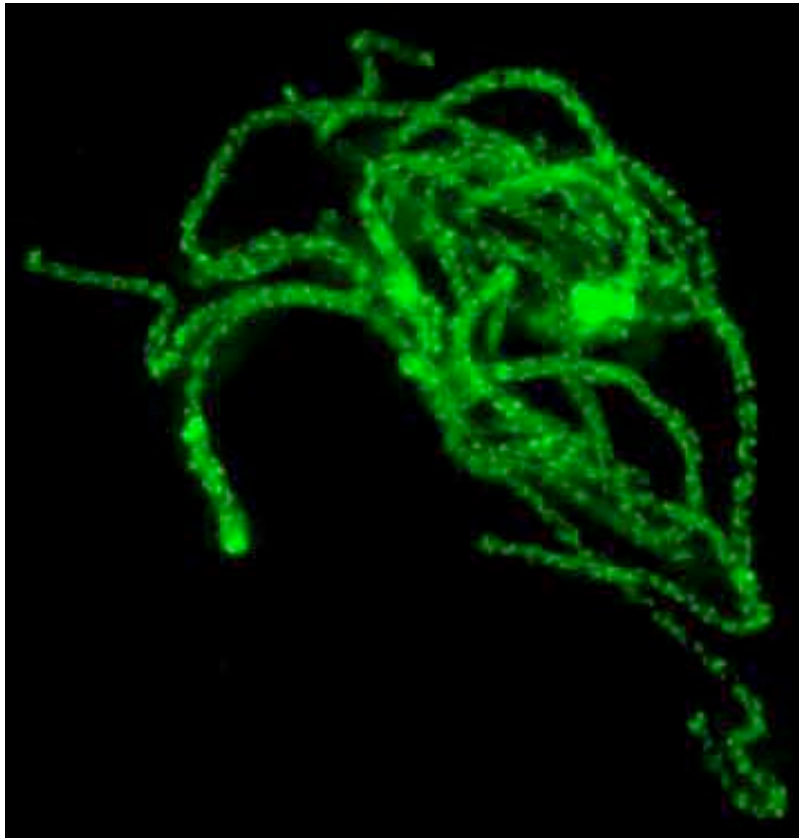
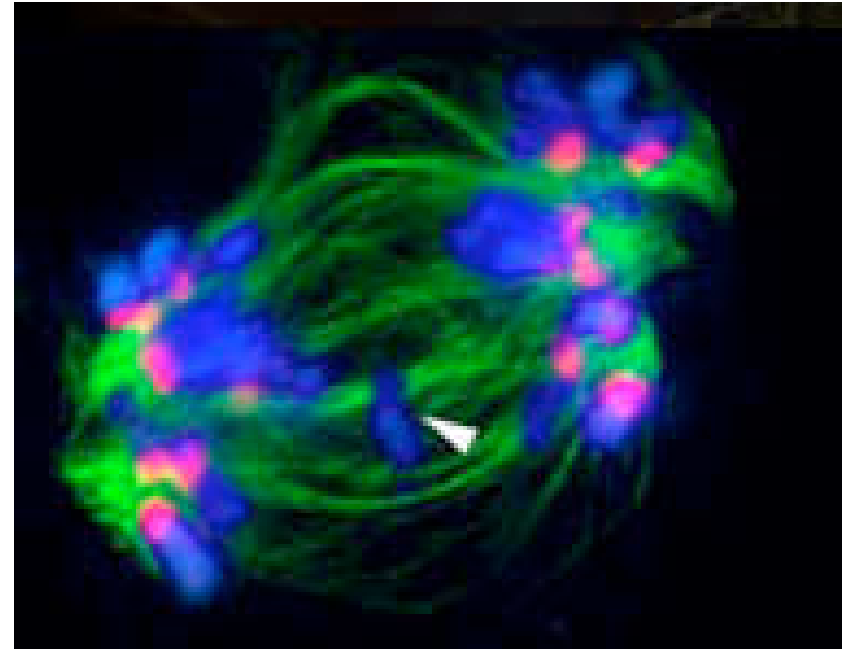


