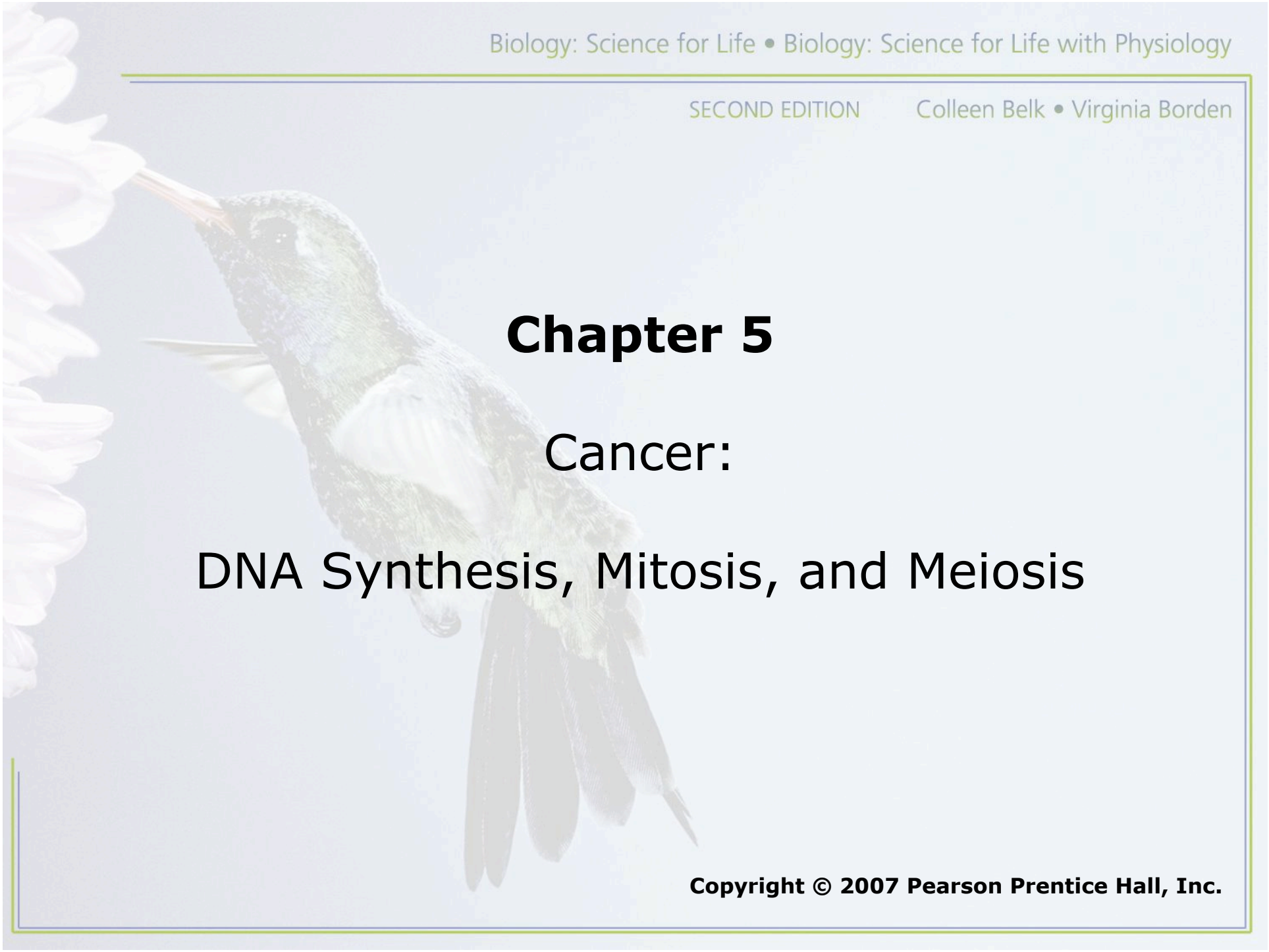
SECOND EDITION Colleen Belk • Virginia Borden



Chapter 5

Cancer:

DNA Synthesis, Mitosis, and Meiosis

5.6 Meiosis

- Another form of cell division, **meiosis**, occurs within **gonads**, or sex organs
  - The point of meiosis is to cut the number of chromosomes in half

- Male gonads are testes and female gonads are ovaries
  - Meiosis (my-oh-sis) happens in my ovaries
  - Mitosis (my-toe-sis) happens in my toes

- Meiosis produces sex cells = **gametes**:
  - Male gametes: sperm cells
  - Female gametes: egg cells

Meiosis

- Gametes have half the chromosomes (23) that **somatic** or regular body cells do (46)
- Meiosis reduces the number of chromosomes by one-half (23)
- Fertilization or joining of the male (23) and female (23) gamete will result in 46 chromosomes

Meiosis

- Which 23 of the 46 chromosomes end up in each gamete?
  - One of each kind or pair
- Chromosomes come in homologous pairs
- Each somatic body cell has two of every chromosome
  - 1 through 22 pairs of autosomal chromosomes
    - Two copies of chromosome #1, two copies of chromosome #2, etc
  - And XX (female) or XY (male) sex chromosomes
- Each gamete has one chromosome from each homologous pair
  - One copy of chromosome #1, one copy of chromosome #2, etc
  - And an X or a Y but not both

