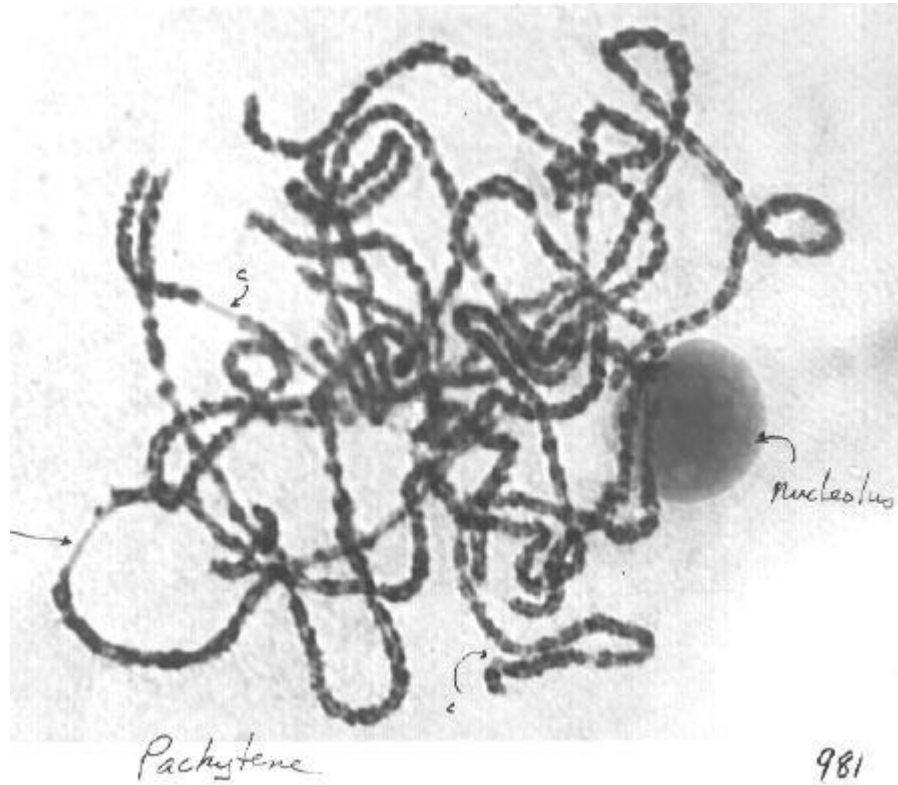


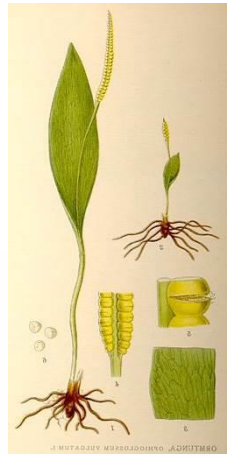
Meiosis and mitosis



Meiotic chromosome dance

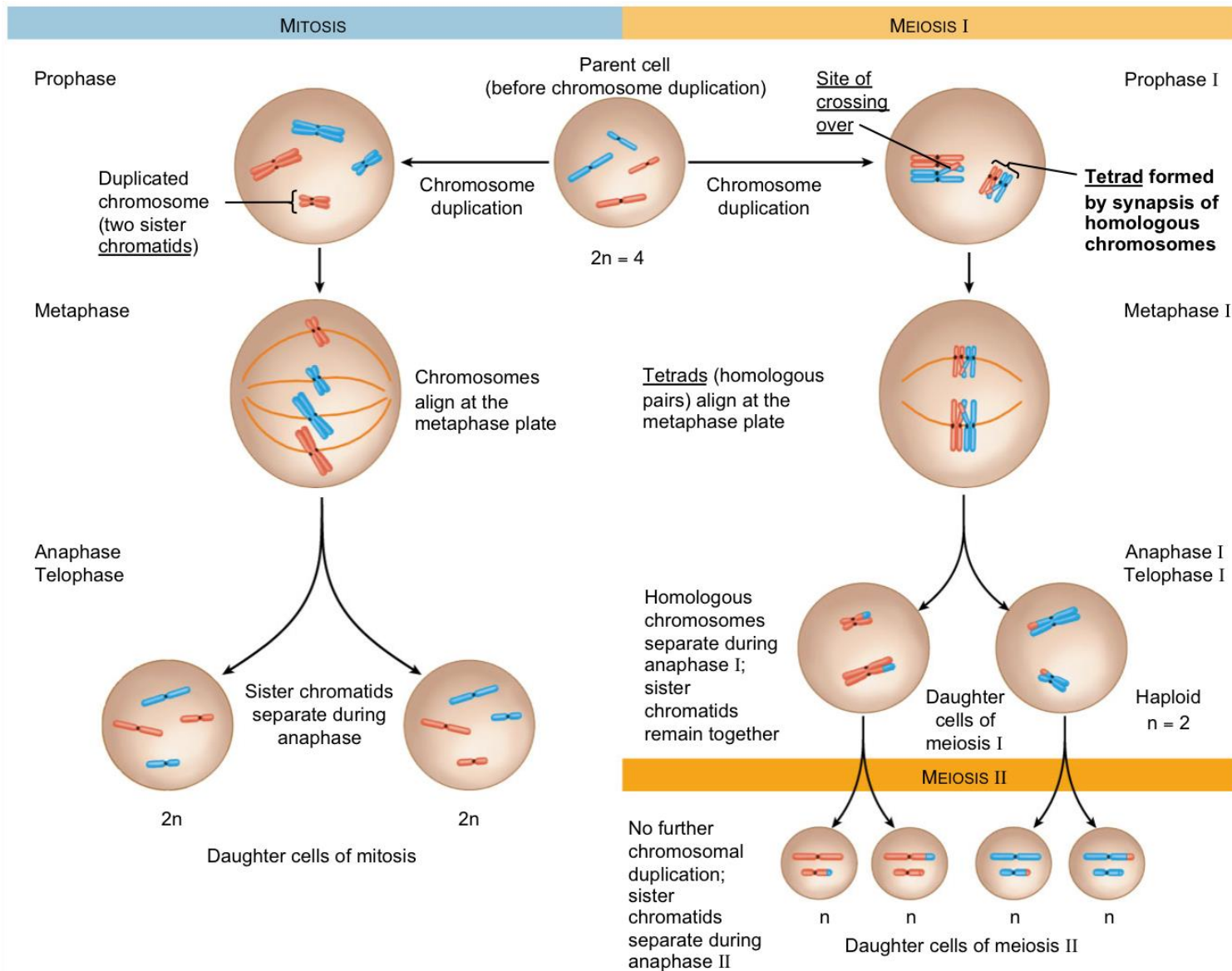
The function of **meiosis** is to generate cells that contain exactly half of the genetic materials of the parental cells and that develop into germ cells.

Chromosome rearrangements could occur during meiosis, get fixed in populations, and eventually can contribute to genetic differentiation and speciation.



Meiotic prophase (diakinesis) in a sporocyte of *Ophioglossum reticulatum*, showing about 630 bivalents.

Mitosis vs. Meiosis



Meiosis I and II

Meiosis I (reductional division)

