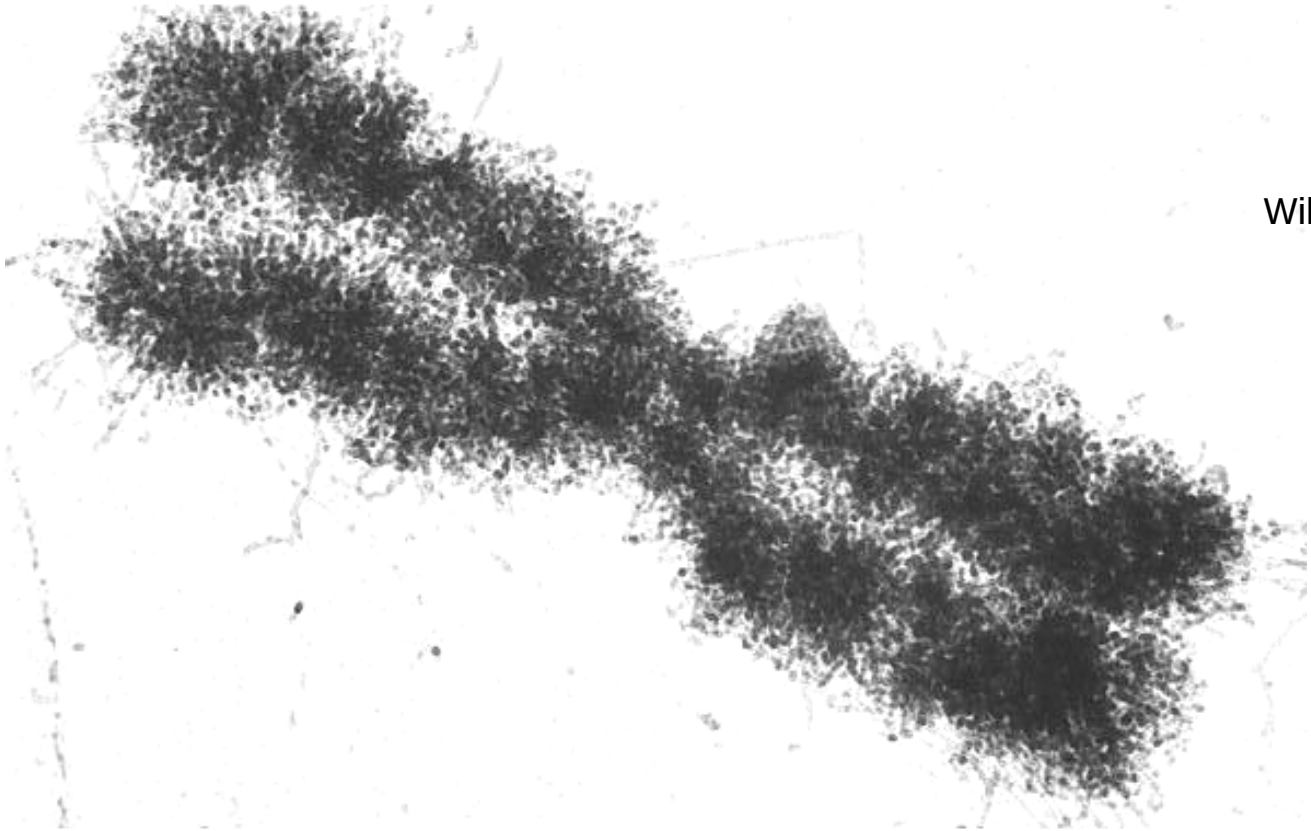
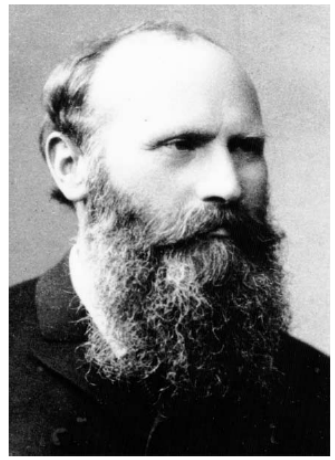
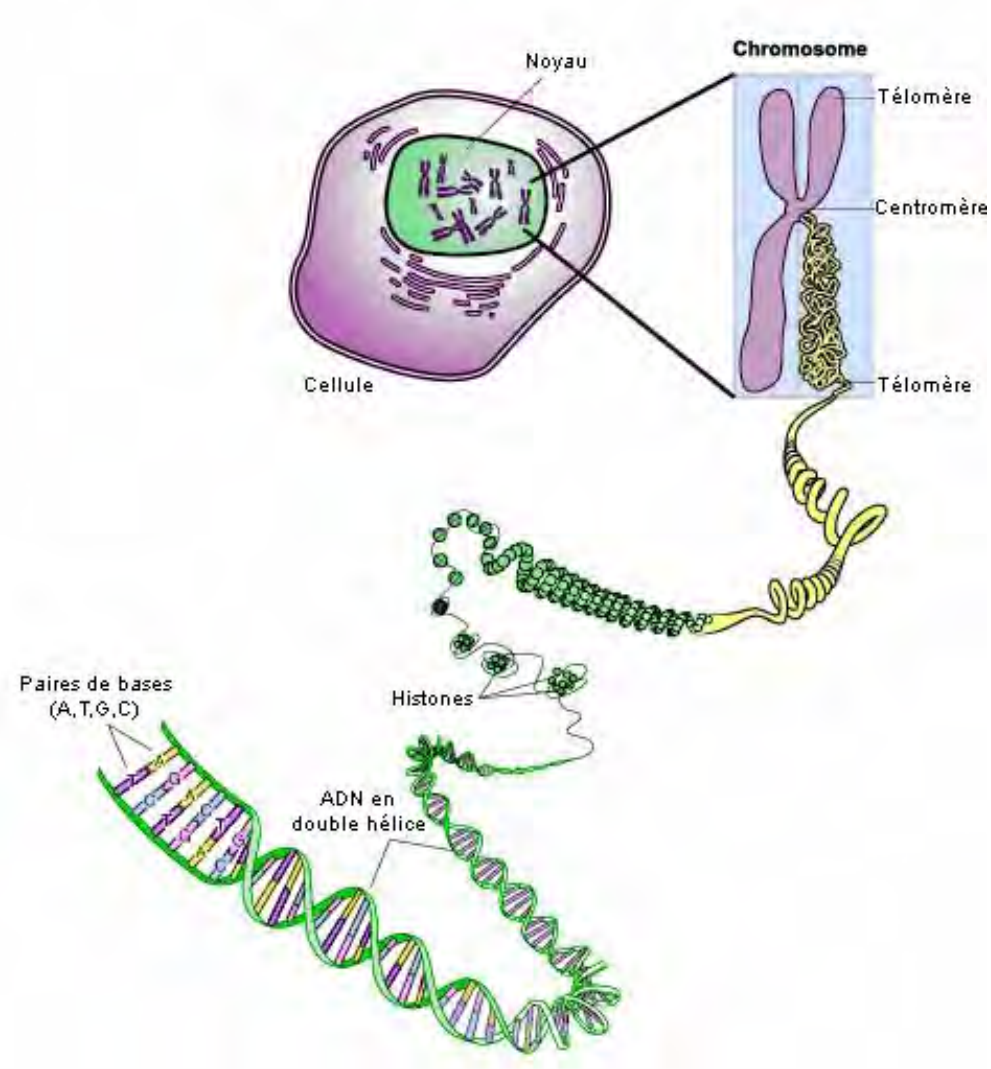
Chromosome