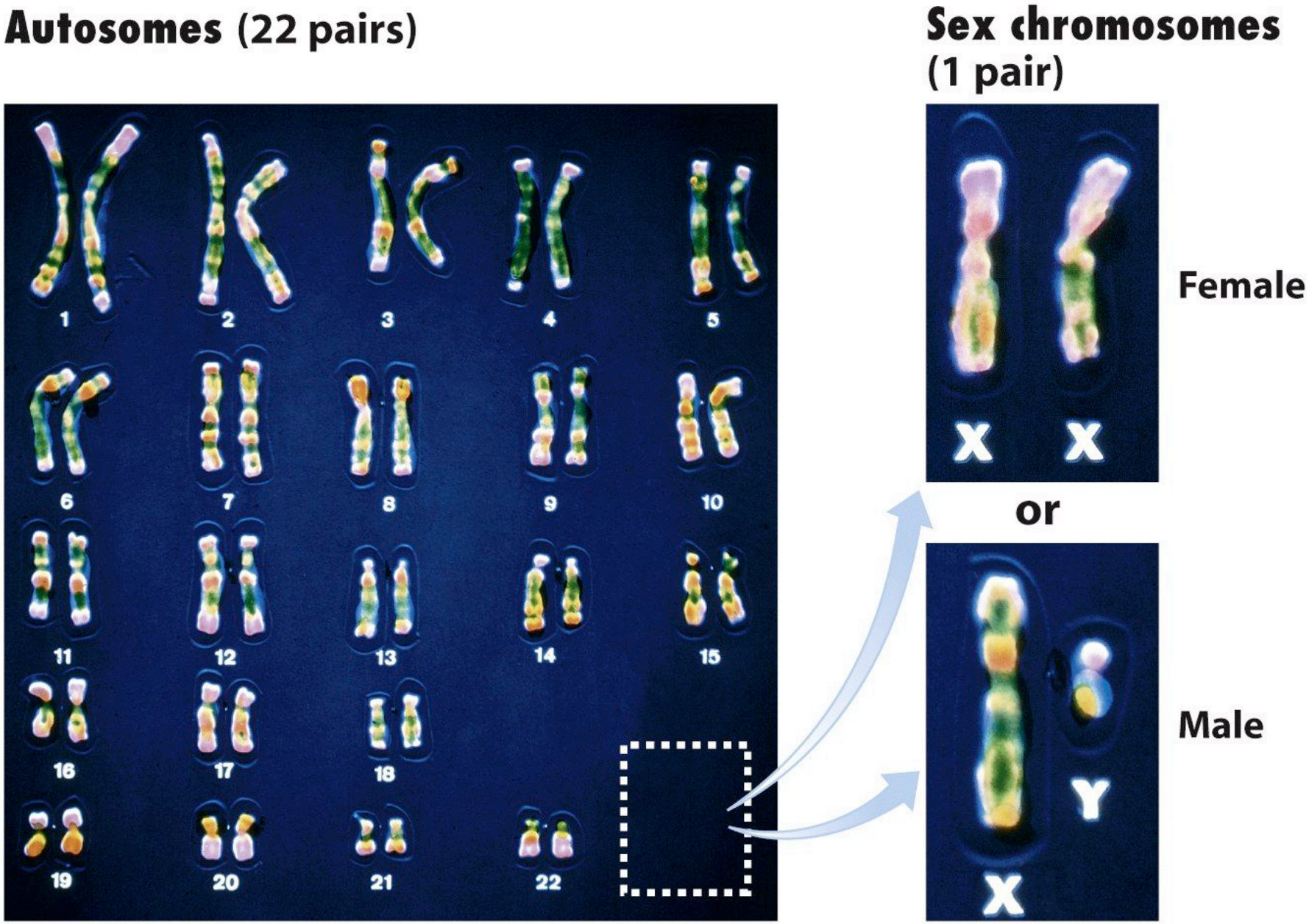


Figure 5-20 Biology: Science for Life, 2/e

Meiosis

- There are 22 pairs of **autosomes**
  - non-sex chromosomes

- Each pair of chromosomes carry the same genes
  - That's why they are called **homologous pairs**
  - Homo = same

- There is one pair of sex chromosomes:
  - Males have one X and one Y chromosome
  - Females have two X chromosomes

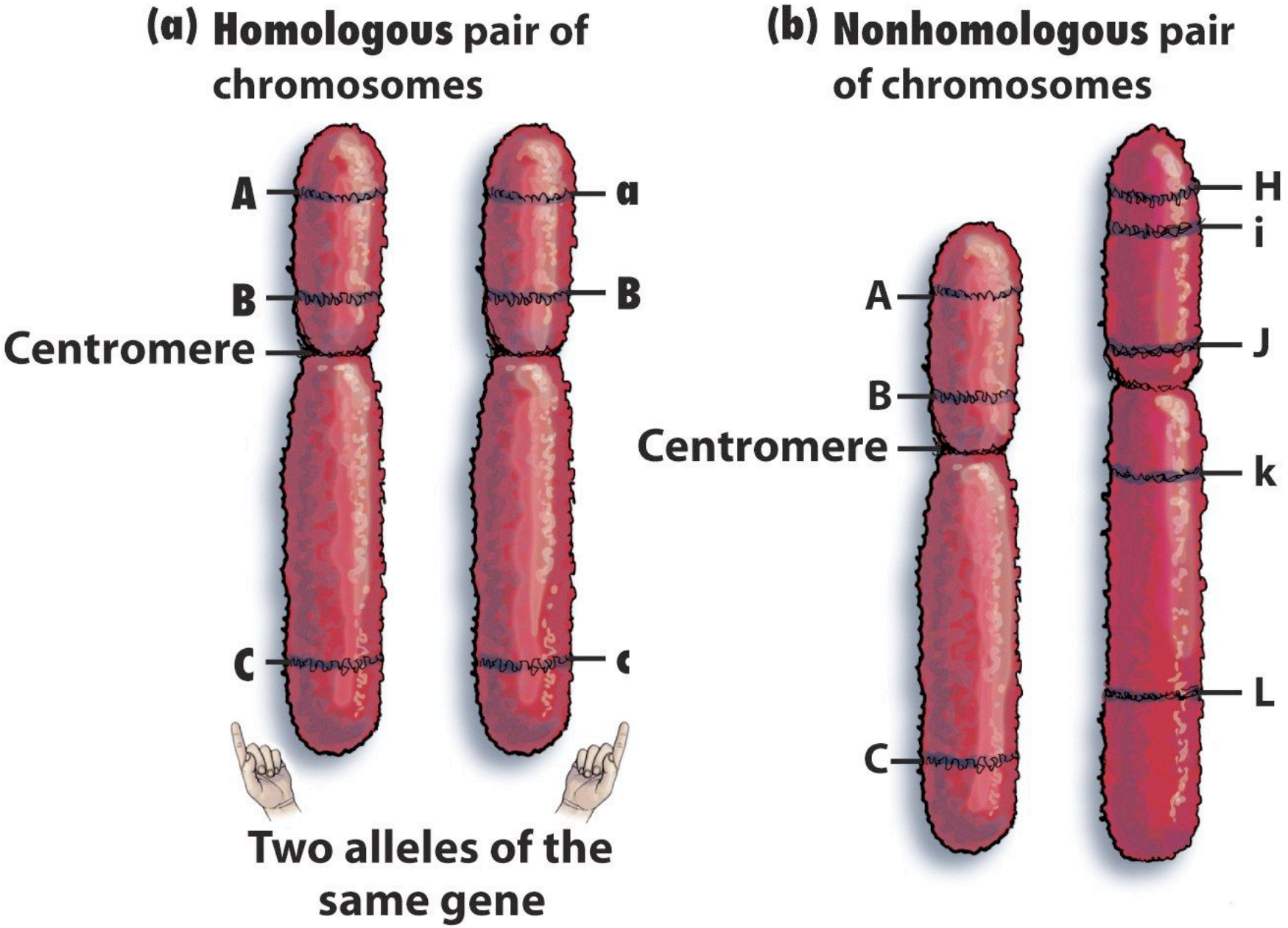


Figure 5-21 Biology: Science for Life, 2/e

Meiosis

- Each homologous pair has the same genes
- Both chromosomes of the pair will have the genes on them in the exact same place
- **Alleles are**
  - The same genes on a homologous chromosome pair
  - For example:
    - You have 2 alleles for the gene for earlobe shape
    - 1 on each of the homologous pair, say chromo 1
      - (in reality it is not known on what chromosome the gene for earlobe shape is located)
    - 1 allele may be for attached earlobes
    - The other allele may be for unattached earlobes