- **prophase**

leptotene

zygotene

pachytene

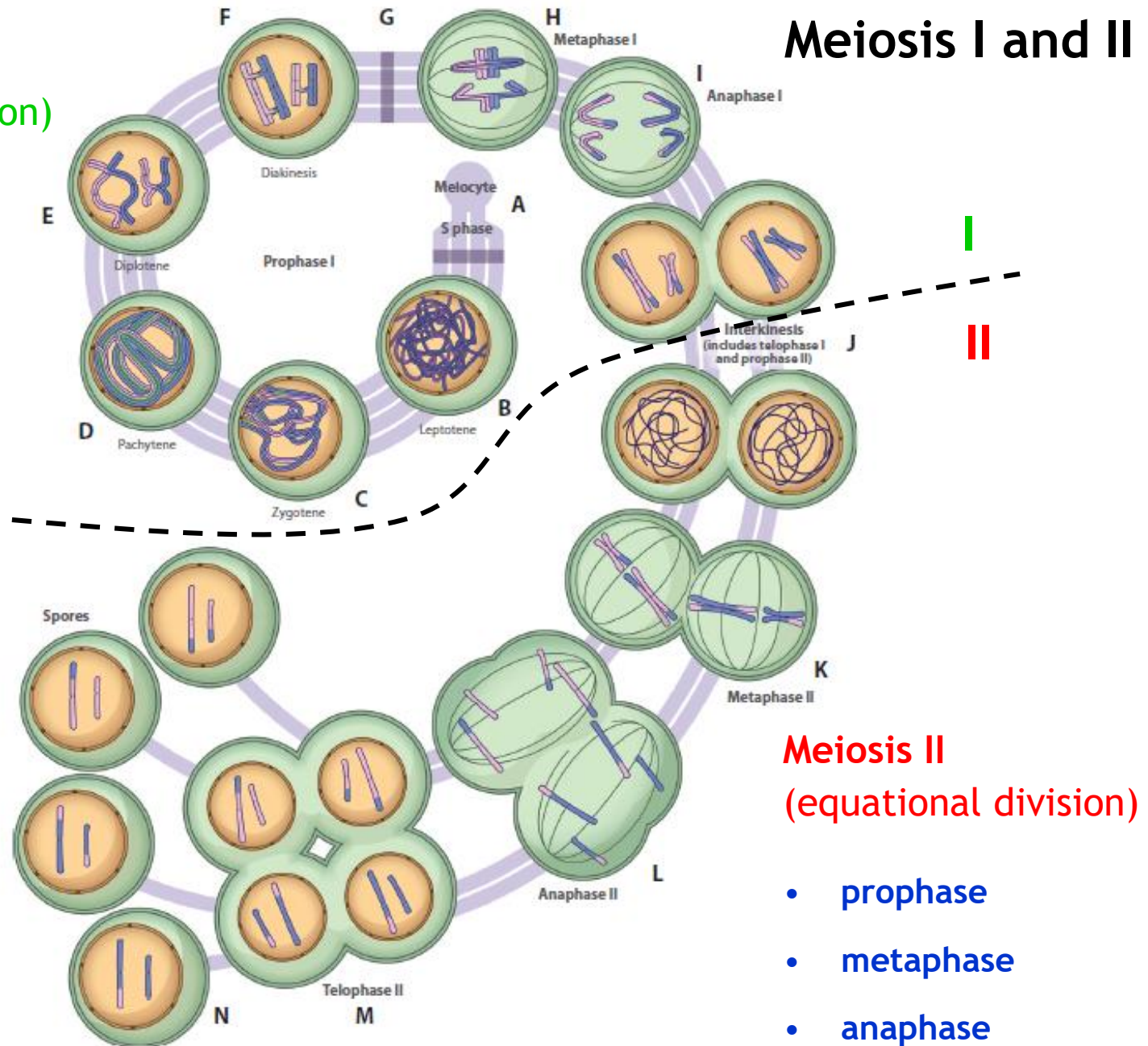
diplotene

diakinesis

- **metaphase**

- **anaphase**

- **telophase**



Meiosis II (equational division)

- **prophase**

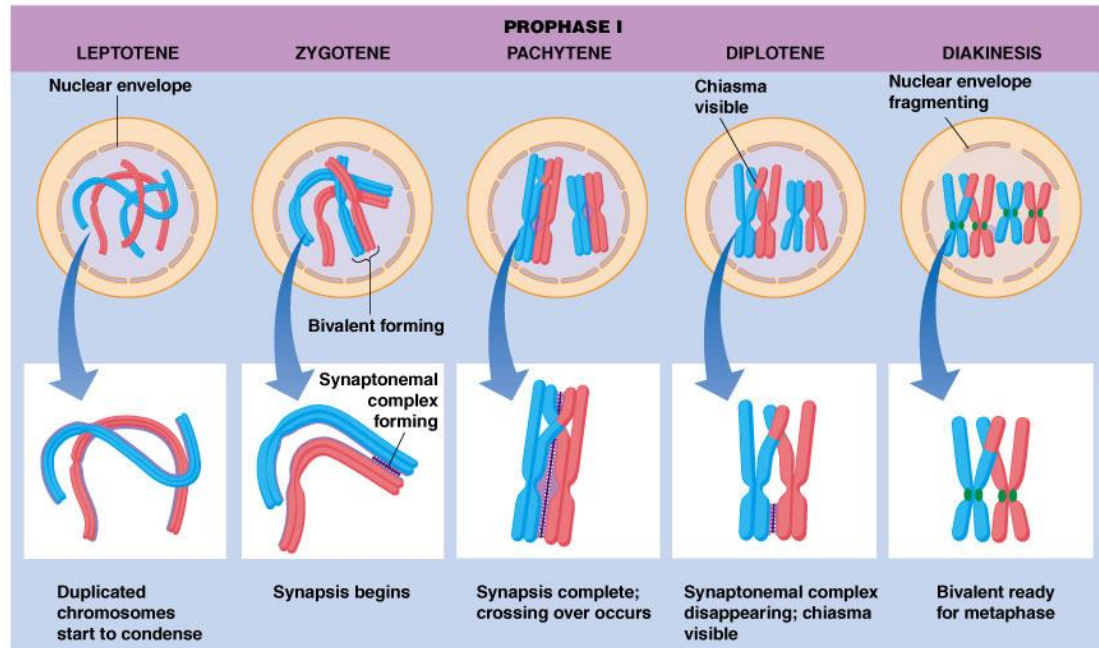
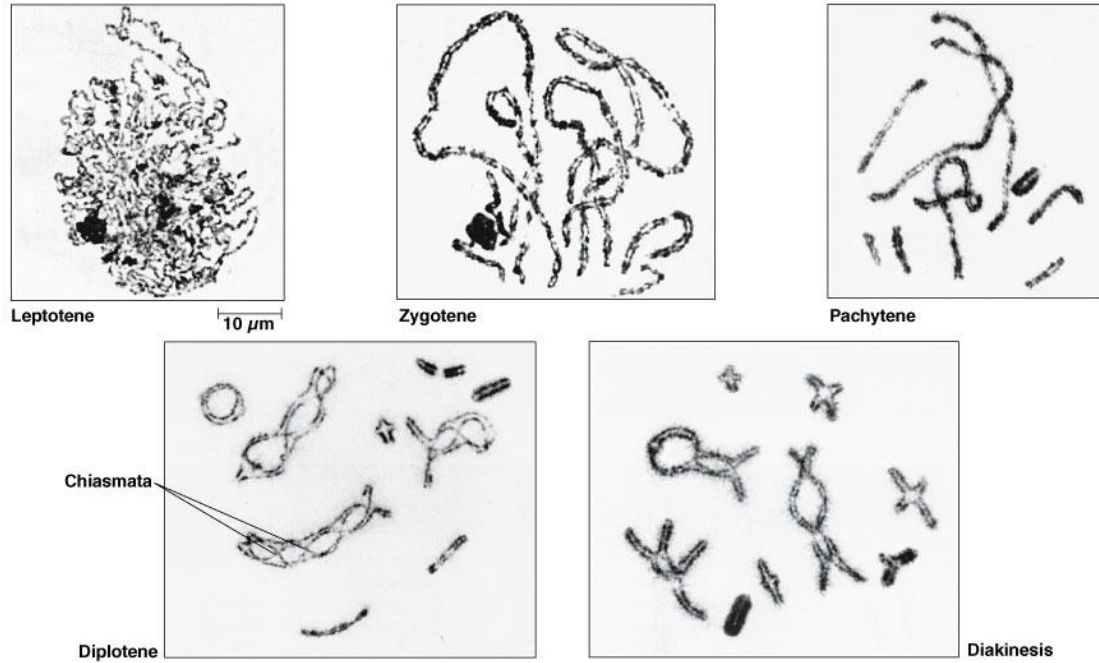
- **metaphase**

