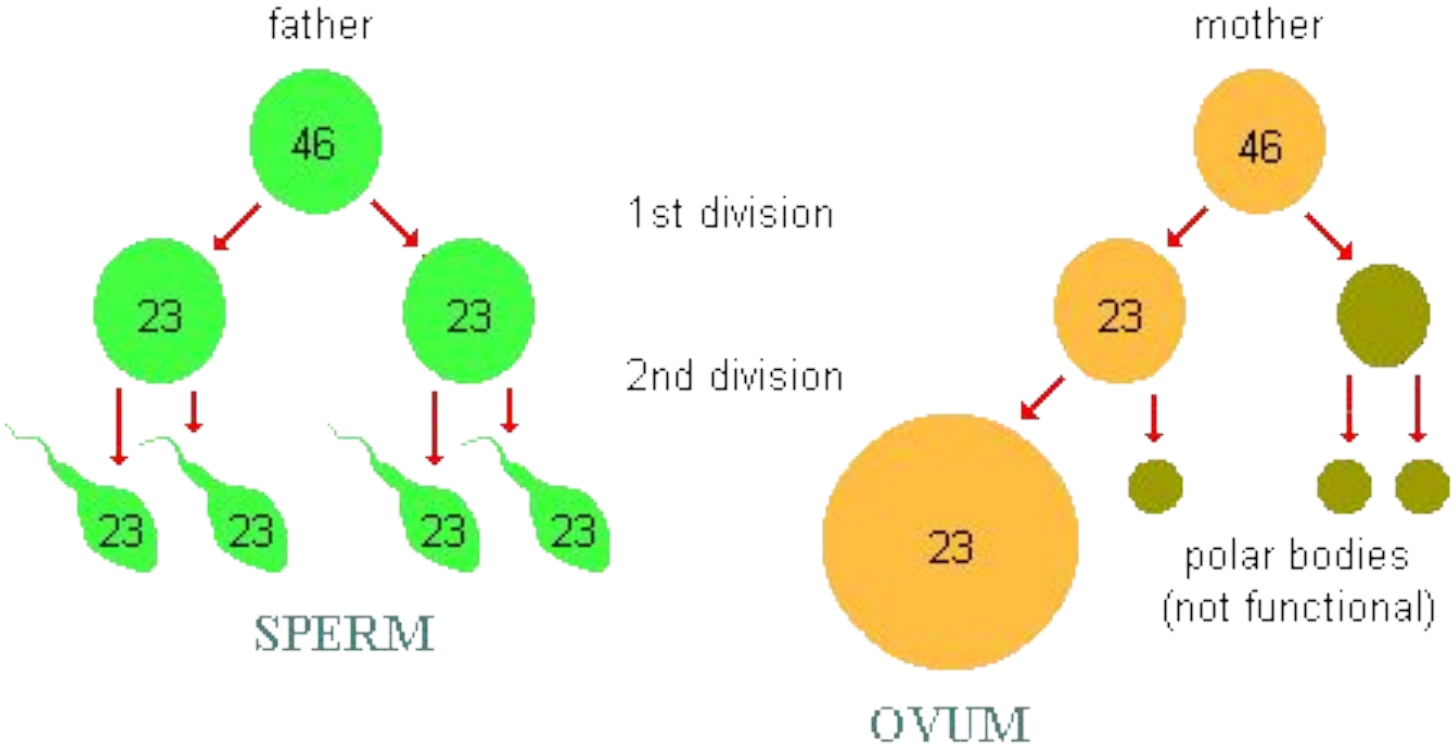
Meiosis

and what makes you special

Meiosis

The process that forms gametes –eggs/sperms- from diploid cell.



In animals…

Somatic cells (cells of the body) are *diploid*. This means that each cell has two chromosomes of each type. They are in PAIRS

⇨ Biologists use "2N" to symbolize *diploid*

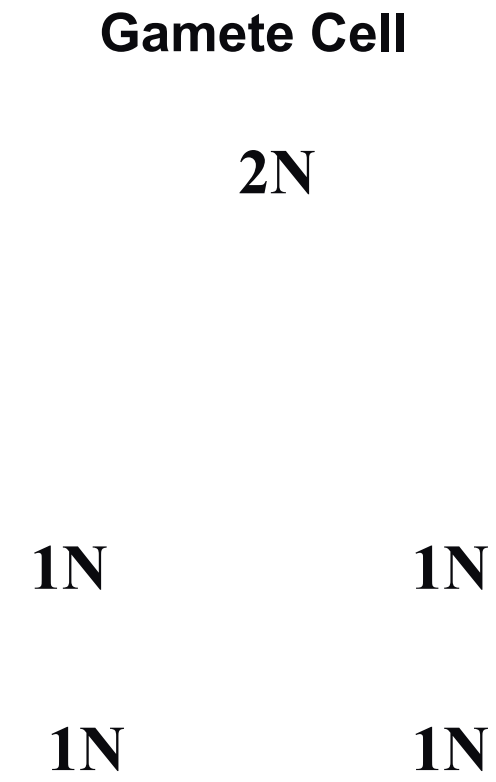
Gamete cells (egg, sperm) are *haploid*.
This means that each cell has only one of each type of chromosome

⇨ Biologists use "1N" to symbolize *haploid*.

Meiosis

When gamete (sperm or egg) cells reproduce themselves the process is called MEIOSIS.

During meiosis, a single diploid cell divides and produces FOUR haploid reproductive cells.



Gamete cells (egg, sperm) are *haploid*.

Somatic cells (all other body cells) are *diploid*

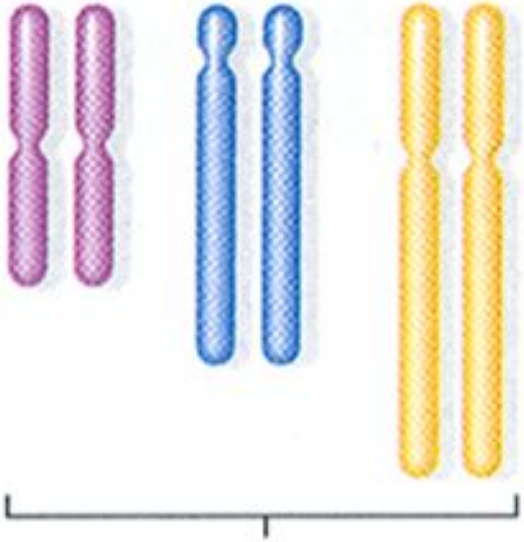
Haploid (N)