Meiosis

- Just like in mitosis, during the S phase of interphase:
  - the chromosomes are copied or replicated
  - now each of the homologous chromosomes have an identical copy called a sister chromatid

- All four sister chromatids carry the same genes at the same locations
  - but not necessarily the exact same information

–the chromosomes are replicated

–now each of the homologous chromosomes have an identical copy called a sister chromatid

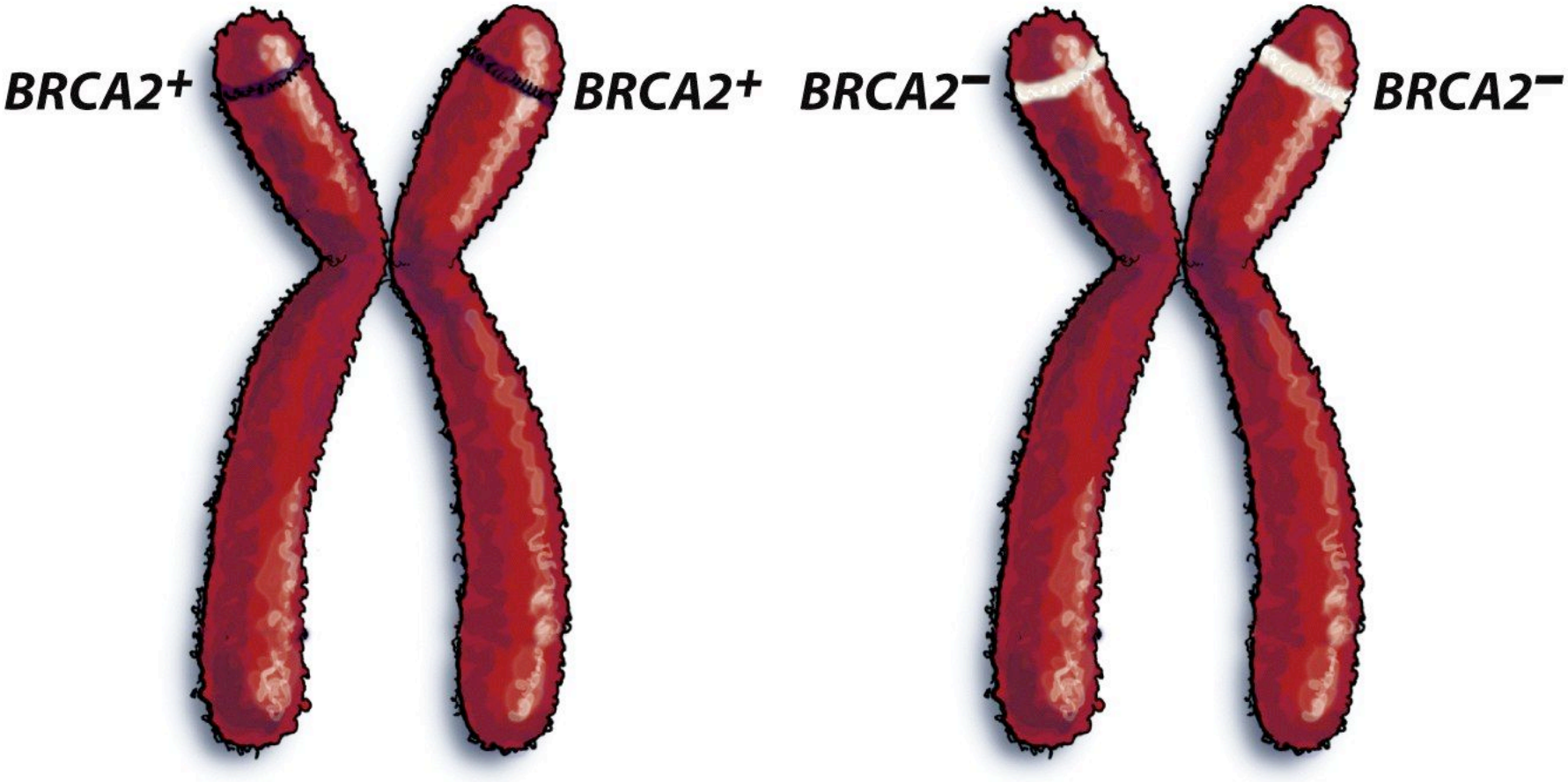


Figure 5-22 Biology: Science for Life, 2/e
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Meiosis