- **anaphase**

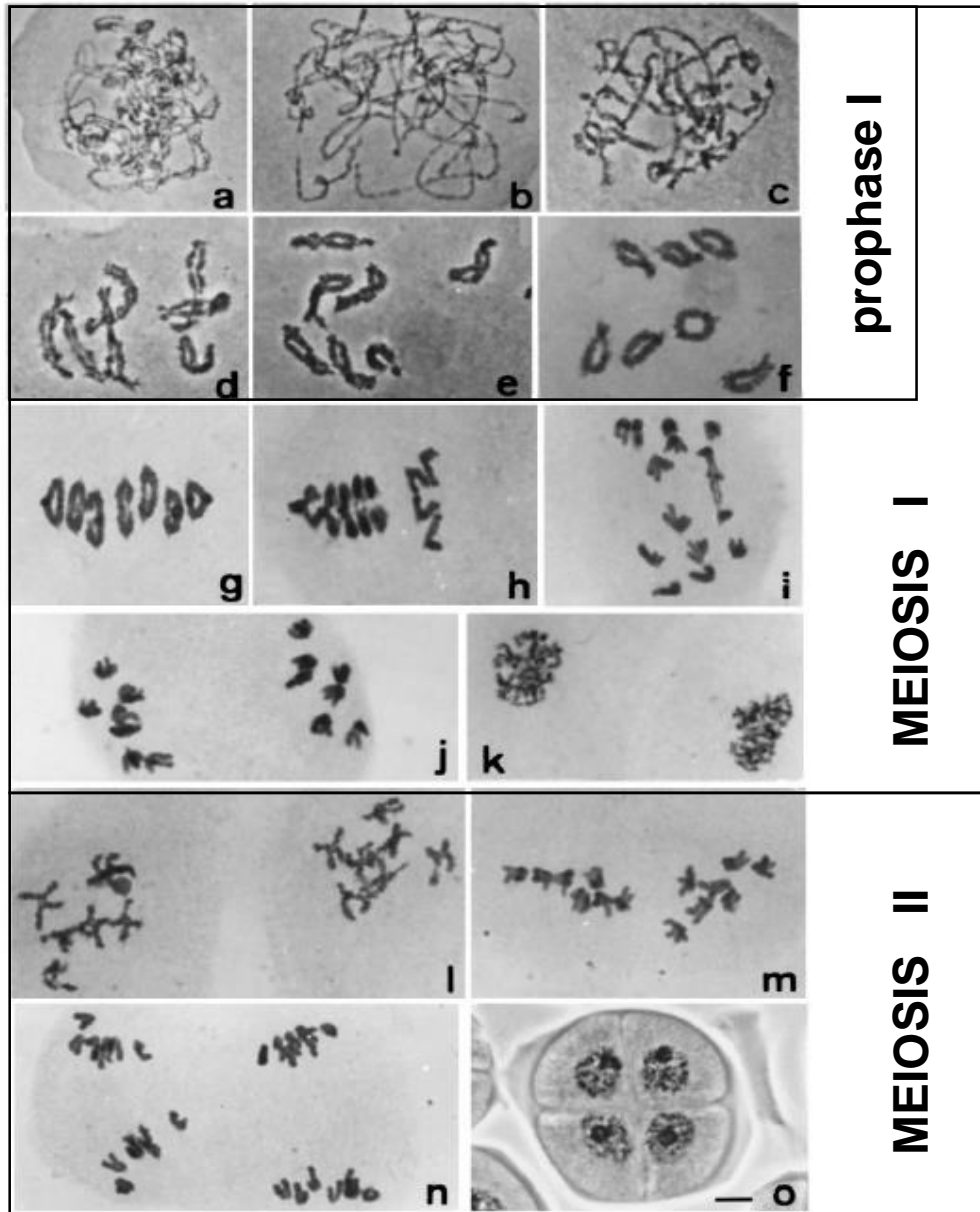
- **telophase**

Prophase I

- leptotene
- zygotene
- pachytene
- diplotene
- diakinesis



Meiotic divisions I and II in the rye (*Secale cereale*)



(a – f) prophase I

(a) early zygotene

(b - d) early to late pachytene

(e) diplotene

(f) diakinesis

(g, h) metaphase I

(i, j) anaphase I

(k) telophase I

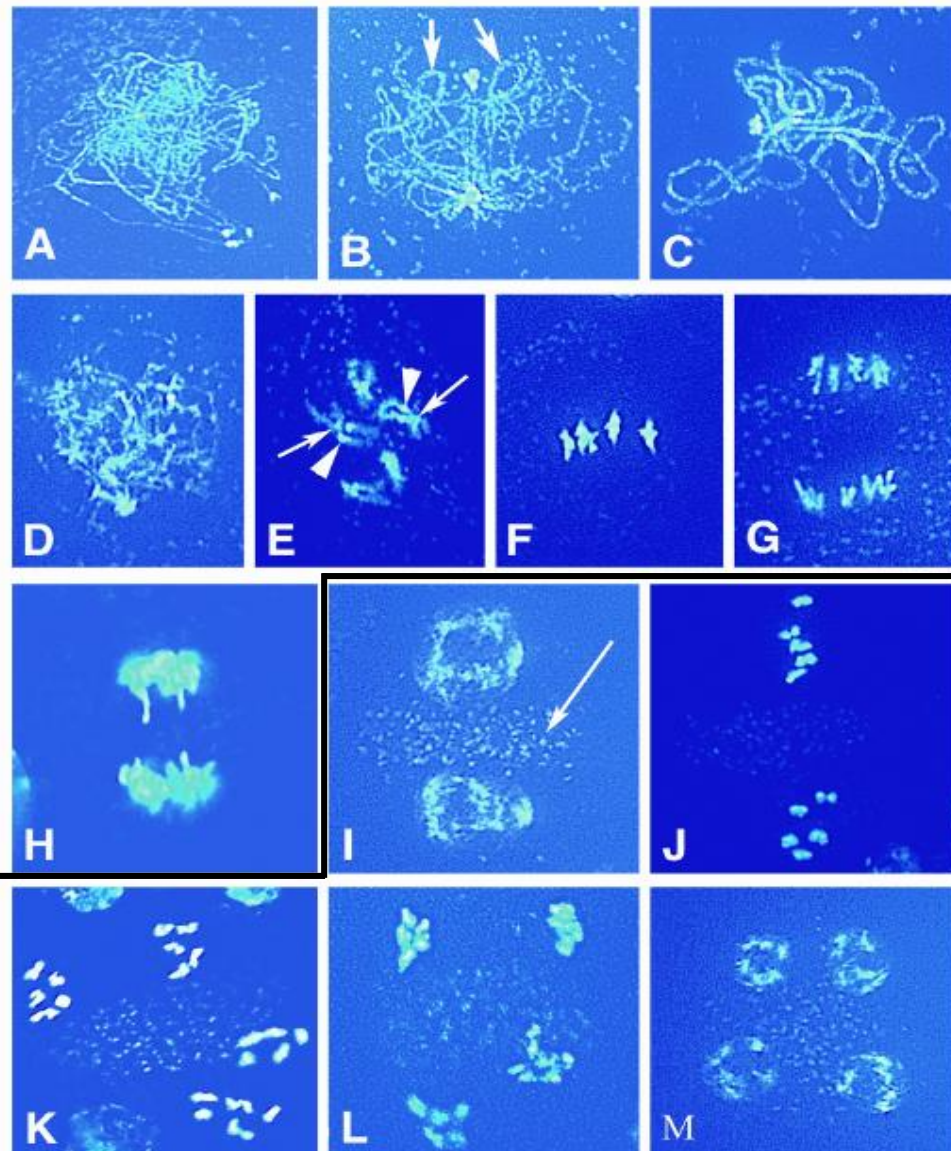
(l) prophase II

(m) metaphase II

(n) anaphase II

(o) telophase II (four haploid pollen mother cells)

Meiotic divisions I and II in *Arabidopsis thaliana*



MEIOSIS I

(A - H) prophase I

(A) leptotene

(B) zygotene

(C) pachytene

(D) diplotene

(E) diakinesis

(F) metaphase I

(G) anaphase I

(H) telophase I

MEIOSIS II

(I) prophase II

(J) metaphase II

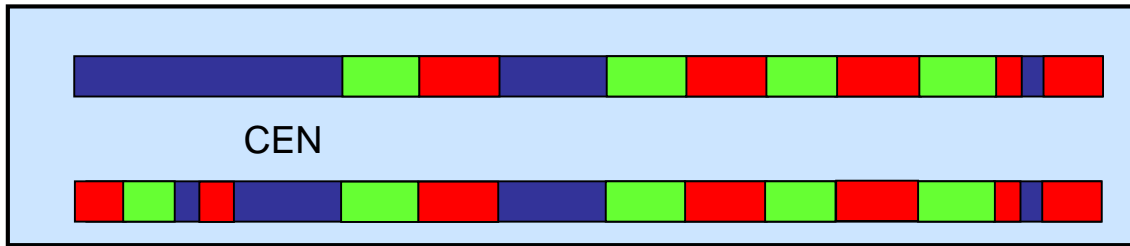
(K) anaphase II

(L) telophase II

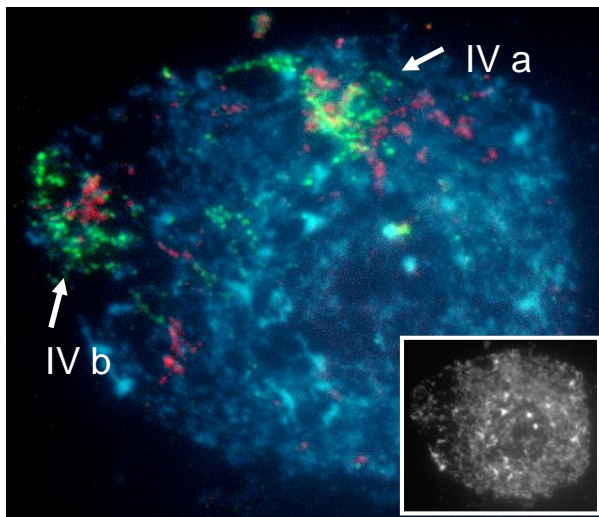
(M) four newly formed nuclei

Prophase I in *Arabidopsis thaliana* as revealed by chromosome painting

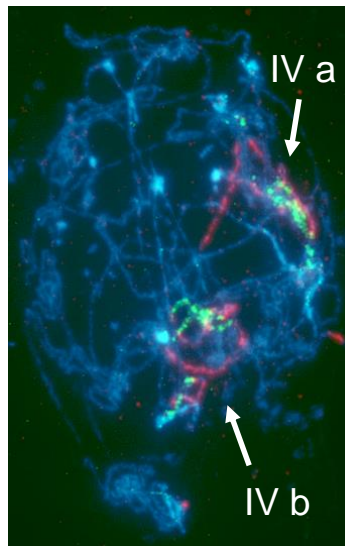
139 clones of a BAC tiling path covering *Arabidopsis* chromosome 4 were divided into 11 pools of 8-18 BACs. Individual pools were labelled either by **biotin-dUTP (red)** or **digoxigenin-dUTP (green)** for painting of either the long arm (113 BACs) or the entire chromosome (139 BACs).