One copy of genetic material subdivided into chromosomes

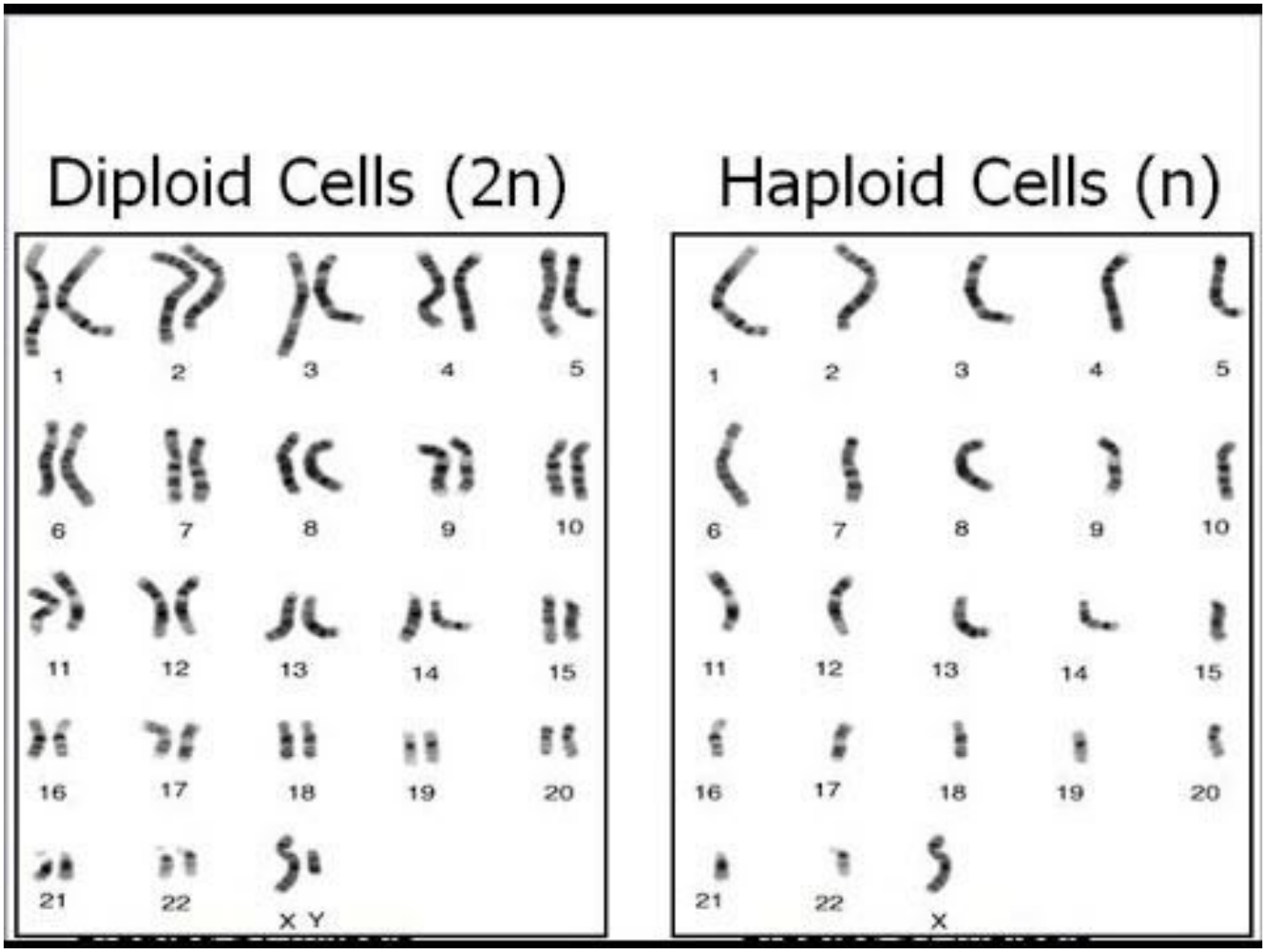
Three nonhomologous chromosomes

Diploid (2N)

Two copies of genetic material subdivided into chromosomes



Three pairs of homologous chromosomes


Diploid Cells (2n)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
X Y
Haploid Cells (n)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
X

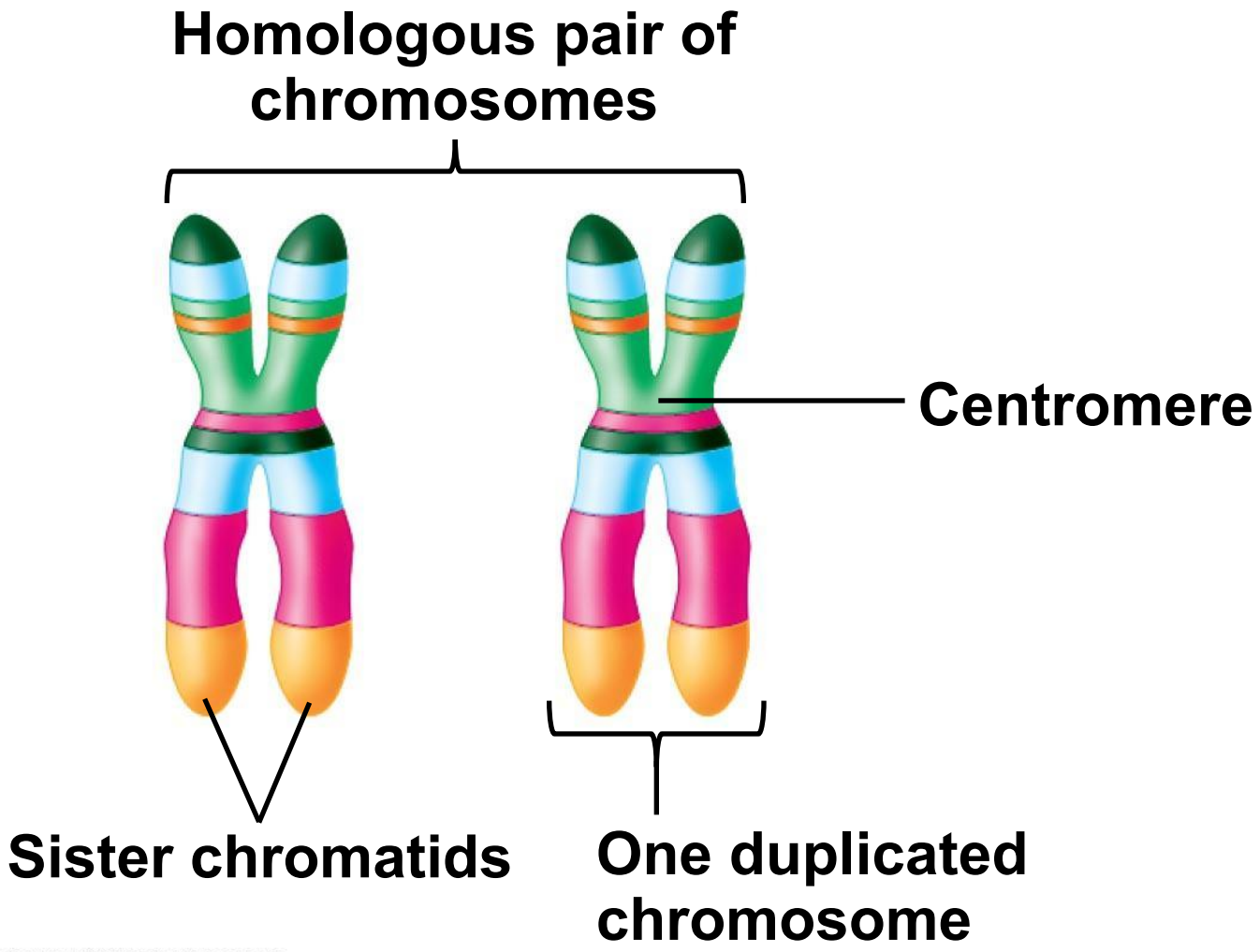
Comparison Chart	Diploid	Haploid
About	Diploid cells contain two complete sets (2n) of chromosomes.	Haploid cells have half the number of chromosomes (n) as diploid - i.e. a haploid cell contains only one complete set of chromosomes.
Cell Division and Growth	Diploid cells reproduce by mitosis making daughter cells that are exact replicas.	Haploid cells are a result of the process of meiosis, a type of cell division in which diploid cells divide to give rise to haploid germ cells. A haploid cell will merge with another haploid cell at fertilization.
Examples	Skin, blood, muscle cells (also known as somatic cells)	Cells used in sexual reproduction, sperm and ova (also known as Gametes).

