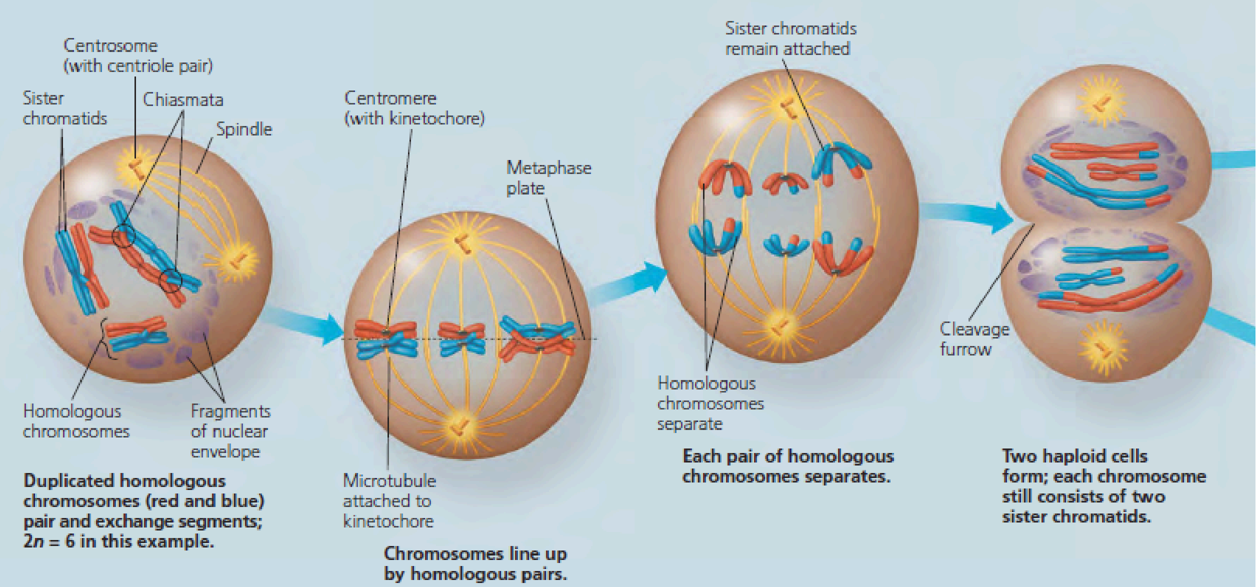
Cheat Sheet

MEIOSIS I: Separates homologous chromosomes

Prophase I | Metaphase I | Anaphase I | Telophase I and Cytokinesis



Prophase I

During early prophase I, before the stage shown above:

- Chromosomes begin to condense, and homologs loosely pair along their lengths, aligned gene by gene.
- Paired homologs become physically connected to each other along their lengths by a zipper-like protein structure, the *synaptonemal complex;* this state is called **synapsis.**
- **Crossing over**, a genetic rearrangement between nonsister chromatids involving the exchange of corresponding segments of DNA molecules, begins during pairing and synaptonemal complex formation, and is completed while homologs are in synapsis.

At the stage shown above:

- Synapsis has ended with the disassembly of the synaptonemal complex in mid-prophase, and the chromosomes in each pair have moved apart slightly.
- Each homologous pair has one or more X-shaped regions called **chiasmata** (singular, *chiasma*). A chiasma exists at the point where a crossover has occurred. It appears as a cross because sister chromatid cohesion still holds the two original sister chromatids together, even in regions beyond the crossover point, where one chromatid is now part of the other homolog.
- Centrosome movement, spindle formation, and nuclear envelope breakdown occur as in mitosis.

Later in prophase I, after the stage shown above:

- Microtubules from one pole or the other attach to the two kinetochores, protein structures at the centromeres of the two homologs. The homologous pairs then move toward the metaphase plate.

Metaphase I

- Pairs of homologous chromosomes are now arranged at the metaphase plate, with one chromosome in each pair facing each pole.
- Both chromatids of one homolog are attached to kinetochore microtubules from one pole; those of the other homolog are attached to microtubules from the opposite pole.