Sexual Reproduction and Meiosis



Maize chromosomes in prophase (pachytene) of meiosis I stained with DAPI



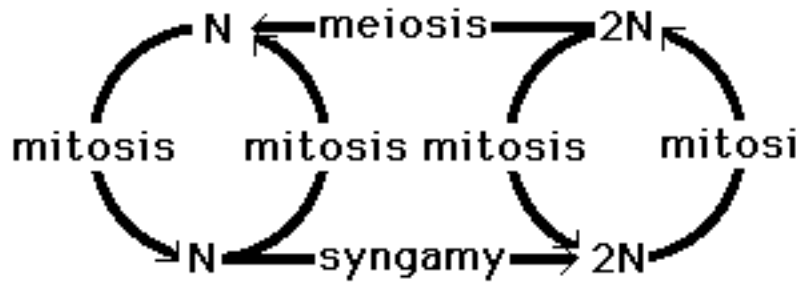
Unlabelled picture from web. My guess is that it shows late anaphase of meiosis; chromosomes blue, kinetochores red, microtubules green. Arrow shows lagging chromosome.

Eukaryotic Life Cycles

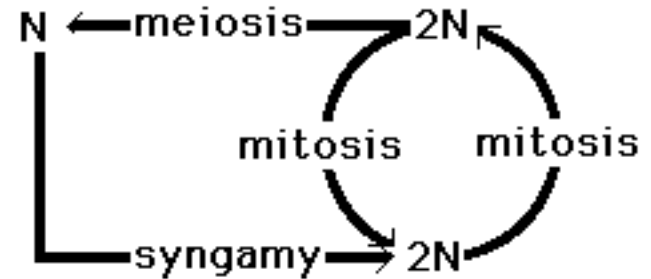
Asexual life cycle = mitosis

Sexual life cycle = meiosis + syngamy

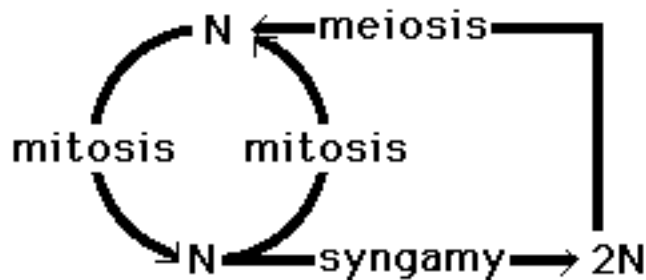
EUKARYOTIC LIFE CYCLES



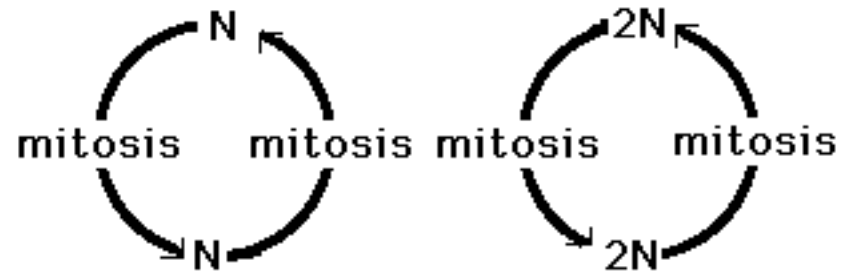
General, most common? e.g. *Saccharomyces*



