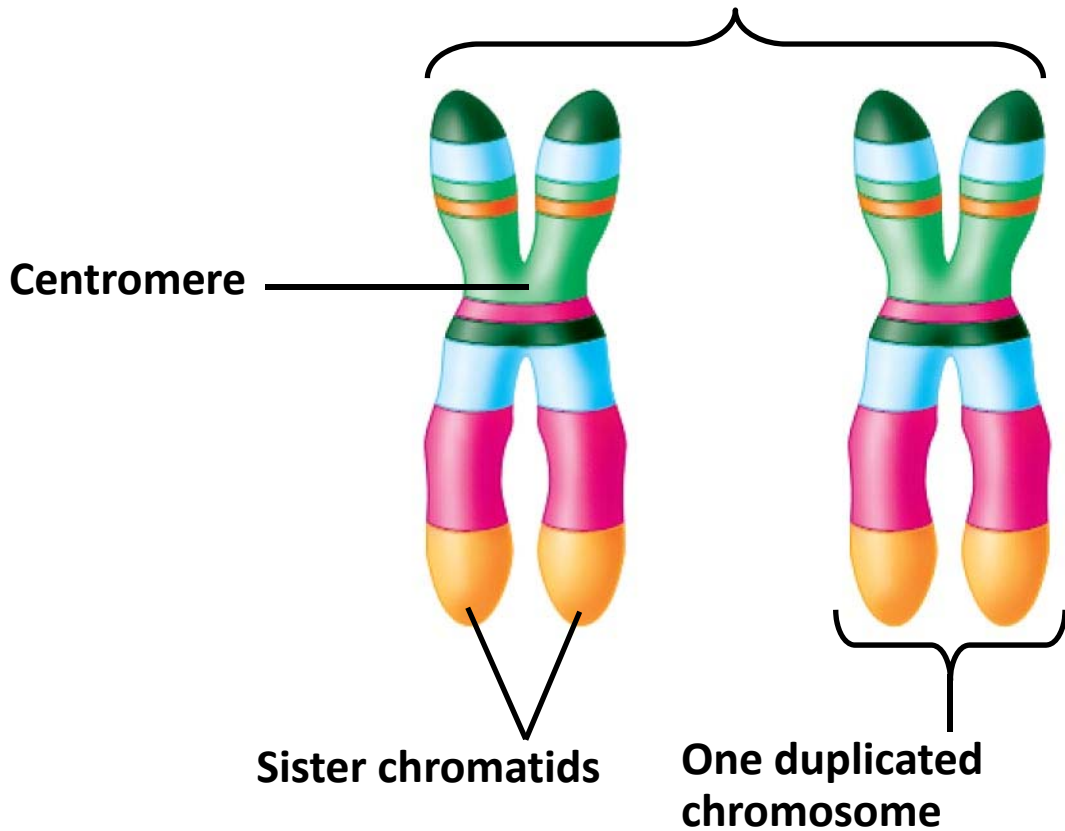

MEIOSIS AND CROSSING OVER

(The story of how we make more)

You have 46 Chromosomes or 23 homologous pairs

- **23 chromosomes come from each parent for a total of 46**
- One pair of chromosomes are **sex chromosomes** X and Y differ in size and genetic composition
- 22 pairs of chromosomes are **autosomes** have the same size and genetic composition