Chromosomes are matched in homologous pairs

- **Somatic cells (body cells)** have pairs of homologous chromosomes, receiving one member of each pair from each parent
- **Homologous chromosomes** are matched in
  - Length
  - Centromere position
  - Gene locations
    - A **locus** (plural, *loci*) is the position of a gene
    - Different versions of a gene may be found at the same locus on maternal and paternal chromosomes

8.12 Chromosomes are matched in homologous pairs

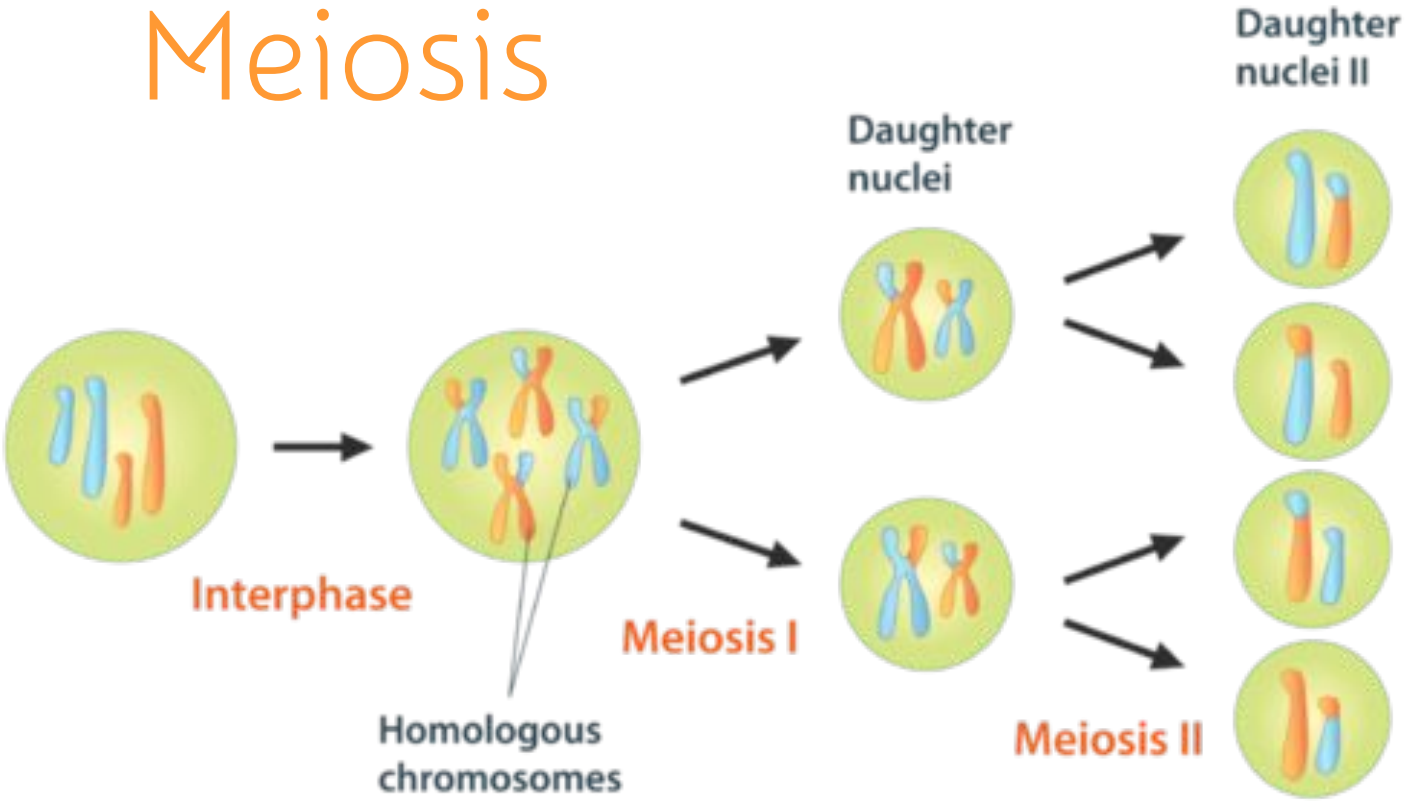
- The human **sex chromosomes** X and Y differ in size and genetic composition
- Pairs of **autosomes (non-sex chromosomes)** have the same size and genetic composition
- Applying Your Knowledge
  - Humans have 46 chromosomes; how many homologous pairs does that represent? 23
  - If there is one pair of sex chromosomes, how many pairs of autosomes are found in humans? 22