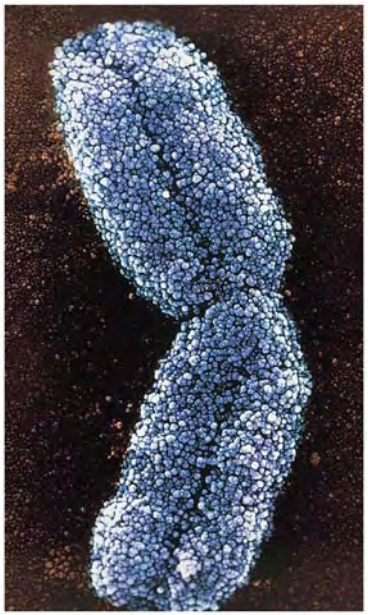


Wilhelm Gottfried Waldeyer
(1836 – 1921)

Basics of chromosome structure



Eukaryotic chromosomes

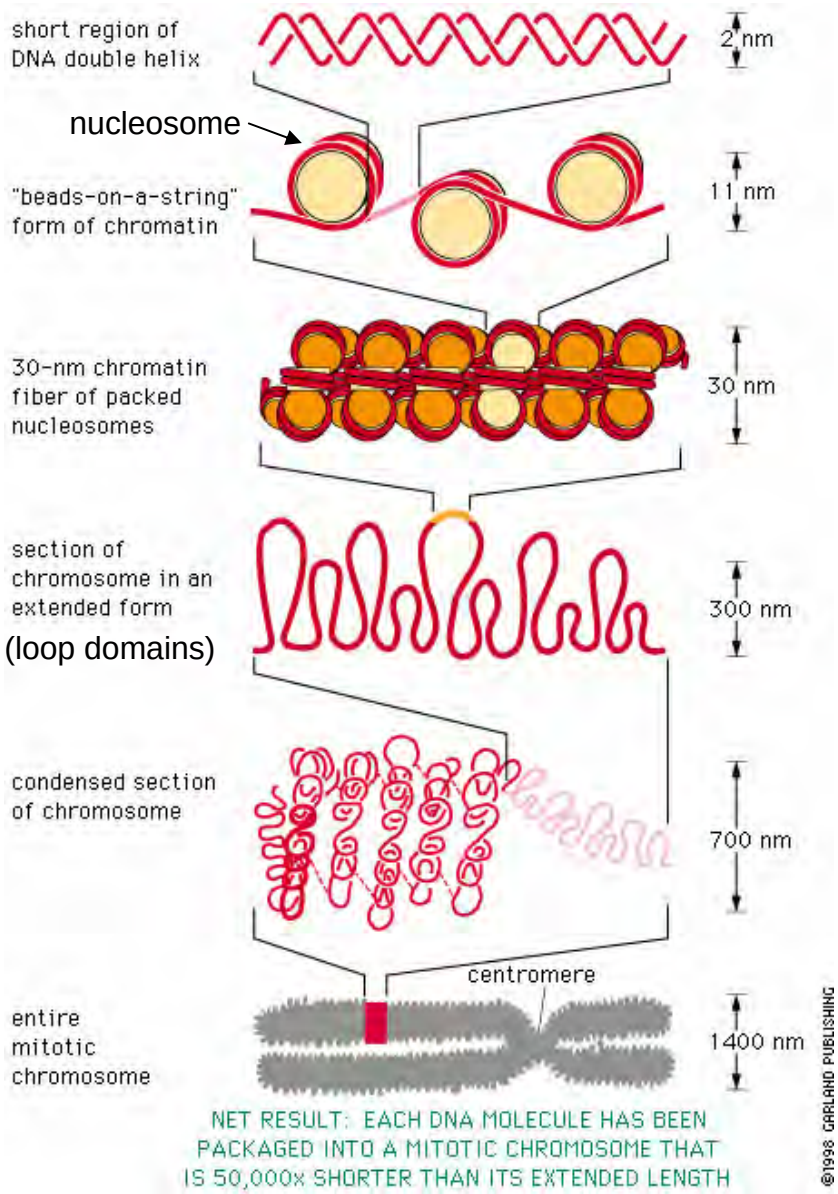


- Usually linear
- Variable in number
- DNA interacts with proteins to form chromatin
- Centromeres ensure segregation
- Telomeres cap ends
- Must be compacted to fit in nucleus

chromatin
(DNA & proteins)

- highly coiled DNA
- histones
- non-histone chromosomal proteins (DNA & RNA polymerase, transcription factors, topoisomerases, histone modifying proteins)

