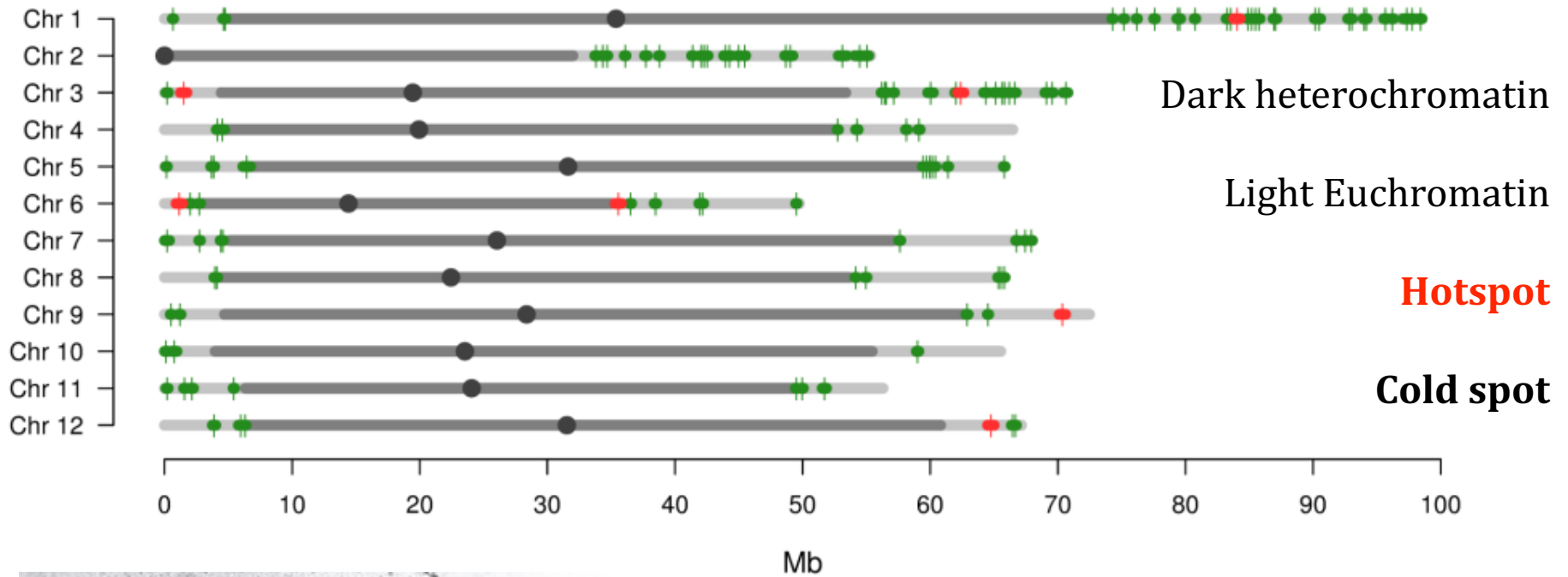# (WILD) RELATIVE TO CROP INTROGRESSIVE HYBRIDIZATIONS

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



AAC**A**TTAC**C**TTGAGTAACGTTT**C**AGGAGT**A**AAAT**G**AAAC  200 SNP window

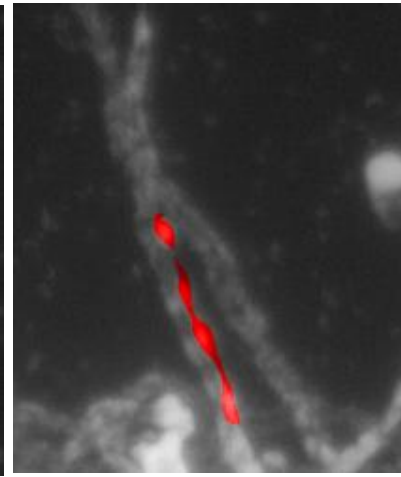Sevgin Demirci, Sander Peters, Dick de Ridder