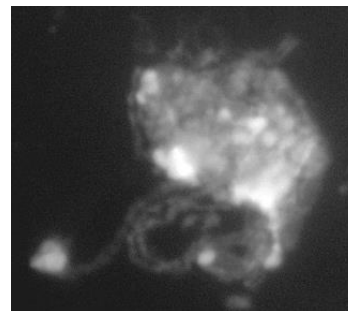
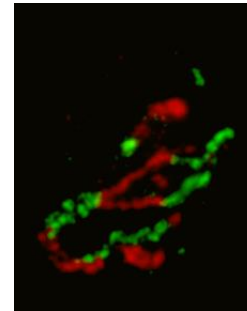
early prophase I



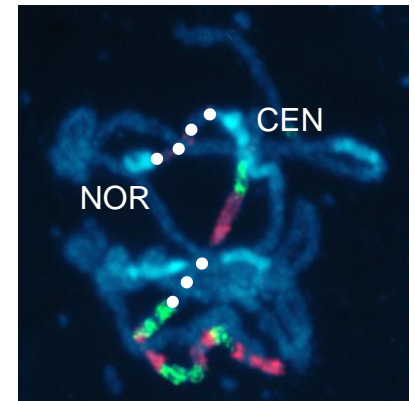
leptotene



zygotene



pachytene



Key events of meiosis I

Links between chromosome pairing, synapsis and recombination are not well understood. Recombination plays a key role in unifying meiotic events in prophase I.

Chromosome recognition and pairing

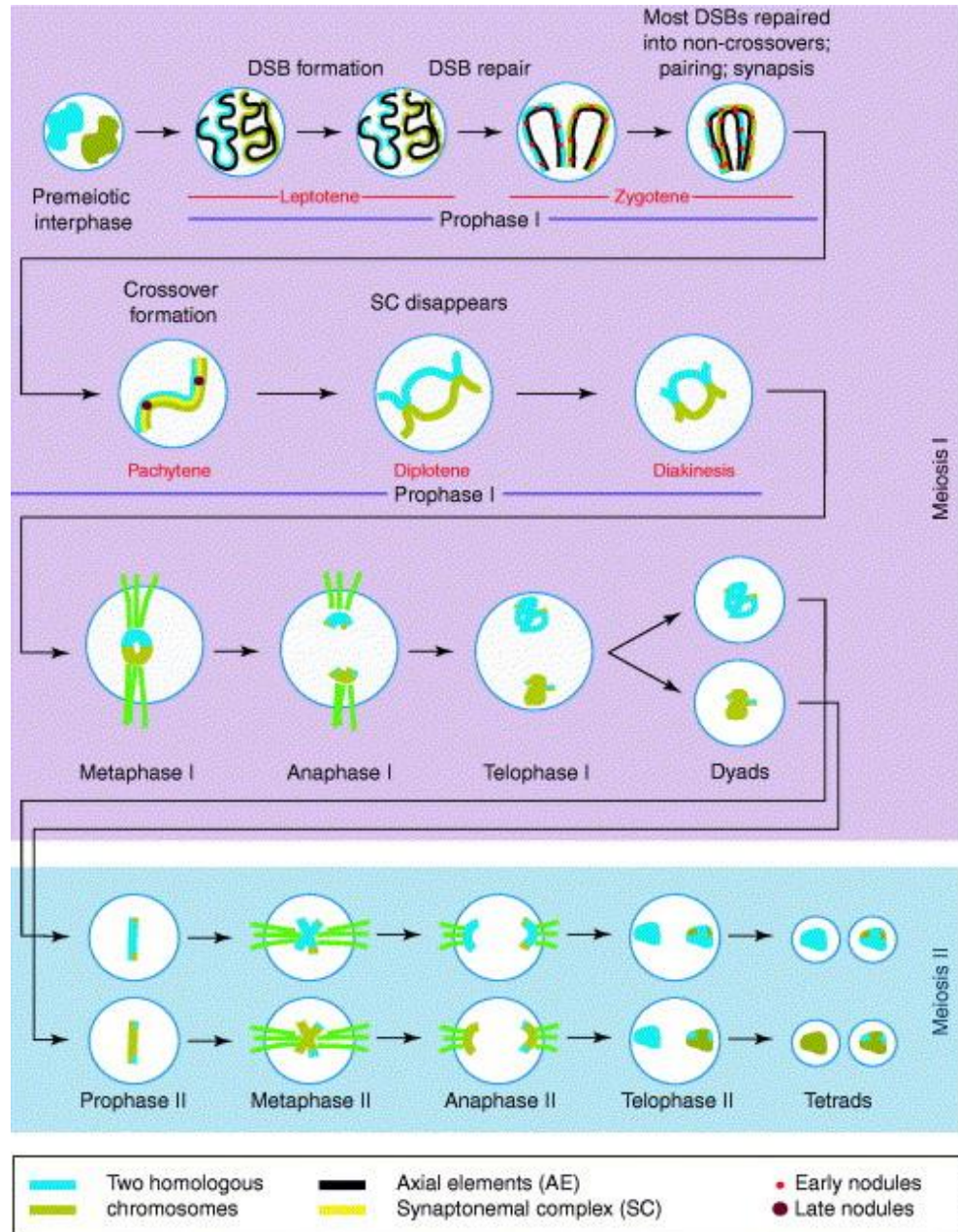
- the mechanism is not known

Synapsis

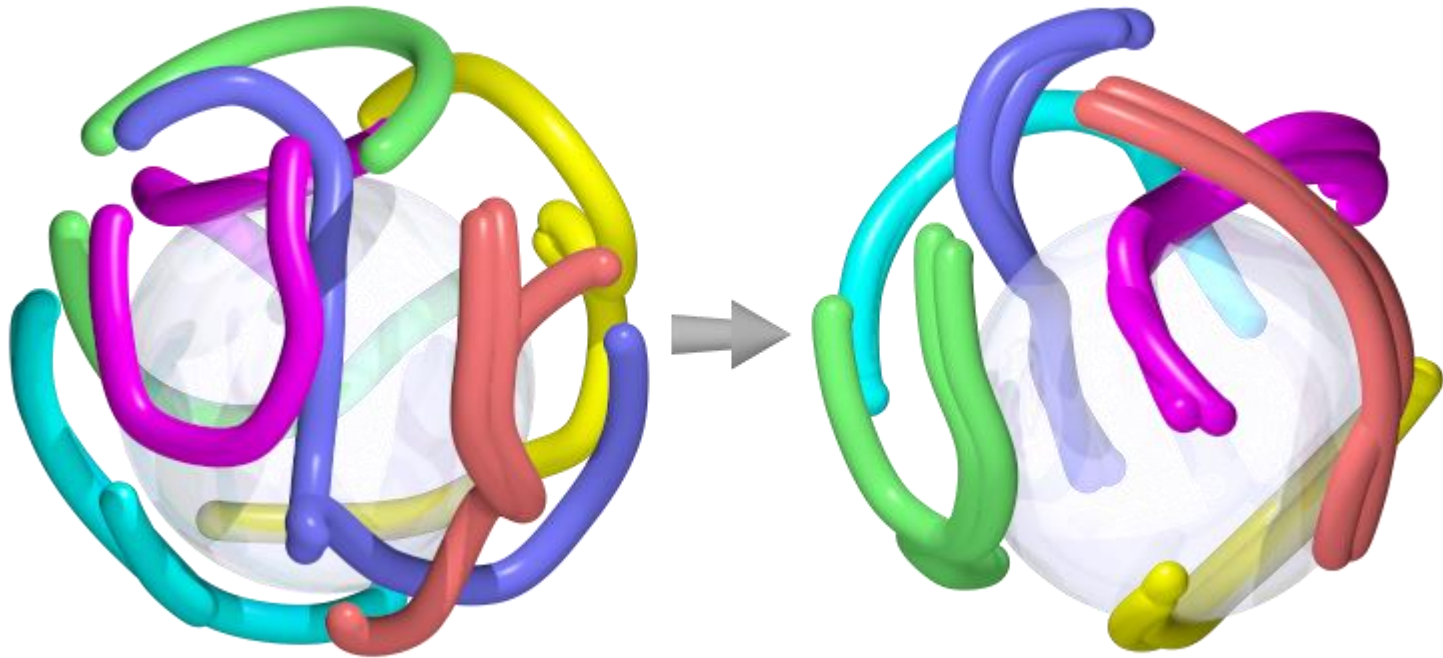
- synaptonemal complex (SC)
- the link between synapsis and recombination is not well understood