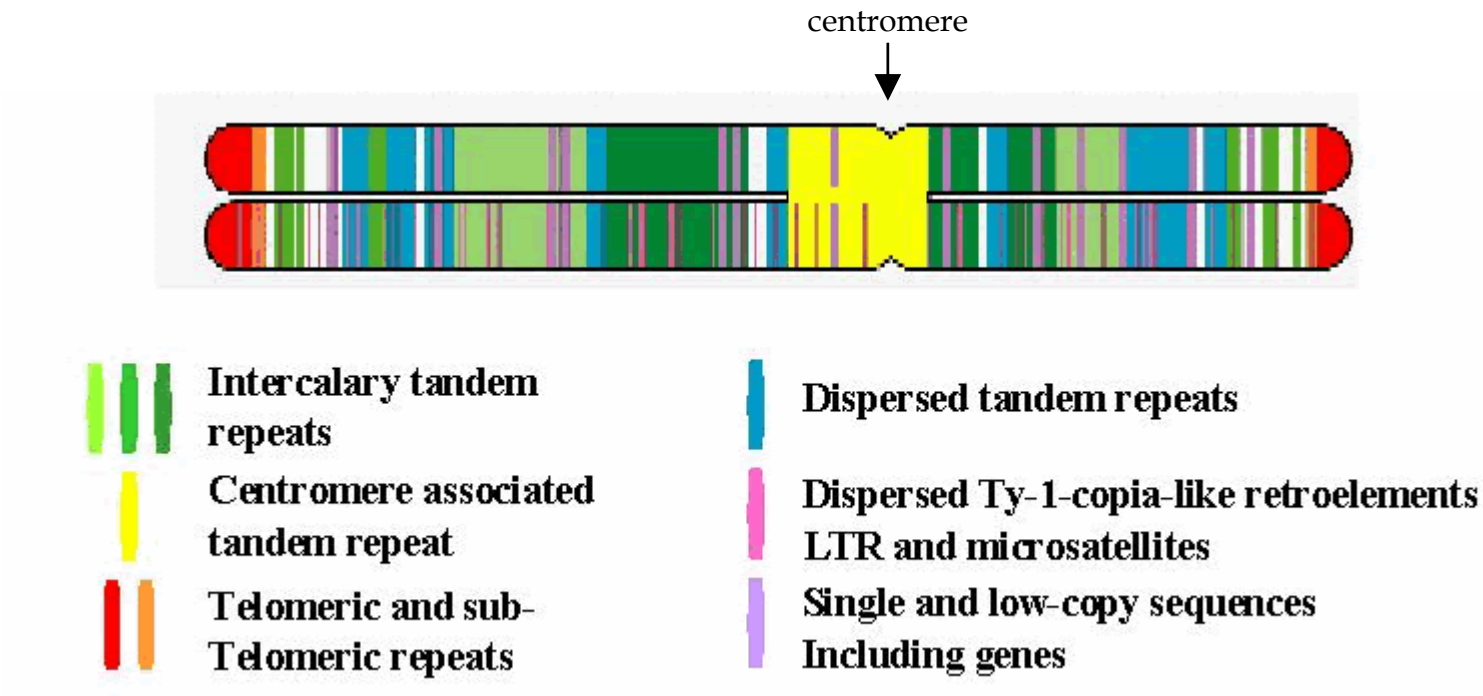
Chromosome packing



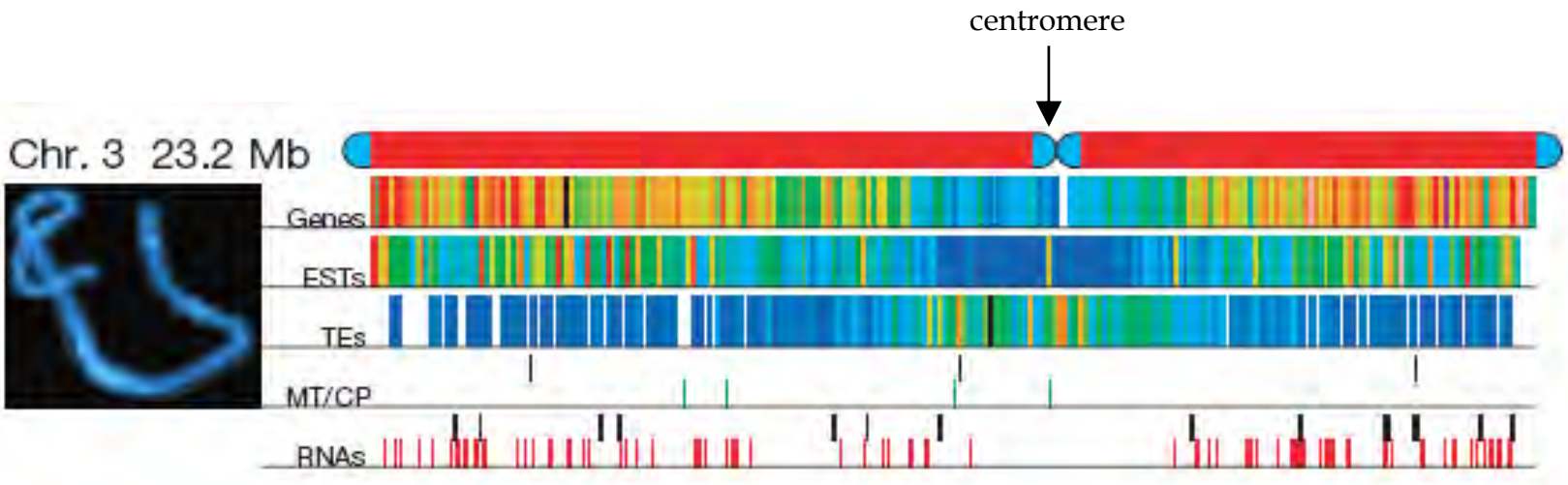
Chromatin structure and gene expression

- Chromatin compaction limits or enhances access to transcription factors
- Accessible chromatin is referred to as euchromatin and is active
- Inaccessible chromatin is called heterochromatin and is generally inactive

Scheme of plant chromosome (after Haslop-Harrison)



Arabidopsis chromosomes

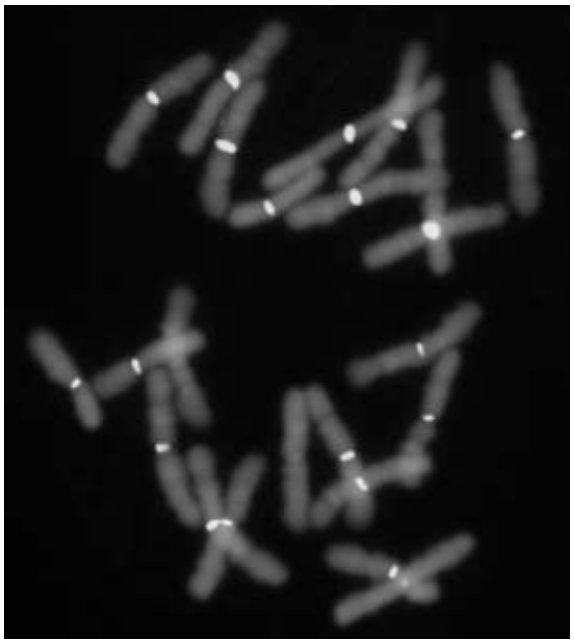


The frequency of features was given pseudo-colour assignments, from red (high density) to deep blue (low density).

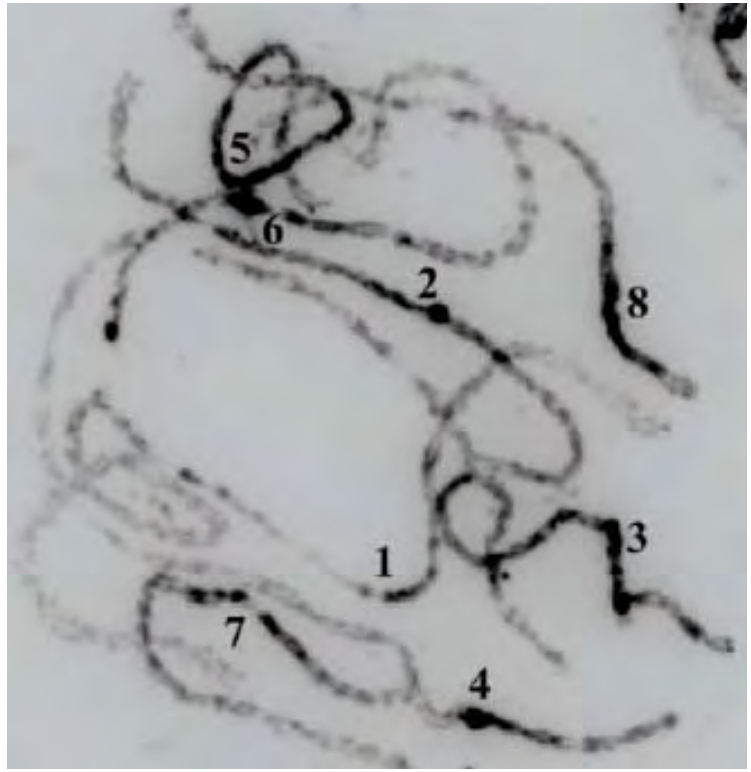
Gene density (`Genes') ranged from 38 per 100 kb to 1 gene per 100 kb; Transposable element densities (`TEs') ranged from 33 per 100 kb to 1 per 100 kb.