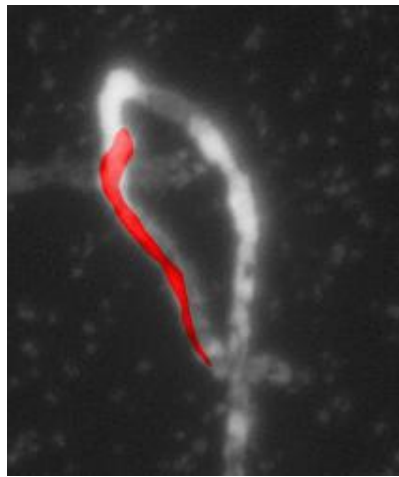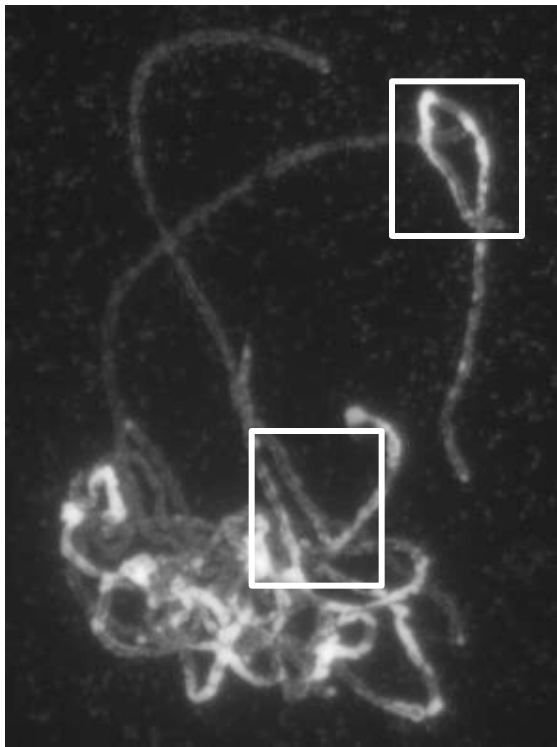
Dark heterochromatin
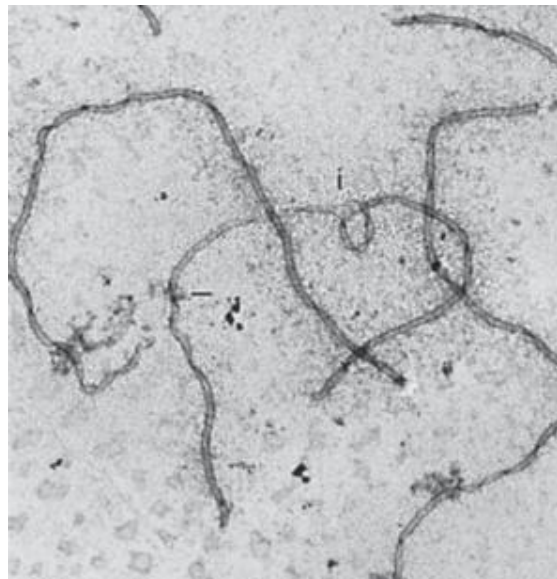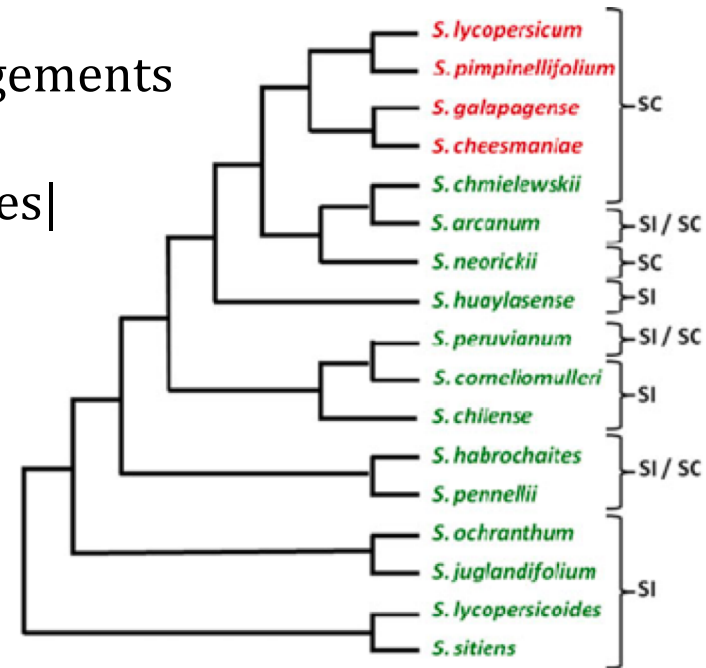
Light Euchromatin

**Hotspot**

**Cold spot**

*Solanum esculentum – pimpinellifolia*
1. Normal pairing as homologues
2. No structural rearrangements
3. Same CO motifs
4. Like tomato heterozygotes