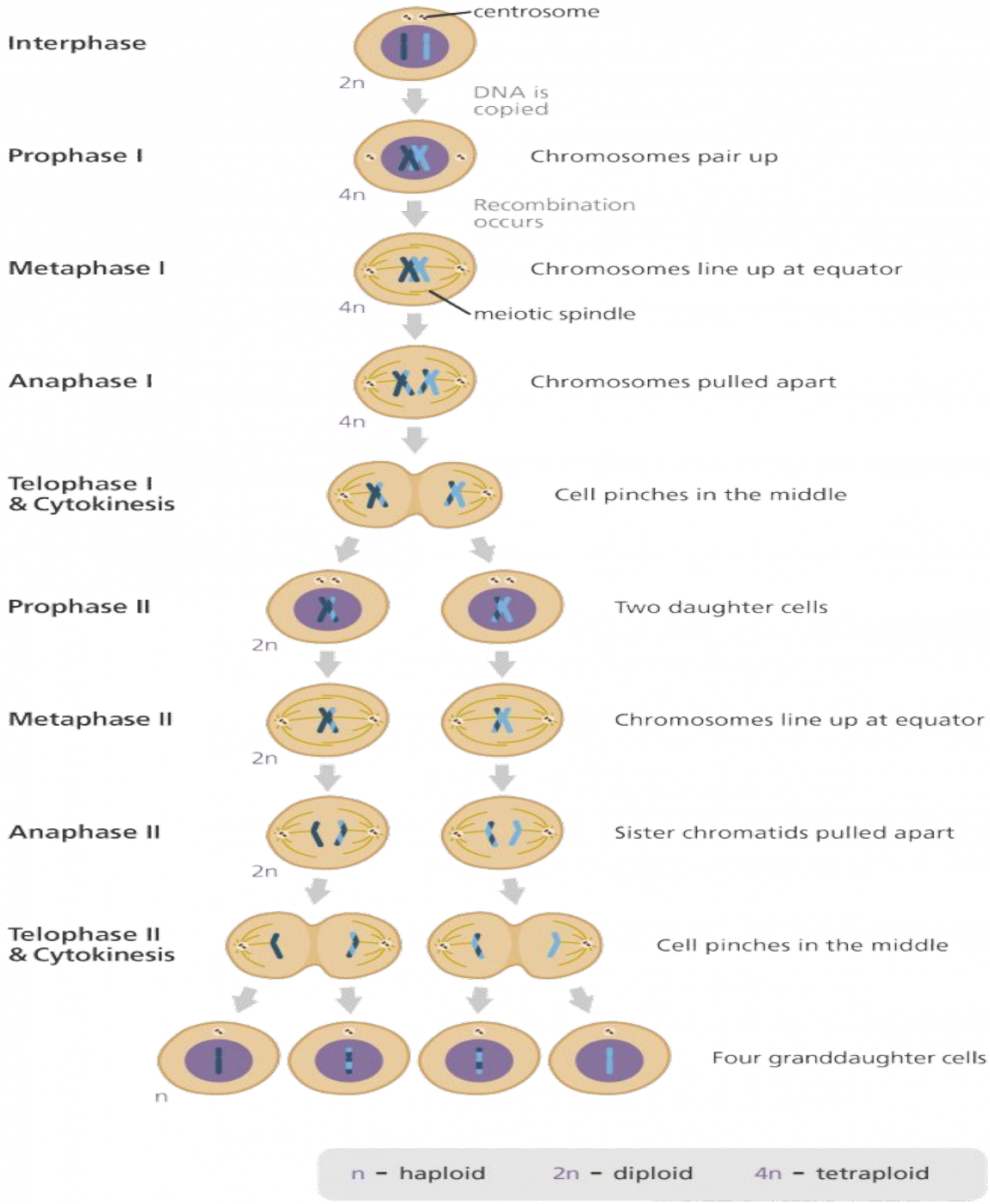


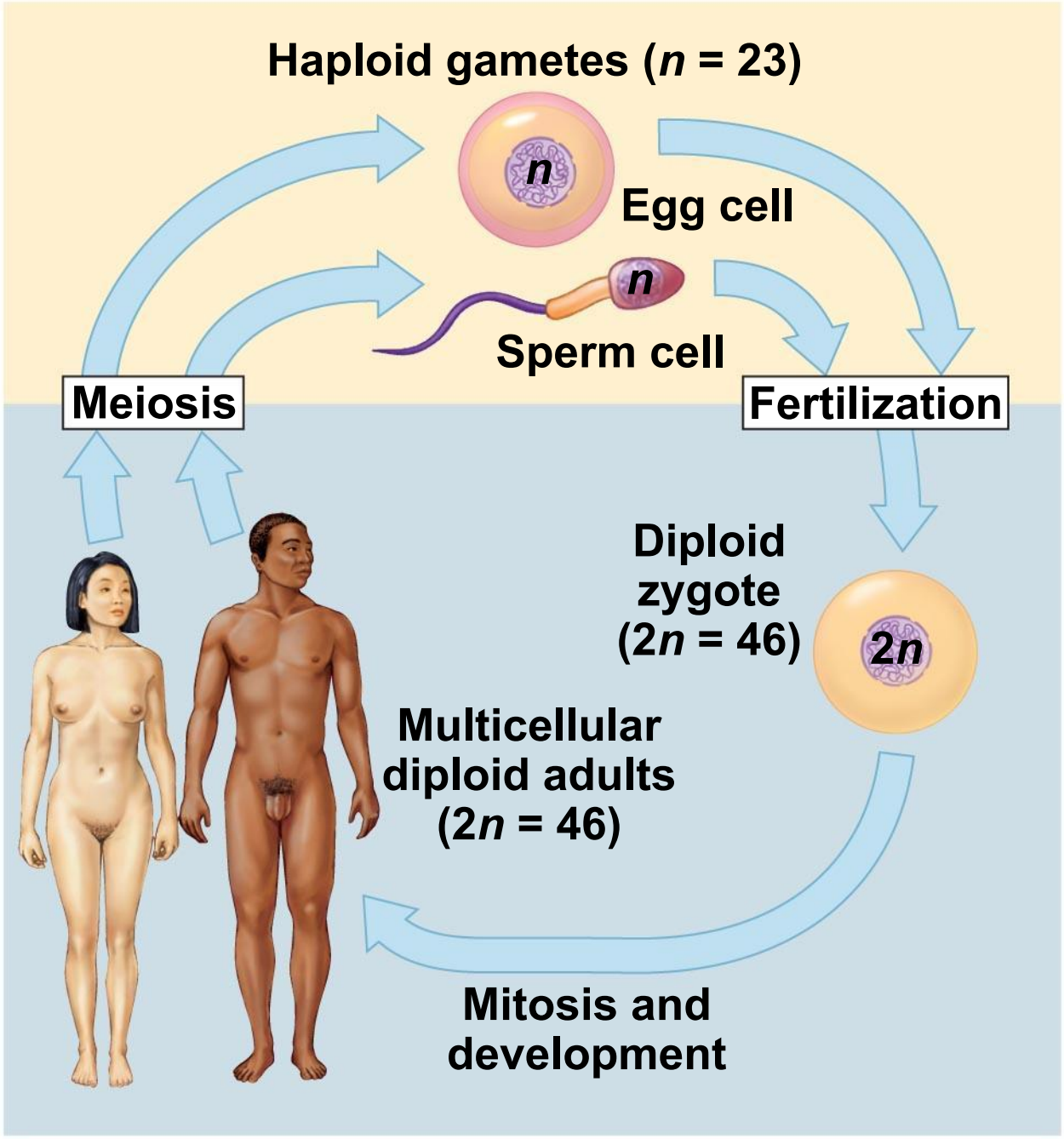
8.13 Gametes have a single set of chromosomes

- 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

Meiosis


Daughter nuclei II
Daughter nuclei
Interphase
Meiosis I
Homologous chromosomes
Meiosis II


Interphase
centrosome
2n
DNA is copied
Prophase I
Chromosomes pair up
4n
Recombination occurs
Metaphase I
Chromosomes line up at equator
4n
meiotic spindle
Anaphase I
Chromosomes pulled apart
4n
Telophase I & Cytokinesis
Cell pinches in the middle
Prophase II
Two daughter cells
2n
Metaphase II
Chromosomes line up at equator
2n
Anaphase II
Sister chromatids pulled apart
2n
Telophase II & Cytokinesis
Cell pinches in the middle
Four granddaughter cells
n
n – haploid
2n – diploid
4n – tetraploid



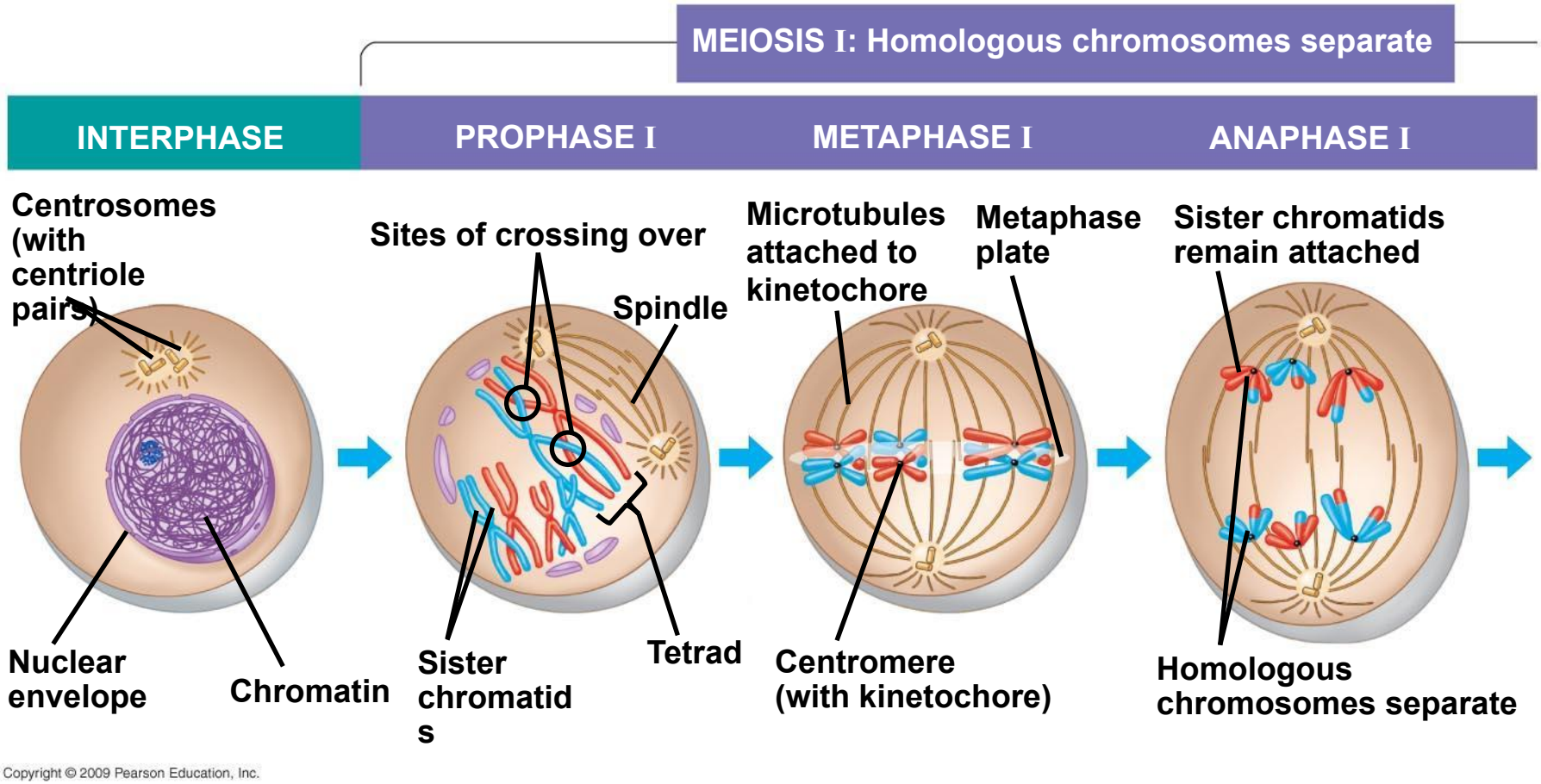
8.15 Mitosis and meiosis have important similarities and differences