Arabidopsis Genome Initiative, Nature 408, 2000

Mitotic and meiotic chromosomes

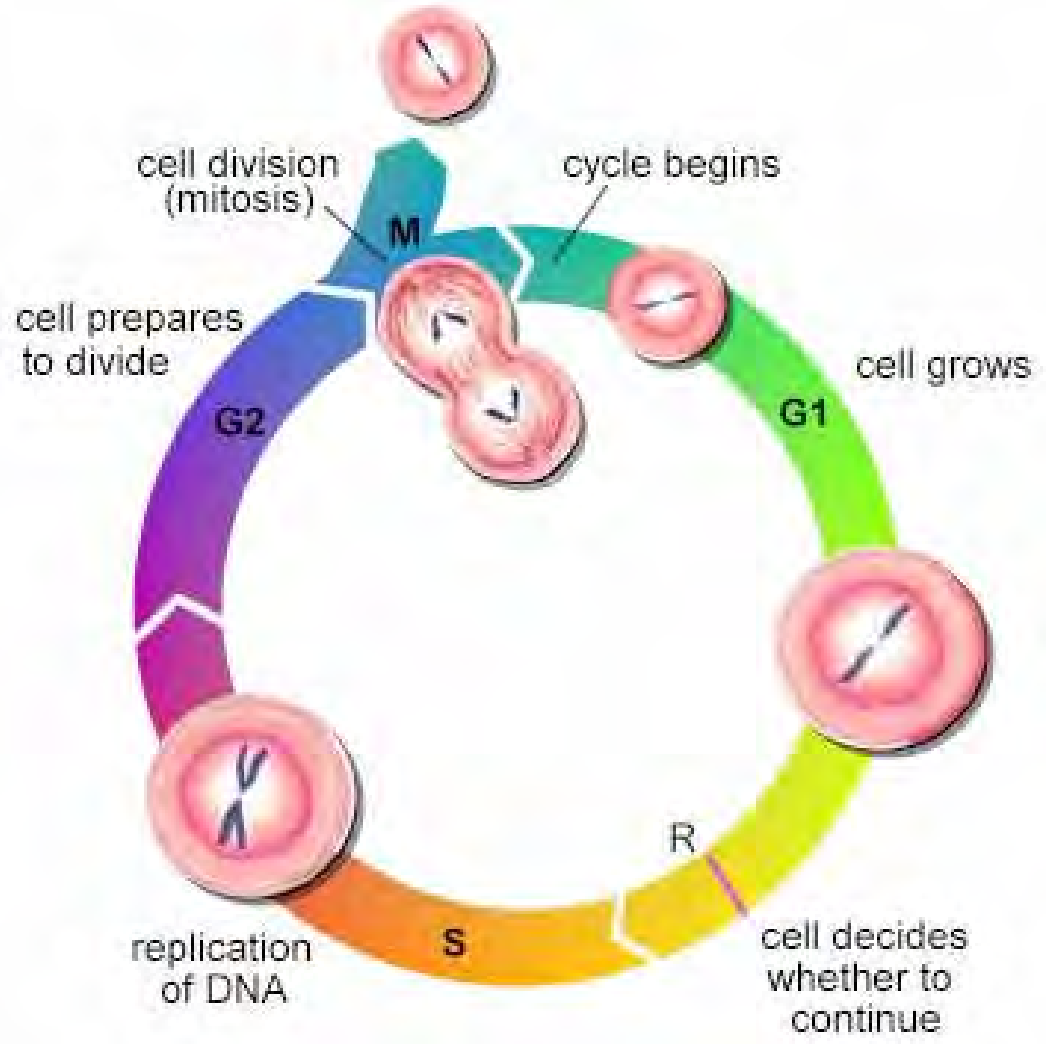


mitotic chromosomes of *Pinus*

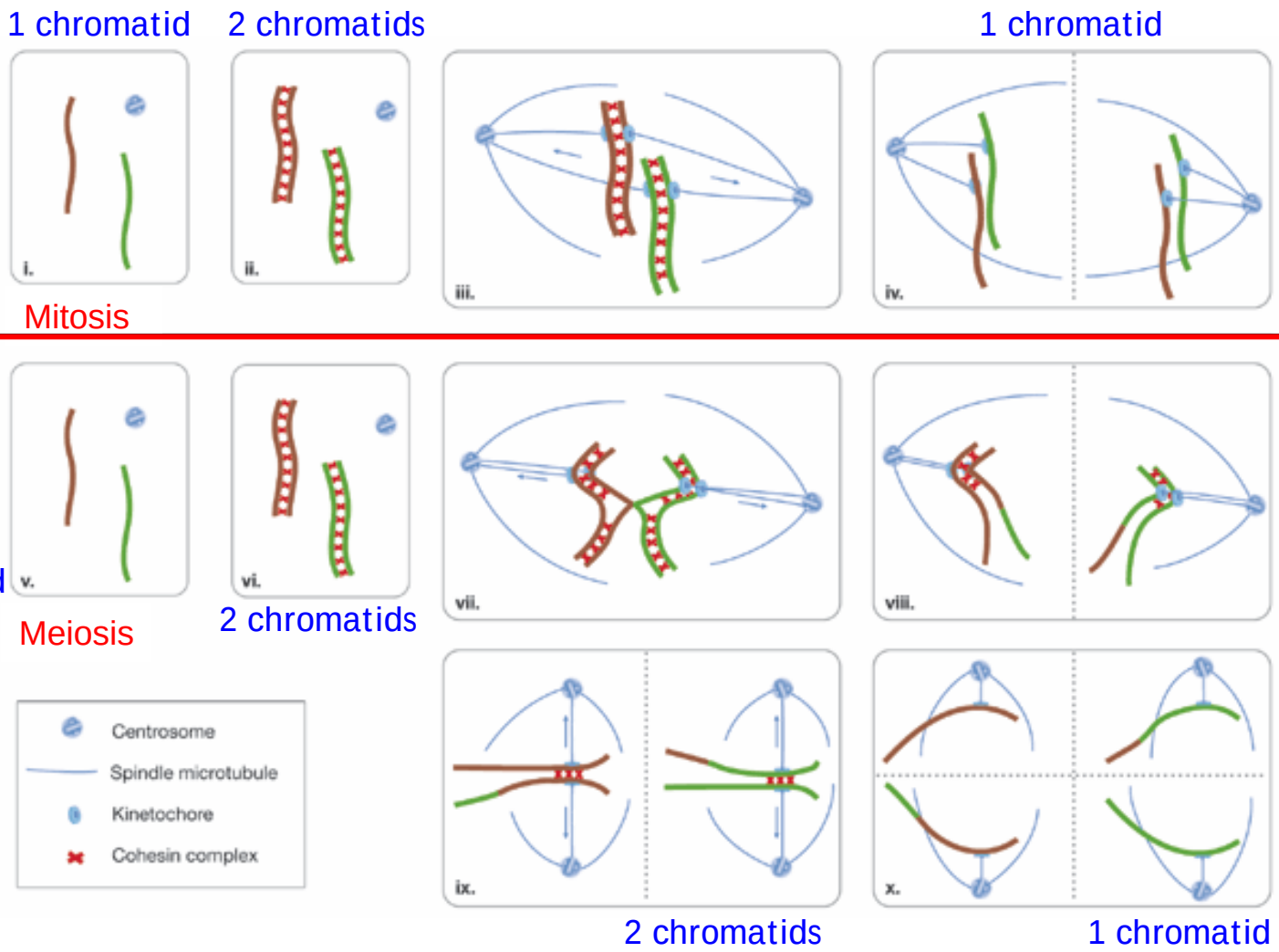


meiotic (pachytene) chromosomes of *Antirrhinum*

Cell cycle, chromosomes and chromatids



Chromosomes and chromatids during mitosis and meiosis



meiosis, DSBs and chromosome rearrangements (next lecture)

Chromatin structure

- Chromatin compaction limits or enhances access to transcription factors
- Accessible chromatin is referred to as euchromatin and is active
- Inaccessible chromatin is called heterochromatin and is generally inactive

Heterochromatin
and heterochromatic knobs

knob ◆◇◇◇◇

1 **knob** **knobs**

A **knob** is a round handle on a door or drawer which you use in order to open or close it.

He turned the knob and pushed against the door.

N-COUNT

2 **knob** **knobs**

A **knob** is a rounded lump or ball on top of a post or stick.

A loose brass knob on the bedstead rattled.

N-COUNT

3 **knob** **knobs**

A **knob** is a round switch on a piece of machinery or equipment.

...the volume knob.

N-COUNT

4 **knob** **knobs**

A **knob of** butter is a small amount of it. (mainly BRIT)

Top the steaming hot potatoes with a knob of butter.