Predominantly diploid, e.g. animals



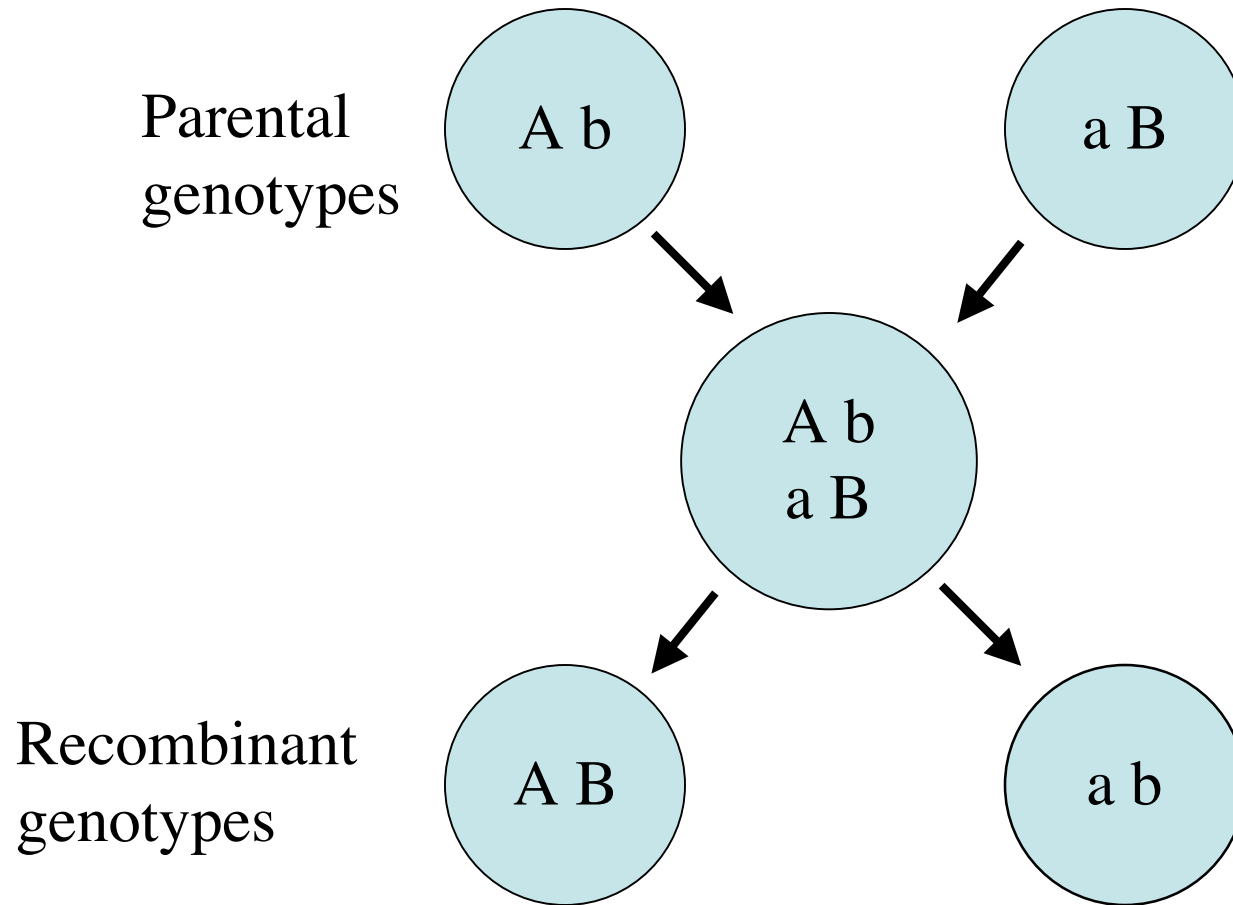
Predominantly haploid, e.g. *Chlamydomonas*



Asexual, common? e.g. some fungi (N, 2N)

Sex

(as the geneticist sees it when doing genetics)



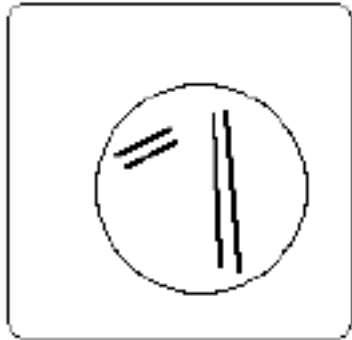
Meiosis

Meiosis

Starts with DNA replication so in each diploid cell, each chromosome replicates to produce two chromatids; these stay tightly bound together.