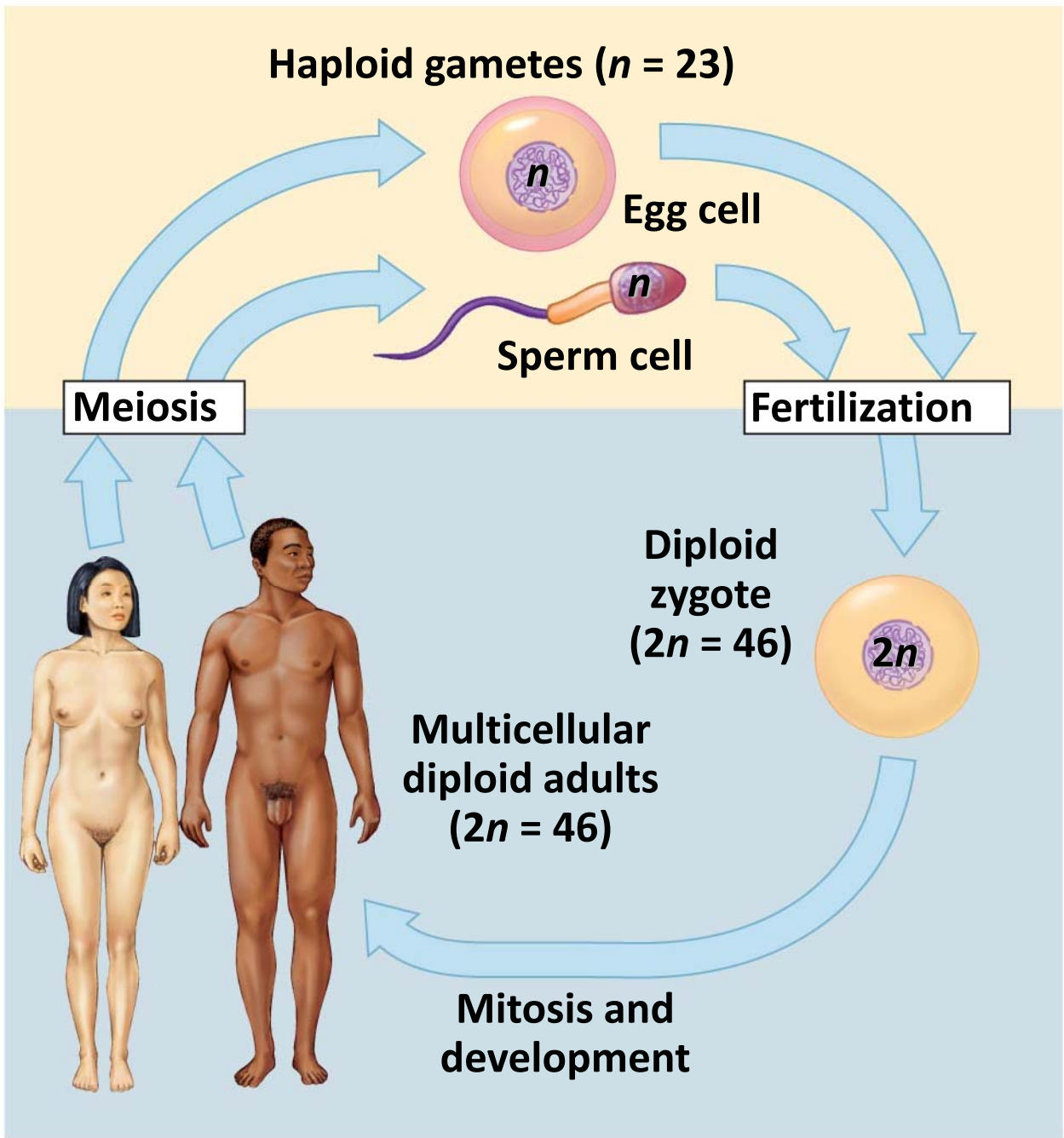
Homologous pair of chromosomes



Homologous chromosomes are matched by their length, Centromere position, and gene Locations (locus)

8.13 Gametes have a single set of chromosomes

- Meiosis is a process that converts diploid nuclei to haploid nuclei
 - **Diploid cells** have two homologous sets of chromosomes
 - **Haploid cells** have one set of chromosomes
 - Meiosis occurs in the sex organs, producing **gametes**— sperm and eggs
- **Fertilization** is the union of sperm and egg
 - The **zygote** has a diploid chromosome number, one set from each parent