N-COUNT: N *of* n

Het knobs are located on chromosomes:

a) terminally

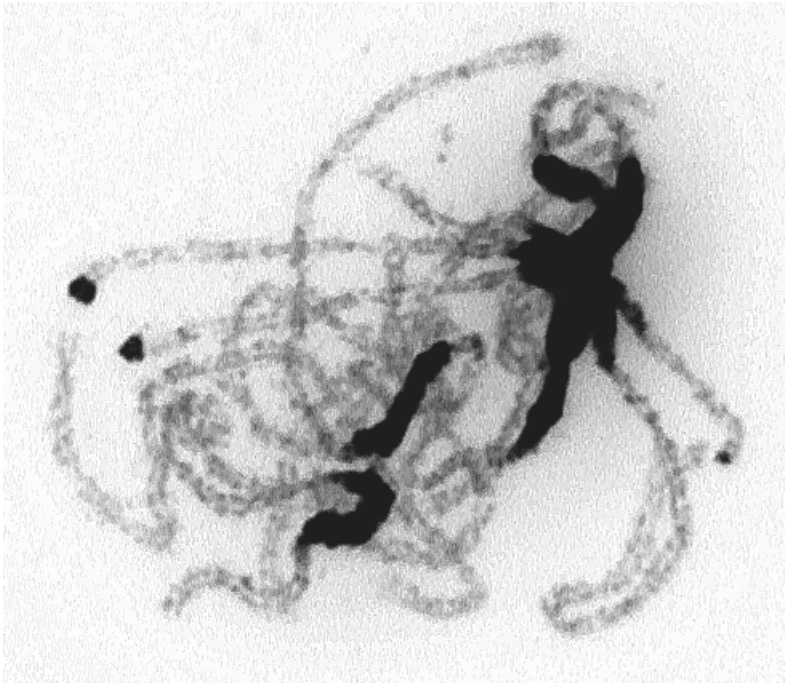
b) insterstitially

c) at pericentromeres

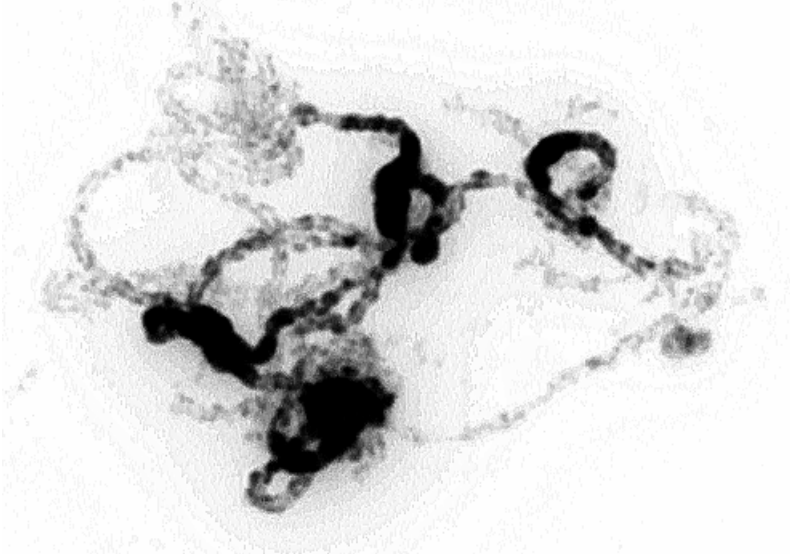
meiotic (pachytene) chromosomes of *Antirrhinum*

Het knobs in *Brassicaceae* species

Myagrum perfoliatum



Thellungiella halophila



Mandáková & Lysak (2008), Plant Cell

Het knobs

- ? origin
- ? composition
- ? function (if any)

Het knobs were discovered by McClintock in maize

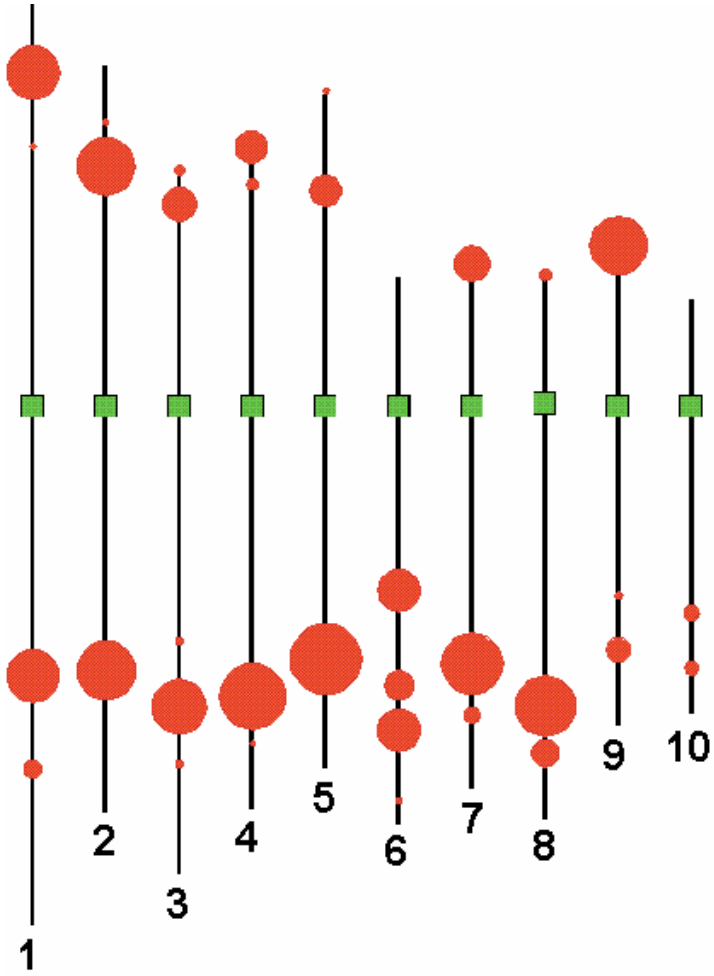
Barbara McClintock
(1902-1992)

America's most distinguished cytogeneticist, was initially denied acceptance to Cornell University's Dept. of Plant Breeding because she was a woman. Eventually allowed to study plant genetics, McClintock received her Ph.D. from Cornell in 1927, and later formulated one of the most important genetic theories of the 20th century.

McClintock B (1929) Chromosome morphology in *Zea mays*. *Science* 69

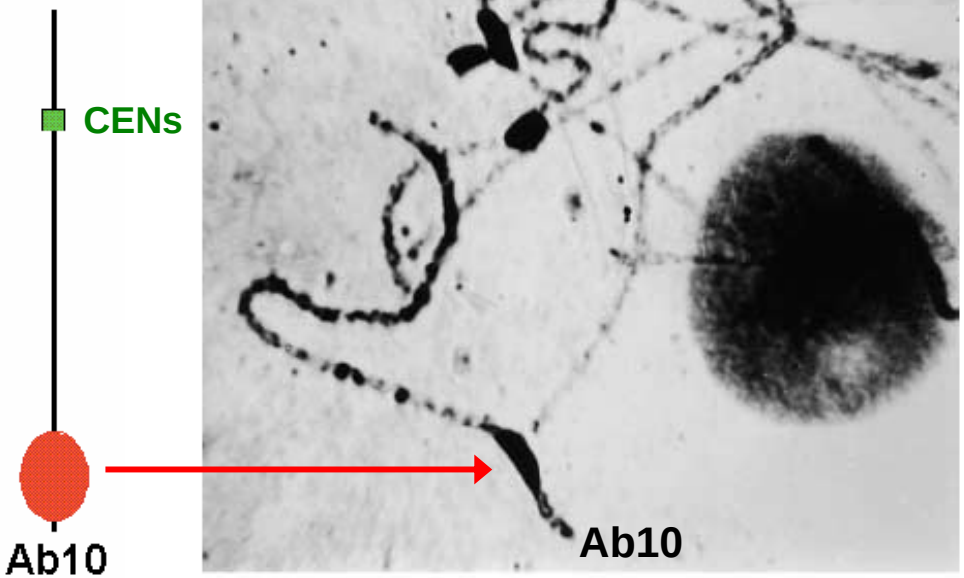
Het knobs in maize

- knobless and knobb-bearing accessions
- the number, size and position of knobs are variable and they are found in 23 locations on the ten maize chromosomes