Meiotic recombination

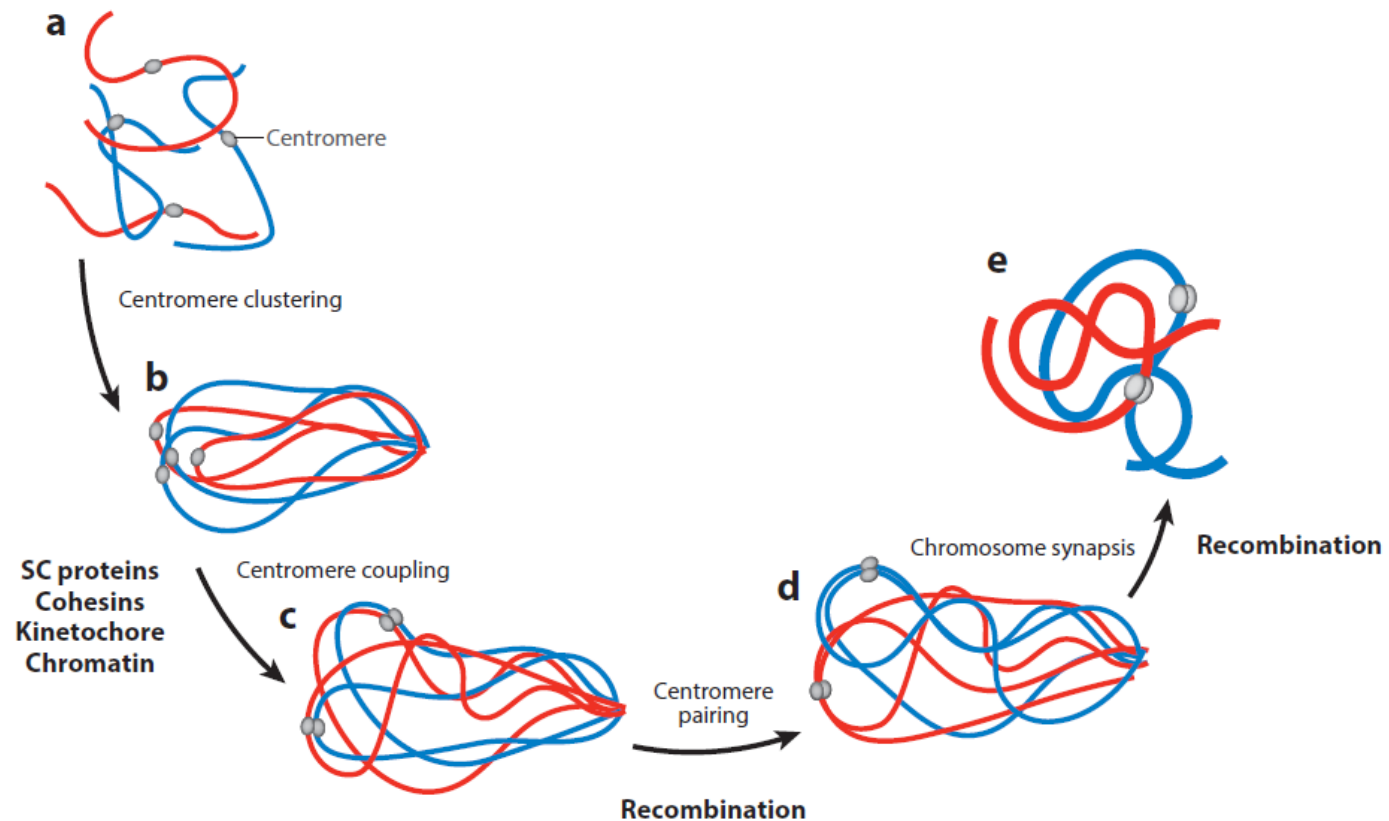
- process of formation of double-strand breaks (DSBs) and their subsequent repair
- results in formation of crossover and non-crossover products



Homologous chromosome recognition and pairing



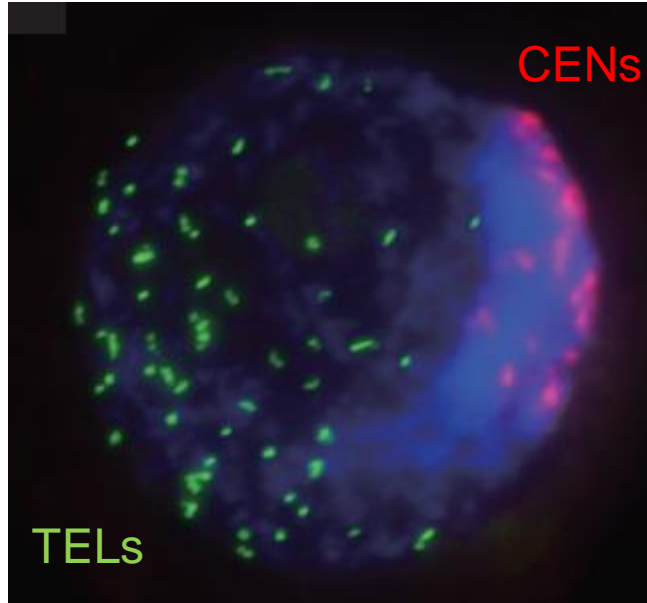
Homologous chromosome pairing facilitated by telomere and centromere clustering/coupling/pairing



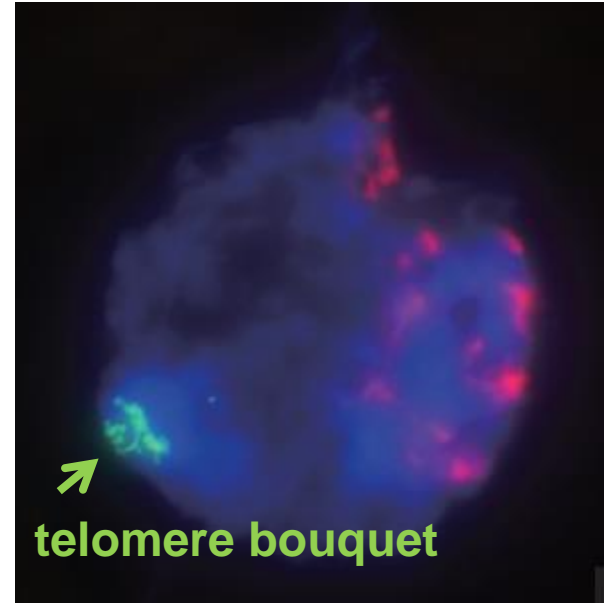
Schematic of centromere behavior in early meiotic prophase I in a hypothetical diploid organism with two pairs of chromosomes