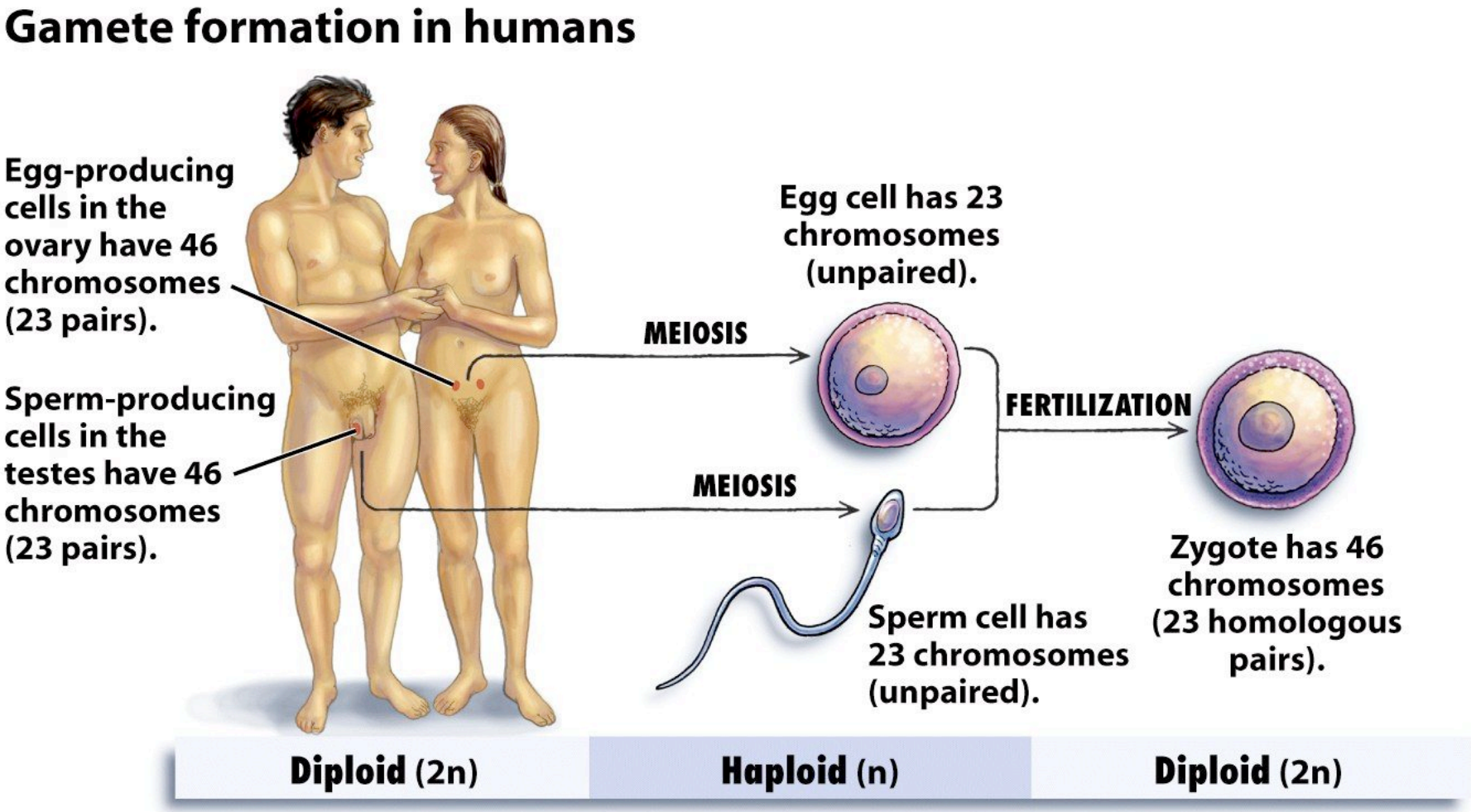
- During meiosis, the homologous pairs are separated
  - so each cell has only one of each pair
  - Each has half the amount of chromosomes
    - Normal cells have 2 of each pair

- This condition is called **haploid** (*n*)
  - having only one of each kind of chromosome
  - Haploid = half

Meiosis and Fertilization

- Meiosis occurs in the sex cells in either the testes or ovaries (for humans) producing gametes
  - Egg or sperm
- The joining of egg and sperm in fertilization forms
  - a **zygote**, or fertilized egg
- The zygote is **diploid** (2*n*)
  - It has two of each kind of chromosome now
    - One of each of the pairs of chromosomes from each gamete
      - Egg has 1 of each homologous pair
        - » one chromosome #1, one chromosome #2, etc
      - Sperm has 1 of each homologous pair
        - » one chromosome #1, one chromosome #2, etc
      - Zygote has 2 of each homologous chromosome
        - » two chromosome #1, two chromosome #2, etc

Meiosis and Fertilization



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Meiosis

- Interphase (G1, S, G2), then meiosis I and a cell division, and then meiosis II and a cell division
  - Equals 4 cells at the end
  - with half the number of chromosomes in each

- Meiosis consists of phases:
  - Meiosis I
    - the homologous pairs are separated
    - Cell divides into 2 cells
  - Meiosis II
    - the sister chromatids are separated
      - In both the 2 cells from meiosis I
    - Both cells divide into 2 cells