abnormal chromosome 10

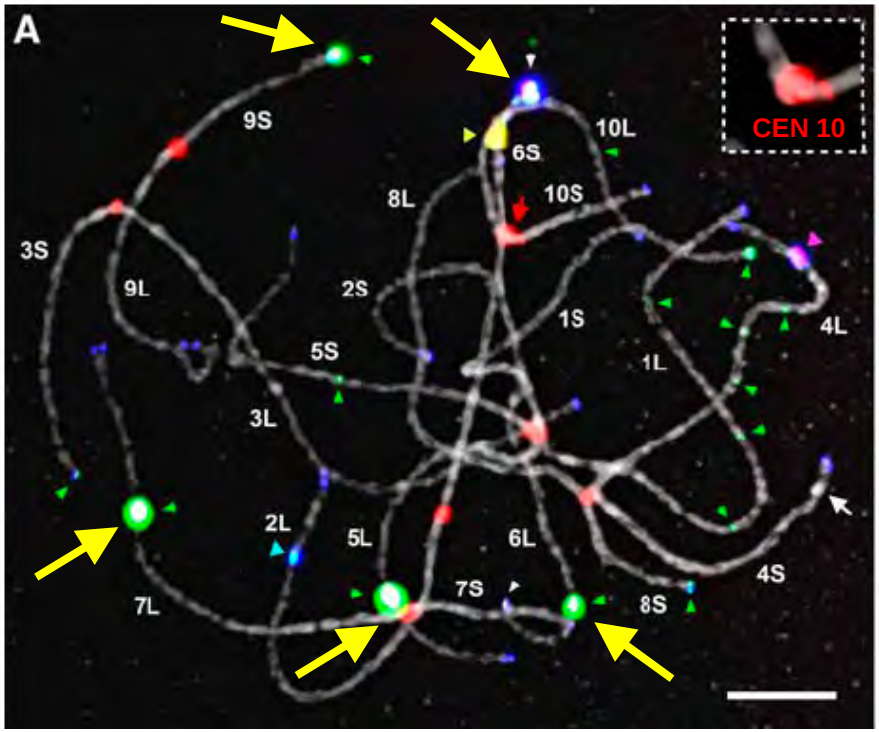
(discovered by Albert Longley; 1937, 1938)



Rhoades 1952

Het knobs in maize

the 180-bp and TR-1 (350-bp) tandem repeats are the major components of knob heterochromatin (Peacock et al. 1981, Ananiev et al. 1998) + different retrotransposons



mFISHed pachytene chromosomes of the Kansas Yellow Saline (KYS) inbred line

180-bp repeat (green)

TR-1 element (pink)

Wang et al. 2006, *Plant Cell* 18

Meiotic drive (transmission distortion)

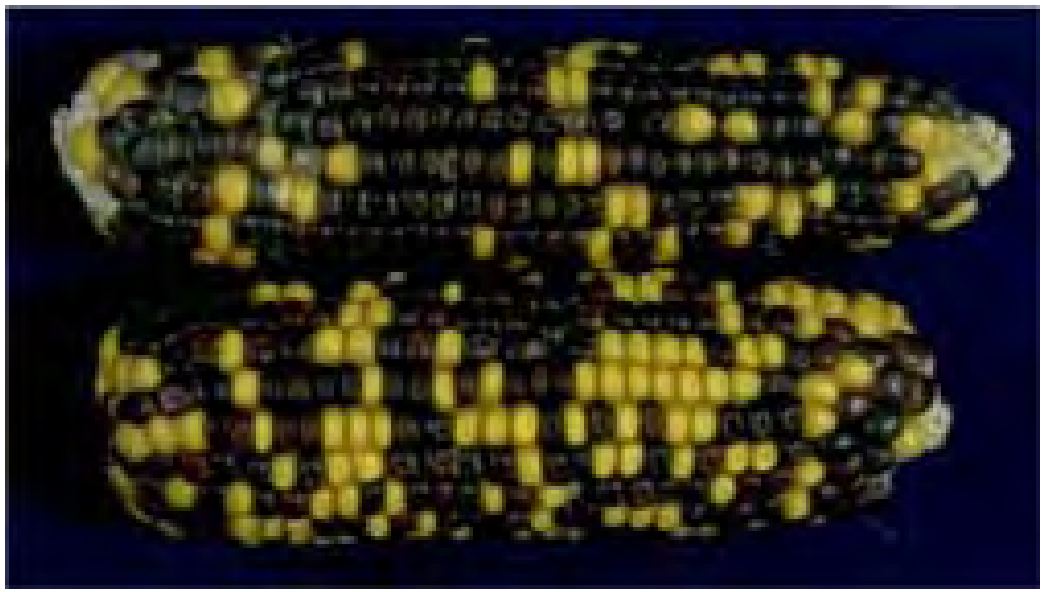
described by **Marcus Morton Rhoades**

Rhoades MM (1942) Preferential segregation in maize. *Genetics* 27: 395–407.

Birchler et al. 2003, *Genetics* 164

Meiotic drive

The ability of one homolog to enhance its probability of transmission at the expense of its partner (e.g. in Aa heterozygote, A-bearing gametes are produced more frequently than a-bearing gametes).



preferential transmission of the Ab 10 chromosome

the 1:1 segregation (normal chromosome 10)

Meiotic drive in maize

Preferential transmission of the knob-bearing chromosomes during female meiosis. But only if the Ab 10 chromosome is present.

heterozygote for Ab 10

↓

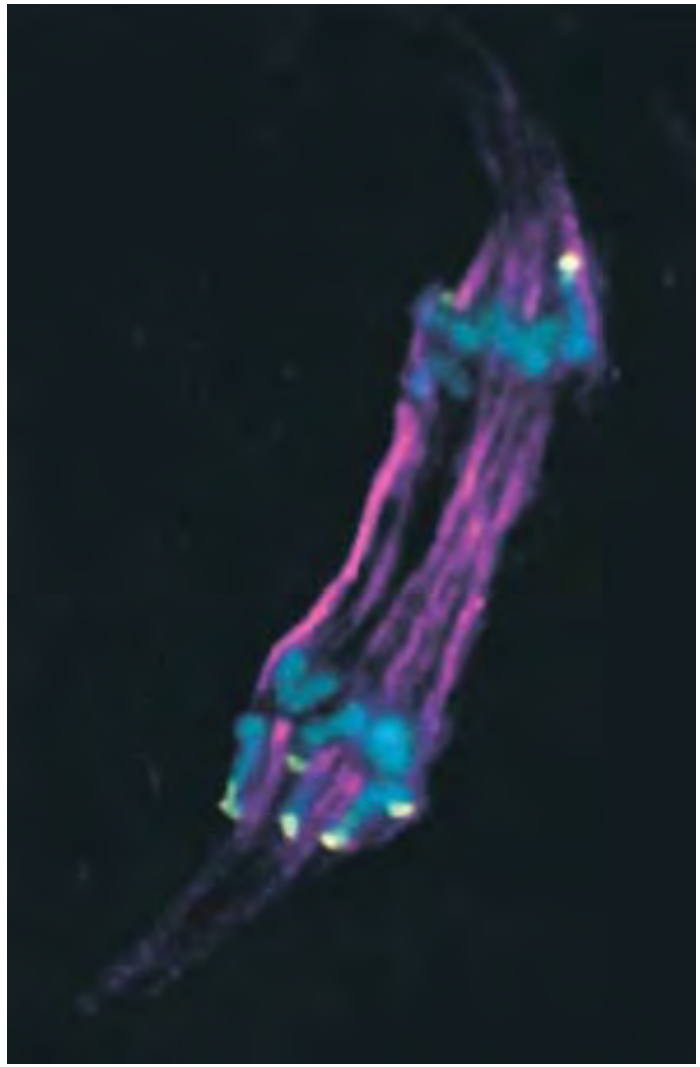
crossing-over located between the knob and centromere