8.14 Meiosis reduces the chromosome number from diploid to haploid

- Like mitosis, **meiosis** is preceded by interphase
 - Chromosomes duplicate during the S phase
- Unlike mitosis, meiosis has two divisions
 - During meiosis I, homologous chromosomes separate
 - The chromosome number is reduced by half
 - During meiosis II, sister chromatids separate
 - The chromosome number remains the same

8.14 Meiosis reduces the chromosome number from diploid to haploid

- Events in the nucleus during meiosis I
 - **Prophase I**
 - Chromosomes coil and become compact
 - Homologous chromosomes come together as pairs by synapsis
 - Each pair, with four chromatids, is called a tetrad
 - Nonsister chromatids exchange genetic material by crossing over

8.14 Meiosis reduces the chromosome number from diploid to haploid

- Events in the nucleus during meiosis I
 - **Metaphase I**
 - Tetrads align at the cell equator
 - **Anaphase I**
 - Homologous pairs separate and move toward opposite poles of the cell
 - Applying Your Knowledge Human cells
have 46 chromosomes. At the end of Metaphase I
 - How many chromosomes are present in one cell?
 - How many chromatids are present in one cell?

8.14 Meiosis reduces the chromosome number from diploid to haploid

- Events in the nucleus during meiosis I
 - Telophase I
 - Duplicated chromosomes have reached the poles
 - A nuclear envelope forms around chromosomes in some species
 - Each nucleus has the haploid number of chromosomes

MEIOSIS I: Homologous chromosomes separate

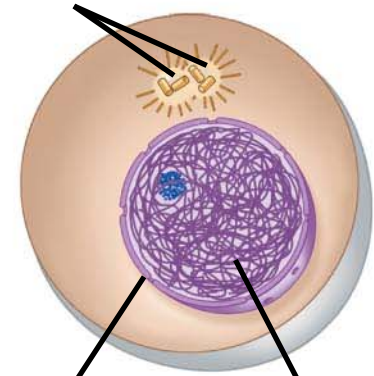
INTERPHASE

PROPHASE I

METAPHASE I

ANAPHASE I

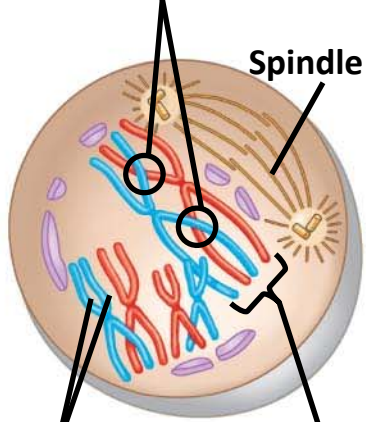
Centrosomes
(with centriole
pairs)



Nuclear
envelope

Chromatin

Sites of crossing over

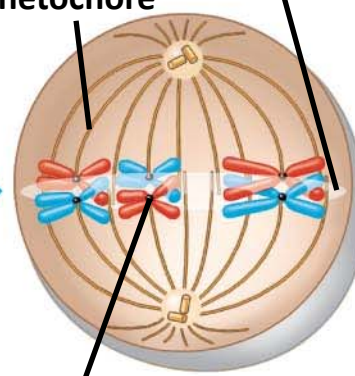


Sister
chromatids

Tetrad

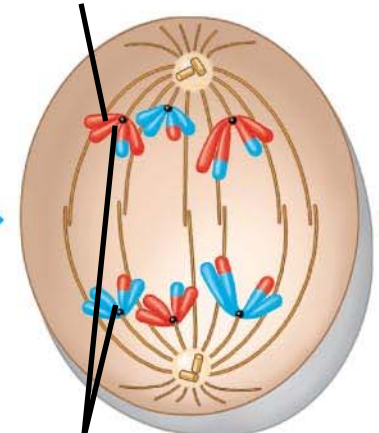
Microtubules
attached to
kinetochore

Metaphase
plate



Centromere
(with kinetochore)