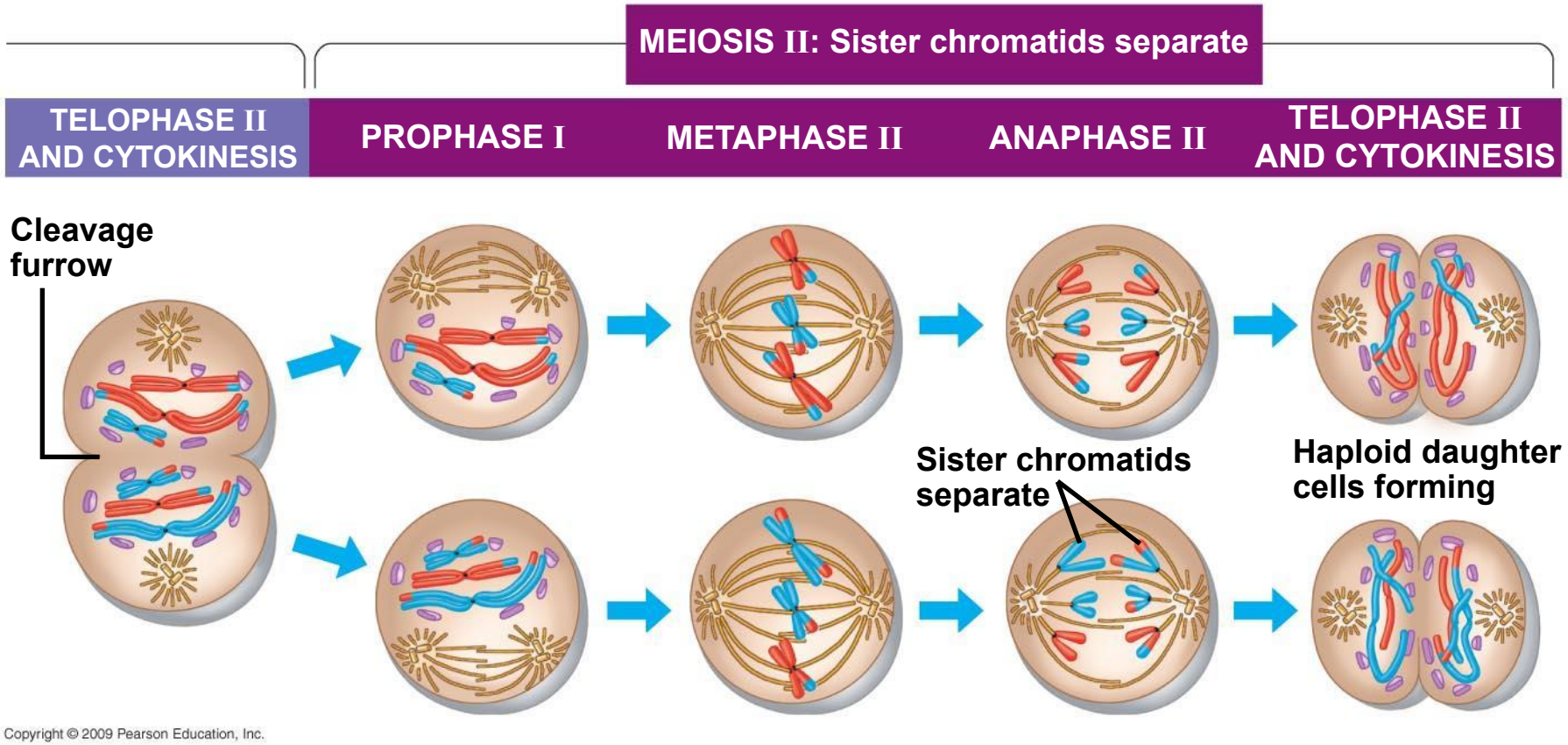
- Which characteristics are similar for mitosis and meiosis?
  - One duplication of chromosomes
- Which characteristics are unique to meiosis?
  - Two divisions of chromosomes
  - Pairing of homologous chromosomes
  - Exchange of genetic material by crossing over

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

Common Name	Genus and Species	Diploid Chromosome Number
Buffalo	***Bison bison***	**60**
Cat	***Felis catus***	**38**
Cattle	***Bos taurus, B. indicus***	**60**
Dog	***Canis familiaris***	**78**
Donkey	***E. asinus***	**62**
Goat	***Capra hircus***	**60**
Horse	***Equus caballus***	**64**
Human	***Homo sapiens***	**46**
Pig	***Sus scrofa***	**38**
Sheep	***Ovis aries***	**54**