Homologous chromosome pairing facilitated by telomere and centromere clustering

$2n = 28$



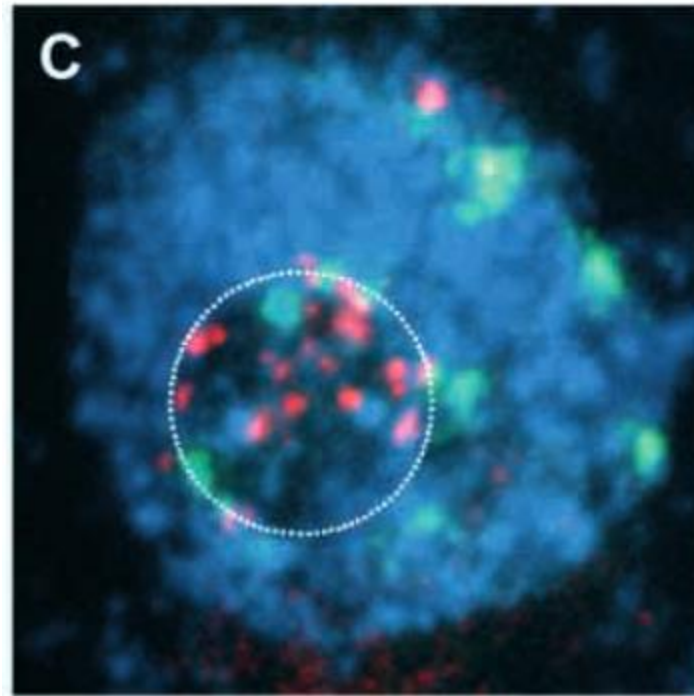
leptotene



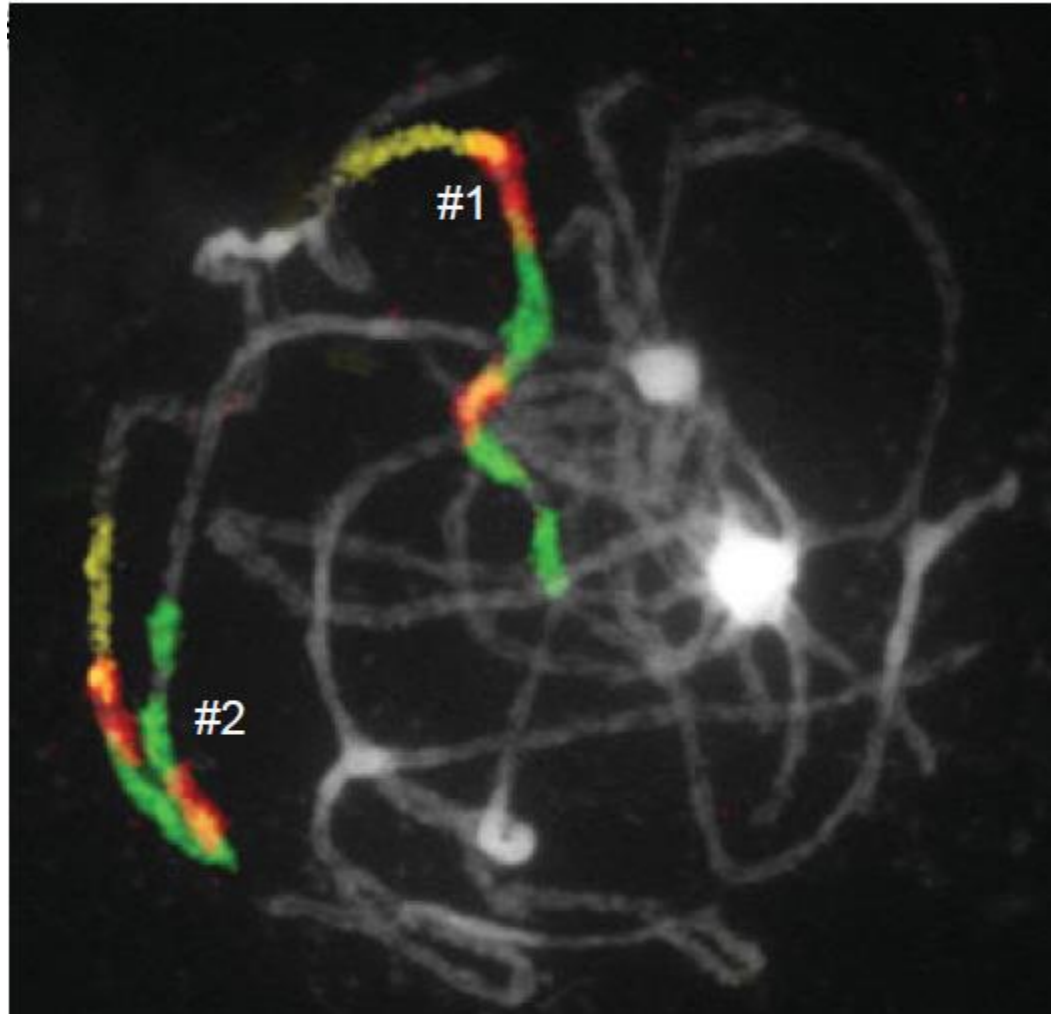
zygotene

(centromere pairing is prior to telomere clustering)

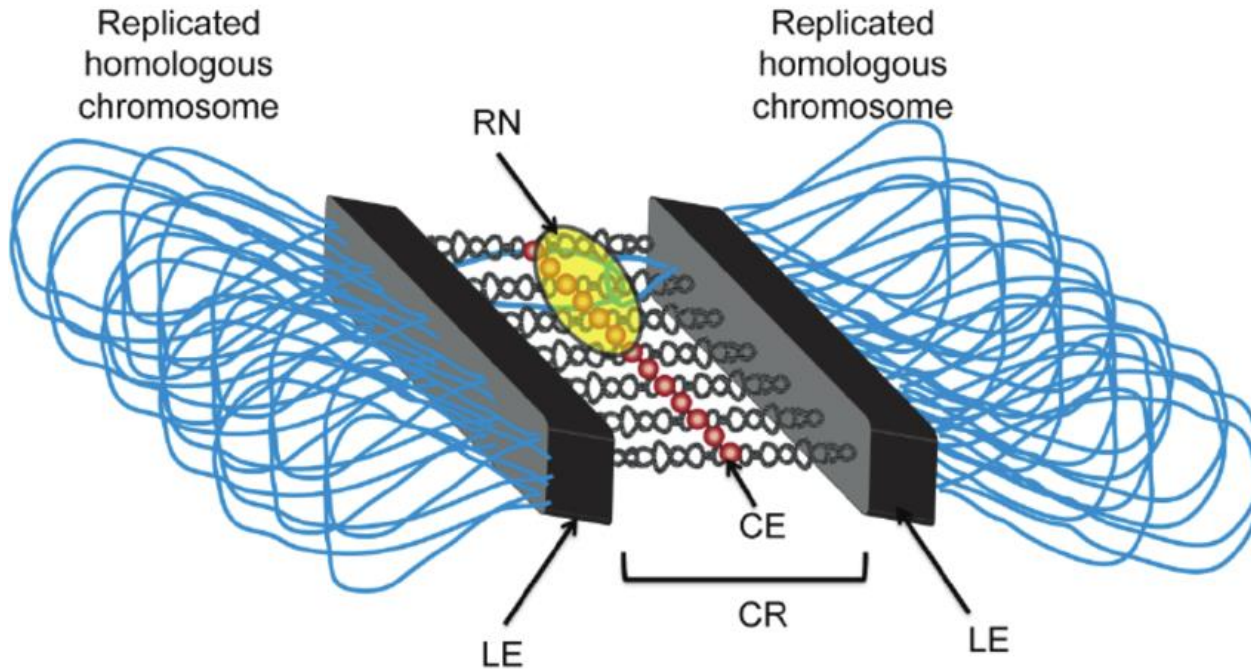
Arabidopsis: telomere clustering around nucleolus



Prophase I - pachytene (synapsis of homologous chromosomes)



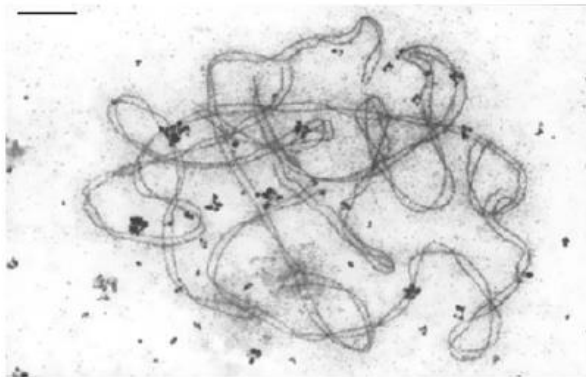
Synaptonemal complex (SC)



- consists of two lateral elements (le) connected by a central element (ce) [the lateral elements formed as axial elements (AEs, also called the chromosome axis) in leptotene]

- the central element assembles following chromosome pairing during zygotene

- recombinational nodule (rn) - place of crossing-over (genetic exchange between homologues)