Sister chromatids
remain attached



Homologous
chromosomes separate

MEIOSIS II: Sister chromatids separate

**TELOPHASE I
AND CYTOKINESIS**

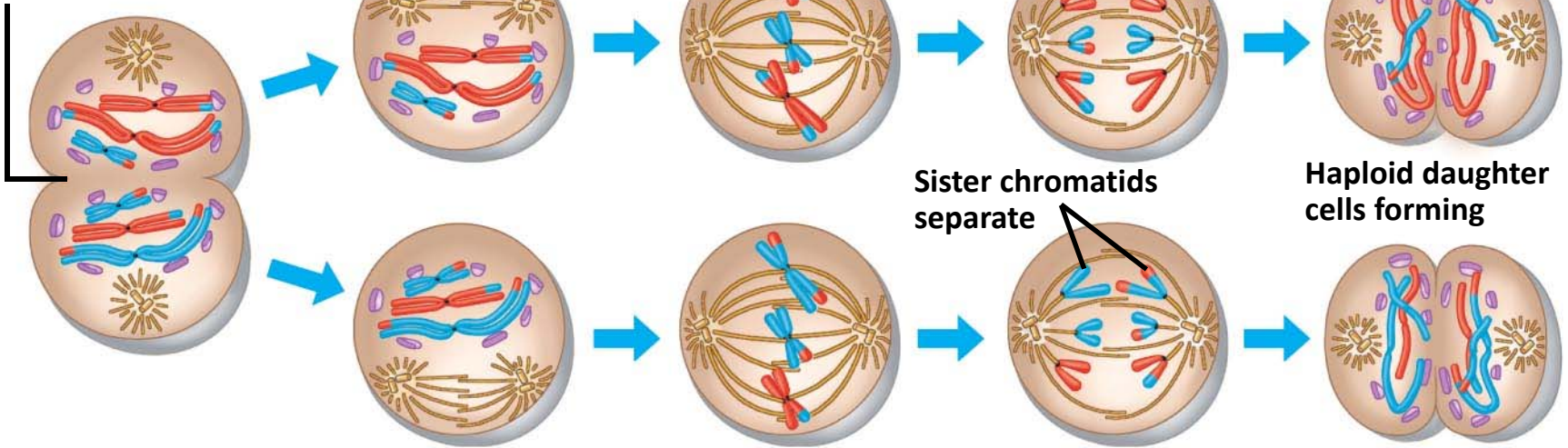
PROPHASE II

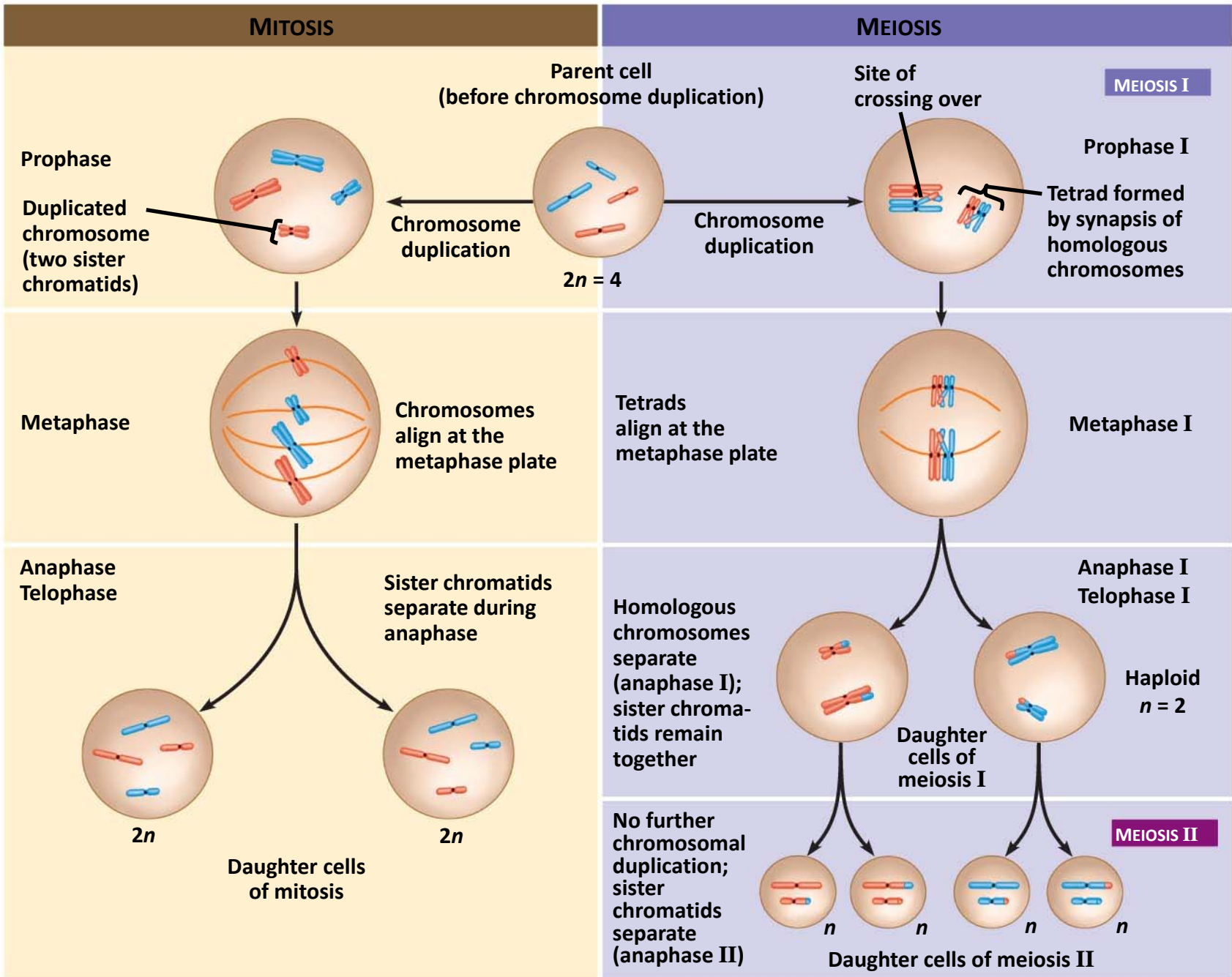
METAPHASE II

ANAPHASE II

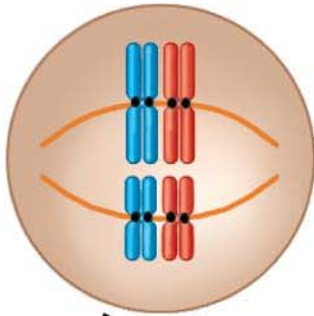