Anaphase I

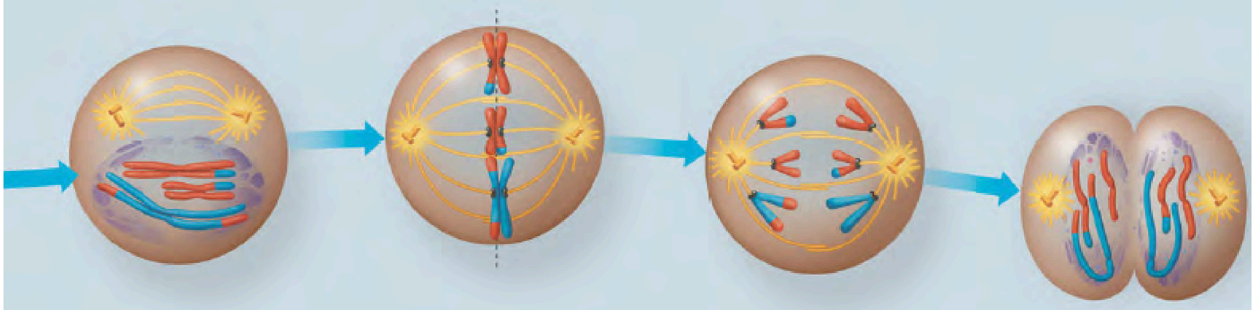
- Breakdown of proteins responsible for sister chromatid cohesion along chromatid arms allows homologs to separate.
- The homologs move toward opposite poles, guided by the spindle apparatus.
- Sister chromatid cohesion persists at the centromere, causing chromatids to move as a unit toward the same pole.

Telophase I and Cytokinesis

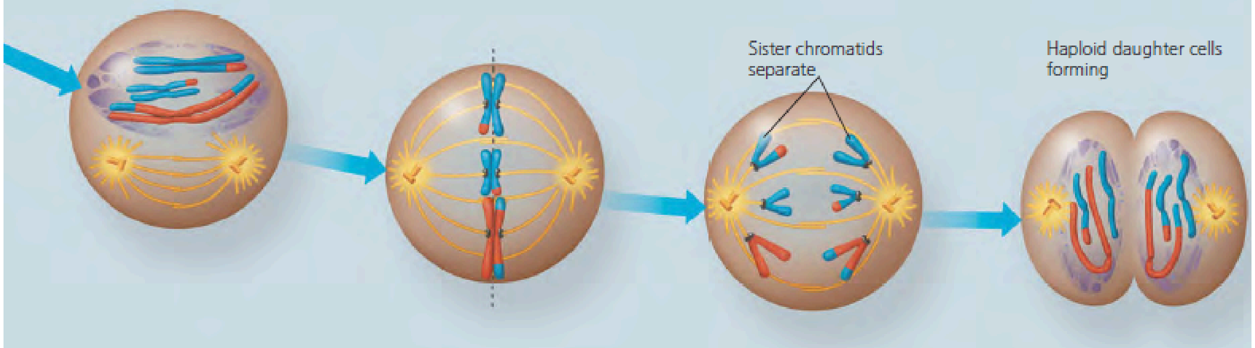
- At the beginning of telophase I, each half of the cell has a complete haploid set of duplicated chromosomes. Each chromosome is composed of two sister chromatids; one or both chromatids include regions of nonsister chromatid DNA.
- Cytokinesis (division of the cytoplasm) usually occurs simultaneously with telophase I, forming two haploid daughter cells.
- In animal cells like these, a cleavage furrow forms. (In plant cells, a cell plate forms.)
- In some species, chromosomes decondense and nuclear envelopes form.
- No chromosome duplication occurs between meiosis I and meiosis II.

MEIOSIS II: Separates sister chromatids

Prophase II	Metaphase II	Anaphase II	Telophase II and Cytokinesis



During another round of cell division, the sister chromatids finally separate; four haploid daughter cells result, containing unduplicated chromosomes.



Prophase II

- A spindle apparatus forms.
- In late prophase II (not shown here), chromosomes, each still composed of two chromatids associated at the centromere, move toward the metaphase II plate.