MEME motif 1

MEME motif 2

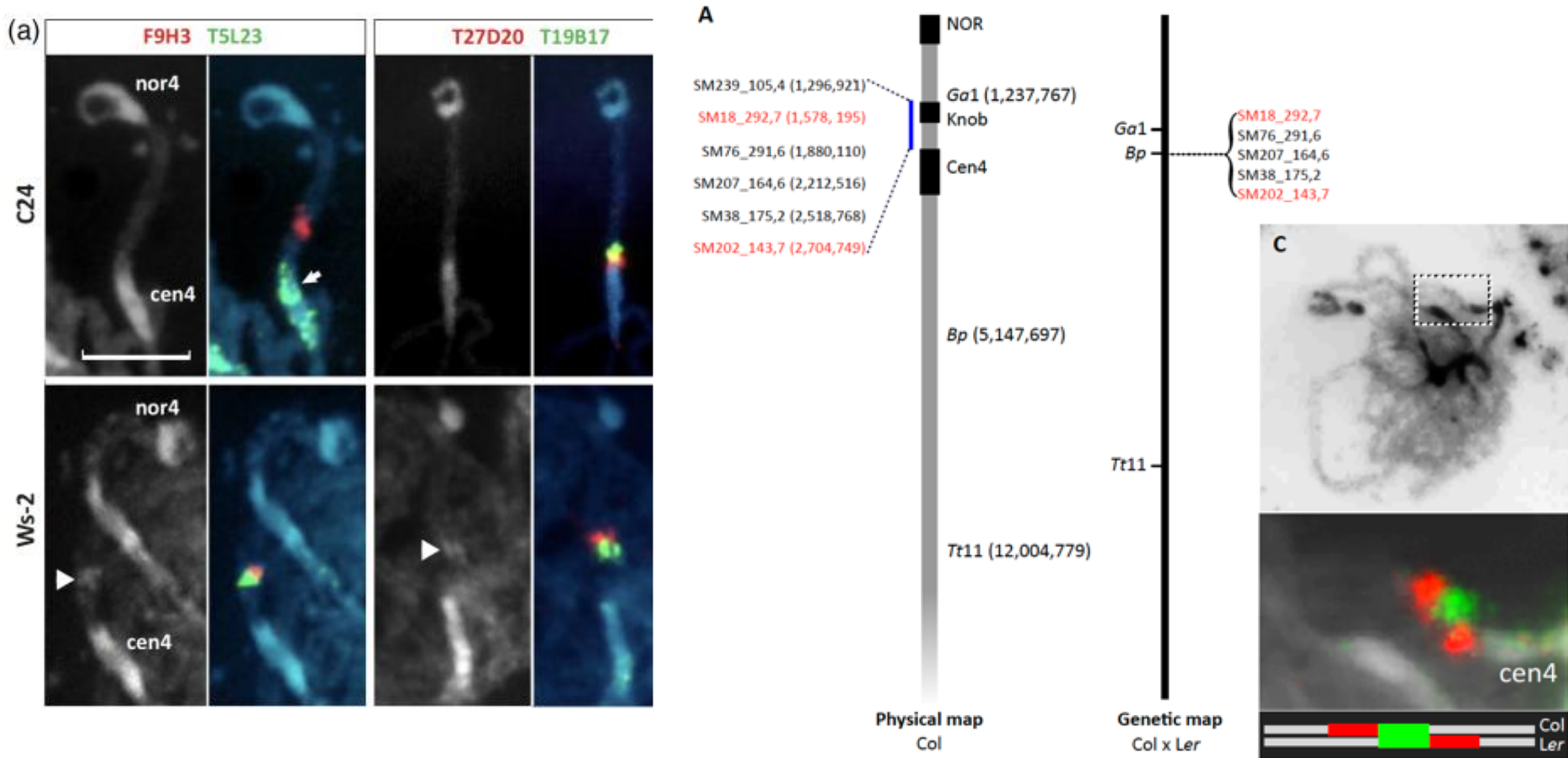MEME motif 3

DREME motif

13

*Solanum lycopersicum* X *S. pennelli*

1. Structural rearrangements

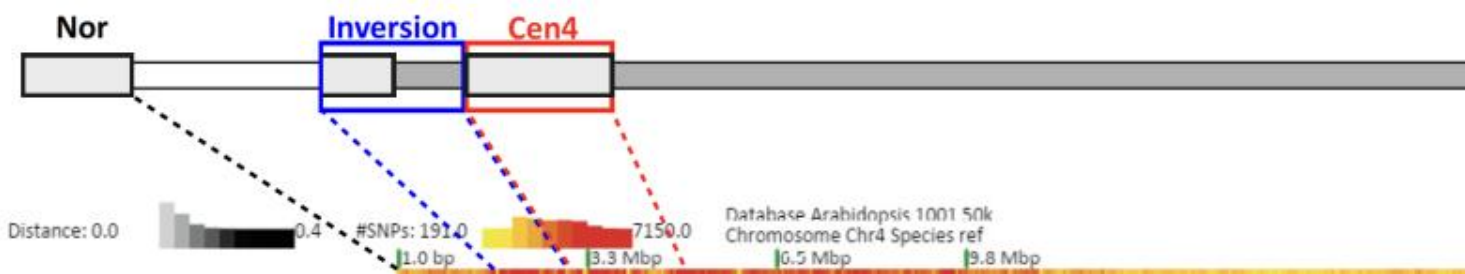2. Meiotic disturbances|

3. Partial sterility

4. Linkage drag

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

15

(a)