**TELOPHASE II
AND CYTOKINESIS**

**Cleavage
furrow**



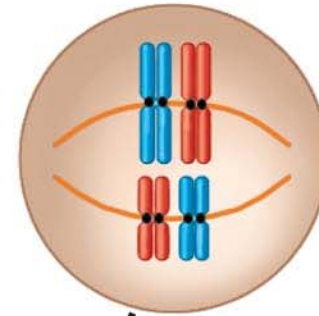


Possibility 1

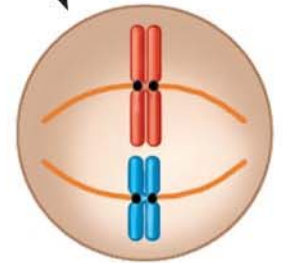
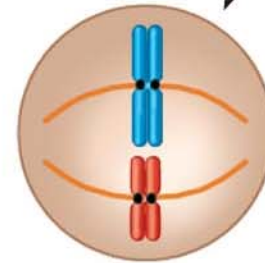
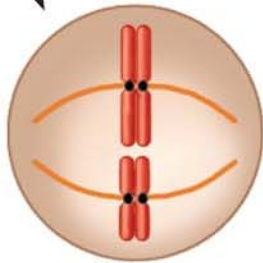
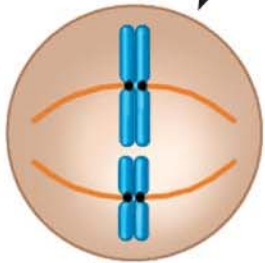