Meiosis = 2 divisions, meiosis I and II or first and second meiotic divisions. No DNA replication between M I and II.

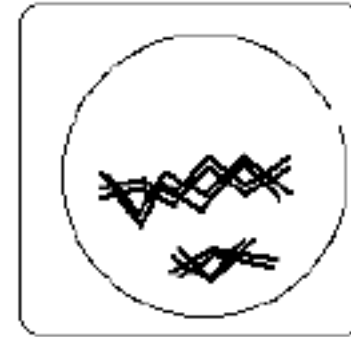
Meiosis I



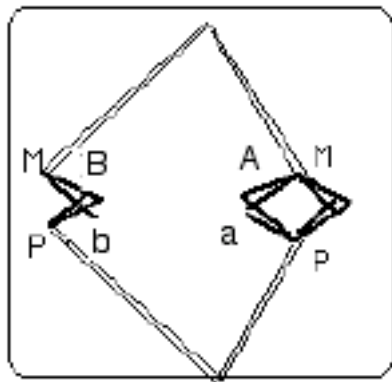
Prophase: leptotene, zygotene. Chromosomes condense, homologues synapse.



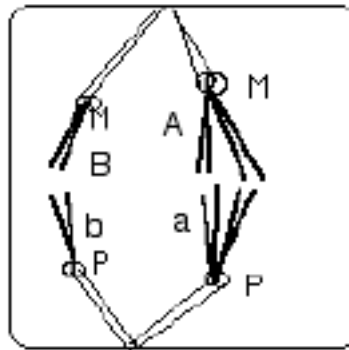
Prophase: pachytene. Chromatids visible, crossing-over occurs.



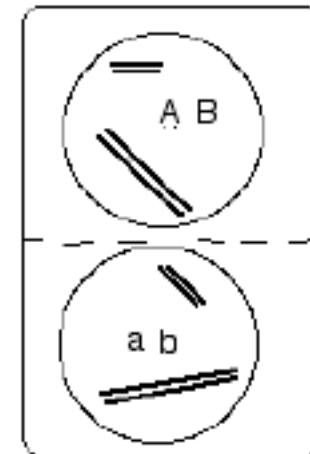
Prophase: diplotene, diakinesis. Chiasmata form and terminalize.



Metaphase. Homologous kinetochores attach to chromosome fibers from opposite poles.



Anaphase. Fibers contract & pull homologous kinetochores to opposite poles.



Telophase. Nuclear membranes form around chromosomes, cytokinesis.