synaptonemal complex in *Arabidopsis thaliana*

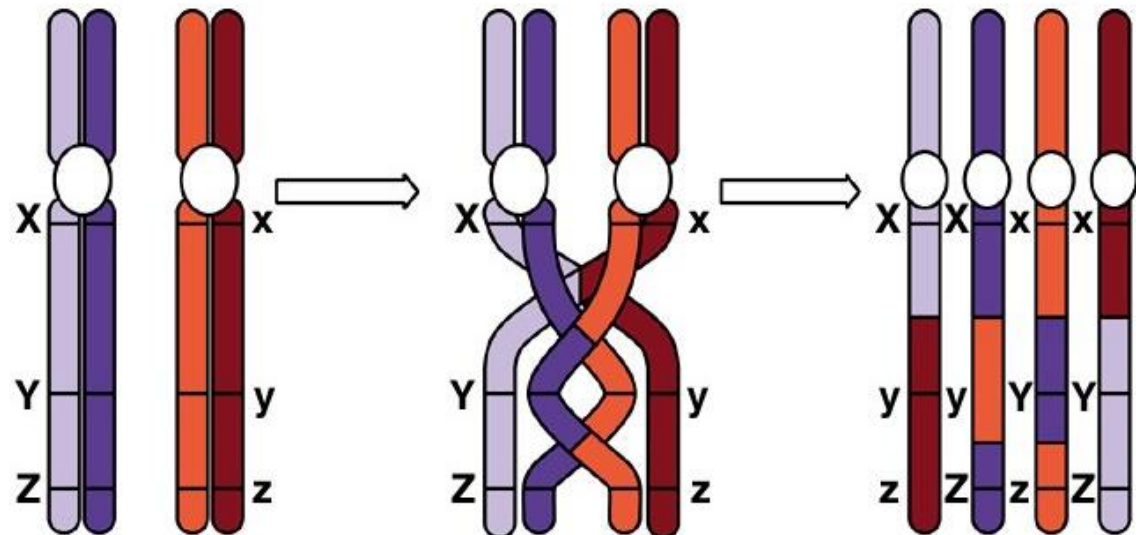
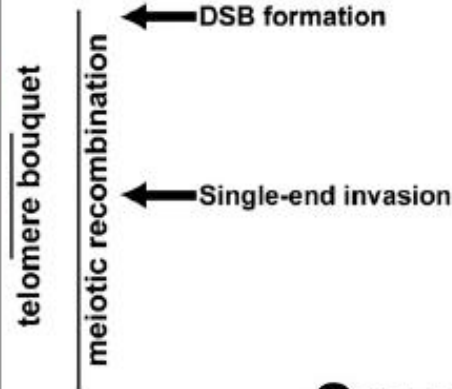
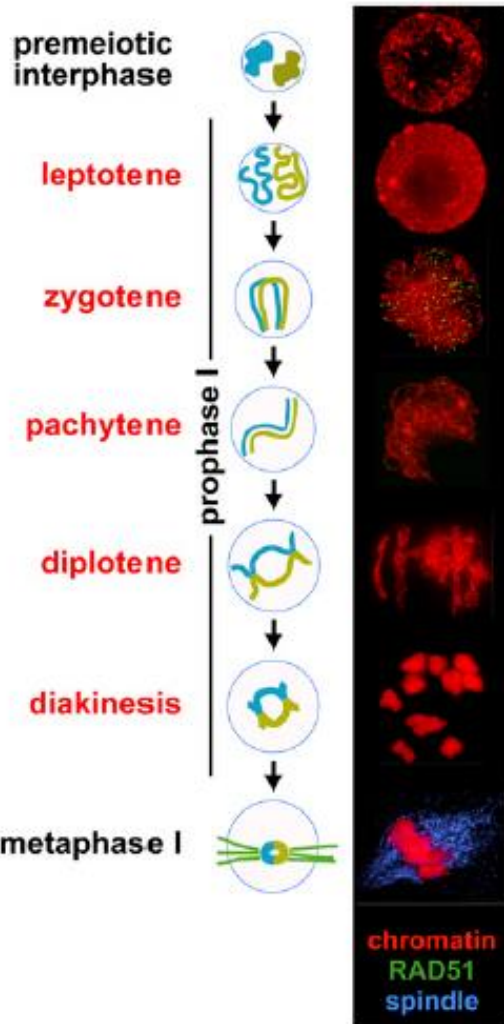
Recombination (crossing over) and chiasmata



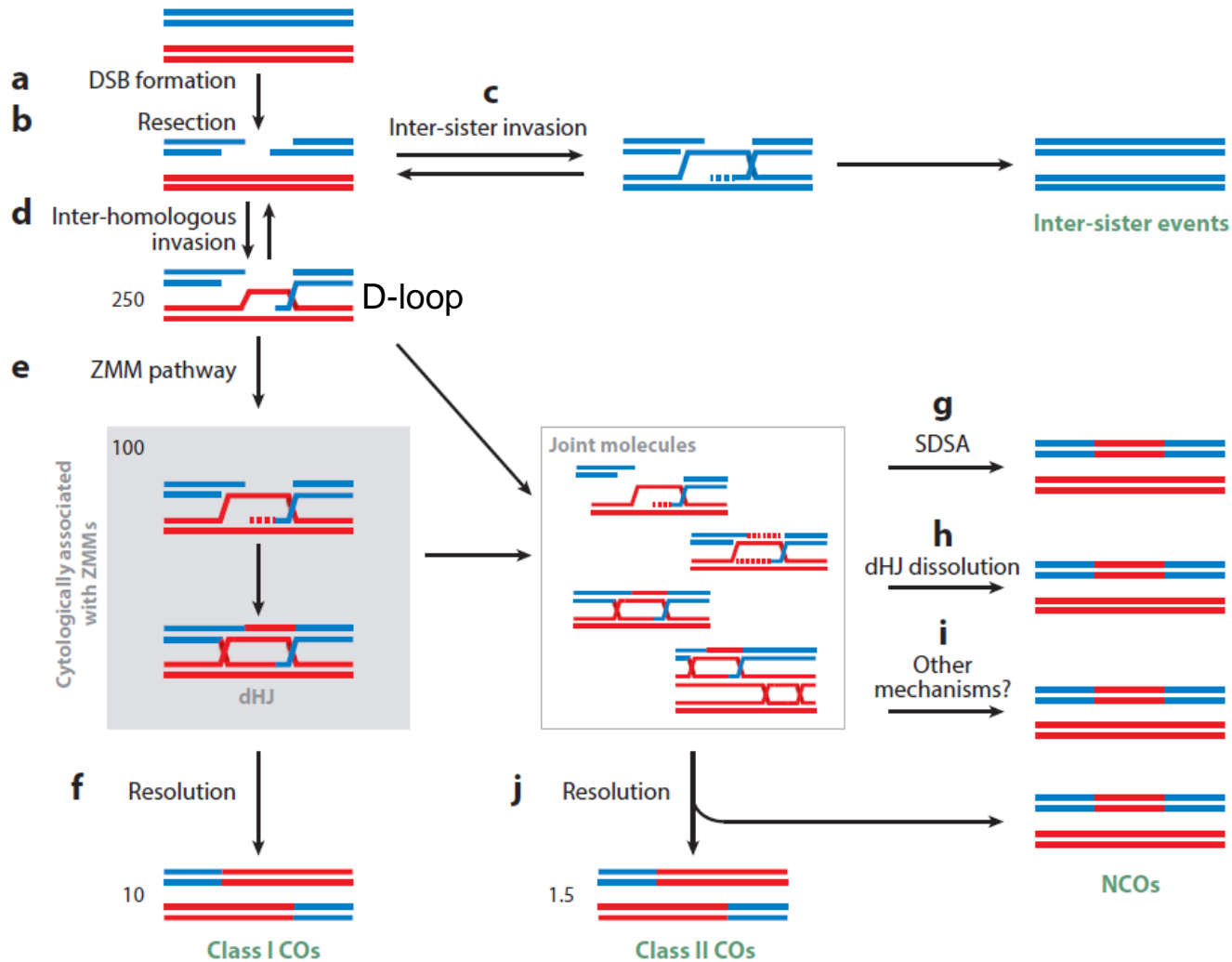
Prophase I: crossing over

- SPO11 protein introduces DSBs into chromosomal DNA
- DNA ends adjacent to these breaks are later bound by **RAD51** and **DMC1** that catalyze single-end invasion of the broken DNA ends into the homologous chromosome

Crossing over during meiosis



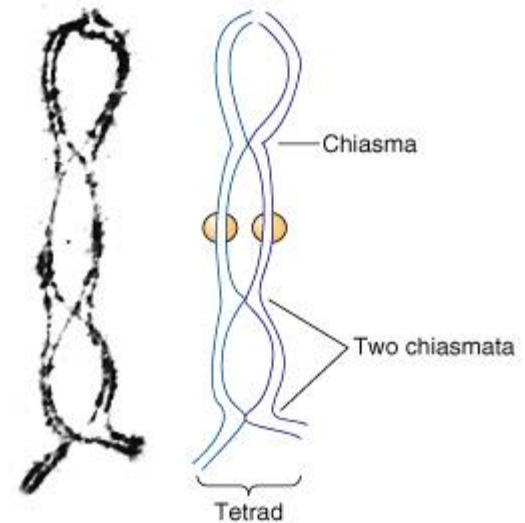
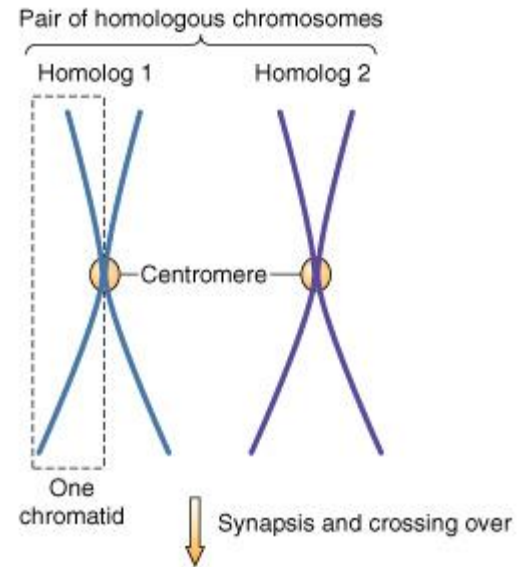
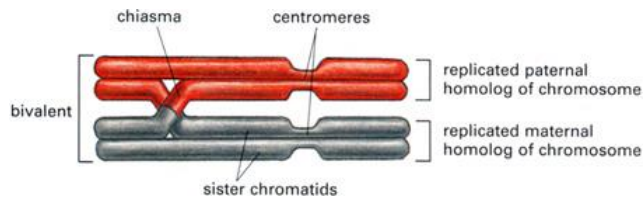
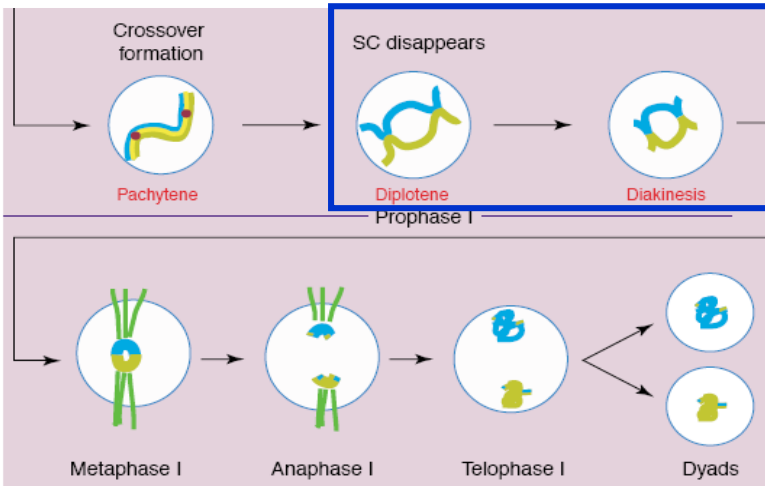
Recombination: double-strand breaks (DSBs) and their repair