↓

cross-over products that carry the knob on only one of its two chromatids (heteromorphic dyad)

↓

pseudokinetochore activity of the knob direct the knob-bearing chromatide to one of the four products of meiosis II, which is one of the two "outside" nuclei, and the only one that is available for fertilization



Birchler et al. 2003, *Genetics* 164

Megasporogenesis and meiotic drive in maize

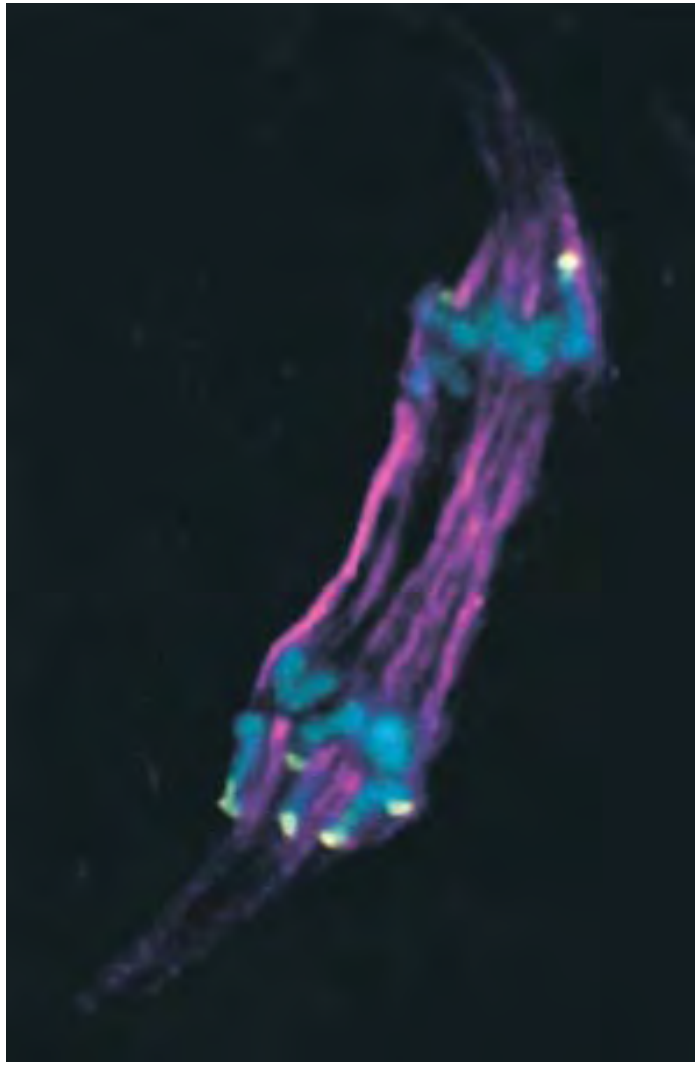
Female meiosis (megasporogenesis) is asymmetric:

-out of 4 haploid products only one will become the egg; other three degenerate

- **the outermost (basal) megaspore** differentiates into the megagametophyte via a few mitoses to produce the egg, polar nuclei, and associated cells

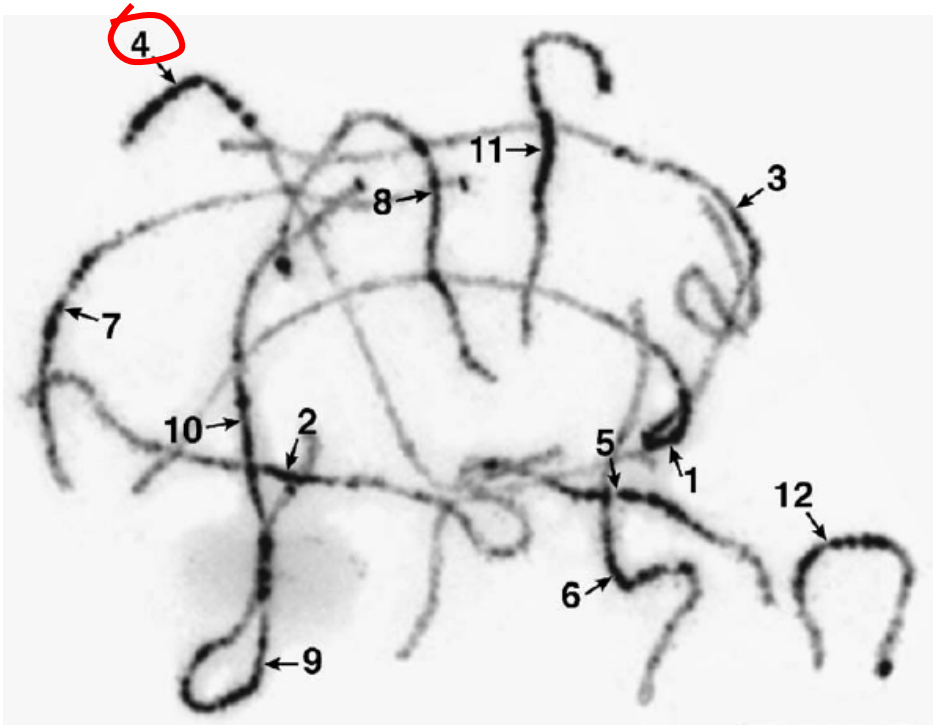
Knob-bearing chromatids are pulled towards the **outermost megaspores** during meiosis II ahead of the centromeres.

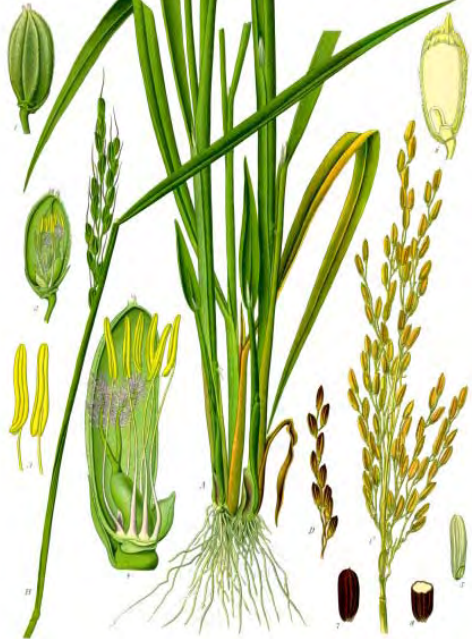
Consequently, instead of a 50% expected ratio of transmission in a heterozygote, knob transmission in female meiosis varies from 59 to 82%.