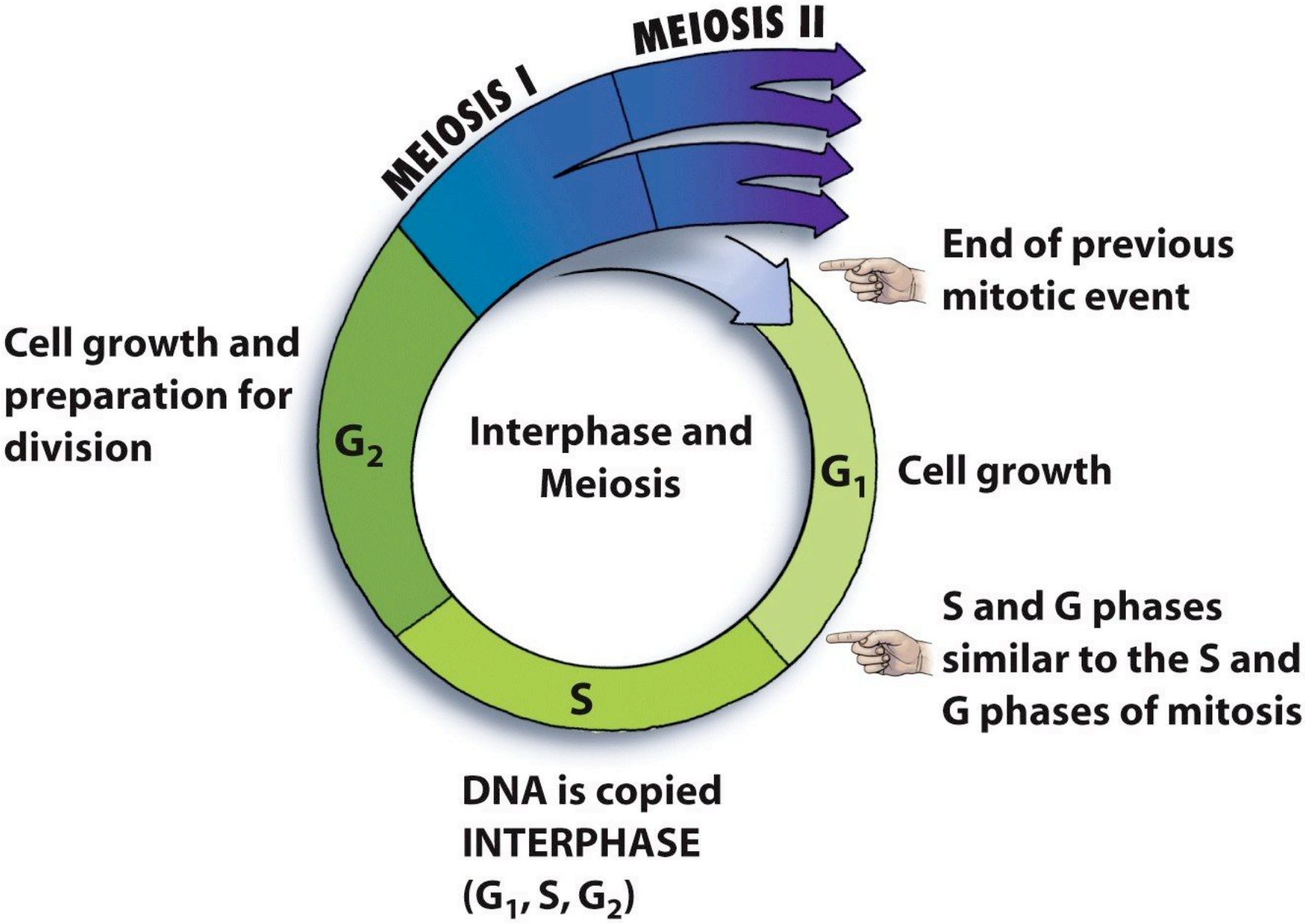
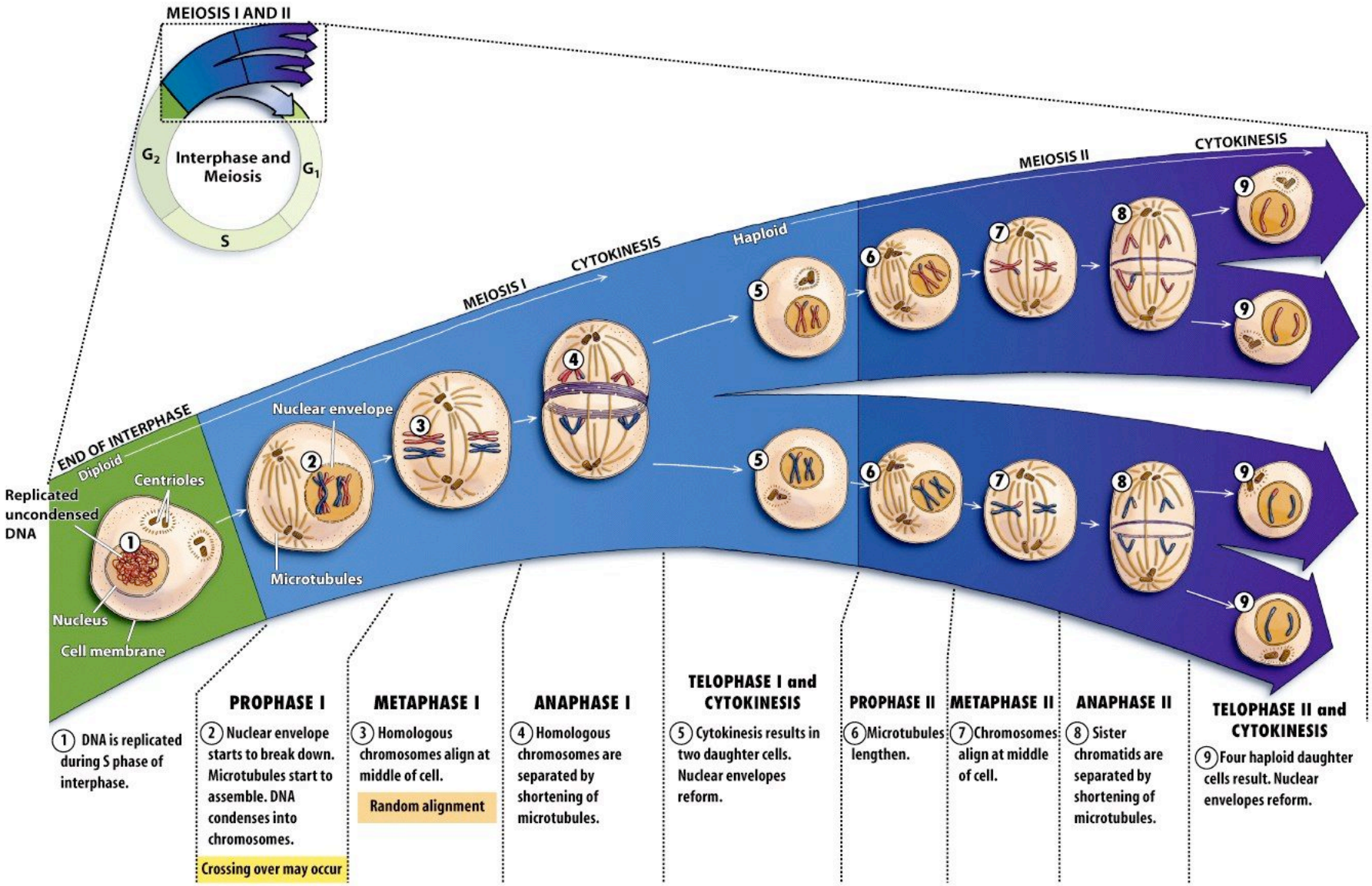