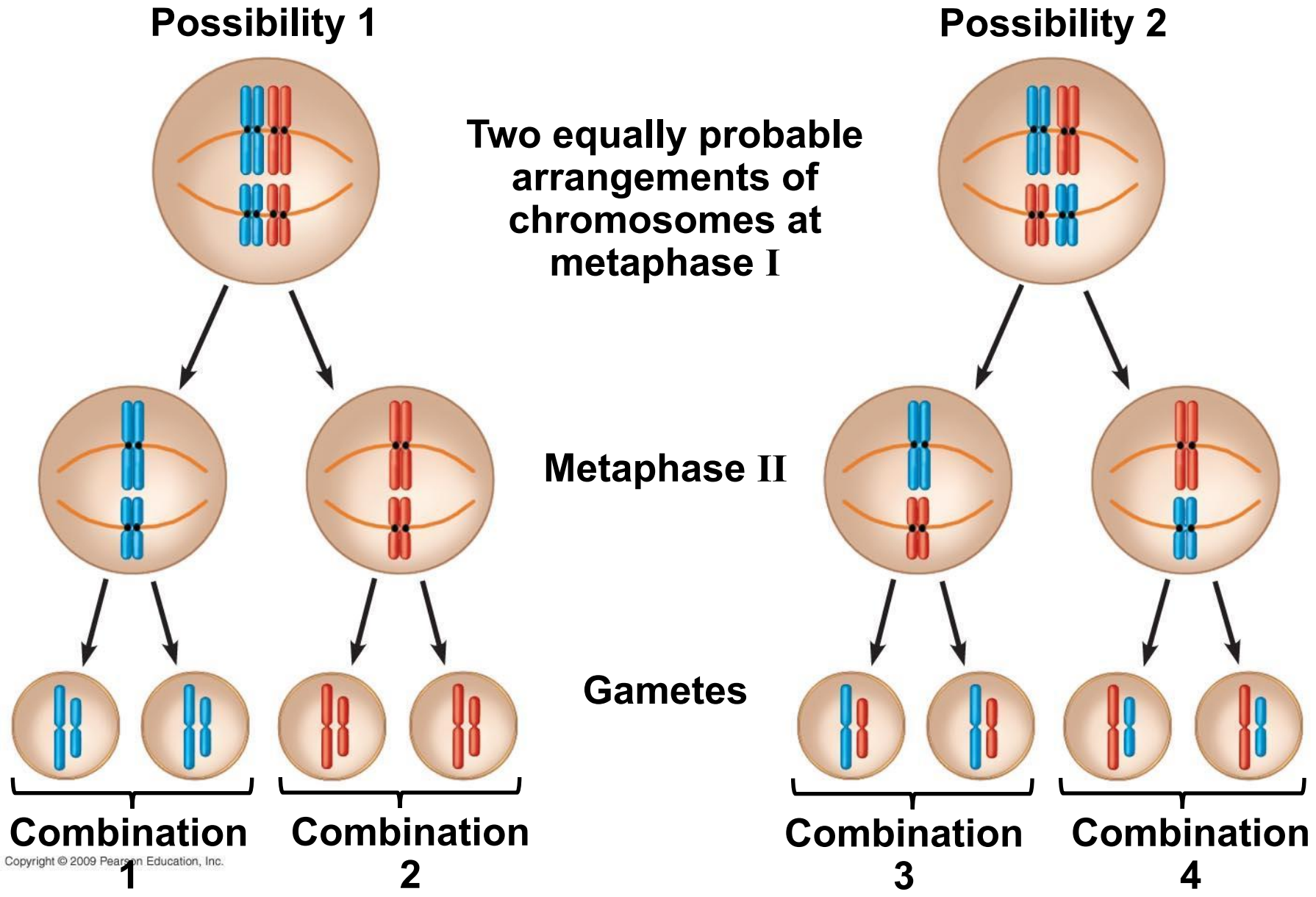


Independent orientation of chromosomes in meiosis and random fertilization lead to varied offspring

- Independent orientation (aka independent assortment) at metaphase I
  - Each pair of chromosomes independently aligns at the cell equator
  - There is an equal probability of the maternal or paternal chromosome facing a given pole

- Random fertilization
  - The combination of each unique sperm with each unique egg increases genetic variability

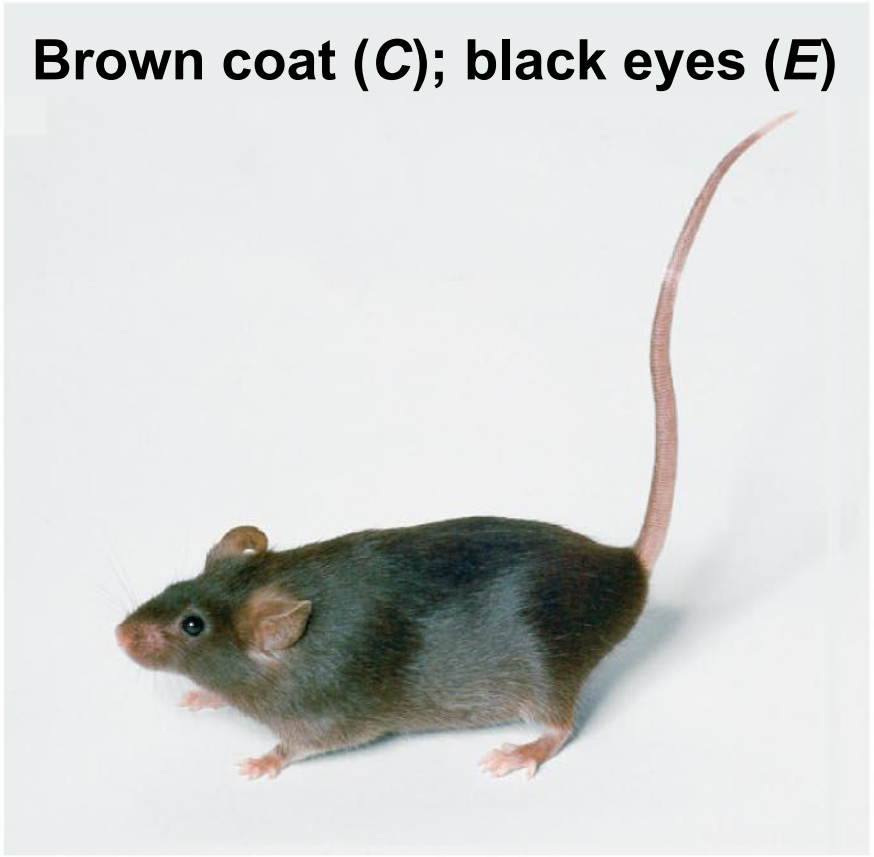
Animation: Genetic Variation



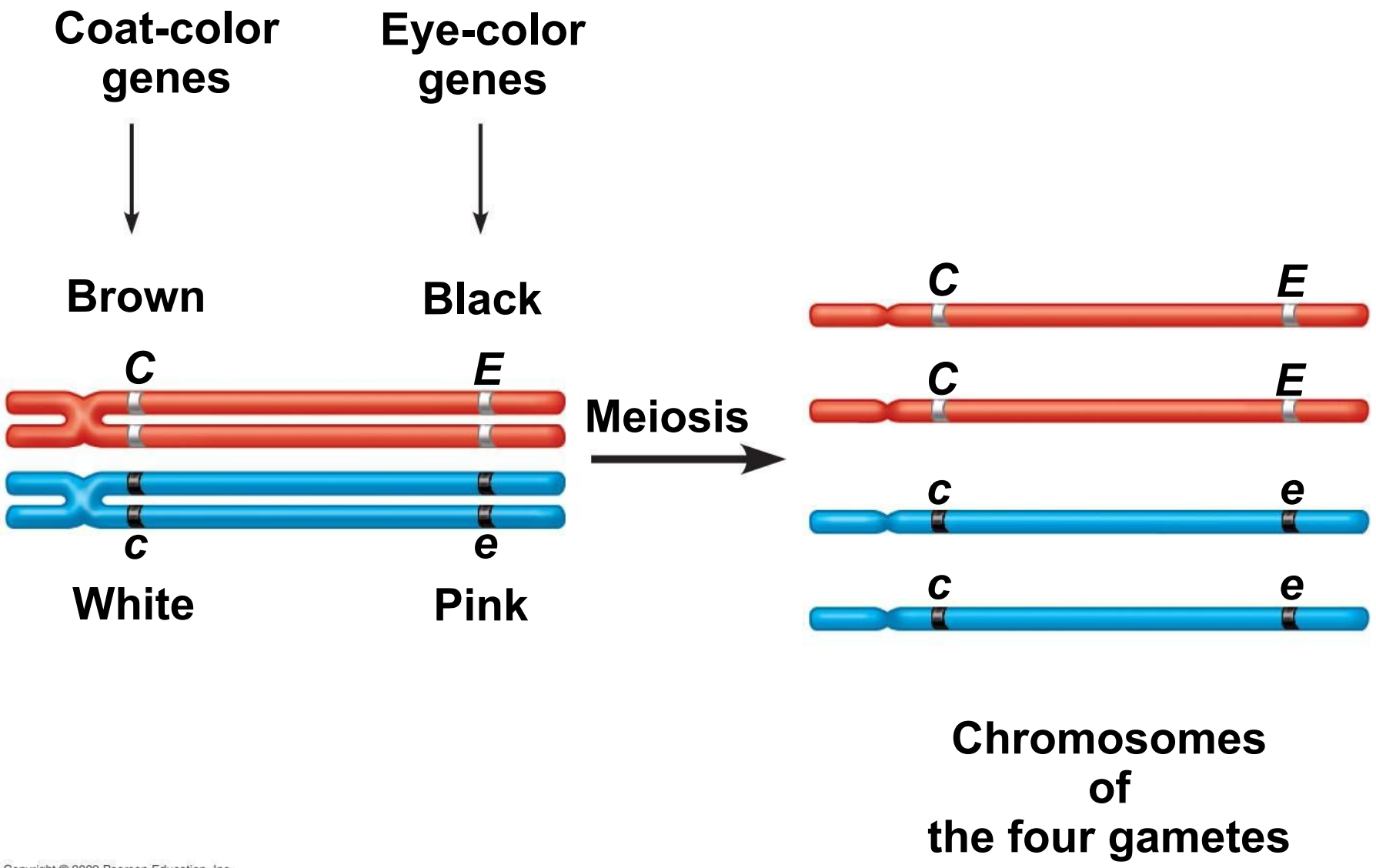
8.17 Homologous chromosomes can carry different versions of genes