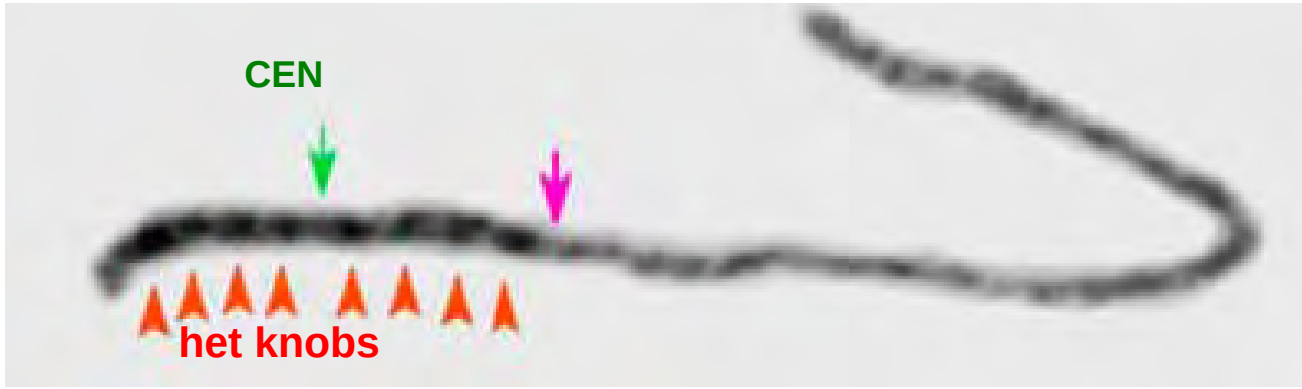
Birchler et al. 2003, *Genetics* 164

Het knobs in rice



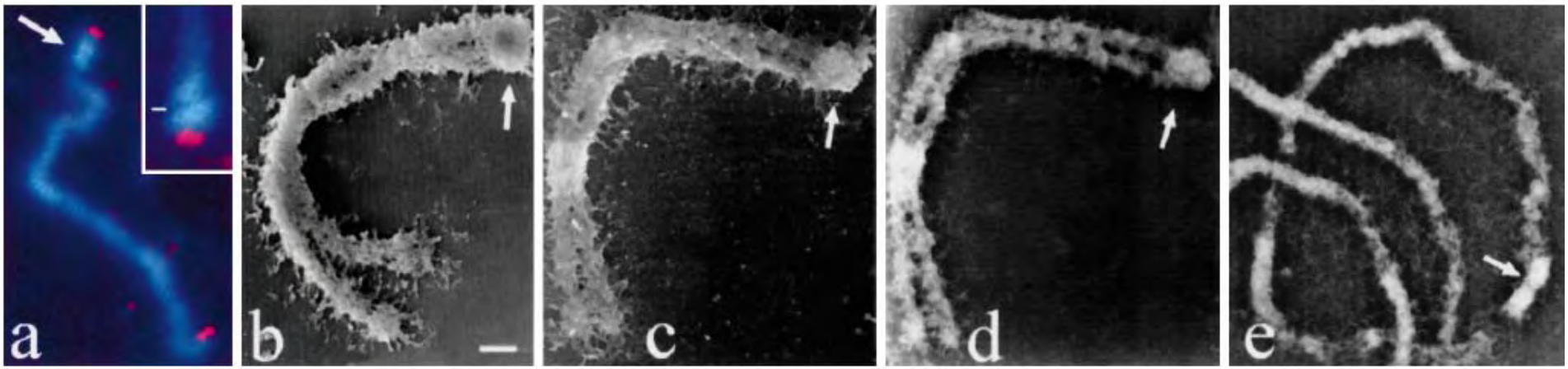


rice chromosome 4



Jiao et al. 2005, *Plant Cell* 17

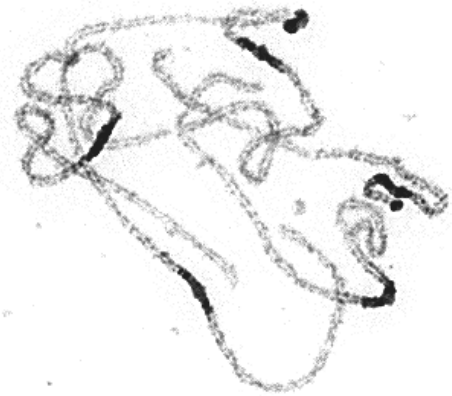
Heterochromatic segment 1 found in *Brachycome dichromosomatica* (*Asteraceae*)



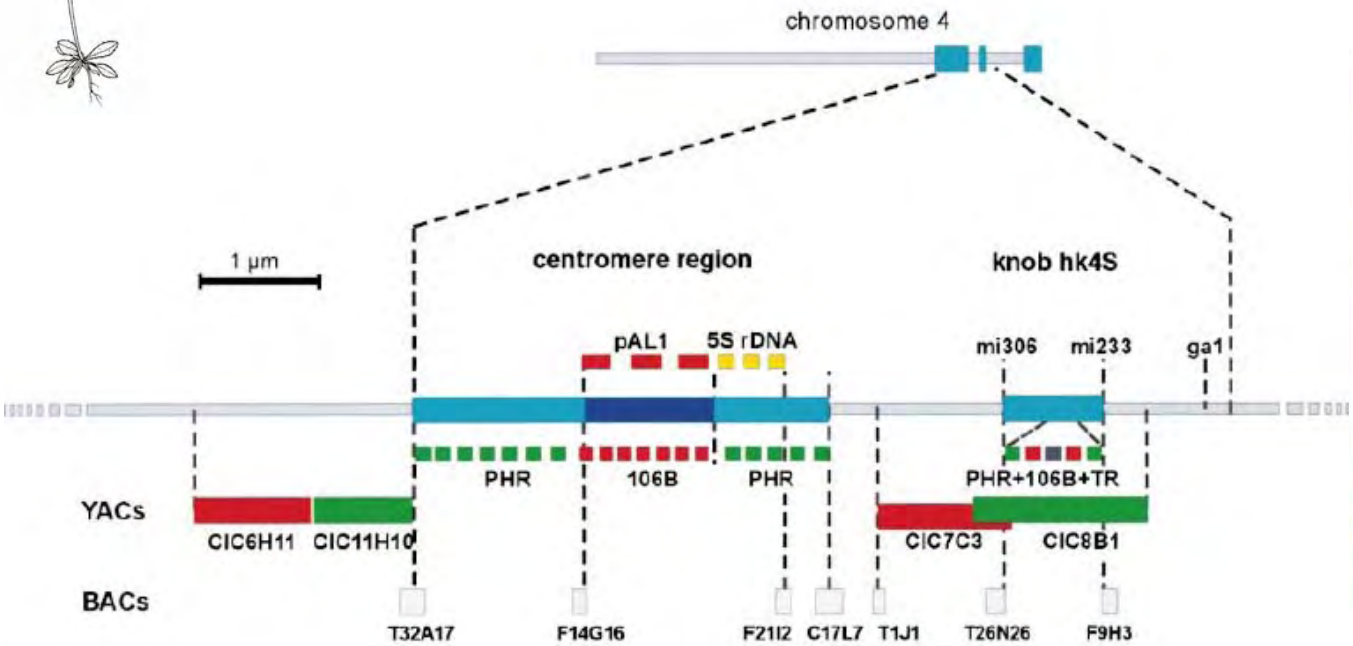
The terminal knob contains the Bds1 tandem repeat.

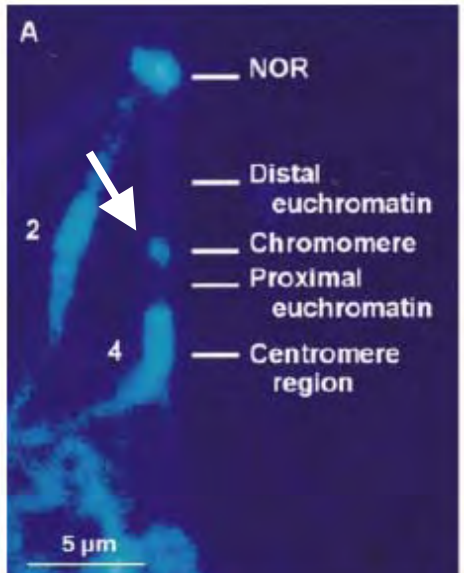
Houben et al. 2000, *Chromosoma* 109

Het knob hk4S in Arabidopsis



The hk4S originated by an inversion event that relocated pericentromeric sequence to an interstitial position.





Fransz et al. 2000, *Cell* 100

"Just get in the lab and start to work; you can't help but find something."

Marcus Rhoades