After meiosis I: N chromosomes 2N chromatids 2C DNA

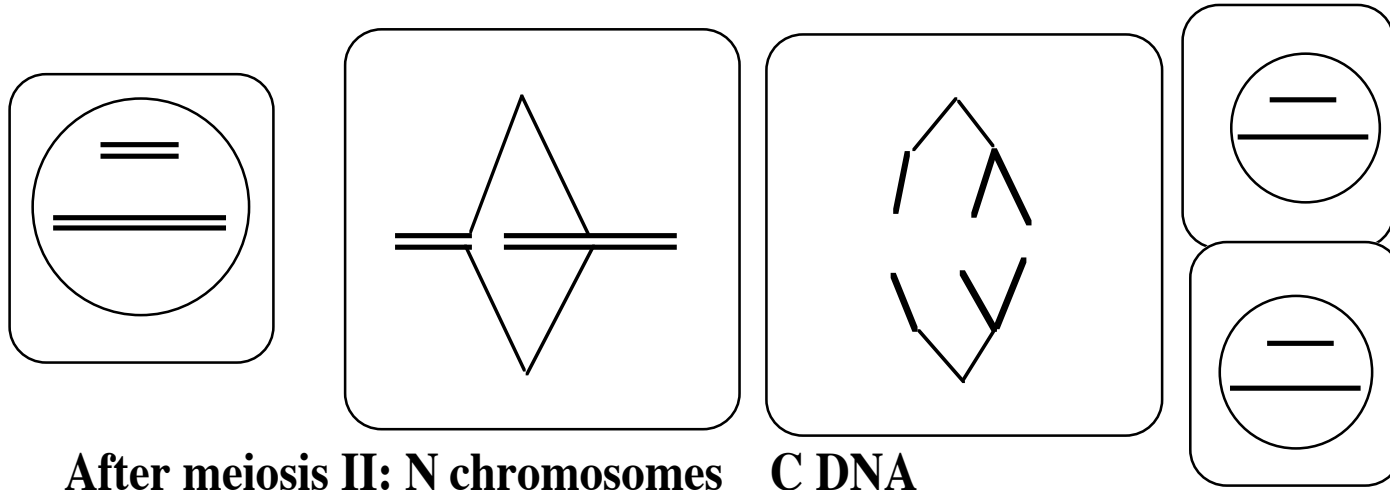
Meiosis II

There is no true interphase between meiosis I and II, and no DNA replication.

Meiosis II is like mitosis:

Metaphase: chromosome fibers attach so as to connect sister kinetochores to opposite poles.

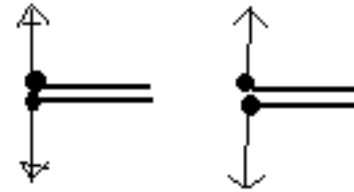
Anaphase: sister kinetochores and chromatids move to opposite poles (segregate).



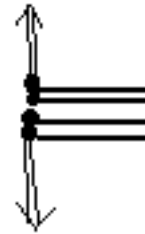
Alleles have segregated.

Reductional and Equational Divisions

Mitosis and meiosis II are called equational divisions in which sister kinetochores and chromatids segregate.



Meiosis I is called a reductional division in which sister kinetochores remain attached while homologous kinetochores segregate.



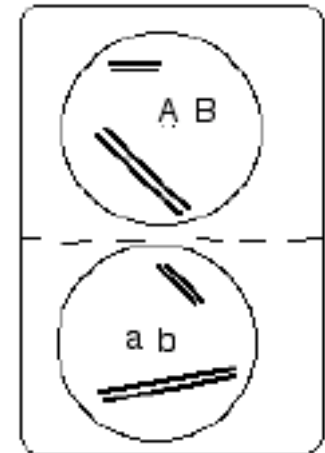
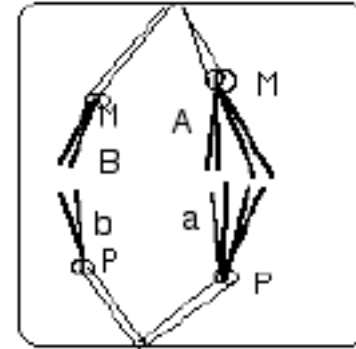
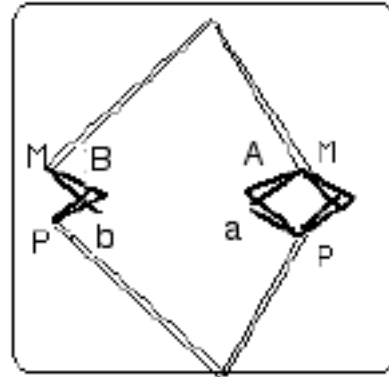
How to Different Chromosomes Behave at Meiosis?

Kinetochores of different chromosomes segregate independently and randomly.

In 1/2 of cells, kinetochores from maternal parent go to same pole and paternal kinetochores go to opposite pole in meiosis I.