- Separation of homologous chromosomes during meiosis can lead to genetic differences between gametes
  - Homologous chromosomes may have different versions of a gene at the same locus
  - One version was inherited from the maternal parent, and the other came from the paternal parent
  - Since homologues move to opposite poles during anaphase I, gametes will receive either the maternal or paternal version of the gene

Brown coat (*C*); black eyes (*E*)



White coat (*c*); pink eyes (*e*)



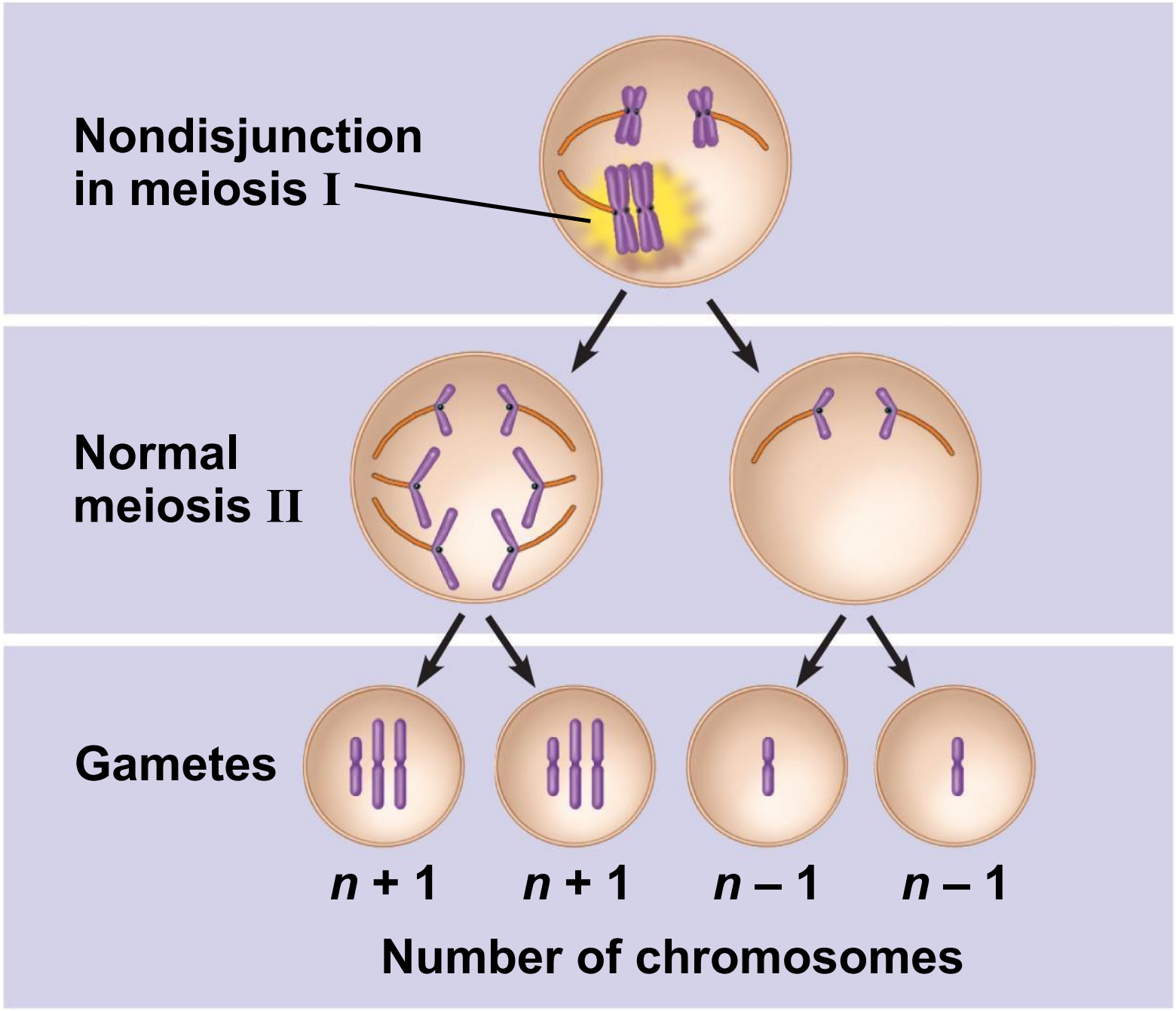
8.18 Crossing over further increases genetic variability

- 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

Show crossing over animation from book

8.21 Accidents during meiosis can alter chromosome number

- **Nondisjunction** is the failure of chromosomes or chromatids to separate during meiosis
  - During Meiosis I
    - Both members of a homologous pair go to one pole
  - During Meiosis II
    - Both sister chromatids go to one pole
- Fertilization after nondisjunction yields zygotes with altered numbers of chromosomes