Two equally probable
arrangements of
chromosomes at
metaphase I

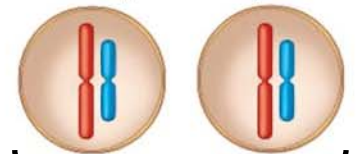
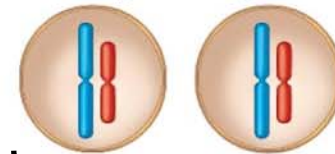
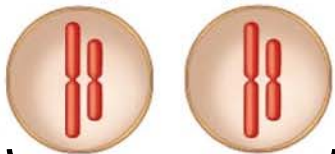
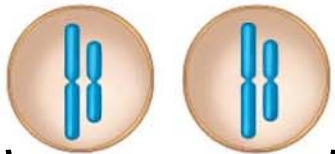
Possibility 2



Metaphase II



Gametes

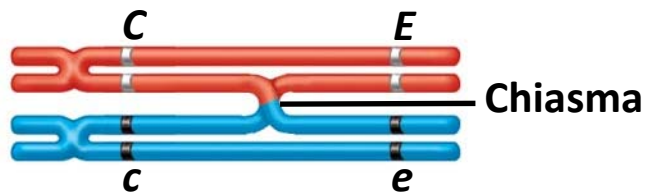


Combination 1

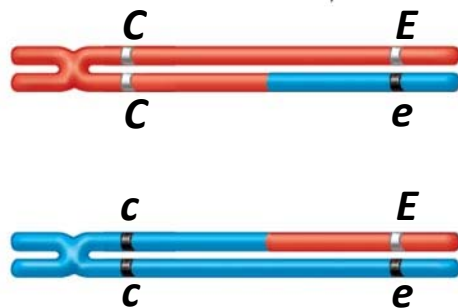
Combination 2

Combination 3

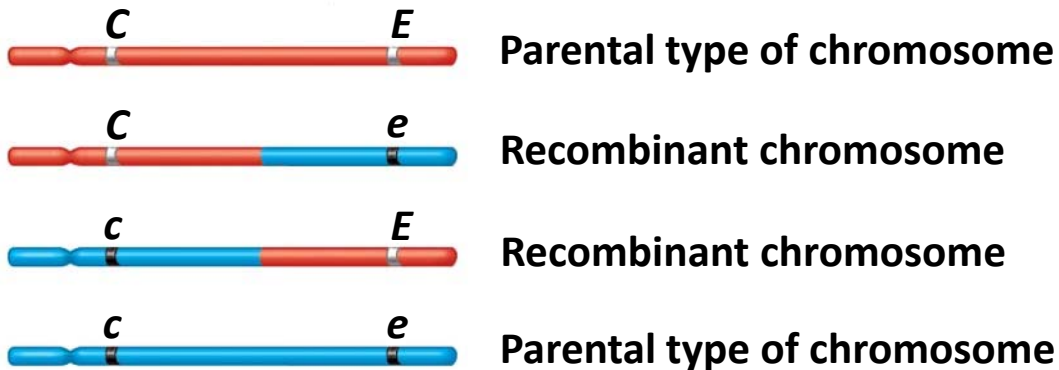
Combination 4



3 Separation of homologous chromosomes at anaphase I



4 Separation of chromatids at anaphase II and completion of meiosis



Gametes of four genetic types

8.14 Meiosis reduces the chromosome number from diploid to haploid

- **Meiosis II** follows meiosis I without chromosome duplication
- Each of the two haploid products enters meiosis II
- Events in the nucleus during meiosis II
 - Prophase II
 - Chromosomes coil and become compact