Probability = 0.5

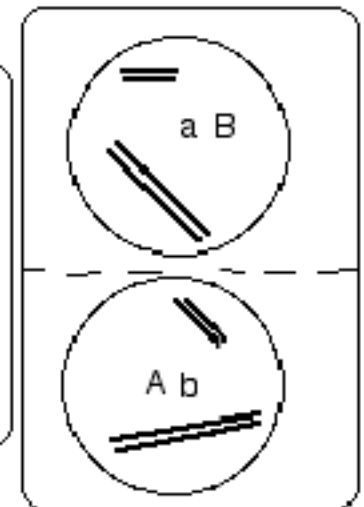
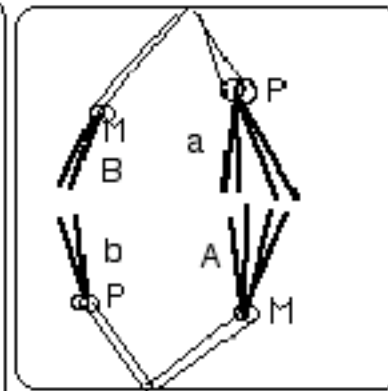
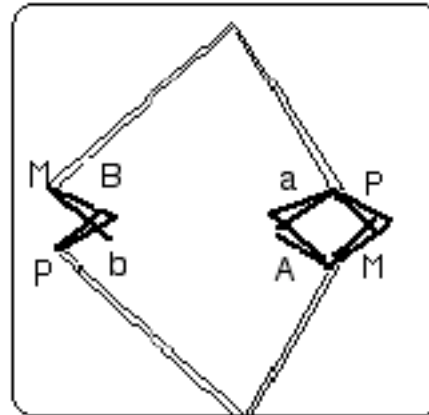
AB and *ab* are parental genotypes.



In 1/2 of cells, kinetochores from maternal parent segregate to opposite poles and chromosomes from paternal parent do the same in meiosis I.

Probability = 0.5

Ab and *aB* are recombinant genotypes.



What will be the genotypes of the gametes produced by a large sample of cells undergoing meiosis?

***AB* 1/4**

***Ab* 1/4**

***aB* 1/4**

***ab* 1/4**

**The alleles of both genes will segregate 1/2 *A* : 1/2 *a*,
1/2 *B* : 1/2 *b***

The two alleles will segregate independently of each other.

Meiosis Summary

Homologous chromosomes synapse and recombine in prophase of meiosis I.

Homologous kinetochores (and centromere sequences) segregate in anaphase of meiosis I.

Sister kinetochores (and centromeres) segregate in anaphase of meiosis II, as in mitosis.

2N -> N

2C -> 1C

The two copies of each gene segregate.

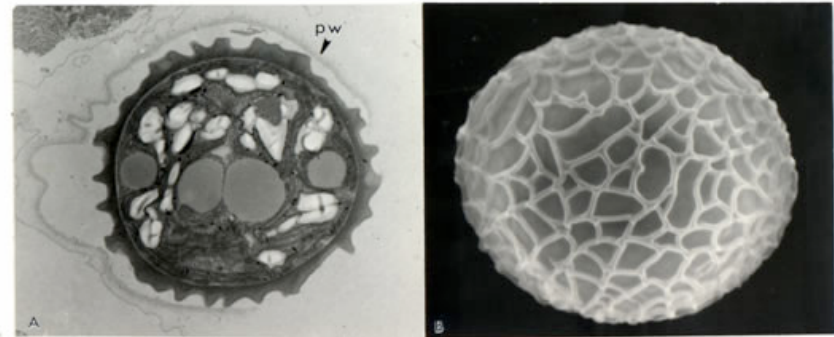
Different kinetochores segregate independently, therefore different chromosomes and different pairs of alleles will segregate independently.

Fate of Products of Meiosis

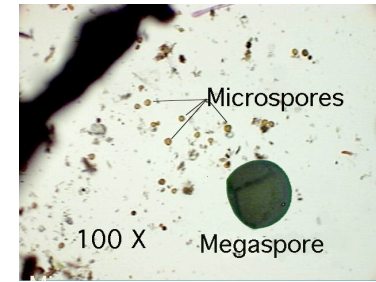
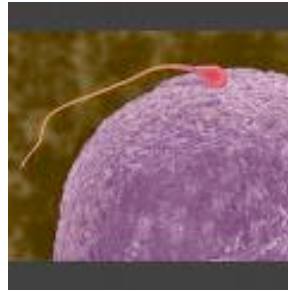
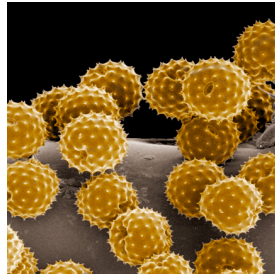
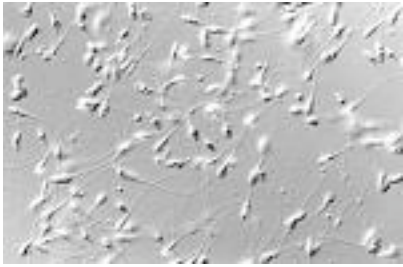
Many protists (unicellular eukaryotes, algae, and fungi: all four products of meiosis survive. In many cases they are bound together as a tetrad which permits very powerful genetic experiments.