GENETICS VOCABULARY

Aneuploidy

- Having an extra or missing chromosomes

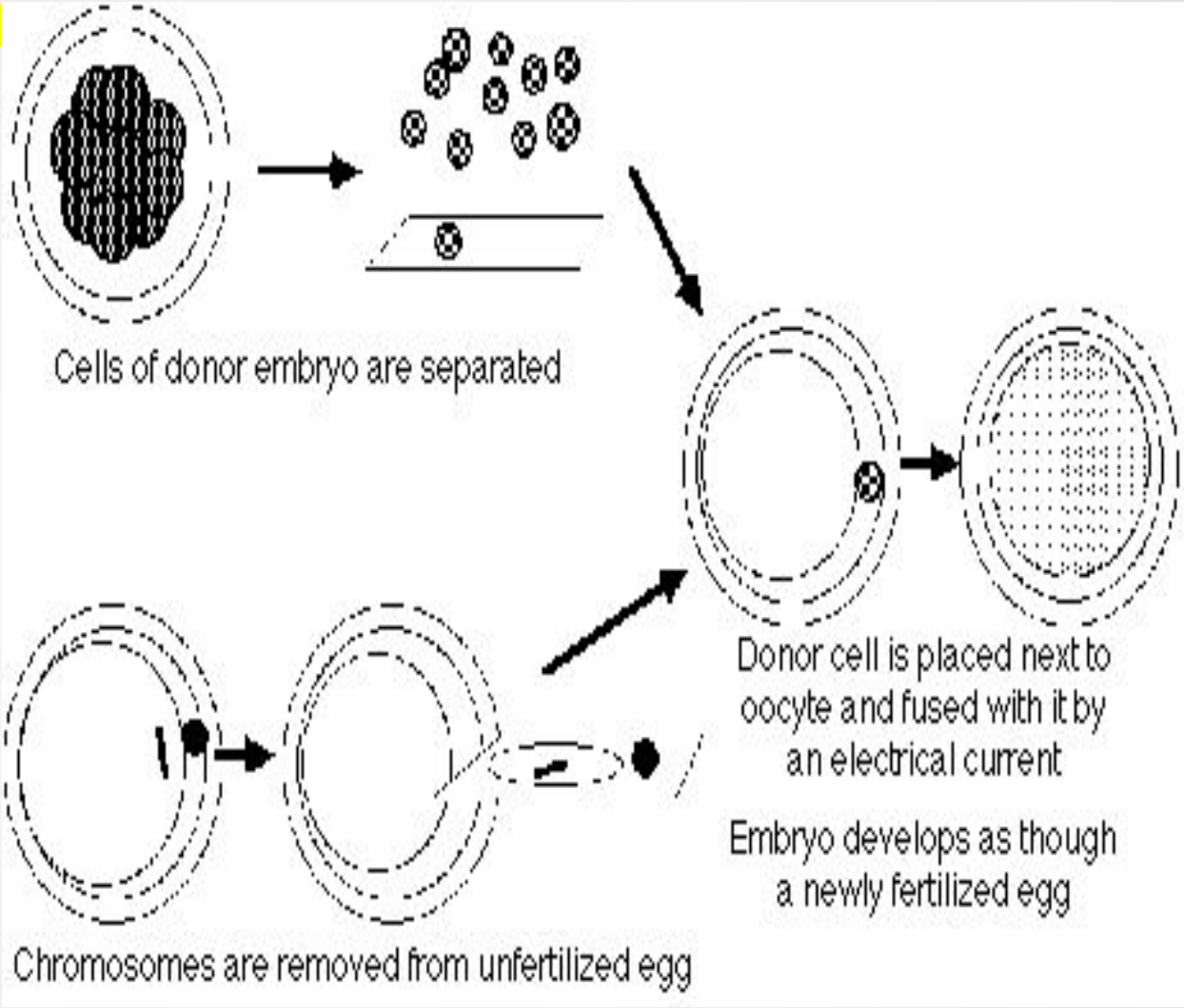
Non-disjunction

- An error in the process of chromosome sorting during cell division

Trisomy

- Having 3 chromosomes of one size instead of the normal pair

CLONING


Cells of donor embryo are separated
Donor cell is placed next to oocyte and fused with it by an electrical current
Embryo develops as though a newly fertilized egg
Chromosomes are removed from unfertilized egg

Meiosis vs Mitosis Review
KNOW THIS CHART

	Mitosis	Meiosis
Purpose?	growth and repair	Make sperm and eggs
Number of cells made?	2	4
Same as parent?	yes	No
Number of chromosomes?	same as parent	½ of parent
Where it takes place?	body cells	gametes

Practice:

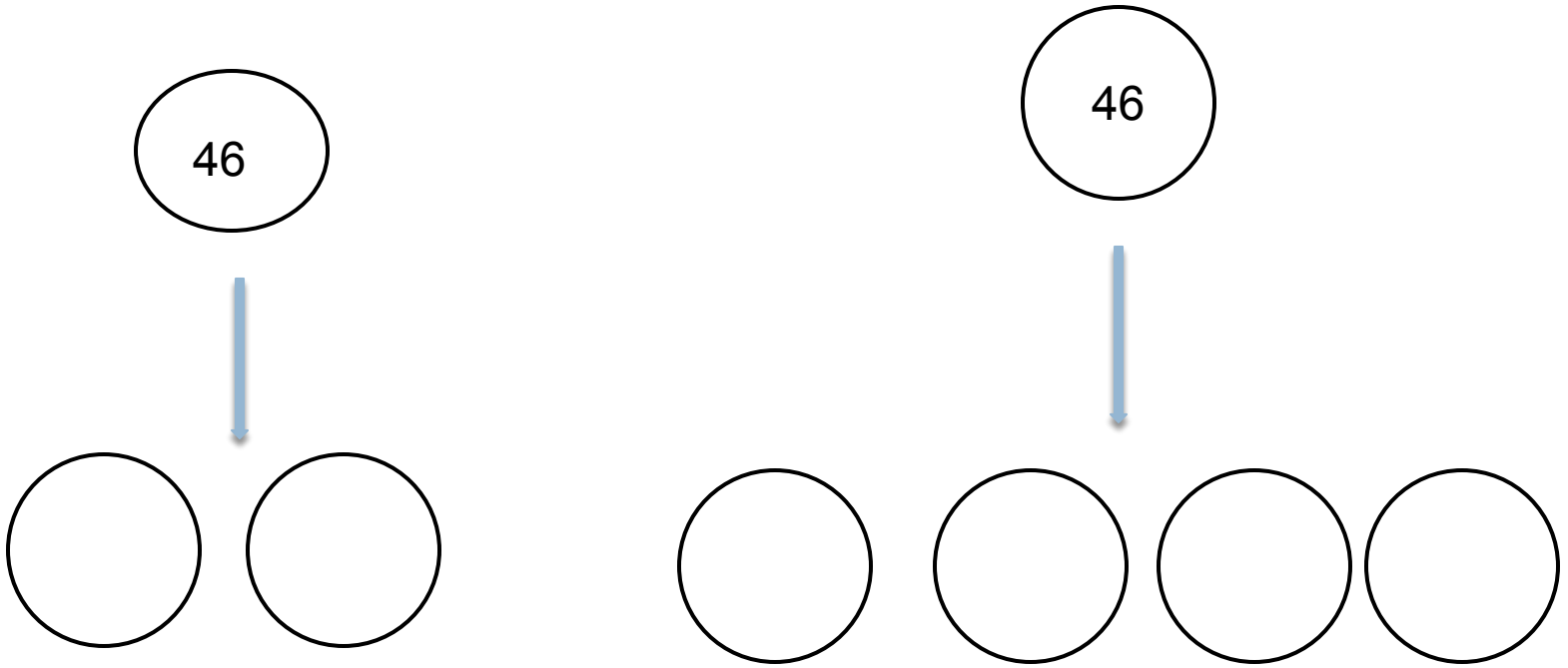
Humans have 46 chromosome in their cells. How many chromosomes do their gametes have after meiosis?

Answer: 23

After fertilization (when a sperm cell and egg cell combine) how many chromosomes will the zygote have?

Answer: 46

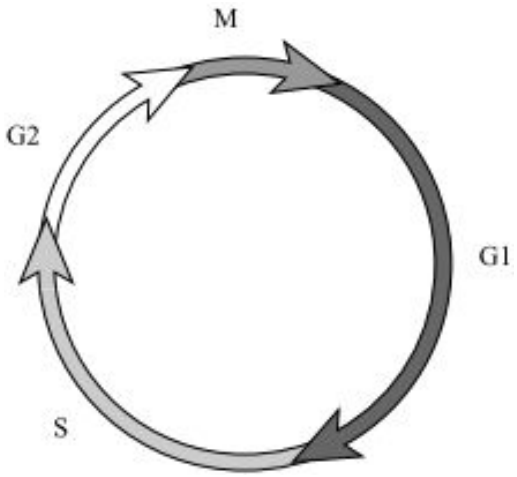
Mitosis and Meiosis Practice



How many chromosomes will each of the resulting cells have? Draw this in your notes this in in your notes.

Practice MCAS Questions

1. The diagram to the right shows the cell cycle. Which of the following activities occurs in the G1 phase?
   a. growth of cell
   b. replication of DNA
   c. formation of mitotic spindle
   d. breakdown of nuclear membrane



2. When gametes are produced from a parent cell during normal meiosis, which of the following describes the number of chromosomes in each resulting cell?

a. Each resulting cell has the same number of chromosomes as the parent cell.
b. Each resulting cell has twice the number of chromosomes as the parent cell.
c. Each resulting cell has one-half the number of chromosomes as the parent cell.
d. Each resulting cell has one-fourth the number of chromosomes as parent cell.

3. Which of the following normally results from meiosis in a human cell that contains 46 chromosomes?

a. an egg cell with 46 chromosomes
b. a blood cell with 46 chromosomes
c. a liver cell with 23 chromosomes
d. a sperm cell with 23 chromosomes