Figure 5-24 Biology: Science for Life, 2/e



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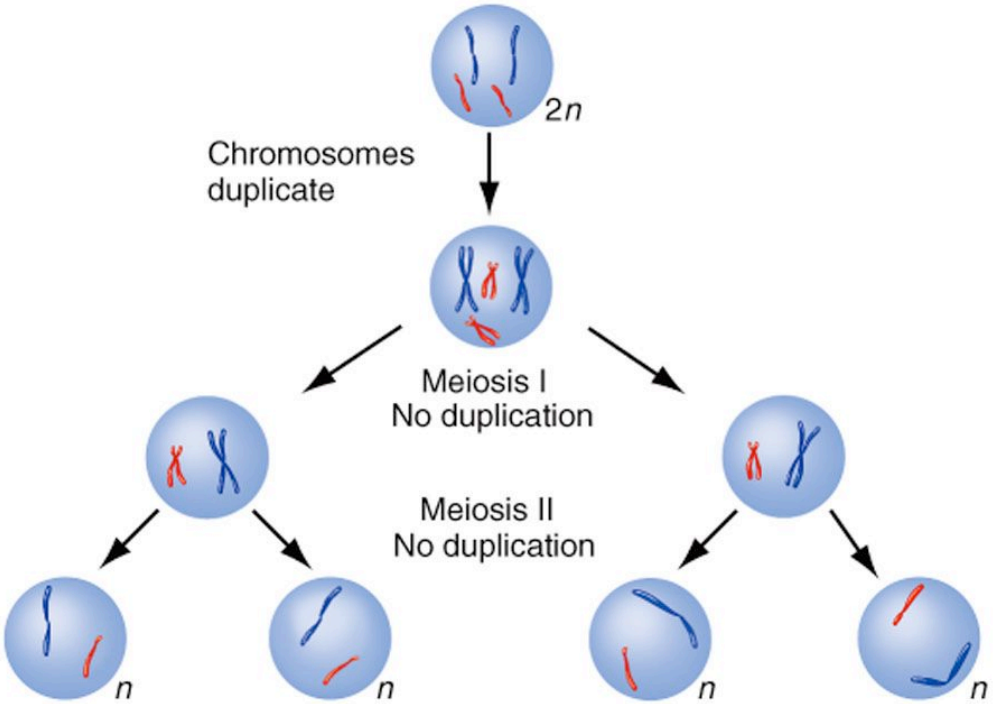
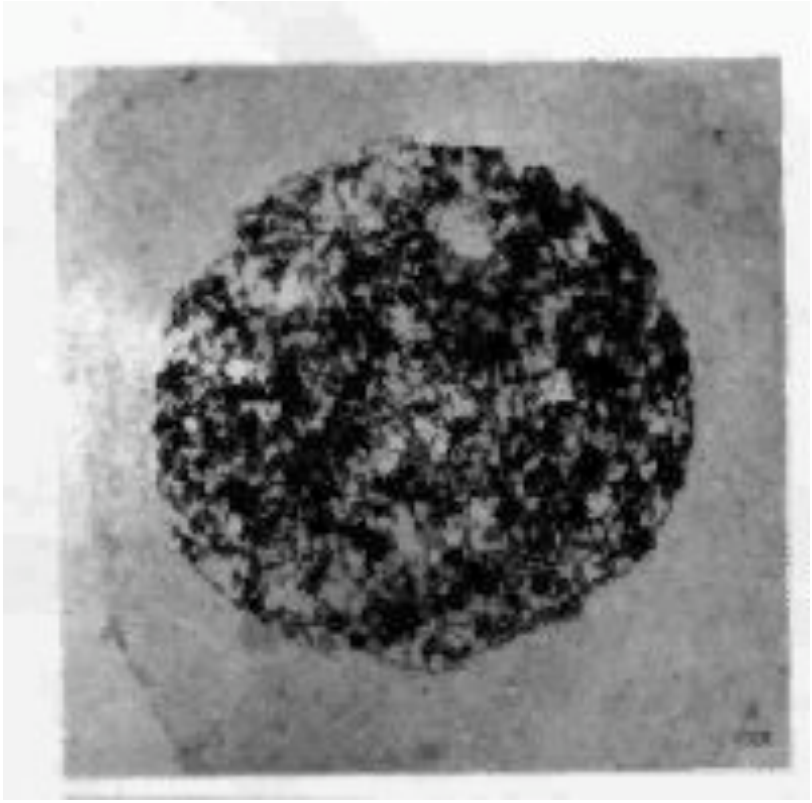
Meiosis

Chromosomes replicate one time, nuclei divide twice



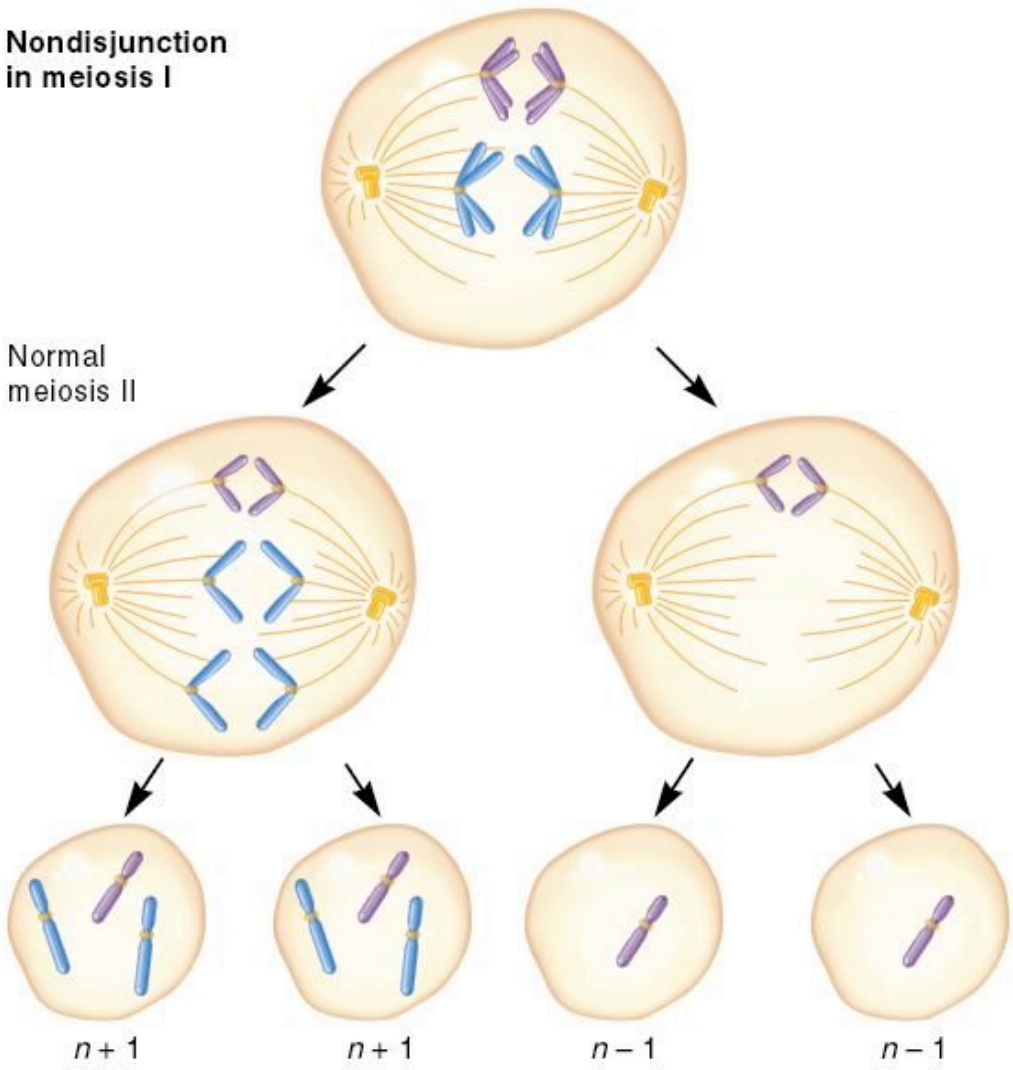


Meiosis

- Notice that the gametes are haploid
  - having one chromosome from each pair
- Each gamete carries half the genetic information as the parent
  - Half the number of chromosomes
- So when the egg and sperm get together
  - they now have the full amount of genetic information as the parent
- If the gametes did not have half number of chromosomes
  - Offspring would have twice as many chromosomes as the parents at every generation.
  - Too many chromosomes!