Yeast ascus with 4 ascospores.



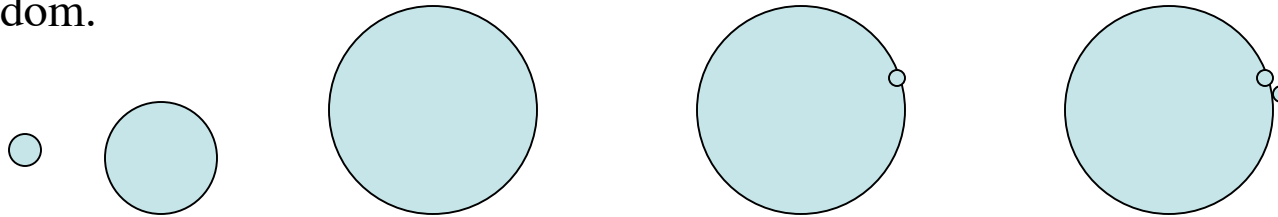
Chlamydomonas zygospore with 4 haploid nuclei.



Animals and plants:

Male animals and plants: all four products of meiosis survive and differentiate into sperm or pollen, but do not stay together in tetrads.

Female animals: cytokinesis after both meiotic divisions is very unequal, producing a large cell and a tiny one called a polar body. These polar bodies disintegrate. The big cell at the end of meiosis differentiates into the egg. Which nucleus survives is purely random.



Female plants: only one of the four products of meiosis becomes an egg, as in animals. Of the four nuclei produced by meiosis, one nucleus divides mitotically and only one product of those divisions becomes the egg. The other products of these mitoses, and sometimes other products of meiosis, become various kinds of accessory cells.

Special terminology for cells undergoing meiosis in animals, not clear in book:

spermatogonia –MI-> primary spermatocytes –MII-> secondary spermatocytes

-differentiate-> sperm

oogonia –MI-> primary oocyte –MII-> secondary oocyte –differentiate-> ovum
+ polar body + polar body

Plants are even more complicated; see text p. 143. You probably won't need to know the plant terminology for exams or quizzes, but you may need to look it up to answer homework questions.

All four cell products of meiosis in males differentiate into spermatozoa or pollen. *But* only small random sample actually participate in fertilization.

In female animals or plants, only one product of meiosis becomes an egg. *But* which product survives is normally a matter of chance, so this makes no difference in heredity and only a small random sample of products of meiosis participate in fertilization.

SUMMARY

- Meiosis consists of 2 divisions, I and II.
- In prophase of meiosis I, homologous chromosomes, each with 2 chromatids, synapse and undergo crossing-over (exchange segments).
- In metaphase of MI, homologous kinetochores attach by chromosome fibers to opposite poles.
- In anaphase of MI, homologous kinetochores migrate to opposite poles, dragging chromosomes behind them. Each chromosome still consists of 2 chromatids.
- The kinetochores of different chromosomes attach to poles independently of each other.
- There is no interphase and no DNA replication between MI and MII.
- MII is like mitosis: sister kinetochores attach to, and migrate to, opposite poles.
- Only a small random sample of the products of meiosis participate in fertilization in animals and plants.

The genetic results are:

- Alleles segregate.
- Alleles on different chromosomes segregate independently.
- Recombinant genotypes are produced.