Metaphase II

- The chromosomes are positioned at the metaphase plate as in mitosis.
- Because of crossing over in meiosis I, the two sister chromatids of each chromosome are *not* genetically identical.
- The kinetochores of sister chromatids are attached to microtubules extending from opposite poles.

Anaphase II

- Breakdown of proteins holding the sister chromatids together at the centromere allows the chromatids to separate. The chromatids move toward opposite poles as individual chromosomes.

Telophase II and Cytokinesis

- Nuclei form, the chromosomes begin decondensing, and cytokinesis occurs.
- The meiotic division of one parent cell produces four daughter cells, each with a haploid set of (unduplicated) chromosomes.
- The four daughter cells are genetically distinct from one another and from the parent cell.

Chapter 13 Questions

1. **What are heredity (inheritance) and genetics?**
2. **What are the hereditary units of living things?**
3. **What are reproductive cells called and what is their fusion called?**
4. **How many chromosomes are in human somatic cells?**
5. **What is a gene’s specific location in the chromosome called?**
6. **What is asexual reproduction and what are its products called?**
7. **What is sexual reproduction?**
8. **What is an ordered display of an organism’s chromosomes called?**
9. **What are chromosomes with the same length, centromere position, and staining pattern called?**
10. **What are the two types of chromosomes?**
11. **What is a cell with two chromosome sets called?**
12. **What type of cell are gametes in terms of chromosomes?**
13. **What are the haploid and diploid numbers of *Drosophila melanogaster* and dogs?**
14. **What is a fertilized egg called?**
15. **Where and how are gametes produced?**
16. **What are the three types of life cycles?**
17. **What are the two stages in meiosis?**
18. **What are alleles?**
19. **What the steps of both stages of meiosis?**
20. **After interphase and before meiosis, what state are chromosomes in?**
21. **How does crossing over occur?**
22. **What are chromosomes that carry genes from two different parents?**
23. **What are bdelloid rotifers?**

Chapter 13 Answers

1. Transmission of traits from one generation to the next, scientific study of heredity and inherited variation
2. Genes
3. Gametes (sperm and egg), meet in fertilization
4. 46
5. The gene's locus
6. Single individual passes copies of genes to offspring without fusion of gametes, produces clone
7. Two parents give rise to offspring with unique combinations of genes inherited from both parents
8. Karyotype
9. Homologous chromosomes, or homologs
10. Sex chromosomes (X and Y) and autosomes (the rest)
11. Diploid cell, has diploid number of chromosomes (abbr. 2n)
12. Haploid cell, haploid number of chromosomes (abbr. n)
13. 4,8 and 39,78
14. zygote
15. Gonads (ovaries and testes) have germ cells from which gametes develop by meiosis
16. Most animals where gametes are only haploid cells. Plants and some algae use alternation of generations (has multicellular haploid and diploid stages) where multicellular diploid stage called sporophyte (produces spores by meiosis, spores divide by mitosis to form gametophyte (haploid, produces gametes by mitosis, fusion creates zygote, which divides to form sporophyte). Most fungi and some protists where gametes fuse to form diploid zygote where meiosis occurs before mitosis, haploid resulting cells divide by mitosis to give rise to create unicellular or a haploid multicellular organism. Mitoses can produce gametes. Only diploid cells can divide by meiosis.
17. Meiosis I and meiosis II result in 4 daughter cells (haploid)
18. Versions of a gene
19. Look at picture
20. Duplicated and sisters are held together by cohesins
21. DNA of two nonsister chromatids is broken by specific proteins at precisely matching points. Synaptonemal complex (zipper-like structure) forms, holds one homolog tightly to the other (association called synapsis). DNA breaks are closed so that each broken end is joined to corresponding segment of the nonsister chromatid. Points of crossing over visible as chiasmata after synaptonemal complex disassembles. At least one crossover per chromosome must occur for homologous pair to stay together
22. Recombinant chromosomes
23. Animal that has not sexually reproduced for 50 million years, generate genetic diversity when live in environments that dry up, enter state of suspended animation, cell membranes crack and allow DNA from other species to enter.