Meiosis and Nondisjunction

- Sometimes the homologous pairs do not separate during meiosis
- Supposed to have one chromo #1 go into one cell and the other Chromo #1 go into the other cel
- Sometimes, both Chromo #1 goes into one cell and no chromo #1 into the other cell
- This is called **nondisjunction** of meiosis 1
- If the sister chromatids do not separate, then it is **nondisjunction** of meiosis II

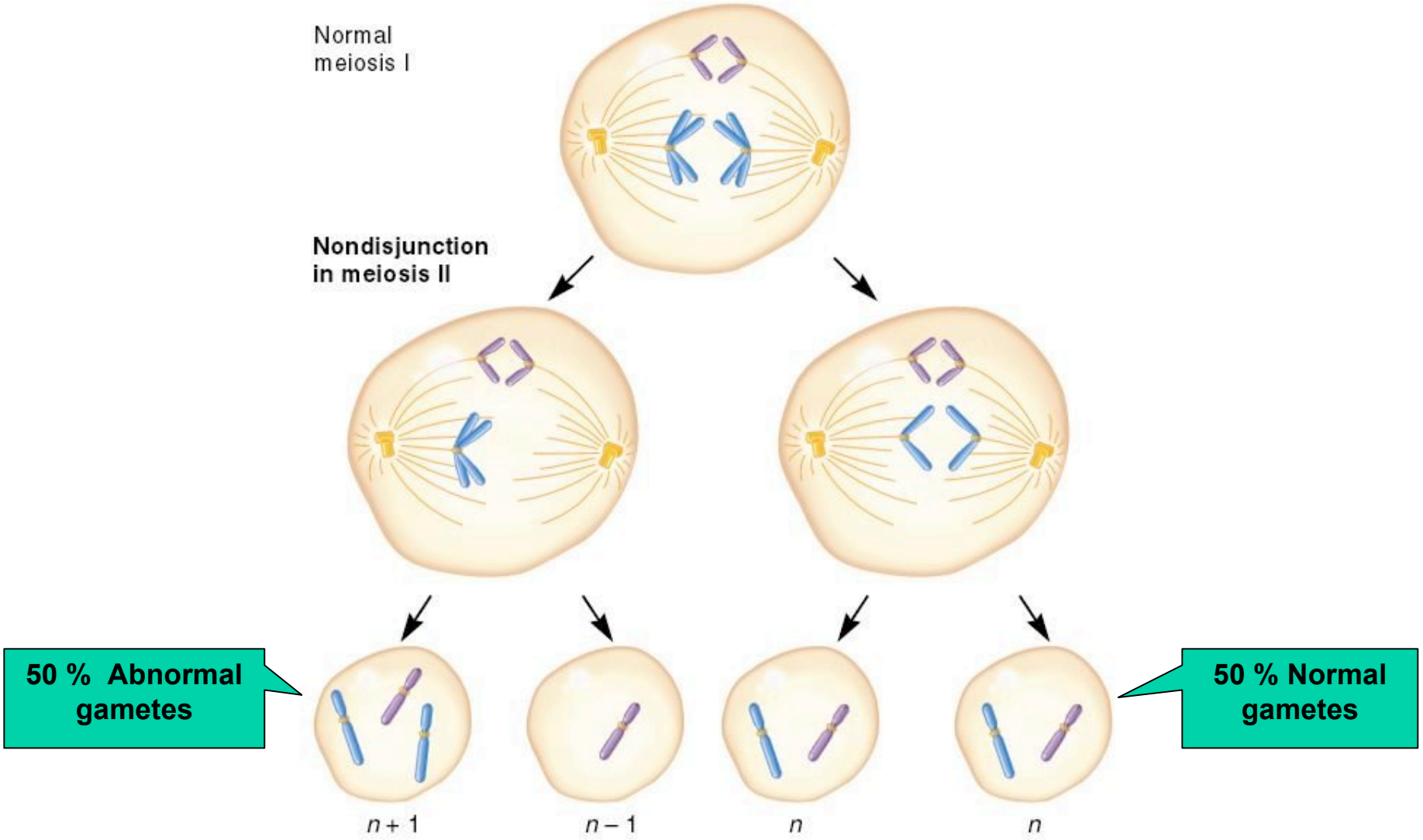


During fertilization, these gametes produce an individual that is trisomic for the missing chromosome

During fertilization, these gametes produce an individual that is monosomic for the missing chromosome

(a) Nondisjunction in meiosis I

All four gametes are abnormal



(b) Nondisjunction in meiosis II

Meiosis and Nondisjunction

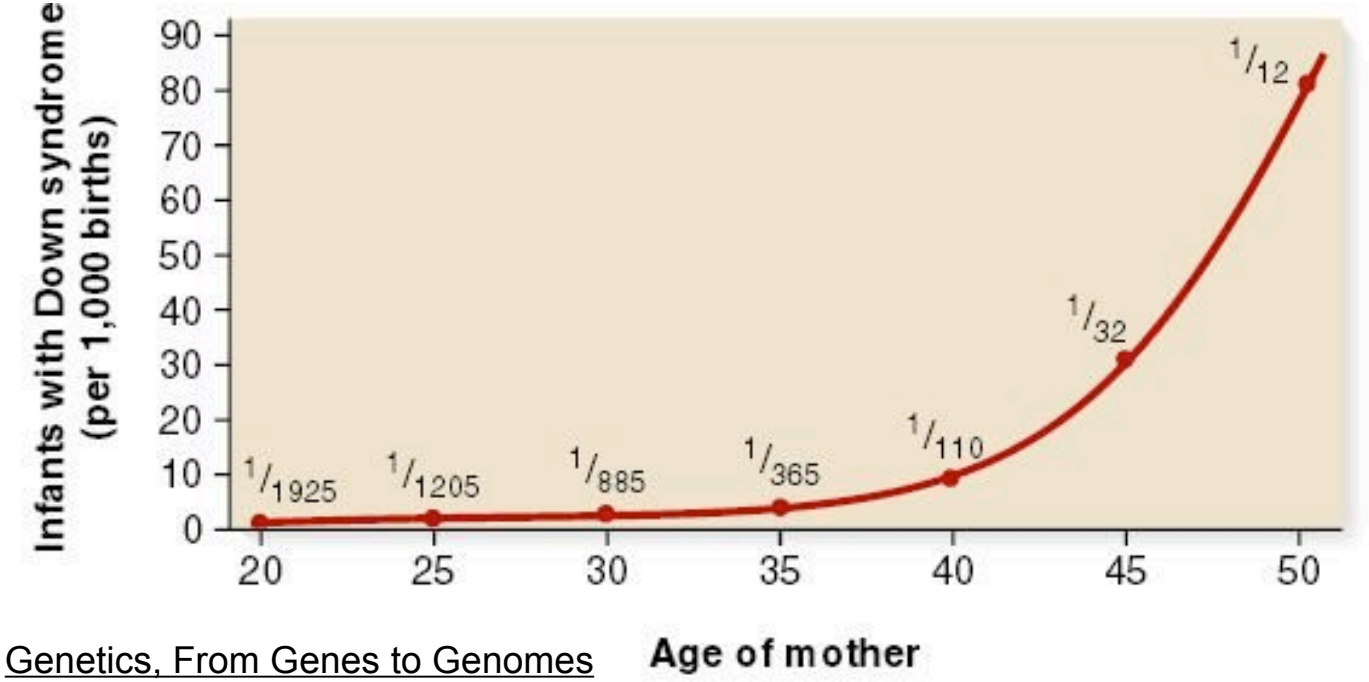
- Nondisjunction results in gametes with incorrect number of chromosomes
  - If fertilized, the offspring has an incorrect number of chromosomes
- An incorrect number of chromosomes is detrimental to humans
  - One example is trisomy 21 (Down Syndrome)
    - One extra chromosome #21