8.14 Meiosis reduces the chromosome number from diploid to haploid

- Events in the nucleus during meiosis II
 - Metaphase II
 - Duplicated chromosomes align at the cell equator
 - Anaphase II
 - Sister chromatids separate and chromosomes move toward opposite poles

8.14 Meiosis reduces the chromosome number from diploid to haploid

- Events in the nucleus during meiosis II
 - Telophase II
 - Chromosomes have reached the poles of the cell
 - A nuclear envelope forms around each set of chromosomes
 - With cytokinesis, four haploid cells are produced

8.15 Mitosis and meiosis have important similarities and differences

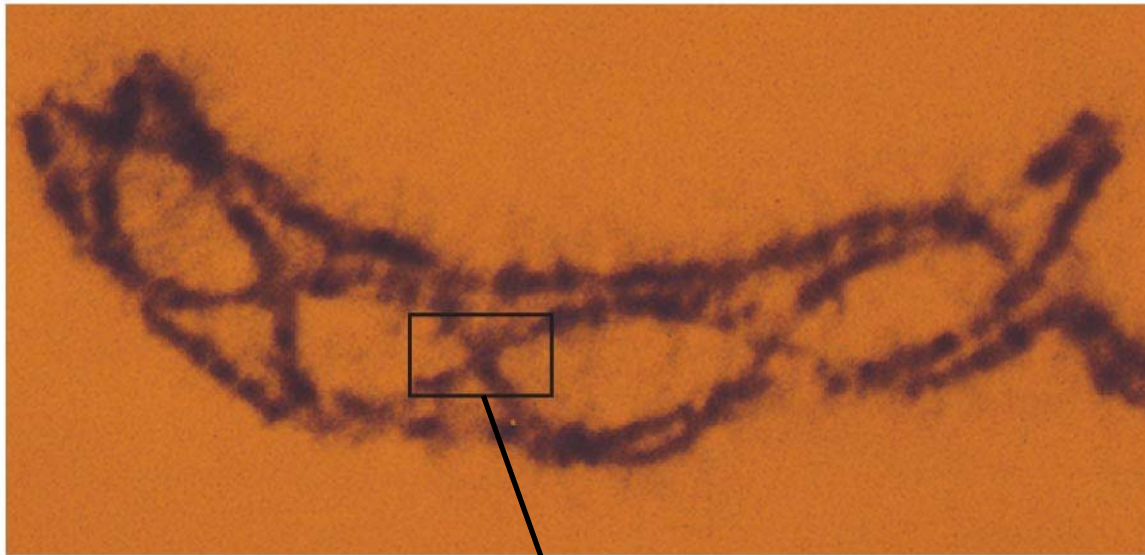
- Which characteristics are similar for mitosis and meiosis?
 - One duplication of chromosomes
- Which characteristics are unique to meiosis?
 - Two divisions of chromosomes
 - Pairing of homologous chromosomes
 - Exchange of genetic material by crossing over

8.15 Mitosis and meiosis have important similarities and differences

- What is the outcome of each process?
 - Mitosis: two genetically identical cells, with the same chromosome number as the original cell
 - Meiosis: four genetically different cells, with half the chromosome number of the original cell

8.18 Crossing over further increases genetic variability

- Genetic recombination is the production of new combinations of genes due to crossing over
- Crossing over involves exchange of genetic material between homologous chromosomes
 - Nonsister chromatids join at a **chiasma** (plural, *chiasmata*), the site of attachment and crossing over
 - Corresponding amounts of genetic material are exchanged between maternal and paternal (nonsister) chromatids



Tetrad



Chiasma



Centromere