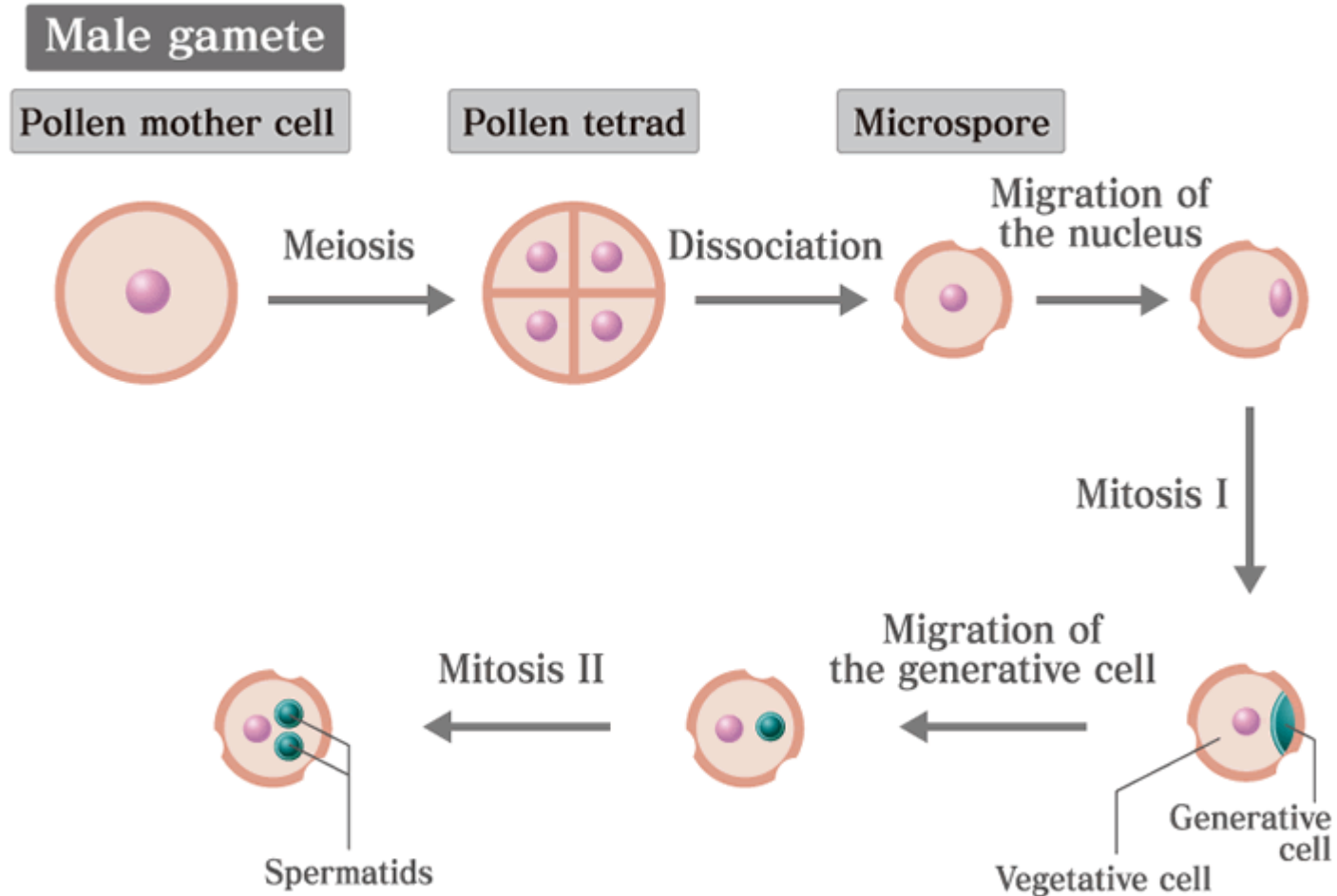
dHJ: double-Holliday junction; SDSA: synthesis-dependent strand annealing; COs: crossovers; NCOs: noncrossovers

Recombination (crossing over) and chiasmata

chiasma formation

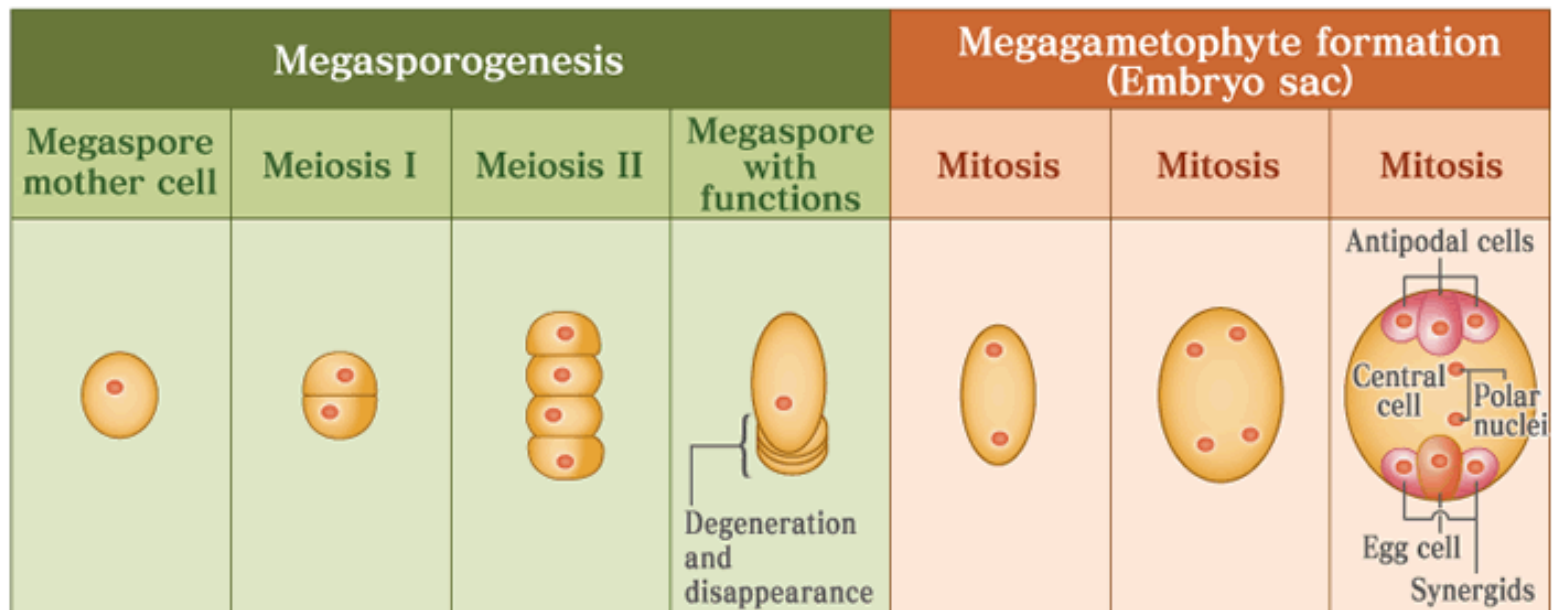


Plants – male gametogenesis



Plants – female gametogenesis

Female gamete



Plants – fertilization