Conditions Caused by Nondisjunction of Autosomes	Approximate Frequency Among Live Births	Comments
Trisomy 21—Down syndrome 	The probability that a woman will have a child with Down syndrome increases with age. In mothers younger than age 35, Down Syndrome occurs in approximately 1 per 1000 births and at age 45, around 4 per 1000 births.	People with Down syndrome tend to be mentally retarded, have abnormal skeletal development, and have heart defects.

Table E7-3 part 1 Biology: Science for Life, 2/e

Age 45 = 33 per 1000
Russell, iGenetics

Meiosis and Nondisjunction



Hartwell, Genetics, From Genes to Genomes

Age of Mother	Frequency of Trisomy 21	Russell, iGenetics
16-34	1/1700	
35-39	1/333	
40-44	1/100	
45-47	1/30	

Meiosis and Nondisjunction

Conditions Caused by Nondisjunction of Autosomes	Approximate Frequency Among Live Births	Comments
Trisomy 13—Patau syndrome 	1 in 5000	Affected individuals are mentally retarded, deaf, and have a cleft lip and palate.

Table E7-3 part 2 Biology: Science for Life, 2/e

Conditions Caused by Nondisjunction of Autosomes	Approximate Frequency Among Live Births	Comments
Trisomy 18—Edwards syndrome 	1 in 6000 1 in 4000 Russell, iGenetics	Babies with Edwards syndrome have malformed organs, ears, mouth, and nose, leading to an elfin appearance. They are mentally retarded and usually die within 6 months of birth.

Table E7-3 part 3 Biology: Science for Life, 2/e

Mitosis and Meiosis

- Both are types of cell division
- Occur in different types of cells
  - Somatic body cells = mitosis
  - Sex cells or gametes = meiosis
- Produce very different products
  - Mitosis
    - 2 cells exact same number of chromosomes
  - Meiosis
    - 4 cells with half the number of chromosomes

Mitosis and Meiosis

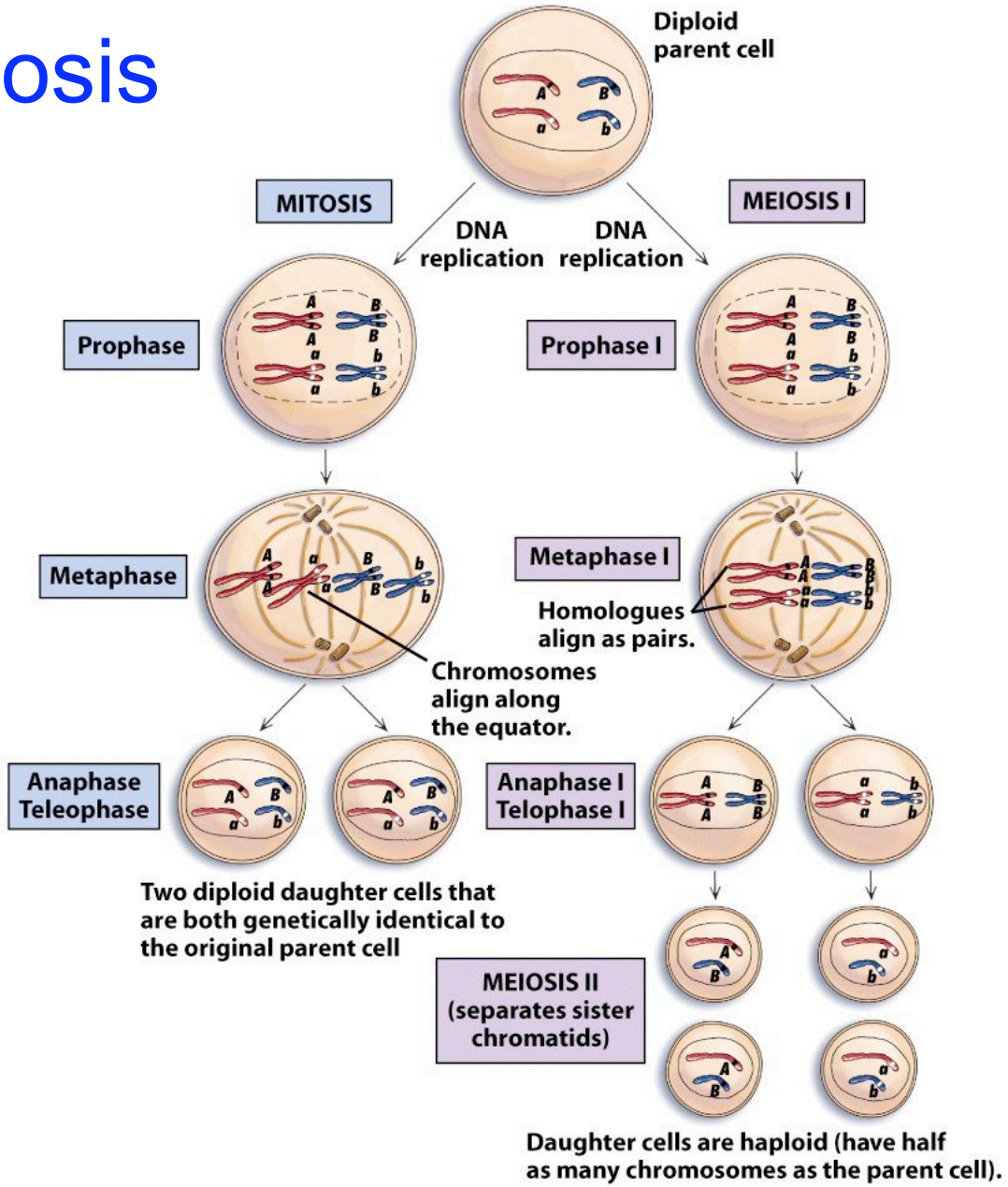


Figure 5-28 Biology: Science for Life, 2/e